

FACULTY OF SCIENCE AND HUMANITIES

ACADEMIC CURRICULA

**POSTGRADUATE DEGREE PROGRAMME
(REGULATIONS - 2025)**

**MASTER OF SCIENCE IN
CHEMISTRY**

Two Years (Full-Time)

National Education Policy

**Learning Outcomes based Curriculum Framework
(LOCF)**

National Credit Framework

Academic Year 2025 - 2026



SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

TABLE OF CONTENTS

| TITLE | PAGE NUMBER |
|---|-------------|
| DEPARTMENT VISION STATEMENT | II |
| DEPARTMENT MISSION STATEMENT | II |
| PROGRAM EDUCATION OBJECTIVES (PEO) | II |
| PROGRAM SPECIFIC OUTCOMES (PSO) | II |
| CONSISTENCY OF PEO'S WITH MISSION OF THE DEPARTMENT | II |
| CONSISTENCY OF PEO'S WITH PROGRAM LEARNING OUTCOMES (PLO) | II |
| PROGRAMME STRUCTURE | III |
| COURSE STRUCTURE | IV |
| IMPLEMENTATION PLAN | V |
| PROGRAM ARTICULATION MATRIX | VI |

SEMESTER I

| SUBJECT CODE | SUBJECT TITLE | PAGE NUMBER |
|--------------|---|-------------|
| PCY25101J | Chemical Kinetics, Electrochemistry and Surface Chemistry | 7 |
| PCY25102J | Chemistry of <i>d</i> - and <i>f</i> -Block Elements | 10 |
| PCY25103T | Organic Chemistry: Structure and Reactivity | 14 |
| PCY25104T | Chemical Bonding, Molecular Geometry and Group Theory | 17 |
| PCY25S01J | Fundamentals and Practical Aspects of Computational Chemistry | 20 |
| PCD25AE1T | Comprehensive Skills in Quantitative and Logical Reasoning | 23 |

SEMESTER II

| | | |
|-----------|--|----|
| POC25201T | Spectroscopy and Applications in Organic Chemistry | 26 |
| POC25202T | Transformations in Organic Chemistry | 30 |
| PCY25203T | Classical and Statistical Thermodynamics | 33 |
| PCY25202J | Main Group Elements and Nuclear Chemistry | 36 |
| POC25203T | Heterocyclic Chemistry and Total Synthesis of Natural Products | 39 |
| POC25D02T | Asymmetric and Enzymatic Synthesis | 42 |
| PCY25D04T | Nanomaterials and Nanochemistry | 45 |
| POC25S01L | Organic Chemistry Practical: Functional Group Analysis and Synthesis | 48 |
| PCD25AE2T | Soft Skills and Verbal Mastery | 50 |

SEMESTER III

| | | |
|-----------|--|----|
| PCY25301T | Organometallic and Bioinorganic Chemistry | 53 |
| PCY25302T | Quantum Chemistry and Molecular Spectroscopy | 56 |
| PCY25D01T | Analytical Chemistry | 59 |
| PCY25D02T | Materials Chemistry | 62 |
| PCY25D03T | Advanced Polymer Science | 65 |
| POC25301T | Modern Synthetic Reagents and Rearrangements | 69 |
| PCY25D05T | Supramolecular Chemistry and Crystal Engineering | 73 |
| PCY25D06T | Advanced Electrochemistry | 76 |
| PCY25S02L | Instrumental Methods of Analysis - Practical | 79 |
| PPY25G01T | LASER Physics | 81 |
| PPY25G02J | Semiconductor Virtual Nanofabrication | 84 |
| PCY25G01T | Research Skills and Learning | 87 |
| PCY25I01L | Internship | 90 |

SEMESTER IV

| | | |
|-----------|--------------|----|
| PCY25P01L | Project Work | 91 |
|-----------|--------------|----|

GENERIC ELECTIVES OFFERED BY CHEMISTRY DEPARTMENT

| | | |
|-----------|------------------------------|----|
| PCY25G01T | Research Skills and Learning | 87 |
| PCY25G02T | Chemistry of Biomolecules | 92 |

DEPARTMENT OF CHEMISTRY

1. Department Vision Statement

| | |
|-----------|--|
| Stmnt - 1 | To be a nationally and an internationally acclaimed hub for high-level teaching in chemistry |
| Stmnt - 2 | To Implement the global standards and nurturing the students through innovation and quality education. |

2. Department Mission Statement

| | |
|-----------|--|
| Stmnt - 1 | To motivate the next generation graduates to effectively contribute to the advancement of society with integrity and commitment. |
| Stmnt - 2 | To expose the students to a breadth of experimental techniques using modern instrumentation. |
| Stmnt - 3 | To contribute to industry and address problems of societal importance. |
| Stmnt - 4 | To attain entrepreneurship and self-empowerment in the field of chemical sciences. |
| Stmnt - 5 | To provide comprehensive specialist expertise in the domain of chemistry |

3. Program Education Objectives (PEO)

| | |
|---------|--|
| PEO - 1 | To develop critical analysis and problem-solving skills required in the field of Chemistry |
| PEO - 2 | To prepare students with a working knowledge of experimental techniques and instrumentation required to work independently in research or industrial environments. |
| PEO - 3 | To develop student strength in organizing and presenting acquired knowledge coherently both orally and in written discourse. |
| PEO - 4 | To prepare the students to successfully compete for current employment opportunities |
| PEO - 5 | To develop an ability to be socially intelligent with good SIQ (Social Intelligence Quotient) and EQ (Emotional Quotient) |

4. Consistency of PEO's with Mission of the Department

| | Mission Stmnt. - 1 | Mission Stmnt. - 2 | Mission Stmnt. - 3 | Mission Stmnt. - 4 | Mission Stmnt. - 5 |
|---------|--------------------|--------------------|--------------------|--------------------|--------------------|
| PEO - 1 | Medium | High | High | High | Medium |
| PEO - 2 | High | High | High | Medium | Medium |
| PEO - 3 | High | High | High | Medium | Medium |
| PEO - 4 | Medium | Medium | Medium | High | High |
| PEO - 5 | High | Medium | Medium | High | High |

3 – High Correlation, 2 – Medium Correlation, 1 – Low Correlation

5. Consistency of PEO's with Program Learning Outcomes (PO)

| | Program Learning Outcomes (PO) | | | | | | | | | | | |
|---------|--------------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. |
| | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical Practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| PEO - 1 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 1 | 3 |
| PEO - 2 | 3 | 2 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 1 | 3 |
| PEO - 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 1 | 2 |
| PEO - 4 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| PEO - 5 | 2 | 3 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |

3 – High Correlation, 2 – Medium Correlation, 1 – Low Correlation

| 6. PG Programme Structure (Total Credits:80) | | | | | | | | | | | |
|---|---|-------------|----|----|----|--|--|-------------|---|---|----|
| 1. Professional Core Courses (C) (10 Courses) | | | | | | 2. Discipline Elective Courses (D) (3 Courses) | | | | | |
| Course Code | Course Title | Hours/ Week | | | C | Course Code | Course Title | Hours/ Week | | | C |
| | | L | T* | P | | | | L | T | P | |
| PCY25101J | Chemical Kinetics, Electrochemistry and Surface Chemistry | 2 | 0 | 4 | 4 | POC25203T | Heterocyclic Chemistry and Total Synthesis of Natural Products | 3 | 1 | 0 | 4 |
| PCY25102J | Chemistry of d- and f-Block Elements | 2 | 0 | 4 | 4 | POC25D02T | Asymmetric and Enzymatic Synthesis | | | | |
| PCY25103T | Organic Chemistry: Structure and Reactivity | 3 | 1 | 0 | 4 | PCY25D04T | Nanomaterials and Nanochemistry | | | | |
| PCY25104T | Chemical Bonding, Molecular Geometry and Group Theory | 3 | 1 | 0 | 4 | PCY25D01T | Analytical Chemistry | 3 | 1 | 0 | 4 |
| POC25201T | Spectroscopy and Applications in Organic Chemistry | 3 | 1 | 0 | 4 | PCY25D02T | Materials Chemistry | | | | |
| POC25202T | Transformations in Organic Chemistry | 3 | 1 | 0 | 4 | PCY25D03T | Advanced Polymer Science | | | | |
| PCY25203T | Classical and Statistical Thermodynamics | 3 | 1 | 0 | 4 | POC25301T | Modern Synthetic Reagents and Rearrangements | 3 | 1 | 0 | 4 |
| PCY25202J | Main Group Elements and Nuclear Chemistry | 2 | 0 | 4 | 4 | PCY25D05T | Supramolecular Chemistry and Crystal Engineering | | | | |
| PCY25301T | Organometallic and Bioinorganic Chemistry | 3 | 1 | 0 | 4 | PCY25D06T | Advanced Electrochemistry | | | | |
| PCY25302T | Quantum Chemistry and Molecular Spectroscopy | 3 | 1 | 0 | 4 | Total Learning Credits | | | | | 12 |
| Total Learning Credits | | | | | | 40 | | | | | |
| 3. Generic Elective Courses (G) (Any 1 Course) | | | | | | 4. Skill Enhancement Courses(S) (3 Courses) | | | | | |
| Course Code | Course Title | Hours/ Week | | | C | Course Code | Course Title | Hours/ Week | | | C |
| | | L | T | P | | | | L | T | P | |
| PPY25G01T | LASER Physics | 3 | 1 | 0 | 4 | PCY25S01J | Fundamentals and Practical Aspects of Computational Chemistry | 1 | 0 | 2 | 2 |
| PPY25G02J | Semiconductor Virtual Nanofabrication | 3 | 0 | 2 | 4 | POC25S01L | Organic Chemistry Practical: Functional Group Analysis and Synthesis | 0 | 0 | 6 | 3 |
| PCY25G01T | Research Skills and Learning | 3 | 1 | 0 | 4 | PCY25S02L | Instrumental Methods of Analysis - Practical | 0 | 0 | 6 | 3 |
| Total Learning Credits | | | | | 4 | Total Learning Credits | | | | | 8 |
| 5. Project Work, Internship In Industry / Higher Technical Institutions(P) (2 Courses) | | | | | | 6.Ability Enhancement Courses (AE) (2 Courses) | | | | | |
| Course Code | Course Title | Hours/ Week | | | C | Course Code | Course Title | Hours/ Week | | | C |
| | | L | T | P | | | | L | T | P | |
| PCY25I01L | Internship | 0 | 0 | 0 | 2 | PCD25AE1T | Comprehensive Skills in Quantitative and Logical Reasoning | 2 | 0 | 0 | 2 |
| PCY25P01L | Project Work | 0 | 0 | 20 | 10 | PCD25AE2T | Soft Skills and Verbal Mastery | 2 | 0 | 0 | 2 |
| Total Learning Credits | | | | | 12 | Total Learning Credits | | | | | 4 |

* Additional one hour as an open contact hour for each core course

| Course Structure | | | | | | | | |
|--------------------------|--|---|--|--|--|---------------------------------------|------------------|----------------|
| Semester | Professional Core Courses (PCC) | Discipline Electives Courses (DEC) | Generic Electives Courses (GEC) | Skill Enhancement Courses (SEC) | Ability Enhancement Courses (AEC) | Project Work, Internship (P) | Total Credits | Total Hours |
| I | PCC-1(4) PCC-2 (4) PCC-3(4) PCC-4(4) | | | SEC-1 (2) | | | 20 | 25 |
| II | PCC-5 (4) PCC-6 (4) PCC-7 (4) PCC-8 (4) | DEC-1 (4) | | SEC-2 (3) | AEC-1 (2) | | 25 | 30 |
| III | PCC-9(4) PCC-10 (4) | DEC-2 (4) DEC-3 (4) | GEC-(4) | SEC-3 (3) | AEC-2 (2) | P (Internship) (2) | 25 | 26 |
| IV | | | | | | P (Project) (10) | 10 | 20 |
| Total Credits | 40 | 12 | 4 | 8 | 4 | 12 | 80 | 101 |

7. Implementation Plan

| Semester - I | | | | | |
|------------------------|---|-------------|---|---|-----------|
| Course Code | Course Title | Hours/ Week | | | C |
| | | L | T | P | |
| PCY25101J | Chemical Kinetics, Electrochemistry and Surface Chemistry | 2 | 0 | 4 | 4 |
| PCY25102J | Chemistry of d- and f-Block Elements | 2 | 0 | 4 | 4 |
| PCY25103T | Organic Chemistry: Structure and Reactivity | 3 | 1 | 0 | 4 |
| PCY25104T | Chemical Bonding, Molecular Geometry and Group Theory | 3 | 1 | 0 | 4 |
| PCY25S01J | Fundamentals and Practical Aspects of Computational Chemistry | 1 | 0 | 2 | 2 |
| PCD25AE1T | Comprehensive Skills in Quantitative and Logical Reasoning | 2 | 0 | 0 | 2 |
| Total Learning Credits | | | | | 20 |
| Total Number of Hours | | | | | 25 |

| Semester - II | | | | | |
|------------------------|--|-------------|---|---|-----------|
| Course Code | Course Title | Hours/ Week | | | C |
| | | L | T | P | |
| POC25201T | Spectroscopy and Applications in Organic Chemistry | 3 | 1 | 0 | 4 |
| POC25202T | Transformations in Organic Chemistry | 3 | 1 | 0 | 4 |
| PCY25203T | Classical and Statistical Thermodynamics | 3 | 1 | 0 | 4 |
| PCY25202J | Main Group Elements and Nuclear Chemistry | 2 | 0 | 4 | 4 |
| POC25203T | Heterocyclic Chemistry and Total Synthesis of Natural Products | 3 | 1 | 0 | 4 |
| POC25D02T | Asymmetric and Enzymatic Synthesis | | | | |
| PCY25D04T | Nanomaterials and Nanochemistry | | | | |
| POC25S01L | Organic Chemistry Practical: Functional Group Analysis and Synthesis | 0 | 0 | 6 | 3 |
| PCD25AE2T | Soft Skills and Verbal Mastery | 2 | 0 | 0 | 2 |
| Total Learning Credits | | | | | 25 |
| Total Number of Hours | | | | | 30 |

| Semester – III | | | | | |
|------------------------|--|-------------|---|---|-----------|
| Course Code | Course Title | Hours/ Week | | | C |
| | | L | T | P | |
| PCY25301T | Organometallic and Bioinorganic Chemistry | 3 | 1 | 0 | 4 |
| PCY25302T | Quantum Chemistry and Molecular Spectroscopy | 3 | 1 | 0 | 4 |
| PCY25D01T | Analytical Chemistry | 3 | 1 | 0 | 4 |
| PCY25D02T | Materials Chemistry | | | | |
| PCY25D03T | Advanced Polymer Science | | | | |
| POC25301T | Modern Synthetic Reagents and Rearrangements | 3 | 1 | 0 | 4 |
| PCY25D05T | Supramolecular Chemistry and Crystal Engineering | | | | |
| PCY25D06T | Advanced Electrochemistry | | | | |
| PCY25S02L | Instrumental Methods of Analysis - Practical | 0 | 0 | 6 | 3 |
| PPY25G01T | LASER Physics | 3 | 1 | 0 | 4 |
| PPY25G02J | Semiconductor Virtual Nanofabrication | 3 | 0 | 2 | |
| PCY25G01T | Research Skills and Learning | 3 | 1 | 0 | |
| PCY25I01L | Internship | 0 | 0 | 0 | 2 |
| Total Learning Credits | | | | | 25 |
| Total Number of Hours | | | | | 26 |

| Semester - IV | | | | | |
|------------------------|--------------|-------------|---|----|-----------|
| Course Code | Course Title | Hours/ Week | | | C |
| | | L | T | P | |
| PCY25P01L | Project Work | 0 | 0 | 20 | 10 |
| Total Learning Credits | | | | | 10 |
| Total Number of Hours | | | | | 20 |

Total Number of Subjects: 21

Total Number of Credits: 80

| 8. Programme Articulation Matrix | | | | | | | | | | | | | |
|----------------------------------|--|-----------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| Course Code | Course Name | Programme Learning Outcomes | | | | | | | | | | | |
| | | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical Practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| | | | | | | | | | | | | | |
| PCY25101J | Chemical Kinetics, Electrochemistry and Surface Chemistry | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| PCY25102J | Chemistry of <i>d</i> - and <i>f</i> -Block Elements | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 3 |
| PCY25103T | Organic Chemistry: Structure and Reactivity | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 |
| PCY25104T | Chemical Bonding, Molecular Geometry and Group Theory | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 |
| POC25201T | Spectroscopy and Applications in Organic Chemistry | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 |
| POC25202T | Transformations in Organic Chemistry | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| PCY25203T | Classical and Statistical Thermodynamics | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| PCY25202J | Main Group Elements and Nuclear Chemistry | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| PCY25301T | Organometallic and Bioinorganic Chemistry | 3 | 3 | 2 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 3 |
| PCY25302T | Quantum Chemistry and Molecular Spectroscopy | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 3 |
| POC25203T | Heterocyclic Chemistry and Total Synthesis of Natural Products | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| POC25D02T | Asymmetric and Enzymatic Synthesis | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 2 | 3 |
| PCY25D04T | Nanomaterials and Nanochemistry | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 |
| PCY25D01T | Analytical Chemistry | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| PCY25D02T | Materials Chemistry | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| PCY25D03T | Advanced Polymer Science | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| POC25301T | Modern Synthetic Reagents and Rearrangements | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| PCY25D05T | Supramolecular Chemistry and Crystal Engineering | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 |
| PCY25D06T | Advanced Electrochemistry | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 2 |
| PPY25G01T | LASER Physics | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 |
| PPY25G02J | Semiconductor Virtual Nanofabrication | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 2 | 2 |
| PCY25G01T | Research Skills and Learning | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 |
| PCY25S01J | Fundamentals and Practical Aspects of Computational Chemistry | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 2 |
| POC25S01L | Organic Chemistry Practical: Functional Group Analysis and Synthesis | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 3 |
| PCY25S02L | Instrumental Methods of Analysis - Practical | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 |
| PCY25I01L | Internship | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 |
| PCY25P01L | Project Work | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| PCD25AE1T | Comprehensive Skills in Quantitative and Logical Reasoning | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 3 |
| PCD25AE2T | Soft Skills and Verbal Mastery | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 |
| PCY25G02T | Chemistry of Biomolecules | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 2 |
| Program Average | | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |

3 – High Correlation, 2 – Medium Correlation, 1 – Low Correlation

SEMESTER I

| Course Code | PCY25101J | Course Title | Chemical Kinetics, Electrochemistry and Surface Chemistry | | | | Category | C | Core Course | L | T | P | C |
|-------------|-----------|--------------|---|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 2 | 0 | 4 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLR-1 | Help the student to understand the basic principles of chemical kinetics. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CLR-2 | Probe the chemical reaction in solutions and the factors influencing reaction kinetics. | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Gather basic knowledge about acid base catalyzed reaction and enzyme catalyzed reaction. | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Learn the electroanalytical methods, interfacial electrochemistry, phase rule and phase equilibria. | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Understand the mechanism of surface adsorption process in terms of thermodynamics and chemical kinetics. | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| CLO-1 | Understand the basic principles of chemical kinetics. | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | - | 3 | - | - | - | 3 | - | - | - | - | - |
| CLO-2 | Gain knowledge about fast reaction kinetics. | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | 3 | - | - | - | - | - | - | - | 2 | - |
| CLO-3 | Understand the mechanisms of chemical reactions in gas and liquid phases. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-4 | Gain knowledge about the fundamental concepts of electrochemistry and the phase diagrams of multi-component systems. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 3 | - | - | - | - | - | - | - | - | 3 |
| CLO-5 | Understand the basic principles of adsorption, kinetics of chemisorption of gases and BET related isotherms. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | 3 | - | - | - | 2 | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--------------------------|---|--|--|---|
| | Reaction Kinetics | Reaction rate descriptors and related effects | EMF determination and interfacial electrostatics | Electroanalytical methods and phase equilibria | Adsorption isotherms |
| | 18 | 18 | 18 | 18 | 18 |
| SLO-1 | Simple collision theory. | Solvent effects on reaction rates, and cage effect. | Electromotive force - measurement of EMF. | Introduction to voltammetry techniques, types of electrochemical reactions and interpretation. | Adsorption of gases and vapors on solids. |

| | | | | | |
|------------------|--|---|---|--|--|
| SLO-2 | Absolute reaction rate theory (ARRT) Application of ARRT to simple bimolecular process. | Factors determining the reaction rates in solution (based on transition state theory). | Reversible cells - types of half cells - classification of cells. | Important electrochemical equations such as Randel-Sevick equation, and Cottrell equation. | Langmuir adsorption isotherm. |
| SLO-3 | Thermodynamic treatment, potential energy surfaces. | Ion-dipole and dipole-dipole interactions. | The standard EMF of a cell - electrochemical potential - standard electrode potentials. | Butler-Volmer equation and derivation. | Kinetic and statistical derivation of Langmuir adsorption isotherm. |
| SLO-4-6 | Practice: Introduction and demonstration of the lab instruments. | Practice: Determination of E_a of saponification of ester by conductometry method. | Practice: Determination of strength of an acid by conductometry. | Practice: Repeat class. | Practice: Adsorption of acetic acid on charcoal – determination of strength of acetic acid using Langmuir adsorption isotherm. |
| SLO-7 | Chain reactions, general characteristics. | Structure, significance of volume and entropy of activation, and pressure effect. | Nernst equation and its applications. | Introduction to phase rule and its components. | Adsorption entropies. |
| SLO-8 | Study of kinetics of chain reaction like H_2-Br_2 reaction. | Primary and secondary salt effects. | Concentration cells. | Degree of freedom, conditions for equilibrium between phases. | Lateral interactions. |
| SLO-9 | Decomposition of acetaldehyde and N_2O_5 . Theory of unimolecular reactions. | Kinetics of photophysical and photochemical processes. Complex photochemical processes, Homogeneous catalysis. | The concept of liquid junction potential. | Derivation of Gibbs phase rule. Phenol-water one component system. | BET and related isotherms. |
| SLO-10-12 | Practice: Determination of rate constant of acid hydrolysis of an ester. | Practice: Determination of molecular weight of substance by transition temperature method. | Practice: Potentiometric titration of a redox reaction. | Practice: Determination of critical solution temperature (CST) of phenol-water system. | Practice: Adsorption of oxalic acid on charcoal – determination of strength of acetic acid using Freundlich adsorption isotherm. |
| SLO-13 | Lindemann and Hinshelwood mechanisms for gas-phase unimolecular reactions. | General catalytic mechanisms, acid-base catalysis. | Decomposition voltages, concentration polarization and over voltage. | Phase diagram of sulphur. | Derivation of BET equation and its related properties. |
| SLO-14 | Steady state approximation. | Catalysis by enzymes, influence of concentration (single substrate, double substrate). | Kinetics of electrode process. Electrical aspects of surface chemistry. | Phase diagram of two component system. | Thermodynamics of adsorption, chemisorption and catalysis. |
| SLO-15 | Principle of microscopic reversibility and detailed balancing. | Influence of concentration (single substrate, double substrate). | Electrical double layer, Stern treatment of the electrical double layer, free energy of a diffuse double layer. | Formation of compounds with congruent and incongruent melting points. | Kinetics of chemisorption. |
| SLO-16-18 | Practice: Kinetics of iodine clock reaction. | Practice: equivalent conductance, degree of dissociation and dissociation constant of weak acid by conductometry. | Practice: Determination of strength of an iron solution by potentiometric method. | Practice: Determination of solubility diagram for a three-component system. | Practice: Repeat class. |

| Resources | | |
|-----------|--|---|
| 1. | K.J. Laidler, <i>Chemical Kinetics</i> , 2nd Edition, Tata-McGraw Hill, Inc., New York, 1973. | 5. J.O.M. Bockris and A.K.N. Reddy, <i>Modern Electrochemistry</i> , Volumes 1 & 2, Plenum Press, New York. 1988 |
| 2. | Gurdeep Raj, <i>Chemical Kinetics</i> , Goel Publishing House, 2002. | 6. S. Glasstone, <i>Electrochemistry</i> , Affiliated East-West Press, Pvt., Ltd., New Delhi, 1974. |
| 3. | P. Atkins, J.D. Paula, <i>Physical Chemistry</i> , W. H. Freeman and Company New York, 8 th Ed., 2018. | 7. M. Soudelle, <i>An Introduction to Chemical Kinetics</i> , John Wiley and Sons, 2005. |
| 4. | A.J. Bard and L.R. Faulkner, <i>Electrochemical methods –Fundamentals and Applications</i> , 2nd Ed., John Wiley and Sons, 2001. | 8. J. U. Keller and, R. Staudt, <i>Gas adsorption equilibria, experimental methods and adsorptive isotherm</i> , Springer nature, 2005. |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|-------------------|--------------|-------------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* | | | |
| | | | | | | | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 |
| 2 | Understand | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 |
| 3 | Apply | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 |
| 4 | Analyze | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 |
| 5 | Evaluate | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 |
| 6 | Create | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 |
| Total (%) | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | |
|----------------------|--|--|---|
| Professional Experts | | Higher Institution Experts | Internal Experts |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 Dr. Arun Prakash P and Dr. Anandhakumar S, Department of Chemistry, SRMIST Email id: arunprap1@srmist.edu.in anandhas2@srmist.edu.in |
| | | 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST; Email id: arthanam@srmist.edu.in |

| Course Code | PCY25102J | Course Title | Chemistry of d- and f-Block Elements | Category | C | Core Course | | L | 2 | T | 0 | P | 4 | C | 4 |
|-------------|-----------|--------------|--------------------------------------|----------|---|-------------|--|---|---|---|---|---|---|---|---|
|-------------|-----------|--------------|--------------------------------------|----------|---|-------------|--|---|---|---|---|---|---|---|---|

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Motivate the learners to understand the different types coordination complexes. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Distinguish and intervene the theories of coordination complexes of d-block elements with variable configurations. | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Identify as well as to predict the feasibility and stability of coordination complexes | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Compare the physicochemical properties of the complexes against spectroscopic and magnetic properties. | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Study the synthetic strategies based on the reactivity with respect to structural and fundamental factors. | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Deduce the structure of different types of coordination complexes. | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - |
| CLO-2 | Correlate the gradational development of theories of coordination complexes due to splitting of orbitals. | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Predict the spectroscopic and magnetic properties of the metal-ligand coordination spheres. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-4 | Conclude the type of reactions to be occurred with the variety of the metal complexes | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Understand the versatile mechanistic pathways associated with the reactions of different coordination sphere | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | - | 3 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|---|---|--|
| | Introduction to Coordination Chemistry | Valence Bond Theory | Magnetic Properties | Inorganic Reaction Mechanism | Lanthanides and Actinides |
| | 18 | 18 | 18 | 18 | 18 |
| SLO-1 | Introduction monodentate, bidentate, and polydentate ligands, coordination sphere, coordination number | Valence bond theory: hybridization, Geometry, magnetism, drawbacks of VBT | Magnetic properties of tetrahedral and octahedral complexes | Ligand substitution reactions in octahedral, square planar complexes | Lanthanides: lanthanide series, abundance and natural isotopes |
| SLO-2 | Nomenclature of mononuclear and dinuclear complexes | Crystal field theory: crystal field effects, assumptions of crystal field theory, crystal | Para, dia, ferromagnetism and | Labile and inert complexes (application of VBT, MOT), dissociation, association | Lanthanide contraction, similarity in properties, occurrence, oxidation states |

| | | | | | |
|------------------|--|---|--|---|--|
| | | field splitting in octahedral and tetrahedral geometries, qualitative crystal field splitting diagrams, high-spin and low-spin complexes | antiferro magnetism, determination of magnetic properties, Gouy's method | mechanism, Mechanism of hydrolysis reactions, acid hydrolysis, base hydrolysis | |
| SLO-3 | Chelate effect, Werner's theory and Sidgwick theory | crystal field splitting in octahedral and tetrahedral geometries, qualitative crystal field splitting diagrams, high-spin and low-spin complexes | Anomalous magnetic moment, thermal effects, single molecular magnets, spin and orbital contribution quenching | <i>trans</i> effect, <i>trans</i> influence, <i>trans</i> effect and its application | Chemical properties of Ln(III) cations, magnetic properties, colour and electronic spectra of lanthanide compounds |
| SLO-4-6 | Practice: Introduction to Inorganic Chemistry Lab | Practice: Synthesis of metal acetylacetonate complex | Practice: <i>Cis</i> and <i>trans</i> isomers of [Co(en) ₂ Cl ₂]Cl | Practice: Preparation of Ferrocene | Practice: Preparation of triphenyl phosphine (Ph ₃ P), and transition metal complexes |
| SLO-7 | EAN and formation of metal-metal bond in dimers | CFSP and factors affecting it, computation of CFSE, evidences of crystal field splitting, spectrochemical series | Spin cross over rule, microstates of electron configuration in free atoms and ions, Term symbols for equivalent and nonequivalent electrons, possible term symbols for given configuration | Theories of <i>trans</i> effect, thermodynamic and kinetic stability of complexes, factors affecting stability of metal complexes | Separation of lanthanides, solvent extraction, ion exchange method |
| SLO-8 | Stability of complexes, determination of stability constants | CFSP and factors affecting it, computation of CFSE, evidences of crystal field splitting, spectrochemical series | p ² -d ² splitting of terms in square planar, tetrahedral, octahedral fields, electronic spectra of various complexes | Electron transfer reactions, one electron transfer reactions, inner and outer sphere mechanism | Actinides: actinide series, abundance and natural isotopes, occurrence |
| SLO-9 | Jobs method, stepwise stability constant, Overall stability constant, factors affecting stability of coordination compounds | Jahn-Teller theorem, crystal field splitting in tetragonally distorted octahedral geometry and in square planar geometry | Selection rules, spin orbit coupling, assignment and intensities of transitions | Marcus theory and its applications, two electron transfer reactions complementary and non - complementary electron transfer reactions | Preparation of actinides, oxidation states, general properties, the later actinide elements |
| SLO-10-12 | Practice: Determination of Cr(III) complexes. [Cr(H ₂ O) ₆]NO ₃ ·3H ₂ O; [Cr(H ₂ O) ₄ Cl ₂]Cl·2H ₂ O; [Cr(en) ₃]Cl ₃ ; Cr(acac) ₃ | Practice: Preparation of Tin(IV) iodide, Tin(IV) chloride, and Tin(II) iodide | Practice: (<i>N,N</i>)-bis(salicylaldehyde)ethylenediamine Salen H ₂ ; and its cobalt complex [Co(Salen)] | Practice: Reaction of Cr(III) with multidentate ligands, a kinetics experiment - Vanadyl acetylacetonate | Practice: Reaction of Mixed valence dinuclear complex of Manganese(III, IV) |
| SLO-13 | Charge of central metal ion, size of central metal ion, chelate ring size, steric effects | Covalency in transition metal complexes, evidences for covalency | Orgel (d ¹ to d ⁹ octahedral and tetrahedral complexes) and Tanabe Sugano diagrams (d ¹ , d ⁶ complexes and its applications) | Synthesis of coordination compounds using electron transfer reactions, metal assisted reactions | Uranium-occurrence, metallurgy; chemical properties of hydrides, oxides, and halides |
| SLO-14 | Isomerism: linkage, ionization, hydrate, coordination, coordination position isomerism, | Intensity of d-d transitions, spin-spin splitting, hyperfine splitting, adjusted crystal field theory MO Theory: metal orbitals and LGOs suitable for σ and π bonding in octahedral geometry, Construction of qualitative MO energy level diagram for bonding in octahedral geometry. | Calculation of D ₀ and D _t and Racah parameters, examples from d ² , d ³ d ⁷ , d ⁸ octahedral complexes | Synthesis of macrocyclic ligands, reaction of coordinated ligands, template effect | Uranium-occurrence, metallurgy; chemical properties of hydrides, oxides, and halides |
| SLO-15 | Geometrical (<i>cis</i> and <i>trans</i> , and <i>fac</i> and <i>mer</i>) and optical isomerism | | Charge transition spectra of metal complexes | Synthesis of macrocyclic ligands, reaction of coordinated ligands, template effect | Complexes of lanthanides and actinides |

| | | | | | |
|------------------|---|---|---|---------------------------------------|-----------------------------|
| SLO-16-18 | Practice: Synthesis of inorganic complexes characterization by physicochemical methods, viz. FT-IR, UV-vis, NMR and magnetic susceptibility | Practice: Any one new novel synthesis reported in recent literature | Practice: Analysis of metal complexes to deduce its structure | Practice: pH meter-based measurements | Practice: Repeat experiment |
|------------------|---|---|---|---------------------------------------|-----------------------------|

| Resources | | |
|-----------|--|---|
| 1 | D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd Ed., W. H. Freeman and Co, London, 1999. | 6. Vogel's Inorganic Qualitative Analysis, 7 th Impression by G. Svehla, Pearson Education, New Delhi, 2009. |
| 2 | J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry, 4th Ed., Harper Collins, New York, 1993. | 7. J. D. Lee, Concise Inorganic Chemistry, Wiley, 5th Edition, 2021. |
| 3 | F. A. Cotton, G. Wilkinson and P. L. Gaus, Basic Inorganic Chemistry, 3 rd Ed., John Wiley, New York, 2008. | 8. R. P. Sarkar, General and Inorganic Chemistry: Volume II, New Central Book Agency (P) Limited, 2009. |
| 4 | N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Ed., Pergamon Press, Oxford, 2005. | 9. R. D. Madan, Modern Inorganic Chemistry, S. Chand & Company limited, 2017. |
| 5 | B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Ed., Wiley, 2013. | 10. J. Chem. Educ. 1977, 54 , 443. |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* (10%) | | | |
| | | | | | | | | | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 |
| 2 | Understand | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 |
| 3 | Apply | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 |
| 4 | Analyze | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 |
| 5 | Evaluate | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 |
| 6 | Create | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 |
| Total (%) | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|----------------------|---|---|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in |
| | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | Dr. Tarak Nath Mandal, Department of Chemistry, SRMIST Email id: taraknam@srmist.edu.in |
| | | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25103T | Course Title | Organic Chemistry: Structure and Reactivity | | | | Category | C | Core Course | | L | T | P | C |
|-------------|-----------|--------------|---|--|--|--|----------|---|-------------|--|---|---|---|---|
| | | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | gain exposure to the field of aromatic compounds | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | gain knowledge about the mechanism of a reaction | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | learn about the reaction intermediates | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | gain insight about how a molecule arrange in 3D space | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | know different types of reactions like substitution and elimination | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand the concept of aromaticity | ✓ | ✓ | ✓ | - | 2 | 75 | 60 | 3 | 3 | - | 2 | - | - | 3 | - | - | - | - | - |
| CLO-2 | Recognize reaction mechanism | ✓ | ✓ | ✓ | - | 2 | 80 | 70 | 2 | 3 | - | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Realize reaction pathways | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 65 | 3 | 3 | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-4 | Visualize molecules in 3D space and understand the arrangements of different atoms around a carbon center | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | 3 | 3 | - | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Know how carbonyl compounds can be utilized in organic transformation | ✓ | ✓ | ✓ | ✓ | 2 | 80 | 70 | 2 | 3 | - | 3 | - | - | - | - | - | - | - | 3 |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|--|---|---|---|
| | Aromaticity and introduction to reaction mechanism | Conformations in organic compounds | Mechanism of aliphatic and aromatic substitution reactions | Introduction to elimination reactions, ring opening and hydrogenation reactions | Introduction to carbonyl compounds and reactions |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Aromaticity, anti-aromaticity and Non aromatic compounds, Hückel's rule of aromaticity | conformational analysis: acyclic system, conformational analysis: acyclic system | SN1, SN2, SNi and NGP, nucleophilic substitutions at allylic, aliphatic and vinyl carbons | E2, E1, E1cb and E2C mechanisms, stereochemistry | Introduction to carbonyl compounds, Nucleophilic addition to carbonyl compounds |
| SLO-2 | homo-aromaticity, aromatic systems (3, 4, 5, and 7- membered ring systems) | cyclic systems | effect of substrate, nucleophile, leaving group, and medium, stereochemistry, ambident nucleophiles | Hoffmann and Saytzeff rules, effect of substrate, base, leaving group and medium, pyrolytic eliminations, | stereochemistry of nucleophilic additions, Cram's rule, Felkin-Anh model |

| | | | | | |
|---------------|--|---|---|---|--|
| SLO-3 | annulenes and fused rings systems, heteroannulenes, aromaticity of heterocycles | effect of conformation on reactivity | Aromatic electrophilic substitution, mechanism and reactivity, selectivity and orientation, the effect of leaving group | Chugaev reaction, Cope elimination, Bamford-Stevens reaction, Peterson Olefination | chemistry of imines, enolates, keto-enol tautomerism |
| SLO-4 | Tutorial : homo-aromaticity, aromatic systems, Types of mechanisms, transition states and intermediates, thermodynamic and kinetic requirements, | Tutorial : conformational analysis and cyclic systems | Tutorial : nucleophilic substitutions at allylic, aliphatic and vinyl carbons | Tutorial : Hoffmann and Saytzeff rules | Tutorial : chemistry of imines, |
| SLO-5 | Hammond postulate, Curtin-Hammett principle, methods of determining mechanisms, isotopic effects, | elements of symmetry, chirality, molecules with more than one chiral center, projection formulae (i) Fischer (ii) Sawhorse | nitration, nitrosation and diazonium coupling, sulphonation, chlorination, bromination, Friedel-Crafts alkylation | Addition reactions to double bonds, triple bonds, electrophilic, nucleophilic additions | condensation reactions of carbonyl compounds, aldol condensations (acid and base catalyzed aldol condensation, crossed aldol condensation |
| SLO-6 | Hammett equation and linear free energy relationship (sigma-rho) relationship, Taft equation and its application | (iii) Newman (iv) Flying Wedge, threo and erythro isomers, methods of resolution, specific rotation, optical purity and enantiomeric excess | Friedel-Crafts acylation, arylation, aromatic nucleophilic substitutions: S _N Ar, S _N 1, benzyne mechanisms | free radical additions, orientation and reactivity, stereochemistry of addition reactions | Claisen-Schmidt condensation, directed aldol condensations, Mukaiyama aldol condensation, Claisen ester condensation |
| SLO-7 | Reaction intermediates: Generation, structure, stability, and reactivity, carbocations | enantiotopic and diastereotopic atoms, groups and faces, | Sommelet-Hauser, Von Richter and Smiles rearrangement | Ring opening of cyclopropanes, Addition of hydrogen halides (Markownikov's rule) and bromine, halohydrin formation, hydroboration (anti-Markownikov's rule) | Dieckmann reaction, Stobbe condensations, Acyloin condensation, Knoevenagel condensations, 1,4-conjugate additions (Michael addition), Robinson annulation |
| SLO-8 | Tutorial: Hammett equation and linear free energy relationship | Tutorial : projection | Tutorial : Friedel-Crafts acylation, arylation reactions | Tutorial : free radical additions, orientation and reactivity, | Tutorial : condensation reactions |
| SLO-9 | Carbanions, free radicals, | enantiotopic and diastereotopic atoms, groups and faces | Bucherer and Rosenmund reactions, aliphatic substitution mechanisms, S _E 2, S _E i and S _E 1 | hydrozirconation, iodolactonization, bromolactonization, oxymercuration | Wittig reactions, Mannich reactions, nucleophilic addition to isocyanates and isothiocyanates, |
| SLO-10 | carbenes, nitrenes | stereospecific and stereoselective reactions | addition-elimination and cyclic mechanisms, halogenations of ketones, aldehydes and carboxylic acids, aliphatic diazonium coupling, sulphonation, sulphenylation, | hydrogenation reactions (hydrogenation of C=C double bonds, triple bonds, and aromatic rings) | esterification reactions, ester hydrolysis, |
| SLO-11 | benzyne, non-classical carbocations | optical activity in the absence of chiral carbon | acylation, Stork enamines, carbene and nitrene insertions, Kolbe-Schmidt reaction | Koch reaction | McMurry coupling, Tabbe reagent, Pinacol Coupling Reaction, haloform reaction. |
| SLO-12 | Tutorial: Carbanions and non-classical carbocations | Tutorial : enantiotopic and diastereotopic atoms | Tutorial : addition-elimination and cyclic mechanisms, | Tutorial : hydrogenation reactions | Tutorial : McMurry coupling |

| Resources | |
|-----------|---|
| 1 | M. B. Smith and J. March, <i>March's Advance Organic Chemistry</i> , 6th Ed., John Wiley and Sons, Inc. |
| 2 | J. Clayden, N. Greeves, and S. Warren, <i>Organic Chemistry</i> 2 nd Ed., Oxford |
| 3 | J. McMurry, <i>Organic Chemistry</i> 5 th Ed., Thomson |
| 4 | T. W. G. Solomons and C. B. Fryhle, <i>Organic Chemistry</i> 10th Ed., John Wiley and Sons, Inc. |
| 5 | I. L. Finar and A. L. Finar, <i>Organic Chemistry</i> Vol. 2, Addison-Wesley |
| 6 | D. N. Nasipuri, <i>Stereochemistry of Organic Compounds: Principles & Applications</i> , 3 rd edition, South Asia Books 2012 |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

| Strategies | | | | |
|----------------------------|---|----------------------|---|--------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | | | | | | | |
|----------------------|--|--|--|----------------------------|--|--|--|------------------|---|--|--|
| Professional Experts | | | | Higher Institution Experts | | | | Internal Experts | | | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | | | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | | | 1 | Dr. Susnata Pramanik, Department of Chemistry, SRMIST, Email: susmatap@srmist.edu.in | | |
| | | | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | | | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in | | |

| Course Code | PCY25104T | Course Title | Chemical Bonding, Molecular Geometry and Group Theory | | | | Category | D | Core Course | L | T | P | C |
|-------------|-----------|--------------|---|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-1 | Recite the types of bonds and illustrate the structure of crystals | | | | | | | | | | | | | | | | | | | | |
| CLR-2 | Solve the radius ratio of the crystals, enthalpy of formation of ionic compound and identify the various crystal defects | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Summarize the molecular geometry, structure of covalent compounds and various weak chemical forces and bonding in metals | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Discuss the acidity and basicity of acids and bases based on various concepts | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Explore the mathematical calculation based on group theory and find its application in chemistry | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Define the types of bonds, structures of crystals and calculate radius ratio and enthalpy of formation of ionic compounds | ✓ | ✓ | ✓ | - | 4 | 75 | 60 | 3 | 3 | 1 | 2 | - | - | - | - | - | - | - | - |
| CLO-2 | Explain the molecular topologies of covalent compounds and illustrate the MOT | ✓ | ✓ | ✓ | - | 4 | 80 | 70 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Relate the Weak chemical bonding forces in predicting the properties of compounds and metals | ✓ | ✓ | ✓ | ✓ | 4 | 70 | 65 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | - | - |
| CLO-4 | Distinguish the acidity and basicity of acids and bases | ✓ | ✓ | ✓ | ✓ | 4 | 70 | 70 | 1 | 3 | 3 | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Identify the molecular vibrations and chirality in compounds using group theory | ✓ | ✓ | ✓ | ✓ | 4 | 80 | 70 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|--|---|---|
| | Chemical bonding and crystal structure | Ionic Compounds and Properties | Concepts in Bonding | Acid-Base Chemistry | Symmetry in Chemistry |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Chemical bond-types of bonds | covalent character in ionic compounds, polarization | orbital mixing, heteronuclear diatomic molecules | proton transfer equilibria under aqueous conditions | Symmetry elements and Symmetry operations |
| SLO-2 | Ionic compounds-Properties, factors favoring the formation | Fajan's rules, effects of polarization, solubility, melting points and thermal stability of typical ionic compounds | polar bonds, ionic compounds, and molecular orbitals, molecular orbitals of polyatomic molecules | non-aqueous solvents and acid-base strength, periodic trends in aqua acid strength, | Point groups |

| | | | | | |
|---------------|--|--|--|---|---|
| SLO-3 | ionization potential, electron affinity and electronegativity | Crystal defects: Schottky defects, controlled valency, F-Center, Frenkel defect, non-stoichiometric, interstitial and electron deficient compounds | Vander Waals forces, inclusion compounds, Layer and Channel structures | oxoacids, anhydrous oxides | Point groups |
| SLO-4 | Tutorial: Problem-Solving in Bonding and Ionic Compounds: Energetics and Trends | Tutorial: Problem-Solving in Polarization and Properties of Ionic Compounds | Tutorial: Solving problems involving polar bonds and their relationship to molecular orbitals. | Tutorial: Comparing acid-base behavior in non-aqueous solvents. | Tutorial: Identifying Symmetry Elements, Symmetry Operations, and Point Groups |
| SLO-5 | packing of ions in crystals and crystal structures, ccp, hcp, bcc, fcc. | Molecular topologies: shared and lone pairs, Lewis structures, isoelectronic and isolobal relationships | cage structures (gas hydrates and clathrates) | Bronsted-Lowry acidity of aqueous cations, | groups and classes of symmetry operations |
| SLO-6 | radius ratio and structure of ionic lattices, Stoichiometry and crystal structures | VSEPR model: Hybridization and geometry | Hydrogen bonding: non-conventional hydrogen bonding, associated molecules, molecular self-assembly | Lewis acid- base concept and frontier orbitals, | non-degenerate representations, degenerate representations |
| SLO-7 | Geometrical method of computing radius ratios, relation between radius ratio and coordination number. | VSEPR model: Hybridization and geometry | supramolecular architectures formed by weak chemical forces | quantification of Lewis basicity, inductive and steric effects on Lewis acidity and basicity, | Great Orthogonality theorem |
| SLO-8 | Tutorial: Problem-Solving in Crystal Structures: Packing, Radius Ratios, and Stoichiometry | Tutorial: Applying VSEPR theory to determine hybridization and molecular geometry. | Tutorial: Solving problems on gas hydrates and clathrates | Tutorial: Quantifying Lewis Acidity and Basicity: Steric and Inductive Effects | Tutorial: Symmetry Groups, Representations, and the Great Orthogonality Theorem |
| SLO-9 | Lattice energy: definition, Born-Landé equation, factors affecting energy | Molecular orbital Theory, Linear Combination of Atomic orbitals | Bonding in metals: packing of atoms in metals, band theory of metals and metallic properties. | frustrated Lewis pairs | Construction of character table |
| SLO-10 | Born-Haber cycle, enthalpy of formation of ionic compounds and stability | bonding, antibonding and non-bonding molecular orbitals | insulators and semiconductors | hard and soft acids and bases, | reduction formula, character of matrices |
| SLO-11 | calculation of ionic radius, Pauling's method and Linde's method, effective nuclear charge, Slater's rule. | MOs of homonuclear diatomic molecules | Bronsted-Lowry concept | thermodynamic acidity parameters, superacid and superbase. | applications to molecular vibrations (IR and Raman activity) and chirality |
| SLO-12 | Tutorial: Problem-Solving in Lattice Energy, Ionic Radii, and Stability of Ionic Compounds | Tutorial: Constructing molecular orbital diagrams using the Linear Combination of Atomic Orbitals (LCAO) approach. | Tutorial: Applying band theory to explain metallic properties, insulators, and semiconductors. | Tutorial: Advanced Concepts in Acid-Base Chemistry: FLPs, HSAB, and Superacids | Tutorial: Character Tables and Molecular Vibrations |

| Resources | |
|-----------|--|
| 1 | <i>D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, 3rd Ed., Oxford University Press, London, 2001</i> |
| 2 | <i>J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry, 4th Ed., Harper and Row, New York, 1983</i> |
| 6 | <i>R. B. Jordan, Reaction mechanisms of Inorganic and Organo metallic systems, OUP, 1991.</i> |
| 7 | <i>Miessler, G. L. and Tarr, D. A. Inorganic Chemistry III Edition, 2004</i> |

| | | | |
|----|--|----|---|
| 3 | Purcell, K.F and Kotz, J.C – Inorganic chemistry, WB saunders Co., USA(1977) | 8 | A.Vincent, Molecular Symmetry and Group Theory. A Programmed Introduction to Chemical Applications, JohnWiley& Sons Ltd, 1977 |
| 4 | M.C. Day and J. Selbin, 1974, Theoretical Inorganic Chemistry, Van Nostrand Co. NY | 9 | F. Albert Cotton, Chemical Applications of Group Theory, 2ndEd., John Wiley & Sons, 1971 |
| 5. | A.F. Wells, - 1984, Structural Inorganic Chemistry, V. Edition, Oxford | 10 | K.V.Raman, 1990, Group Theory and its applications to chemistry, Tata Mc.Graw Hill |

| Assessment | | | | | | | | | | | | Strategies | | | | | | | |
|---------------------------|--------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|------------|--|----------------------|--|-------------------------|--|--|--|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | | | | | | | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | Theory (%) | Practice (%) | | | | | | | | |
| Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | | | | | | | | |
| 1 | Remember | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | | | | | | | |
| 2 | Understand | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | | | | | | | |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | | | |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | | | |
| 5 | Evaluate | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | | | |
| 6 | Create | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | |
|----------------------|---|----------------------------|--|------------------|---|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Kamataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. Tumpa Sadhukhan, Department of Chemistry, SRMIST Email id: tumpas@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25S01J | Course Title | Fundamentals and Practical Aspects of Computational Chemistry | Category | S | Skill Enhancement Course | L 1 | T 0 | P 2 | C 2 |
|-------------|-----------|--------------|---|----------|---|--------------------------|--------|--------|--------|--------|
|-------------|-----------|--------------|---|----------|---|--------------------------|--------|--------|--------|--------|

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|---------------------------------------|------------------------|---------------|------------------------------|--------------------|--|--|
| CLR-1 | Enable them to learn the principles of computer aided chemical information tools and techniques | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Explore the data base search for the molecules and its access for the chemical reactions | | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Explore about IUPAC names, design of molecules at different platforms. | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | To make the students aware about the basic concepts in computational chemistry | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Develop strategies of drug design and target oriented receptor interaction study | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethicalpractices&SocialResponsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLO-1 | Understand the basic principles of computer aided drug design through chemistry approaches. | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | - | | |
| CLO-2 | Explain the concept of HF method and DFT Methods | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 2 | 3 | 3 | - | - | - | - | - | - | 2 | | |
| CLO-3 | Gain knowledge about the chemical databases | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 3 | 3 | 2 | 3 | 3 | - | - | - | - | - | - | - | | |
| CLO-4 | Acquaint the student with the fundamental concepts of drug discovery and different stages | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 3 | | |
| CLO-5 | Understand the principles of modeling tools and concepts In molecular modeling and drug design | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|--------------------------------------|---|--|
| | Chemical Structures | Electronic Structure | Density Functional Theory | Molecular Mechanics | Molecular Dynamics |
| | 9 | 9 | 9 | 9 | 9 |
| SLO-1 | Concepts in Molecular Modelling and chemical representation of molecules | Introduction to Ab-initio methods and Electronic structure calculations | Theorems and Functionals in DFT | Introduction to Molecular Mechanics and combinatorial optimization approach | Development of drug and drug development time lines and stages of drug discovery |
| SLO-2 | Practice Design of chemical structures | Practice: Small molecules energy calculation at HF method | Practice: Gaussian model chemistry I | Practice: PyMol software with examples case study | Practice: Protein Modelling using PDB database |

| | | | | | |
|--------------|---|---|---|---|---|
| SLO-3 | Practice: Molecular Modelling | Practice: Small molecules energy calculation at HF method | Practice: Gaussian model chemistry I | Practice: PyMol software with examples case study | Practice: Protein Modelling using PDB database |
| SLO-4 | Structure design and search parameters | Discussion on post Hartree-Fock Methods and basis sets | Time independent DFT | Computer Assisted Drug Design and Structure-based library | Introduction to force fields |
| SLO-5 | Practice: Open database creation of CIFs | Practice: Small molecules frequency calculation at HF level of theory | Practice: Application of DFT in UV-Vis spectroscopy | Practice: PDB data base – Protein preparation | Practice: Protein molecular dynamics in Gromacs |
| SLO-6 | Practice: Crystallographic Open Database COD | Practice: Small molecules binding energy calculation at HF level of theory | Practice: Application of DFT in UV-Vis spectroscopy | Practice: PDB data base for Ligand preparation | Practice: Protein molecular dynamics in Gromacs |
| SLO-7 | Chemical markup languages and IUCr Crystallographic Information Framework | Potential energy surface and PDB Ligand Explorer Chemspider, Other Data Bases | Basics of spectroscopy principles | QSAR Drug design and Target Identification and Validation | Introduction to Molecular Dynamics |
| SLO-8 | Practice: CIF creation and analysis with examples | Practice: Generation of PES at HF level of theory | Practice: Application of DFT in IR spectroscopy | Practice: Docking with Autodock Vina | Practice: Protein molecular dynamics in Gromacs |
| SLO-9 | Practice: Analysis of CCDC structures and parameters with examples | Practice: Generation of PES at HF level of theory | Practice: Application of DFT in NMR spectroscopy | Practice: Docking with Autodock Vina | Practice: Protein molecular dynamics in Gromacs |

| Resources | | |
|------------------|--|---|
| 1 | <i>An Introduction to Cheminformatics”, Revised Edition, Springer Publication, 2007.</i> | 6 <i>Silverman, Richard B., and Mark W. Holladay. The organic chemistry of drug design and drug action. Academic press, 2014.</i> |
| 2 | <i>Johann Gasteiger, Dr. Thomas Engel, “Cheminformatics”, Wiley-VCH Press, 2003.</i> | 7 <i>Bajorath, Jurgen. Chemoinformatics for Drug Discovery. John Wiley & Sons, 2013.</i> |
| 3 | <i>Jurgen Bajorath, “Cheminformatics: Concepts, Methods and Tools for Drug Discovery”, Humana Press, 2004</i> | 8 <i>Engel, T., & Gasteiger, J. (2018). Cheminformatics: Concepts, Workflows, and Applications. Wiley-VCH</i> |
| 4 | <i>F. Jensen, Introduction to Computational Chemistry, (Wiley, New York, 1999). Good introductory textbook covering a variety of topics.</i> | 9 <i>Young, D. C. (2001). Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems. Wiley-Interscience</i> |
| 5 | <i>Tudor. L.Oprea, “Cheminformatics in Drug Discovery”, Wiley-VCH Press, 2005</i> | 10 <i>Hehre, W. J., Radom, L., Schleyer, P. R., & Pople, J. A. (1986). Ab Initio Molecular Orbital Theory. Wiley</i> |

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|------------|----------------------|----------------------|--------------------------|-------------------------|--|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | | - | Group Discussion | ✓ | Quality Education | ✓ | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | ✓ | Hands-on Practice | - | Gender Equality | ✓ | |
| 1 | Remember | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 | | Debate | - | | | |
| 2 | Understand | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 | | Interactive Lecture | ✓ | | | |
| 3 | Apply | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 | | Brainstorming | ✓ | | | |
| 4 | Analyze | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 | | | | | | |
| 5 | Evaluate | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 | | | | | | |
| 6 | Create | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 | | | | | | |
| Total (%) | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|----------------------|---|--|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | Dr. Tumpa Sadhukhan, Department of Chemistry, SRMIST, Chennai Email: tumpas@srmist.edu.in |
| | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2. Department of Chemistry, SRMIST Email id: prakashm4@srmist.edu.in 3. Prof. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Code | PCD25AE1T | Title | Comprehensive Skills in Quantitative and Logical Reasoning | | | | Category | AE | Ability Enhancement Course | L | T | P | C |
|------|-----------|-------|--|--|--|--|----------|----|----------------------------|---|---|---|---|
| | | | | | | | | | | 2 | 0 | 0 | 2 |

| Offering Department | Career Guidance | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|---------------------|-----------------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|---------------------|-----------------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|----------------|--|----------|--------|-----------|---------|-------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CR-1 | Build a strong foundation in numerical concepts and arithmetic techniques, enabling learners to solve mathematical problems accurately and efficiently. | | | | | | | | | | | | | | | | | | | |
| CR-2 | Equip learners with essential skills for understanding and solving financial and proportional reasoning problems relevant to real-life scenarios and career needs. | | | | | | | | | | | | | | | | | | | |
| CR-3 | Develop problem-solving skills in time, work, speed, distance, and ratio-based applications, enabling learners to tackle real-world mathematical challenges efficiently. | | | | | | | | | | | | | | | | | | | |
| CR-4 | Enhance learners' logical reasoning and data interpretation skills, enabling them to solve real-life problems involving clocks, calendars, directions, relationships, and data analysis. | | | | | | | | | | | | | | | | | | | |
| CR-5 | Sharpen learners' logical thinking and problem-solving abilities, helping them develop skills in tackling number puzzles, logical puzzles, reasoning-based problems, and coding challenges. | | | | | | | | | | | | | | | | | | | |
| Outcomes (CO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| | | ✓ | ✓ | ✓ | ✓ | 1 | 85 | 75 | - | 3 | 1 | 3 | 1 | - | - | - | 2 | - | - | - |
| CO-1 | Apply numerical methods to solve problems involving number classification, divisibility tests, progressions, HCF & LCM, simplification techniques, and vinculum-based calculations. | ✓ | ✓ | ✓ | ✓ | 1 | 85 | 75 | - | 3 | 1 | 3 | 1 | - | - | - | 2 | - | - | - |
| CO-2 | Calculate interest, analyze profit and loss, and solve problems related to percentages, discounts, permutations, combinations, and probability, enhancing their quantitative reasoning skills. | ✓ | ✓ | ✓ | ✓ | 3 | 85 | 75 | - | 3 | 1 | 3 | 1 | - | - | - | 2 | - | - | - |
| CO-3 | Solve problems related to time and work, speed and distance, boats and streams, mixtures and alligations, height and distance, and age-based calculations with accuracy and efficiency. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | 3 | 1 | 3 | 1 | - | - | - | 2 | - | - | - |
| CO-4 | Solve problems related to clocks, calendars, directions, blood relations, and interpret data from various graphical representations, including tables, bar charts, pie charts, and line graphs, with accuracy and clarity. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | 3 | 1 | 3 | 1 | - | - | - | 2 | - | - | - |
| CO-5 | Solve number puzzles, logical puzzles, sequential output tracing, and reasoning problems, as well as alphanumeric series and coding/decoding problems, with precision and speed. | ✓ | ✓ | ✓ | ✓ | 5 | 85 | 75 | - | 3 | 1 | 3 | 1 | - | - | - | 2 | - | - | - |

| Title & Session Outcomes | Numbers and Basic Arithmetic | Business Mathematics and Applications | Applied Arithmetic Problems | Logical Reasoning and Data Interpretation | Reasoning and Puzzle Solving |
|--------------------------|---|---|-------------------------------------|--|--|
| Duration (hour) | 6 | 6 | 6 | 6 | 6 |
| SO-1 | Classification of Numbers & Tests of Divisibility | Problems on Averages and Percentage | Time and work - Problems | Clock - Problems | Number Puzzles - Problems |
| SO-2 | Unit Digit & Trailing Zeroes | Problems on Discount | Time, Speed and Distance Problems | Problems on Calendar | Logical Puzzles –Problems |
| SO-3 | Arithmetic Progression Geometric Progression | Problems on Simple Interest and Compound Interest | Boats and Streams - Problems | Direction Sense - Problems | Sequential Output Tracing - Problems |
| SO-4 | Highest Common Factor (HCF) Least Common Multiples (LCM) | Profit and Loss - Problems | Mixtures and Alligations - Problems | Blood relation-Problems | Inductive, Logical, Abstract and Diagrammatic Reasoning - Problems |
| SO-5 | Simplification - Problems | Permutation and Combination – Problems | Height and Distance - Problems | Data Interpretation – Table and Bar chart | Alphanumeric Series - Problems |
| SO-6 | Vinculum - Problems | Problems on Probability | Problems based on Ages | Data Interpretation – Pie Chart and Line graph | Coding and Decoding - Problems |

| Assessment | | | | | | | | | |
|-------------------|---|--------------|------------|--------------|------------|--------------|------------|--------------|--|
| Level of Thinking | Continuous Learning Assessment (CA) (100 % weightage) | | | | | | | | |
| | CLA- 1 | | CLA- 2 | | CLA- 3 | | CLA – 4 | | |
| | (20%) | | (20%) | | (30%) | | (30%) | | |
| | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | |
| 1 Remember | | | | | | | | | |
| 2 Understand | 40 | - | 30 | - | 30 | - | 40 | - | |
| 3 Apply | | | | | | | | | |
| 4 Analyze | 40 | - | 40 | - | 40 | - | 40 | - | |
| 5 Evaluate | | | | | | | | | |
| 6 Create | 20 | - | 30 | - | 30 | - | 20 | - | |
| Total | 100 | | 100 | | 100 | | 100 | | |

| Strategies | | | | |
|------------------------------|---|------------------------|---|---------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | ✓ | Case Studies | | No Poverty |
| Emulations | | Group Discussion | ✓ | Zero Hunger |
| Prototypes | | Hands-on Practice | ✓ | Good Health & Well Being |
| Hands-on Practice Tools | ✓ | Inquiry Learning | ✓ | Quality Education |
| Mathematical Computing Tools | ✓ | Interactive Lecture | ✓ | Gender Equality |
| Field Visit | | Leading Question | ✓ | Clean Water & Sanitation |
| | | Mind Map | | Affordable & Clean Energy |
| | | Minute Paper | | |
| | | Peer Review | | |
| | | Problem Based Learning | ✓ | |

| | | | |
|---|---|---|--|
| 1 | Dr. Agarwal.R.S, Quantitative Aptitude for Competitive Examinations, S. Chand and Company Limited, 2018 Edition | 2 | Archana Ram, PlaceMentor: Tests of Aptitude for Placement Readiness, Oxford University Press, Oxford, 2018 |
| 3 | Abhijit Guha, Quantitative Aptitude for Competitive Examinations, Tata McGraw Hill, 5th Edition | 4 | Edgar Thrope, Test Of Reasoning for Competitive Examinations, Tata McGraw Hill, 6th Edition |

| Professional Experts | | Higher Institution Experts | | Internal Experts | |
|----------------------|--|----------------------------|--|------------------|---|
| 1 | Mr. Varadha Rajan M (External Expert), Assistant Manager – Human Resources, Justdial Limited, Chennai – 600015 varadha1723@gmail.com | 1 | Dr. Premavathy M, Associate Professor , Department of English Center for Distance and Online Education, Bharathidasan University, Tiruchirappalli – 620024 drmpremavathy@bdu.ac.in | 1 | Dr. Deepalakshmi S, HoD, Department of Career Guidance Cell, FSH, SRMIST |
| | | | | 2 | Dr. Sathish K, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST |
| | | | | 3 | Dr. Aarthi S, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST |

SEMESTER-II

| Course Code | POC25201T | Course Title | Spectroscopy and Applications in Organic Chemistry | | | | Category | C | Core Course | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLR-1 | Understand the fundamentals and importance of UV and photoluminescence spectroscopy | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CLR-2 | Understand the fundamental, importance and instrumentation of FTIR spectroscopy | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Understand the fundamentals and importance of Mass spectroscopy | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Understand the fundamentals and importance of NMR spectroscopy | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Provide a basic understanding of the concepts involved in various chromatographic techniques | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| CLO-1 | Describe the physical and chemical changes at the molecular level during a Mass, IR, or NMR experiment. | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - |
| CLO-2 | Identify different functional groups present in organic compounds using IR spectra. | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | 3 | - | - | - | - | - | - | - | - | 2 |
| CLO-3 | Explain common terms in NMR spectroscopy such as chemical shift, coupling constant, and anisotropy, and describe how they are affected by molecular structure. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | 3 | - | - | - | 2 | - | - | - | - | - |
| CLO-4 | Analyze and interpret ¹ D, ¹ H, ¹³ C NMR, and 2D NMR to determine the chemical structure of organic compounds. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | 2 | - | - | - | - | - | - | - | - | 3 |
| CLO-5 | Explain major fragmentation patterns of organic compounds using mass spectra | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | - | - | - | 3 | - | - | - | - | 2 | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--------------------------------------|-----------------------|-------------------|----------------------------|--|
| | Absorption and emission spectroscopy | Infrared spectroscopy | Mass spectroscopy | Nuclear magnetic resonance | Separation and purification techniques |

| | 12 | 12 | 12 | 12 | 12 |
|--------------|---|---|---|--|--|
| SLO-1 | Ultraviolet and photoluminescence spectroscopy: Introduction. Interaction of electromagnetic radiation with matter. | Fourier-transform infrared spectroscopy (FTIR): Introduction to FTIR spectrometer. Units of frequency wavelength and wave number, molecular vibrations. | Mass spectroscopy: Basic Principles and Instrumentation of mass spectrometer. | Nuclear Magnetic Resonance (NMR) spectroscopy: Basics Larmor precession, resonance absorption | Separation Techniques: Solvent extraction and Ion exchange techniques principles and applications. |
| SLO-2 | Absorption laws and selection rules, measurement of UV, fluorescence, phosphorescence, and lifetimes. Introduction to time-resolved techniques for absorption and emission measurements. | Factors influencing vibrational frequencies and selection rules. Sampling techniques for characteristic frequencies of organic molecules and interpretation of spectra. | Isotope abundances, molecular, and metastable ions. Reactions of ions in gas phase – effect of isotopes. | Magnetic fields, shielding, and chemical shifts chemical equivalence. Relaxation processes: Solution state (¹ H, ¹³ C) | Chromatographic techniques: adsorption chromatography. Thin-layer and gas chromatography. High-performance liquid chromatography |
| SLO-3 | Electronic energy levels: Singlet-Triplet excited states. Excited state lifetime, Steady-state, and Time-resolved emission. Factors affecting excited state energy: solvent effect, electronic transitions in organic, and molecules and application to structure elucidation | Theory of IR spectroscopy: various stretching and vibration modes for diatomic and triatomic molecules (both linear and nonlinear). | Nitrogen rule, determination of molecular formula. fragmentations and rearrangements - metastable ions – fragmentation of organic compounds | Spin-spin coupling AX, AX ₂ , and AX _n systems. Paramagnetic shifts and their applications | Size exclusion chromatography. Supercritical fluid chromatography |
| SLO-4 | Tutorial: Absorption and Emission Spectroscopy | Tutorial: Discussion about FTIR Spectroscopy | Tutorial: Discussion about Mass Spectroscopy | Tutorial: Discussion about NMR spectroscopy | Tutorial: Discussion about Chromatographic techniques |
| SLO-5 | Applications of UV spectroscopy to Conjugated dienes, trienes, unsaturated carbonyl compounds, and aromatic compounds. Excited state kinetics: quantum yield expressions, excimer and exciplex, formation, energy transfer, FRET. | Various ranges of IR (Near, Mid, Fingerprint, and far) and their usefulness. Instrumentation (Only the sources and detectors used in different regions). | Instrumentation, various ionization methods (field ionization, field desorption, FAB, MALDI,). | Instrumentation of NMR spectroscopy. chemical shift, calculations of chemical shifts of aliphatic, olefinic, alkyne, aromatic, hetero aromatic, and carbonyl carbons. Factors affecting chemical shifts. | Electrophoresis. |
| SLO-6 | Woodward -Fieser rules for calculating absorption maxima (λ_{max}) for dienes and carbonyl compounds. Fieser and Kuhn rules Effects of auxo chromes and effects of conjugation on the absorption maxima. | Instrumentation (Only the sources and detectors used in different regions) | Different detectors - magnetic analyzer | APT, INEPT, DEPT Homo nuclear (¹³ C, ¹³ C) and Hetero nuclear (¹³ C, ¹ H) coupling constants. | Thermal methods of analysis -thermal methods of analysis and evolution of analytical data |
| SLO-7 | Difference in the absorption and emission spectra of organic and | Sample preparation techniques (Gas, Liquid, and solid) | Ion cyclotron analyzer, Quadrupole mass filter, time of flight (TOF) | | TGA - principles, instrumentation, and applications |

| | | | | | |
|---------------|---|---|--|---|---|
| | inorganic compounds and complexes. Different shifts of emission peaks (Bathochromic, hypsochromic, hypochromic, hyperchromic). | | | 2D NMR Techniques: General idea about two-dimensional NMR spectroscopy | |
| SLO-8 | Tutorial: Applications of UV and fluorescence spectroscopy | Tutorial: Discussion about the techniques of FTIR and the theory of FTIR. | Tutorial: Various methods of Mass spectrometry. | Tutorial: General discussion about the chemical shift | Tutorial: Discussion about various types of Chromatography |
| SLO-9 | Instrumentation for single-beam and double-beam UV and fluorescence spectrophotometer. | Qualitative analysis of alkanes, alkenes. | Rules of fragmentation for different functional groups | Correlation spectroscopy (COSY)- Homo COSY (¹ H, ¹ H) | DTA - principles, instrumentation, and applications. |
| SLO-10 | Application in organic molecules using UV and fluorescence analyses Optical rotatory dispersion and circular dichroism: Phenomena of ORD and CD. Classification of ORD and CD Curves. | Qualitative analysis of carbonyl compounds. | Factors controlling fragmentation | TOCSY, Hetero COSY (HMQC, HMBC). Homo and Hetero nuclear 2D resolved spectroscopy | DSC - principles, instrumentation, and applications. Types of errors. |
| SLO-11 | Cotton effect curves and their application to stereochemical problems. The Octant rule and its application to alicyclic ketones. | Organic functional group identification through IR spectroscopy. | Introduction: HRMS | NOESY and 2D-INADEQUATE experiments and their applications. | Evaluation of analytical data statistical methods. |
| SLO-12 | Tutorial: Instrumentation and effect of UV and fluorescence | Tutorial: Quantitative analysis of organic functional group | Tutorial: Rules of fragmentation for different functional groups | Tutorial: Correlation spectroscopy COSY and NOESY | Tutorial: Discussion about the Thermoanalytical techniques. |

| Resources | | |
|------------------|---|---|
| 1 | Fundamentals of Molecular Spectroscopy. C. N. Banwell and E. M. McCash, Tata McGraw Hill publishing | 5. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw Hill, 6th edition 2007. |
| 2 | Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, Fourth Ed., Brooks/Cole Thomson Learning 2009. | 6. Spectroscopic Methods in Organic Chemistry. Fourth Edition D.M. Williams and I. Fleming Tata - McGraw Hill, New Delhi, 1990. For all spectral methods except ORD and CD and ESR. |
| 3 | R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric identification of organic compounds, 7th edition, John Wiley, 2005. | 7. Organic Spectroscopy, Second Edition, W. Kemp, ELBS Macmillan, 1987 for ORD and CD. |
| 4 | Organic Spectroscopy, W. Kemp, 3rd edition, Macmillan, 2011. | 8. Molecular Fluorescence: Principles and Applications, B. Valeur, Wiley-VCH Verlag GmbH, Weinheim, 2002. |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyse | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

| Strategies | | | | |
|----------------------------|---|----------------------|---|--------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) case studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | | | | | | | |
|----------------------|--|--|--|----------------------------|--|--|--|------------------|---|--|--|
| Professional Experts | | | | Higher Institution Experts | | | | Internal Experts | | | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | | | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | | | 1 | Dr. Ravindran E, Department of Chemistry, SRMIST Email id: ravindre@srmist.edu.in | | |
| | | | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | | | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in | | |

| Course Code | POC25202T | Course Title | Transformations in Organic Chemistry | | | | Category | C | Core Course | L | T | P | C |
|-------------|-----------|--------------|--------------------------------------|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|---------------------------------------|------------------------|---------------|------------------------------|--------------------|--|--|
| CLR-1 | Understand various C-C bond forming reactions and alkene chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Gain knowledge of transition metal catalysis | | | | | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethicalpractices&SocialResponsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLR-3 | explore oxidation/reductions reactions as elegant synthetic methods | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Introduce to the reactivity radical | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Introduce to the chemistry and application of the polycyclic aromatic hydrocarbons (also heteroatom based) | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethicalpractices&SocialResponsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLO-1 | Understand boron, silicon and tin chemistry | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - | | |
| CLO-2 | Understand transition metal-based C-C bond formation | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | 2 | | |
| CLO-3 | Comprehend Oxidation and reduction methods in chemistry | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 3 | - | - | 3 | - | - | - | - | - | | |
| CLO-4 | Understand reactivity and usefulness of radicals | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 2 | - | - | - | - | - | - | - | 3 | | |
| CLO-5 | Know polyaromatic hydrocarbons and heteroatom based polyaromatic hydrocarbons and their applications | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | - | 3 | - | - | - | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|--|--|---|
| | Organometallic compounds | Various oxidation reactions | Reduction reactions and applications | Reactions involving free radicals | Synthesis and applications of various aromatic and heteroaromatic |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Grignard reagents, cuprates (Gilman reagent) and other conjugate reactions | Metal-based and non-metal based oxidations of alcohols to carbonyls | Catalytic hydrogenation (Heterogeneous: palladium/platinum/rhodium/nickel, etc.) | Introduction, natural sources, radical reactions in body | Origin of fused aromatics hydrocarbons, naphthalene, anthracene, acenaphthene, phenanthrene, pyrene |

| | | | | | |
|---------------|---|--|--|--|---|
| SLO-2 | Olefination and cyclopropanation reaction, Bayliss Hillman reaction | Corey-Kim oxidation, Dess-Martin oxidation | Catalytic hydrogenation (Homogeneous: Wilkinson). Noyori asymmetric hydrogenation) | Reactions involving free radical intermediates | Aromatic stabilization, electron delocalization |
| SLO-3 | Organoboron compounds, synthesis of organoboranes, carbonylation | Swern oxidation, phenols (Fremy's salt, silver carbonate) | Metal based reductions using Li/Na/Ca in liquid ammonia | Generation of radical intermediates | Synthesis |
| SLO-4 | Tutorial: Grignard reagents, Organoboron compounds | Tutorial: Corey-Kim, Dess-Martin and Swern oxidation. | Tutorial: Homogeneous/Heterogeneous hydrogenations | Tutorial: Various ways for generating free radicals | Tutorial: Discussion on fused aromatic compounds |
| SLO-5 | Other one-carbon homologation reactions, homologation via α -halo enolates | Alkenes to epoxides (peroxides/per acids based) Sharpless asymmetric epoxidation | Metal based reductions using sodium, magnesium, zinc etc. Birch reduction, dehalogenation and deoxygenation | Nucleophilic and electrophilic radicals | Reactivity |
| SLO-6 | Stereoselective alkene synthesis, nucleophilic addition of allylic groups from boron compounds | Introduction to asymmetric synthesis, Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation | Hydride transfer reagents from Group III and Group IV in reductions. NaBH_4 , triacetoxyborohydride | Mechanisms of radical reactions, solvent and neighboring group effects | heteroatomic polycyclic hydrocarbons, indole, benzofuran, benzothiophene, quinoline, phenanthroline |
| SLO-7 | Organosilicon compounds, general features carbon-carbon bond forming reactions of organosilicon compounds | Alkenes to diols (manganese, osmium based), Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification | Hydride transfer reagents from Group IV in reductions. L-selectride, Kselectride | Free radical substitutions at aliphatic substrates | aromatic stabilization, electron delocalization |
| SLO-8 | Tutorial: Stereoselective alkene synthesis, Organosilicon compounds | Tutorial: Different Oxidation reactions | Tutorial: Various metal-based reductions | Tutorial: Mechanism of free radical reactions | Tutorial: Different heteroatomic polycyclic hydrocarbons |
| SLO-9 | Acylation reactions, conjugate addition reactions. | Alkenes to carbonyls with bond cleavage (manganese, osmium, ruthenium and lead based, ozonolysis) | Luche reduction, LiAlH_4 , DIBAL-H, and Red-Al, MPV reduction) | Free radical substitutions at aromatic substrates | Synthesis |
| SLO-10 | Organotin compounds, synthesis of organostannanes | Alkenes to alcohols/carbonyls without bond cleavage (hydroboration-oxidation, etc. | Stereo/enantioselective reductions (chiral boranes, Corey-Bakshi-Shibata reduction) | Cyclization of free radical intermediates, additions to $\text{C}=\text{N}$ double bonds | Reactivity |
| SLO-11 | carbon-carbon bond forming reactions using tin reagents | ketones to ester/lactones (Baeyer-Villiger) | Clemmenson and Wolff-Kishner reduction | Fragmentation and rearrangement reactions, intramolecular functionalization by radical reactions | Applications of these compounds |
| SLO-12 | Tutorial: Acylation reactions, Organotin compounds | Tutorial: Conversion of alkene to alcohols/carbonyl compounds | Tutorial: Luche, Clemmenson and Wolff-Kishner reduction | Tutorial: Free radical substitution reactions | Tutorial: Synthesis and reactivity of heteroaromatic compounds |

Resources

| | |
|---|--|
| 1 | J. Clayden, N. Greeves, S. Warren and P. Wothers, <i>Organic Chemistry</i> , 1st Ed., Oxford University Press, 2001. |
| 2 | M.B. Smith & J. March, <i>March's Advanced Organic Chemistry</i> , 6th Ed., John Wiley & Sons, New York, 2007. |
| 3 | F.A. Carey and R.A. Sundberg, <i>Advanced Organic Chemistry, Part A and Part B</i> , 5th Ed., Kluwer Academic/Plenum Publishers, New York, 2004. Unit-II: Chapter 9, 20, 22 (Clayden), Chapter 15, 16, 18 (Smith), Chapter 7, 9 (Carey). Unit-III: Chapter 9, 20, 22 (Clayden), Chapter 19 (Smith). Unit-IV: Chapter 41 (Clayden), Chapter 19 (Smith), Chapter 5 (Carey). |
| 4 | Clar, E. (1964). <i>Polycyclic Hydrocarbons</i> . New York, NY: Academic Press. LCCN 63012392. |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignment

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|--|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| Designers | | | | | | | | |
|----------------------|---|--|----------------------------|---|--|------------------|--|--|
| Professional Experts | | | Higher Institution Experts | | | Internal Experts | | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Kamataka, Email Id: Ravikiran.Allada@Steri-science.com | | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | | 1 | Dr. Anjan Das, Department of Chemistry, SRMIST Email id: anjand@srmist.edu.in | |
| | | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | |
|----------------------|--|----------------------------|---|------------------|--|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. Anjan Das, Department of Chemistry, SRMIST Email id: anjand@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25203T | Course Title | Classical and Statistical Thermodynamics | | | | Category | C | Core Course | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|----|----|----|--|--|
| CLR-1 | Understand the basic principles & concepts of classical thermodynamics. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Strengthen the knowledge of the students in numerical problems in classical & statistical thermodynamics. | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Understand the basic concepts of Born-Oppenheimer approximation & Partition function. | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Acquaint the student with the fundamental concepts of statistical thermodynamics and its applications. | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Acquaint the student with the fundamental concepts of Non-equilibrium thermodynamics. | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical Practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand the basic principles & concepts of classical thermodynamics. | ✓ | ✓ | ✓ | - | 4 | 75 | 60 | 3 | 3 | 1 | 2 | 2 | 1 | 3 | - | - | - | - | - |
| CLO-2 | Acquaint students with the numerical problems in classical & statistical thermodynamics. | ✓ | ✓ | ✓ | - | 4 | 80 | 70 | 3 | 3 | 2 | 3 | 2 | 3 | - | - | - | 2 | - | - |
| CLO-3 | Gain the knowledge about concepts & approach of statistical thermodynamics. | ✓ | ✓ | ✓ | ✓ | 4 | 70 | 65 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | - | - | - | - | - |
| CLO-4 | Understand the concept of Born-Oppenheimer approximation & Partition function. | ✓ | ✓ | ✓ | ✓ | 4 | 70 | 70 | 3 | 3 | 3 | 2 | 2 | 3 | - | - | - | 3 | - | - |
| CLO-5 | Gain knowledge of Non-equilibrium thermodynamics, phenomenological equations & Onsager relations. | ✓ | ✓ | ✓ | ✓ | 4 | 80 | 70 | 3 | 3 | 1 | 3 | 2 | 3 | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|---|--|---|
| | Thermodynamics: Laws, Processes, and Applications | Advanced Thermodynamics: Variable Composition, Fugacity, and Third Law Concepts | Statistical Thermodynamics: Fundamentals, Quantum Statistics, and Partition Functions | Applications of Partition Functions and Quantum Statistical Thermodynamics | Non-Equilibrium Thermodynamics: Principles, Coupled Flows, and Applications |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | First law of thermodynamics concept of work & internal energy | Thermodynamic equation of state and Applications of Maxwells relation. | Introduction of Statistical thermodynamics; Aim | Thermodynamic functions in terms of the partition function | Basics of Non- equilibrium thermodynamics |

| | | | | | |
|---------------|---|---|---|--|---|
| SLO-2 | enthalpy and heat capacities | Internal pressure in case of ideal and non-ideal gas | Thermodynamic probability, apriori probability | Continue. monoatomic and diatomic gases | Steady state process concept |
| SLO-3 | second law of thermodynamics | thermodynamics of systems of variable composition | Distinguishability and particles | Continue: Applications such as dissociation of diatomic molecule | Phenomenological laws and equations |
| SLO-4 | Tutorial: Understanding the First and Second Laws of Thermodynamics | Tutorial: Applications of Thermodynamic Equations and Maxwell's Relations | Tutorial: Problems on distinguishability of particles and their implications for statistical systems. | Tutorial: Calculating thermodynamic functions using partition functions for monoatomic and diatomic gases. | Tutorial: Solving problems using phenomenological laws and equations in non-equilibrium systems. |
| SLO-5 | Cyclic process & Carnot cycle | Gibbs-Duhem equation & application | Quantum mechanical statistics viz. Fermi- Dirac; conditions, concept of fermions | Canonical partition function | Onsager relations for coupled flows |
| SLO-6 | efficiency of heat engine | Relationship with partial molar entropy | Bose-Einstein statistics; conditions & concept of Bosons | theories of heat capacities of solids; Dulong Petit's law | conservation of mass and energy in closed and an open system |
| SLO-7 | coefficient of performance of heat engine | Concept of fugacity | Concept of degeneracy | Einstein's theory of heat capacities of solids; limitations | entropy production in chemical reactions, especially spontaneous process |
| SLO-8 | Tutorial: Heat Engines and Their Efficiency | Tutorial: Solving problems on partial molar entropy and its relationship with other properties. | Tutorial: Solving problems using Fermi-Dirac statistics and understanding conditions for fermions. | Tutorial: Applying Einstein's theory of heat capacities and understanding its constraints. | Tutorial: Solving problems related to mass and energy conservation in closed and open systems. |
| SLO-9 | Gibbs– Helmholtz equation & applications | Nernst-Heat theorem | evaluation of the partition function; translational & numerical problems | nuclear spin statistics | transformation properties of rates and affinities |
| SLO-10 | Entropy change in various processes | exceptions to third law | Electronic partition function; term symbols of ground state of atoms, degeneracy | residual entropy of H ₂ at 0 K | irreversible thermodynamics and biological systems |
| SLO-11 | Isothermal, reversible-irreversible, adiabatic processes | unattainability of absolute zero; residual entropy | Nuclear partition function | Brief of applications of quantum statistical approach | oscillatory reactions |
| SLO-12 | Tutorial: Entropy and Gibbs–Helmholtz Equation in Thermodynamic Processes | Tutorial: Applying the Nernst-Heat theorem to practical problems. | Tutorial: Evaluating translational, electronic, and nuclear partition functions with numerical problems | Tutorial: Brief applications of quantum statistical approaches to real-world problems. | Tutorial: Exploring irreversible thermodynamics in biological systems, including oscillatory reactions. |

| Resources | | | |
|-----------|--|----|---|
| 1. | <i>K. Rajaram and J.C. Kuriacose, Thermodynamics for Students of Chemistry, 2nd Ed., S.L.N. Chand and Co, Jalandhar, 1986.</i> | 6. | <i>Cengel, Y. A., & Boles, M. A. (2014). Thermodynamics: An Engineering Approach (8th ed.). McGraw-Hill</i> |
| 2. | <i>I.M. Klotz and R.M. Rosenberg, Chemical thermodynamics, 6th Ed., W.A. Benjamin Publishers, California, 1972</i> | 7. | <i>Sears, F. W., & Salinger, G. L. (1986). Thermodynamics: An Engineering Approach. Addison-Wesley.</i> |

| | | | |
|----|--|-----|--|
| 3. | <i>P. W. Atkins, J. De Paula, Physical Chemistry, 9th Ed., Oxford University Press, Oxford, 2010</i> | 8. | <i>De Groot, S. R., & Mazur, P. (1984). Non-Equilibrium Thermodynamics. Dover Publications</i> |
| 4. | <i>M.C. Gupta, Statistical Thermodynamics, New Age International, Pvt. Ltd, New Delhi, 1995.</i> | 9. | <i>Alberty, R. A., & Silbey, R. J. (2002). Physical Chemistry (3rd ed.). Wiley-Interscience</i> |
| 5. | <i>B. R. Puri, L.R. Sharma and M.S. Pathania, Principles of Physical Chemistry, 46th Ed., Vishal Publishing Co., 2014.</i> | 10. | <i>Van Wylen, G. J., & Sonntag, R. E. (1986). Fundamentals of Classical Thermodynamics (4th ed.). Wiley.</i> |

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------------|------------|--|-----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|---|-----------------|----------------------------------|---|-------------------------|---|-----------------------------|---|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | | Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | | Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| 7 | Remember | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | | Debate | - | | |
| 8 | Understand | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | | Interactive Lecture | ✓ | | |
| 9 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | Brainstorming | ✓ | | |
| 10 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | |
| 11 | Evaluate | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| 12 | Create | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | | 100 | - | 100 | - | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | | | | | | | |
|----------------------|--|--|--|----------------------------|--|--|--|------------------|--|--|--|
| Professional Experts | | | | Higher Institution Experts | | | | Internal Experts | | | |
| 1 | Dr. Sudarshan Mahapatra, General Manager at Encube Ethicals Private Limited, Mumbai, Maharashtra, Email Id: sudarshan.m@encubeethicals.com | | | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | | | 1 | Dr. Tumpa Sadhukhan, Department of Chemistry, SRMIST Email id: tumpas@srmist.edu.in | | |
| 2 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | | | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in | | |

| Course Code | PCY25202J | Course Title | Main Group Elements and Nuclear Chemistry | | | | Category | C | Core Course | L | T | P | C |
|-------------|-----------|--------------|---|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 2 | 0 | 4 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Provide specialized knowledge in the area of periodicity in Chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Provide the background for understanding fundamental principles behind the classification and nature of elements | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Provide knowledge of numerous useful compounds that can be obtained from the main group elements | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Understanding the importance and practical utility of compounds derived from main group elements | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Provide in-depth knowledge, understanding and hands-on training on their syntheses, reactivity and properties | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Familiar with the knowledge of chemical periodicity and classification of elements | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - |
| CLO-2 | Knowledge of library of compounds obtained from main group elements, underlying chemistry and their practical utility | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Skill and efficiency in inorganic syntheses of useful compounds | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-4 | Familiar with the scope and societal utility of nuclear science | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Implicate the knowledge and understanding into research on novel technologies. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | - | 3 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|--|---|---|---|
| | Introduction to s-Block Elements | Introduction to Polymorphism | Introduction to Boron Chemistry | Introduction to Boron Chemistry | Introduction to Nuclear Chemistry |
| | 18 | 18 | 18 | 18 | 18 |
| SLO-1 | Description and chemical properties of s-block metals, reaction with water, air, nitrogen | Polymorphism of carbon, phosphorus and sulfur, catenation and heterocatenation | Boron oxides and oxoacids, boron sesquioxide, borax, sodium peroxoborates | Boronhydrides, reaction with ammonia, hydroboration | Composition of nucleus, nuclear forces, packing fraction, nuclear density, mass defect, binding energy of the nucleus, nuclear models, concept of nuclear spin. |
| SLO-2 | Applications of their compounds, oxides, hydroxides | Carbides, salt like carbides | Organic compounds containing boron-oxygen bonds | Structure of boranes, borohydrides and their uses | Radioactivity, radioactive disintegration |

| | | | | | |
|------------------|--|--|--|---|--|
| SLO-3 | Peroxides, superoxides | Interstitial carbides, covalent carbides | B-N compounds - aminoboranes, borazines, polyborazines, boroxines and boron nitrides | Boron and multicentre bonding, boron cages, vacuum technique of synthesis, lower and higher boranes reactions | Radioactive decay and half-life |
| SLO-4-6 | Practice: Introduction to semi-micro qualitative analysis – description of the course | Practice: Analysis of cations of Li, Na, Ca, Ba, Sr | Practice: Analysis of cations of Li, Na, Ca, Ba, Sr | Practice: Analysis of cations of Co, Ni, Cu, Zn, Cd, Pb | Practice: Analysis of cations of Co, Ni, Cu, Zn, Cd, Pb |
| SLO-7 | Preparation and properties, oxo salts, carbonates, bicarbonates, nitrates, and halides | Properties and structures of ortho, pyro, cyclic, chain, sheet, three dimensional silicates, silicates in technology-alkali silicates, ceramics, glass | Chemistry of P-N compounds - synthesis and reactivity | Structure and bonding, topological treatment, Wade's rule, styx numbers | Geiger-Nuttall rule, radioactive equilibrium, steady state, transmutation of elements |
| SLO-8 | Anomalous behavior of Li and Be | Organosilicones, preparation, structures, and applications | Phosphazene and its polymers theories of bonding, electronic structure and aromaticity | Carboranes, metallocarboranes, other hetero atom boron derivatives | Group displacement rule, nuclear stability, radioactive series, isotopes, isobars, isotones, separation of isotopes, |
| SLO-9 | Complexes of s-block metals-with crown ethers, complexes with cryptands | Synthesis, structure and bonding in polyanions of phosphorous | Phosphazene and its polymers theories of bonding, electronic structure and aromaticity | Metal atom cluster, di, tri, tetra, and hexanuclearity metal clusters | Artificial radioactivity, induced radioactivity, transuranic elements, |
| SLO-10-12 | Practice: Analysis of cations and anions of Se, Te, Mo | Practice: Analysis of cations and anions of As, Sb | Practice: Analysis of cations of Ce, Be, Th | Practice: Analysis of cations of Zr, Ti, V, Cr, Mn | Practice: Analysis of cations of Zr, Ti, V, Cr, Mn |
| SLO-13 | Organometallic compounds of Li, Mg and Be | Vanadium, chromium, molybdenum and tungsten | Synthesis and reactivity of S-N compounds: S ₄ N ₄ , S ₂ N ₂ , and S ₃ N ₃ Cl ₃ | Cluster structure based on electron counting schemes | Nuclear fission, nuclear fusion |
| SLO-14 | Organometallic compounds of Li, Mg and Be | Oxides and oxyacids of Se and Te | Poly thiazyl (SN) _x compounds | Capping rule, isoelectronic and isolobal analogy, relationship between fragments | Detectors: scintillation counter, gas ionization chamber, proportional counter, Cerenkov counter |
| SLO-15 | Reactivity and bonding | Structure and properties of interhalogen compounds [ClF ₃ , ClF ₅ , BrF ₅ , IF ₅ , IF ₇], poly halides, pseudohalogens, [cyanide, thiocyanate and azide] and xenon compounds | Properties and applications of S-N compounds | Isolobal relationships between main-group and transition metal fragments | Activation analysis, isotopic dilution technique, radiometric titration, applications of radioactivity in mankind |
| SLO-16-18 | Practice: Analysis of unknown metal salt | Practice: Analysis of unknown mixture salts | Practice: Analysis of unknown mixture salts | Practice: Analysis of unknown mixture salts | Practice: Repeat experiment |

Resources

| | | | |
|---|--|----|--|
| 1 | D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3 rd Ed., W. H. Freeman and Co, London, 1999. | 6. | Vogel's Inorganic Qualitative Analysis, 7 th Impression by G. Svehla, Pearson Education, New Delhi, 2009. |
| 2 | J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry, 4 th Ed., Harper Collins, New York, 1993. | 7. | N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, Pergamon Press, Oxford, 1984. |
| 3 | J. D. Lee, Concise Inorganic Chemistry, Wiley, 5th Edition, 2021. | 8. | H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Ed., New Age International, New Delhi, 1995. |

| | | |
|---|--|---|
| 4 | R. P. Sarkar, General and Inorganic Chemistry: Volume II, New Central Book Agency (P) Limited, 2009. | F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochman, Advanced Inorganic Chemistry, 6 th Ed., John Wiley, New York, 1999. |
| 5 | R. L. Dutta, Inorganic Chemistry Part-I and II, The New Book Stall, 1999. | |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 |
| 2 | Understand | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 10 | 15 | 15 |
| 3 | Apply | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 |
| 4 | Analyze | 20 | 25 | 25 | 20 | 25 | 25 | 25 | 25 | 25 | 25 |
| 5 | Evaluate | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 |
| 6 | Create | 15 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 10 | 10 |
| Total (%) | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | | | | | | | |
|----------------------|---|--|--|----------------------------|--|--|--|------------------|---|--|--|
| Professional Experts | | | | Higher Institution Experts | | | | Internal Experts | | | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | | | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | | | 1 | Dr. Tarak Nath Mandal, Department of Chemistry, SRMIST Email id: taraknam@srmist.edu.in | | |
| | | | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | | | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in | | |

| Course Code | POC25203T | Course Title | Heterocyclic Chemistry and Total Synthesis of Natural Products | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|-------|---|---|---|------------|---|---|---|---|---|-----------------------|---|---|---|---|---|----|----|----|--|--|--|
| | | | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Give the student a broad understanding of the major classes of heterocyclic compounds | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| CLR-2 | Introduce the nomenclature, structure, properties, syntheses, and reactions of non-aromatic heterocycles | | | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Inculcate the nomenclature, structure, properties, syntheses, and reactions of aromatic heterocycles | | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Learn various nucleophilic, substitution and electrophilic reactions in heterocyclic chemistry | | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Learn the importance of naturally occurring alkaloids, terpenoids and antibiotics | | | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand the structures, syntheses, reactions, and properties of the major classes of heterocyclic compounds | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | - | 3 | 2 | - | - | - | - | - | - | - | - |
| CLO-2 | Predict the nucleophilic and electrophilic reaction mechanisms, catalyst and rearrangements reactions | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | 3 | - | 3 | - | - | - | - | - | - | - | - | 2 |
| CLO-3 | Able to draw mechanisms for reactions involving heterocycles as starting materials, intermediates and products, and to propose syntheses of heterocycles from the major classes | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 3 | 3 | - | - | - | - | - | - | - | - |
| CLO-4 | Explain the classification of alkaloids, terpenoids and their importance and uses | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 2 | - | - | - | - | - | - | - | - | 3 |
| CLO-5 | To evaluate and propose syntheses of complex natural products | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | 3 | - | 3 | - | - | - | - | - | - | - | - | 3 |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|--|---------------------------|---|------------------------------|
| | Introduction to heterocyclic compounds | Structure and reactivity of heterocyclic compounds | Synthesis of heterocycles | Reactions of heterocycles, introduction to natural products | Natural product synthesis |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Introduction of aliphatic heterocyclic compound with four, five and six membered rings, classification based on one and more than one heteroatom containing rings. | Tautomerism in aromatic heterocycles and factors, general trends in the reactivity of aromatic heterocycles- furan, pyrrole, thiophene | Synthesis of azirines | Reactions of pyrrole, furan, thiophene and pyrazole | Total synthesis of forskolin |

| | | | | | |
|---------------|--|--|---|--|---|
| SLO-2 | The replacement nomenclature, the Hantzsch-Widman nomenclature for Monocyclic heterocycles | Strain in small ring heterocycles, consequences of bond angle strain in small ring heterocycles | Synthesis of pyrrole, furan and thiophene | Reactions of imidazole, oxazole, thiazole, pyrimidine and pyrazine | Importance and uses of reserpine, retrosynthetic synthesis of reserpine |
| SLO-3 | The Hantzsch-Widman nomenclature for fused and bridged heterocycles, effect of heteroatoms on organic reactions in comparison with carbogenic compounds-their Properties | Conformation of six-membered heterocycles | Synthesis of pyrazole | Reactions of benzofuran, indole, benzothiophene, pyridine, quinoline and isoquinoline | Woodward's synthesis of reserpine |
| SLO-4 | Tutorial : Hantzsch-Widman nomenclature | Tutorial : General trends in the reactivity of aromatic heterocycles-furan, pyrrole, thiophene | Tutorial : Synthesis of pyrrole, furan and thiophene | Tutorial : Reactions of pyrrole, furan, thiophene | Tutorial : Woodward's synthesis of reserpine |
| SLO-5 | Comparison of basicity of pyrrolidine, piperidine and morpholine, heterocycles in organic synthesis | Barrier to ring inversion, pyramidal inversion | Synthesis of imidazole | Synthesis of six membered rings containing two heteroatoms | Introduction to decalin as a segment in cholesterol, importance and uses of cholesterol |
| SLO-6 | Heterocycles in biomolecules, oxidation in heterocyclic chemistry | 1,3-diaxial interactions, factors affecting anomeric effect | Synthesis of oxazole and thiazole | Introduction and importance of natural products, introduction to retrosynthetic analysis | Woodward's synthesis of cholesterol |
| SLO-7 | Reductions in heterocyclic chemistry, aromatic heterocycles: classification | Consequences of anomeric effect, double anomeric effect, Rabbit-ear effect (lone pair-lone pair interactions) | Synthesis of pyrimidine and pyrazine | Total synthesis of Penicillin | Corey's synthesis of prostaglandins (E ₂ , F _{2α}), Importance and uses of Taxol |
| SLO-8 | Tutorial : Oxidation and reduction in heterocyclic chemistry, aromatic heterocycles. | Tutorial : Factors affecting anomeric effect, consequences of anomeric effect | Tutorial : Synthesis of imidazole, oxazole and thiazole | Tutorial : Total synthesis of Penicillin | Tutorial : Woodward's synthesis of cholesterol |
| SLO-9 | Criteria of aromaticity, structural Criteria: Bond length | Repulsive-gauche effect (hockey-sticks effect), hydrogen bonding and intermolecular nucleophilic, electrophilic interactions | Synthesis of benzofuran, indole and benzothiophene | Alkaloids: Morphine - importance and uses, retrosynthetic analysis of morphine | Retrosynthetic approach of Taxol, Nicolaou's synthesis of Taxol |
| SLO-10 | Electronic criteria: Dipole moment, Energetic Criteria: Delocalization energy | Basic principles of heterocycle synthesis, Baldwin's Rule | Synthesis of pyridine, quinoline and isoquinoline | Total synthesis of morphine | Danishefsky's synthesis of indolizomycin |
| SLO-11 | Energetic criteria: Dewar resonance energy, magnetic criteria: Ring current and chemical shifts in ¹ H NMR-spectra | Synthesis of aziridines, reactions of aziridines | Reactions of azirines | Terpenes: Forskolin - importance and uses, retrosynthetic analysis of forskolin | Takasago synthesis of menthol |
| SLO-12 | Tutorial : Electronic and magnetic criteria of heterocycles | Tutorial : Synthesis of aziridines, reactions of aziridines | Tutorial : Synthesis of benzofuran, indole and benzothiophene | Tutorial : Morphine - importance and uses, retrosynthetic analysis of morphine | Tutorial : Danishefsky's synthesis of indolizomycin |

| Resources | | |
|-----------|--|----|
| 1 | T. L. Gilchrist, <i>Heterocyclic Chemistry</i> , 3rd Ed., Prentice Hall, 1997. | 6 |
| 2 | A. R. Katritzky, and C. W. Rees, <i>Comprehensive Heterocyclic Chemistry</i> , Pergamon Press, 1996. | 7 |
| 3 | R. R. Gupta, M. Kumar, and V. Gupta, <i>Heterocyclic Chemistry</i> , Vo1.1-3, Springer Verlag, 2008. | 8 |
| 4 | D. T. Davies, <i>Aromatic Heterocyclic Chemistry</i> , Oxford Chemistry Primers, 1992. | 9 |
| 5 | K. C. Nicolaou, <i>Classics in total synthesis</i> , Wiley, 1996. | 10 |

| Assessment | | | | | | | | | | | |
|---------------------------------|------------|--|--------------|-----------------------|--------------|-----------------------|--------------|------------|--------------|---|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* | | | |
| | | | | | | | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

| Strategies | | | | |
|----------------------------|---|----------------------|---|----------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality ✓ |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|--|---|--|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. Gopal Chandru Senadi, Dr. P. Gopinath Department of Chemistry, SRMIST Email id: chandrug@srmist.edu.in, gopinathp1@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | POC25D02T | Course Title | Asymmetric and Enzymatic Synthesis | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|------------------------------------|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|-------|---|---|---|------------|---|---|---|---|---|-----------------------|---|---|---|---|---|----|----|----|--|--|--|
| | | | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | enable them to learn idea of asymmetric synthesis | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| CLR-2 | enable them to think of multistep synthesis of important organic molecules | | | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | help to understand the role of organocatalysts in organic synthesis | | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | explore them to the enzyme structure and reactivity | | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | learn about the applications of enzymes in organic synthesis. | | | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand the methods and fundamentals of asymmetric synthesis | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | - | 3 | 2 | - | - | - | - | - | - | - | - |
| CLO-2 | Understand the use of organocatalysts in organic synthesis | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | 3 | - | 3 | - | - | - | - | - | - | - | - | 2 |
| CLO-3 | Understand the preparation and use of NHC | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 3 | 3 | - | - | - | - | - | - | - | - |
| CLO-4 | Comprehend biocatalysis and their role in organic synthesis | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 2 | - | - | - | - | - | - | - | - | 3 |
| CLO-5 | Gain knowledge about the different organocataly | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | 3 | - | 3 | - | - | - | - | - | - | - | - | 3 |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|---------------------------------|---|---|---|
| | Introduction to asymmetric synthesis | Asymmetric organocatalysis - I | Asymmetric organocatalysis - II | Enzyme catalysis | Biocatalysis |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Asymmetric synthesis: chiral auxiliaries, methods of asymmetric induction | Introduction to organocatalysis | Carbenes as organocatalysts | Introduction to biocatalysts, advantages and disadvantages of biocatalysts | Biocatalytic oxidation reactions of alcohols and aldehydes |
| SLO-2 | Substrate, reagent and catalyst controlled reactions | Lewis acid catalysis | Types of different NHCs and their synthesis | Isolated enzymes vs. whole cell systems, brief overview of structure of enzymes | Biocatalytic carbon-carbon bond formations, aldol reaction, Michael-type additions, |

| | | | | | |
|---------------|--|---|--|--|--|
| SLO-3 | Determination of enantiomeric and diastereomeric excess, enantiodiscrimination | Lewis base catalysis | NHC catalyzed umpolung, NHC catalyzed transesterification reactions | Mechanistic aspects of enzyme catalysis | Thiamine-dependant benzoin condensation |
| SLO-4 | Tutorial : Substrate, reagent and catalyst controlled reactions | Tutorial : Lewis acid and base catalysis | Tutorial : Carbenes as organocatalysts, NHC catalysis | Tutorial : Mechanistic aspects of enzyme catalysis | Tutorial : Biocatalytic carbon-carbon bond formations, aldol reaction, Michael-type additions, |
| SLO-5 | Resolution – optical and kinetic | Iminium catalysis | Oxidative NHC catalysis | Classification and nomenclature | Cyanohydrin formation, amino transfer reaction |
| SLO-6 | Asymmetric oxidation [epoxidation: Sharpless, Jacobsen, Shi] | Enamine catalysis | Cooperative catalysis with metal catalysts | Coenzymes, enzyme sources | Halogenations and dehalogenations |
| SLO-7 | Dihydroxylation (Sharpless)] | Bronsted acid catalysis | Cooperative catalysis with other organocatalysts | Biocatalysed hydrolytic reactions, hydrolysis of amides, esters | Enzymes in organic solvents, ester synthesis, lactone synthesis |
| SLO-8 | Tutorial : Asymmetric oxidation [epoxidation: Sharpless, Jacobsen, Shi] | Tutorial : Iminium, enamine and Bronsted acid catalysis | Tutorial : Oxidative NHC catalysis, cooperative catalysis with metal catalysts | Tutorial : Coenzymes, enzyme sources | Tutorial : Enzymes in organic solvents, ester synthesis, lactone synthesis |
| SLO-9 | Asymmetric reduction (Noyori, Corey, Pfaltz) | Bronsted base catalysis | Homo and cross benzoin type reactions | Biocatalytic hydrolysis of epoxides and nitriles | Amide synthesis, peptide synthesis |
| SLO-10 | Stereoselective aldol reactions (Cram's rule and Felkin Anh models) | Quaternary ammonium salts as catalyst and phase transfer catalyst | Stetter reaction, enolate chemistry, homoenolate derived reactions | Biocatalytic reduction reactions, recycling of cofactors | Artificial enzyme mimics, |
| SLO-11 | Auxiliary controlled stereoselection, Evans oxazolidones | Physical influence in asymmetric synthesis | Addition to ketenes and analogs | Reduction of aldehydes, ketones and C=C bonds | Catalytic antibodies |
| SLO-12 | Tutorial : Stereoselective aldol reactions (Cram's rule and Felkin Anh models) | Tutorial : Bronsted base, quaternary ammonium salts as catalyst and phase transfer catalyst | Tutorial : Stetter reaction, enolate chemistry, homoenolate derived reactions | Tutorial : Biocatalytic reduction reactions, recycling of cofactors, reduction of aldehydes, ketones and C=C bonds | Tutorial : Artificial enzyme mimics, catalytic antibodies |

| Resources | |
|-----------|--|
| 1 | <i>R. Gawley and J. Aube, Principles of Asymmetric Synthesis, 2nd Ed., Elsevier, 2012.</i> |
| 2 | <i>K. Faber, Biotransformations in Organic Chemistry, 6th Ed., Springer, 2011.</i> |
| 3 | <i>Seayad, Jayasree, and Benjamin List. "Asymmetric organocatalysis." Organic & biomolecular chemistry 3.5 (2005): 719-724.</i> |
| 4 | <i>Hopkinson, Matthew N., et al. "An overview of N-heterocyclic carbenes." Nature 510.7506 (2014): 485-496.</i> |
| 5 | <i>Flanigan, Darrin M., et al. "Organocatalytic reactions enabled by N-heterocyclic carbenes." Chem. Rev 115.17 (2015): 9307-9387.</i> |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

| Strategies | | | | |
|----------------------------|---|----------------------|---|--------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|--|---|--|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. Gopal Chandru Senadi, Department of Chemistry, SRMIST Email id: chandrug@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25D04T | Course Title | Nanomaterials and Nanochemistry | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|---------------------------------|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|--|--|
| CLR-1 | Acquire sound knowledge about nanophenomena | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Learn various synthetic routes of nanomaterials | | | | | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical Practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLR-3 | Gain deep knowledge about the analytical techniques used to characterize the nanomaterials | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Learn carbon nanostructures and their properties | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Learn the applications of nanomaterials in catalysis | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | | | | | | | | | | | | | | | | | |
| CLO-1 | Apply various phenomena underlying the nanoscale materials for new designs | ✓ | ✓ | ✓ | - | 2 | 75 | 60 | 2 | - | 3 | - | - | - | 1 | - | - | - | - | - | | |
| CLO-2 | Identify the suitable methods for the synthesis of any specific nanomaterial | ✓ | ✓ | ✓ | - | 2 | 80 | 70 | 3 | - | 2 | - | 1 | - | - | - | - | - | - | - | | |
| CLO-3 | Apply the suitable technique to characterize nanomaterial and understand the results obtained | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 65 | 2 | - | 3 | - | 3 | - | - | - | - | - | - | - | | |
| CLO-4 | Rationalize the carbon nanomaterials and their properties | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | 3 | - | 2 | - | - | - | 1 | - | - | - | - | - | | |
| CLO-5 | Understand the parameters responsible for the catalytic efficiency of nanomaterials. | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | 3 | - | 2 | - | - | - | 2 | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|---|--|---|---|
| | Fundamentals of Nanochemistry | Synthesis of Nanomaterials | Characterization of Nanomaterials | Functional Nanomaterials | Applications of Nanomaterials |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | History, fundamentals, and scope of nanoscience and nanotechnology. | Synthesis strategies of nanoscale materials. Top-down and bottom-up approaches. | Characterization methods of nanomaterials - Importance and advancements. | Functional nanomaterials: overview. Classical examples and importance of applied nanomaterials. | Nanocatalysts: fundamentals. Design principle of nanostructures for catalysis applications. |
| SLO-2 | Nanoscale phenomena: Surface area to volume ratio (SAVR). | Gas phase, liquid phase, solid phase synthesis. Merits and challenges of these methods. | Physical characterization of nanostructures: XRD. Phase, | Carbon nanostructure: Allotropes of carbon. Structural differences in the allotropes | Essential properties of nanomaterials for energy conversion reactions. |

| | | | | | |
|---------------|--|---|--|--|---|
| | Calculation of SAVR for cube and sphere. | | crystallinity, and particle size analyses. | of carbon. | Factors influencing energy conversion reactions. |
| SLO-3 | Nanoscale phenomena: Quantum confinement effect. Quantization of energy states. | Co-precipitation and sol-gel method. Nucleation and growth processes in the co-precipitation and sol-gel route. | Microscopic characterization of nanostructures: SEM and TEM. Size, shape, morphology, and compositional analyses. | Carbon nanostructure: Graphene, Structural properties of graphene. | Nanomaterials are used for photocatalytic water splitting. Examples: HER and OER |
| SLO-4 | Tutorial: Nanoscale phenomena. | Tutorial: Synthesis strategies. | Tutorial: Characterization methods. | Tutorial: Functional nanomaterials | Tutorial: HER and OER |
| SLO-5 | Nanoscale phenomena: Surface plasmon resonance effect. Mechanism of light and plasmon interaction. | Hydrothermal and solvothermal methods. Merits and challenges of these temperature and pressure-assisted methods. | Microscopic characterization of nanostructures: STEM and AFM. Thickness and roughness analyses. | C60 (Fullerenes). Structural properties of C60. | Nanomaterials for electrocatalytic water splitting and Examples. |
| SLO-6 | Nanoscale phenomena: Nano-self-assembly effect. Self-assembly factors at nanoscale. | Self-assembly, template-assisted, and micro-emulsion methods. Merits and challenges of these methods. | Spectroscopic characterization of nanostructures: XPS. Composition and oxidation state. Mechanism of light and plasmon interaction analyses. | Carbon nanotubes: SWCNTs and MWCNTs. | Nanomaterials for dye degradation. Basic principles and examples |
| SLO-7 | Nanoscale phenomena: Quantum tunneling effect. Features of quantum tunneling at nanoscale. | Electrodeposition and CVD methods. Regulation strategy of the deposition process and scope. | Surface area characterization of nanostructures: BET. Surface area and pore-size distribution analysis. | Arrangement and orientation of hexagons in CNTs. Structure-property relationship. | Mechanism of photocatalytic reaction at nanointerface. Examples of nanostructured materials for photocatalysis. |
| SLO-8 | Tutorial: Conductor and semi-conductor properties at the nanoscale | Tutorial: Synthesis of special nanostructures: Quantum dots. Unique steps involved in the QDs synthesis route. | Tutorial: SEM Demonstration | Tutorial: Carbon nanowires | Tutorial: Nanomaterials uses |
| SLO-9 | Physical and electronic properties at the nanoscale. The boiling, melting point, and density of energy states vary at the nanoscale. | Photochemical and Microwave-assisted synthesis. Light and wave interaction of molecules during nanostructure formations and scope of the methods. | Thermal characterization of nanostructures: TGA. Stability vs temperature profile analysis. | Chemical modification of SWCNTs and MWCNTs. Mechanism of surface modification in CNTs. | Nanomaterials for water treatment. Example nanomaterials for water treatment. |
| SLO-10 | Conductor and semi-conductor properties at the nanoscale. Band gap variation upon size reduction. | Synthesis of special nanostructures: CNT. Unique steps involved in the CNT synthesis route. | Surface charge characterization: Zeta potential analyzer. Charge distribution analyses | Carbon nanowires. Finalization of carbon nanowires. | Nanomaterials for CO ₂ capture. Unique requirements of nanostructures for CO ₂ capture |
| SLO-11 | Magnetic and mechanical properties at the nanoscale. Examples of nanomaterials exhibiting changes in magnetic and mechanical properties. | Synthesis of special nanostructures: core-shell morphology. Turing of core-shell thickness: steps. | Spectrophotometer analysis: UV-visible and fluorescence. Absorption and emission properties of nanostructures. | Conductive/semiconductive oxide nanostructures: Structure-property relationship. | Nano-catalysis: Applied nanomaterials in industry. Scope and challenges of nano-catalysis. |

| | | | | | |
|---------------|---|------------------------|--------------------------------|--------------------------|----------------------------------|
| SLO-12 | Tutorial: Physical and electronic properties. | Tutorial: Quantum dots | Tutorial: UV-visible analysis. | Tutorial: CNT structures | Tutorial: Applied nanomaterials. |
|---------------|---|------------------------|--------------------------------|--------------------------|----------------------------------|

Resources

| | | | |
|----|--|----|--|
| 1. | C. N. R. Rao, A. Muller and A. K. Cheetham, (Eds): <i>The Chemistry of Nanomaterials</i> , 2004 | 6 | U. Heiz, and U. Landman, <i>Nanocatalysis</i> , Springer, New York, 2006 |
| 2. | C. P. Poole, and Jr. F. J. Owens, <i>Introduction to Nanotechnology</i> , Wiley Inter-science, New Jersey. 2003 | 7 | |
| 3. | K. J. Klabunde, <i>Nanoscale Materials in Chemistry</i> , Wiley- Inter-science, New York, 2001 | 8 | |
| 4. | T. Pradeep, <i>Nano: The Essentials in Understanding Nanoscience and Nanotechnology</i> , Tata McGraw Hill, New Delhi, 2007 | 9 | |
| 5. | T. Tang and P. Sheng, <i>Nano Science and Technology – Novel Structures and Phenomena</i> , Taylor & Francis, New York, 2004 | 10 | |

Assessment

| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

Strategies

| Technology | Pedagogy / Andragogy | Sustainable Development |
|----------------------------|------------------------|----------------------------|
| Simulations | - Clarification/Pauses | ✓ Good Health & Well Being |
| Presentation Tools | - Group Discussion | ✓ Quality Education |
| Learning Management System | - Hands-on Practice | - Gender Equality |
| | Debate | - |
| | Interactive Lecture | ✓ |
| | Brainstorming | ✓ |
| | | |
| | | |
| | | |
| | | |
| | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

Designers

| Professional Experts | | Higher Institution Experts | | Internal Experts | |
|----------------------|--|----------------------------|---|------------------|--|
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. N. Clament Sagaya Selvam, Department of Chemistry, SRMIST Email id: clamentn@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | POC25S01L | Course Title | Organic Chemistry Practical: Functional Group Analysis and Synthesis | | | | Category | S | Skill Enhancement Course | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|--------------------------|---|---|---|---|
| | | | | | | | | | | 0 | 0 | 6 | 3 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Gain exposure to the practical knowledge of organic reactions | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Gain insight about setting up a basic reaction for synthesis of simple compounds | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Learn about the analysis of different organic functional groups | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Gain knowledge about the structural elucidation of synthesized compounds using different techniques | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Know how to maintain the record of experiments conducted | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand different purification techniques in organic chemistry like recrystallization, distillation, steam distillation and extraction. | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | 3 | 2 | - | - | - | - | - | - | - | - |
| CLO-2 | Get awareness of safety techniques and handling of chemicals. | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 2 | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-3 | Understand how to carry out different types of reactions and their workup methods. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | 3 | - | - | - | 3 | - | - | - | - | - |
| CLO-4 | Understand the principles of mass spectroscopy, gas chromatography and HPLC | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | 3 | - | 2 | - | - | - | - | - | - | - |
| CLO-5 | Apply the techniques for structure determination of organic molecules. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | 3 | 2 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|--|---|------------------------|---------------------|
| | Spectroscopic technique | Synthesis -1 | Synthesis-2 | Qualitative separation | Structural analysis |
| | 18 | 18 | 18 | 18 | 18 |
| SLO-1 -6 | Introduction Spectroscopic Techniques: Compounds to be synthesized by one step reaction have to be characterized by modern spectroscopic techniques (UV-Vis, FT-IR, NMR). | 3. 4-Nitrobenzoic acid to 4-nitrobenzanilide (Substitution) | 6. Cyclohexanone → Phenyl hydrazone → 1,2,3,4-Tetrahydrocarbazole | 3. Mixture 3 | 6. Mixture 6 |
| SLO-6-12 | 2,4,6-Trinitrophenol(picric acid) from phenol (nitration) | 4. o-Chlorobenzoic acid from anthranilic acid (Sandmeyer reaction) | Analysis of an organic mixture containing two components: Mixture 1 | 4. Mixture 4 | Repeat Class -1 |

| | | | | | |
|------------------|---|--|--------------|--------------|-----------------|
| SLO-13-18 | Benzophenoneoxime from benzophenone (addition reaction) | 5. 4-Nitro toluene → 4-Nitro benzoic acid → 4-Amino benzoic acid | 2. Mixture 2 | 5. Mixture 5 | Repeat Class -2 |
|------------------|---|--|--------------|--------------|-----------------|

| Resources | |
|------------------|--|
| 1 | <i>Vogel, A Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall, 1996.</i> |
| 2 | <i>Fieser and Fieser, Reagents in Organic Synthesis, Wiley, 2006.</i> |
| 3 | <i>Mann & Saunders, Practical Organic Chemistry, 4th Ed., Longmans, 1960.</i> |
| 4 | <i>H. T. Clarke., A Handbook of Quantitative & Qualitative Analysis, Arnold Heinemann, 1975.</i> |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | - | 15 | - | 15 | - | 15 | - | 15 | - | 15 |
| 2 | Understand | - | 15 | - | 15 | - | 15 | - | 15 | - | 15 |
| 3 | Apply | - | 20 | - | 20 | - | 20 | - | 20 | - | 20 |
| 4 | Analyze | - | 20 | - | 20 | - | 20 | - | 20 | - | 20 |
| 5 | Evaluate | - | 15 | - | 15 | - | 15 | - | 15 | - | 15 |
| 6 | Create | - | 15 | - | 15 | - | 15 | - | 15 | - | 15 |
| Total (%) | | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 |

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | ✓ | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | - | | |
| | | Brainstorming | - | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|--|--|---|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. Baburaj Baskar, Department of Chemistry, SRMIST Email id: baskarb@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Code | PCD25AE2T | Title | Soft Skills and Verbal Mastery | | | | Category | AE | Ability Enhancement | L | T | P | C |
|------|-----------|-------|--------------------------------|--|--|--|----------|----|---------------------|---|---|---|---|
| | | | | | | | | | | 2 | 0 | 0 | 2 |

| Offering Department | Career Guidance | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | |
|---------------------|-----------------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|--|
|---------------------|-----------------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|--|

| Rationale (CR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|----------------|---|----------|--------|-----------|---------|-------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CR-1 | Help individuals develop key skills for personal and professional growth | | | | | | | | | | | | | | | | | | | |
| CR-2 | Prepares individuals to navigate daily challenges with confidence, professionalism, and a positive mindset | | | | | | | | | | | | | | | | | | | |
| CR-3 | Create a strong resume, participate in group discussions, and perform well in interviews | | | | | | | | | | | | | | | | | | | |
| CR-4 | Enhance vocabulary and verbal reasoning skills | | | | | | | | | | | | | | | | | | | |
| CR-5 | Develop the skills needed for effective communication and critical thinking in both written and spoken language | | | | | | | | | | | | | | | | | | | |
| Outcomes (CO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| | | | | | | | | | | | | | | | | | | | | |
| CO-1 | Gain a deeper understanding of self, including emotional intelligence and career aspirations | ✓ | ✓ | ✓ | ✓ | 3 | 85 | 75 | 1 | - | 3 | - | 3 | 3 | - | - | 3 | 3 | 2 | 3 |
| CO-2 | Apply effective presentation skills for clear, engaging communication | ✓ | ✓ | ✓ | ✓ | 6 | 85 | 75 | 1 | 3 | 3 | - | 3 | 2 | - | - | 3 | 3 | 2 | 3 |
| CO-3 | Participate confidently and effectively in group discussions and interviews | ✓ | ✓ | ✓ | ✓ | 3 | 85 | 75 | 1 | 3 | 1 | - | 3 | 2 | - | - | 3 | 3 | 2 | 3 |
| CO-4 | Enhance their ability to understand and use language effectively in different contexts | ✓ | ✓ | ✓ | ✓ | 2 | 85 | 75 | 1 | - | - | - | 1 | - | - | - | - | 3 | 2 | 2 |
| CO-5 | Improve language comprehension and accuracy | ✓ | ✓ | ✓ | ✓ | 5 | 85 | 75 | 1 | - | - | - | 1 | - | - | - | - | 3 | 2 | 2 |

| Title & Session Outcomes | Personal Development | Mastering Workspace Dynamics | Career Essentials | Verbal Ability | Verbal Reasoning and Comprehension |
|--------------------------|---|--|--|-----------------------|------------------------------------|
| Duration (hour) | 6 | 6 | 6 | 6 | 6 |
| SO-1 | Self-analysis through SWOT, The Johari Window | Personal, Professional and Social Etiquette | Resume Preparation and Activity | Synonyms and Antonyms | Statement and Assumption |
| SO-2 | Goal Setting Importance, Goal Setting based on the Principle of SMART | Professional Communication - Presentation Skills | E-mail Drafting and Practice | One Word Substitution | Paragraph Summary |
| SO-3 | Emotional Intelligence (Identifying, Managing and Understanding Emotions) | Presentation for Internal and External Communication - online & offline Meetings | Techniques to Follow in Group Discussion | Word Analogy | Idioms and Phrases |
| SO-4 | Process of Career Exploration | Time Management and Planning Tools | Mock Group Discussion | Verbal Classification | Cloze Test |
| SO-5 | STAR Technique (situation, task, approach and response) for Facing an Interview | Decision Making Skills | Interview Techniques | Spotting Errors | Theme Detection |
| SO-6 | Professional Attitude – Entrepreneurial, Rational, Optimistic Attitude | Teamwork in Workspace - Resilience and Stress Management | Mock Personal Interview | Sentence Correction | Reading Comprehension |

| Assessment | | | | | | | | | |
|--|---------|----------|---------|----------|---------|----------|---------|----------|--|
| Continuous Learning Assessment (CLA) (100 % weightage) | | | | | | | | | |
| Level of Thinking | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4 | | |
| | (20 %) | | (20 %) | | (30 %) | | (30%) | | |
| | Theory | Practice | Theory | Practice | Theory | Practice | Theory | Practice | |
| 1 Remember | | | | | | | | | |
| 2 Understand | 25% | - | 20% | - | 30% | - | 50% | - | |
| 3 Apply | | | | | | | | | |
| 4 Analyze | 50% | - | 50% | - | 40% | - | 25% | - | |
| 5 Evaluate | | | | | | | | | |
| 6 Create | 25% | - | 30% | - | 30% | - | 25% | - | |
| Total | 100 % | | 100 % | | 100 % | | 100 % | | |

| Strategies | | | | |
|------------------------------|---|------------------------|---|---------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | ✓ | Case Studies | ✓ | No Poverty |
| Emulations | ✓ | Group Discussion | ✓ | Zero Hunger |
| Prototypes | | Hands-on Practice | ✓ | Good Health & Well Being |
| Hands-on Practice Tools | ✓ | Inquiry Learning | ✓ | Quality Education |
| Mathematical Computing Tools | | Interactive Lecture | ✓ | Gender Equality |
| Field Visit | | Leading Question | ✓ | Clean Water & Sanitation |
| | | Mind Map | ✓ | Affordable & Clean Energy |
| | | Minute Paper | | |
| | | Peer Review | ✓ | |
| | | Problem Based Learning | ✓ | |

| Resources | | | |
|-----------|--|---|---|
| 1 | "The Johari Window: A Model for Self-awareness and Personal Growth" by Joseph Luft & Harrington Ingham | 2 | Campus Recruitment complete Reference , Praxis Groups |
| 3 | "The 7 Habits of Highly Effective People" by Stephen R. Covey | 4 | A Modern Approach to Verbal and Non Verbal Reasoning – Dr A S Agarwal |
| 5 | "SMART Goals: How to Set and Achieve Your Personal and Professional Goals" by S.J. Scott | 6 | Verbal Ability & Reading Comprehension for CAT - Arun Sharma |

| Designers | | | | | |
|----------------------|--|----------------------------|--|------------------|---|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Mr. Varadha Rajan M (External Expert), Assistant Manager – Human Resources, Justdial Limited, Chennai – 600015 varadha1723@gmail.com | 1 | Dr. Premavathy M, Associate Professor , Department of English Center for Distance and Online Education, Bharathidasan University, Tiruchirappalli – 620024 drmpremavathy@bdu.ac.in | 1 | Dr. Deepalakshmi S, HoD, Department of Career Guidance Cell, FSH, SRMIST |
| | | | | 2 | Dr. Muthu Deepa M, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST |
| | | | | 3 | Dr. Sam Israel S, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST |
| | | | | 4 | Dr Elamathiyan E, Assistant Professor, Department of Career Guidance Cell, FSH, SRMIST |

SEMESTER-III

| Course Code | PCY25301T | Course Title | Organometallic and Bioinorganic Chemistry | | | | Category | C | Core Course | L | T | P | C |
|-------------|-----------|--------------|---|--|--|--|----------|---|-------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|----------------------------------|------------------------|---------------|----------------------|--------------------|--|--|
| CLR-1 | Gain knowledge of the basic concepts of organometallic chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Address concepts related to organometallic chemistry using stability based on 18-electron rule | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Respo | Individual & Team Work | Communication | Project Management & | Life Long Learning | | |
| CLR-3 | Employ various organic reactions towards the design of fine chemical and drug molecules for industries | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Get knowledge on organometallic compounds as various types of catalyst | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Utilize the bioinorganic chemistry in various pharmaceutical problems and identify appropriate solutions | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | | | | | | | | | | | | | | | | | | | | | |
| CLO-1 | Apply 18-electron rule to rationalize the stability of organometallic compounds | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - | | |
| CLO-2 | Employ concepts of organometallic chemistry in fine chemical for industry | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | 2 | | |
| CLO-3 | Develop a general idea of catalysis and describe the mechanism in detail | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 3 | - | - | 3 | - | - | - | - | - | | |
| CLO-4 | Solve periodically by incorporation of organometallic compounds into organic synthesis problems | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 2 | - | - | - | - | - | - | - | 3 | | |
| CLO-5 | Explain the sources and consequences of excess and deficiency of trace metals and learn about the toxicity of certain metal ions | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | - | 3 | - | - | - | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|--|--|---|---|
| | Introduction to Organometallic Chemistry | Introduction to Sandwich complexes | Various Catalysis reactions | Introduction to Bioinorganic Chemistry | Importance of Various Metalloenzymes |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Type of ligands and eighteen electron rule | Synthesis and reactivity of metal arenes | Suzuki reactions, Stille reactions, Negishi coupling reactions, Ullman coupling reactions, Heck reaction | Introduction of Bioinorganic chemistry. | Nitrogen fixation |
| SLO-2 | Transition metal carbonyl complexes, substitutes for carbonyl ligands | Synthesis and reactivity of metal arenes | Suzuki reactions, Stille reactions, Negishi coupling reactions, Ullman coupling reactions, Heck reaction | Essential and trace elements | Metalloenzymes containing different metals (Mg, Mo, Fe, Zn, Co, Cu) |

| | | | | | |
|---------------|---|--|--|--|---|
| SLO-3 | Non-carbon ancillary ligands | Vaska's complex, Isolobal analogy | Homo and hetero-geneous catalysts. | Photosystems | Metalloenzymes containing different metals (Mg, Mo, Fe, Zn, Co, Cu) |
| SLO-4 | Practice / Tutorial: 18-e rule related questions | Practice / Tutorial: Various sandwich complexes related | Practice / Tutorial: Related to various catalysis reactions | Practice / Tutorial: Bioelements and biomolecules. | Practice / Tutorial: Metalloenzymes |
| SLO-5 | Synthesis of Carbene complexes | Fluxional properties of organometallics | Hydrogenation, hydroformylation | Porphyrins | Roles of metals in medicines |
| SLO-6 | Reactivity of Carbene complexes | Synthesis, structure, bonding of transitional metal complexes with alkenes | Fischer-Tropsch reaction | Ion (Na ⁺ and K ⁺) transport | Non-heme proteins (hemocyanin & hemerythrin), their coordination geometry, electronic structure |
| SLO-7 | Various examples of carbene complexes | Aromaticity of various cyclic compounds | Ziegler-Natta polymerization | Ion (Na ⁺ and K ⁺) transport | Non-heme proteins (hemocyanin & hemerythrin) |
| SLO-8 | Practice / Tutorial: Carbene complexes | Practice / Tutorial: Aromaticity of various cyclic compounds | Practice / Tutorial: Various catalysts and their usage. | Practice / Tutorial: Na ⁺ and K ⁺ channel | Practice / Tutorial: Non-heme proteins |
| SLO-9 | Transition metal organometallics: square planar complexes | Oxidative addition, Reductive elimination, transmetallation, (β-hydride and alkyl) elimination reactions, migratory insertion reaction | Olefin oxidation, isomerization, Addition of HX to olefins | Oxygen binding | Electron transfer proteins |
| SLO-10 | Synthesis and properties of metal alkyls, alkylidenes | Oxidative addition, Reductive elimination, transmetallation, (β-hydride and alkyl) elimination reactions, migratory insertion reaction | Abstraction, Cyclooligomerisation, ethylene dimerization using RhCl ₃ as catalyst, Asymmetric catalysis | Oxygen transport and utilization | Active site structure and functions of ferredoxin and rubridoxin |
| SLO-11 | Synthesis and properties of metal alkyls, alkylidenes | Metathesis reaction, | Organometallic compounds in medicine, agriculture, horticulture, and other industries | Oxygen binding properties with haemoglobin, myoglobin, electronic structure, co-operativity effect | Cytochromes and their comparisons |
| SLO-12 | Practice / Tutorial: related to metal alkyls, alkylidenes | Practice / Tutorial : Give the topic of the session | Practice / Tutorial: Various catalysis and their usage. | Practice / Tutorial: Oxygen transport and storage phenomenon | Practice / Tutorial: Fe-S proteins structure and their functions |

| Resources | | | |
|-----------|---|-----|---|
| 1 | J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry, 4thEd., Harper Collins, New York, 1993. | 6. | R.D. Madan, Modern Inorganic Chemistry, S.Chand & Company limited, 2017. |
| 2 | R. P. Sarkar, General and Inorganic Chemistry: Volume II, New Central Book Agency (P) Limited, 2009. | 7. | R. L. Dutta, Inorganic Chemistry Part-I and II, The New Book Stall, 1999. |
| 3 | G. O. Spessard and G. L. Miessler, Organometallic Chemistry, Prentice Hall, Upper Saddle River, NJ, 1997. | 8. | I. Bertini, H. B. Gray, S. J. Lippard, and J.S. Valentine, Bioinorganic chemistry, University Science Books, 1994. |
| 4 | C. Eischenbroich, Organometallics: A Concise Introduction Wiley-VCH: Weinheim, 2006. | 9. | E.I.Stiefel, and G. N. George, Ferredoxins, hydrogenases, and nitrogenases: Metal-sulfide proteins. Bioinorganic Chemistry, 1994. |
| 5 | D. Steinborn, Fundamentals of Organometallic Catalysis Wiley-VCH, 2012. | 10. | D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rdEd., W. H. Freeman and Co, London, 1999. |

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|---|--------------------|---------------------|----------------------|---|--------------------------|---|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | | Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | | Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ | | |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - | | Debate | - | | | |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - | | Interactive Lecture | ✓ | | | |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | Brainstorming | ✓ | | | |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - | | | | | | |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | |
|----------------------|---|----------------------------|--|------------------|---|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. Tarak Nath Mandal, Department of Chemistry, SRMIST Email id: taraknam@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25302T | Course Title | Quantum Chemistry and Molecular Spectroscopy | | | | Category | C | Core Course | | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|-------------|--|---|---|---|---|
| | | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|----|----|----|--|--|
| CLR-1 | Emphasize the need of quantum mechanics and apply the required mathematics for solving problems | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Apply the quantum mechanics in solving for the shapes of orbitals | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Address the quantization of energy and the interaction of electromagnetic radiation with matter | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Learn the molecular spectroscopy fundamentals and selection rules of spectroscopy | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Explore the Rotational, Vibrational, Raman and Electronic spectra molecules | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Describe about various theories of hypothesis of matter waves | ✓ | ✓ | ✓ | - | 4 | 75 | 60 | 3 | 3 | 2 | 2 | - | - | - | - | - | - | - | - |
| CLO-2 | Evaluate the quantum mechanical operator, eigen value of wave functions | ✓ | ✓ | ✓ | - | 4 | 80 | 70 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Understand the physical and mathematical aspects of quantum chemistry and atomic structure | ✓ | ✓ | ✓ | ✓ | 4 | 70 | 65 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | - |
| CLO-4 | Identifies the basic elements and selection rules of various spectroscopy | ✓ | ✓ | ✓ | ✓ | 4 | 70 | 70 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Examine the rotational and vibrational, Raman, Electronic and Spin Resonance spectra of molecules | ✓ | ✓ | ✓ | ✓ | 4 | 80 | 70 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|---|--|--|
| | Fundamentals of Quantum Chemistry | Particle in a box and Simple Harmonic Oscillator | Rigid Rotor and H-atom | Absorption and Vibrational Spectroscopy | Rotational and NMR Spectroscopy |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Experimental verification and de Broglie's concept of matter waves | Particle in a one-dimensional box- Derivation of Schrodinger wave equation and Energy | Rigid rotator- Derivation of Schrodinger wave equation and Energy | Time-dependent states and spectroscopy: Absorption and emission of radiation | Electronic spectroscopy: diatomic molecules - The Born-Oppenheimer Approximation |
| SLO-2 | Compton effect | Particle in a one-dimensional box- Quantization of energy of a Particle in a 1D Box and Zero-point energy | Spherical harmonics with various l, m values | Selection rules line shapes and widths | Franck-Condon principle- Intensity of vibrational-electronic spectra The |

| | | | | | |
|---------------|--|---|---|---|--|
| | | | | | Fortrat diagram, Dissociation and pre dissociation |
| SLO-3 | Heisenberg 's uncertainty principle-Illustration | Normalization and orthogonality of wave function of 1D box | Normalization orthogonality of wave Equation of rigid rotator | Rotational spectra of diatomic molecules: Rigid rotor-wave functions and energies | Rotational fine structure of electronic vibration transitions- Formation of P, R, Q branches |
| SLO-4 | Tutorial: Problem solving on De Broglie's concept of matter | Tutorial: Problem solving on particle in a 1D box | Tutorial: Numerical problems based on rigid rotor model | Tutorial: Numerical on rotational spectroscopy | Tutorial: Numerical on electronic spectroscopy |
| SLO-5 | Derivation of Schrodinger wave equation (SWE) | average position and average Momentum of a Particle in a 1D Box | Hydrogen atom- Derivation of Schrodinger wave equation | Rigid rotor- Rotational energy levels, intensity of spectral lines, selection rules, effect of isotopic substitution | Lasers and laser spectroscopy – principle and instrumentation, application |
| SLO-6 | Requirements for acceptable wave functions | Illustration of uncertainty principle and Bohr's Correspondence principle | Separation of variable in polar spherical coordinates and its solution | Vibrational spectra of diatomic molecules: Simple Harmonic Oscillator-wave functions and energies. | XPS-PES - principle and instrumentation, application |
| SLO-7 | Operators- Linear operators& Quantum mechanical operators | Particle in a Three-Dimensional Box- Derivation of Schrodinger wave equation and Energy | Normalization and orthogonality of wave functions of H-atom | Simple Harmonic Oscillator- Selection rules, Allowed vibrational energy levels and transition | the nature of spinning particles and interaction between spin and magnetic field |
| SLO-8 | Tutorial: Problem solving on operators | Tutorial: Problem solving on particle in a 2D and 3D box | Tutorial: Numerical problems on H-atom | Tutorial: Numerical on rotational spectroscopy | Tutorial: Numerical on XPS |
| SLO-9 | Hermicity & evaluation of commutator algebra upon Quantum mechanical operators | The concept of degeneracy of energy levels and problems in 3D box | Principle, azimuthal and magnetic quantum numbers and the magnitude of their values | Vibrational – rotational spectrum of diatomic molecule- Born-Oppenheimer approximation, vibration-rotation spectra, selection rules, Symmetry properties and nuclear spin effects | Larmor precession and population of energy levels. |
| SLO-10 | eigen functions and eigen values | Linear harmonic oscillator-Derivation of Schrodinger wave equation using polynomial method and Energy | Radial distribution and Probability distribution functions | Raman Spectroscopy- Theories of Raman Spectra, Polarization of Raman lines, mutual exclusion principle | Nuclear magnetic resonance spectroscopy: hydrogen nuclei |
| SLO-11 | Postulates of quantum mechanics | Linear harmonic oscillator- Normalization and orthogonality | shape of atomic orbitals (s, p & d) | Raman effect: rotational and vibrational transitions, Vibration of polyatomic molecules, normal co-ordinates | chemical shift and coupling constant-coupling between several nuclei |
| SLO-12 | Tutorial: Eigen value problems | Tutorial: Problem solving on SHO | Tutorial: Numerical on H-atom problem. | Tutorial: Numerical on Raman Spectroscopy | Tutorial: Numerical on NMR spectroscopy |

| Resources | | | |
|-----------|---|---|---|
| 1 | R.K.Prasad, <i>Quantum Chemistry, 4th edition, New Age International, (P) Ltd., Publishers, 2010.</i> | 6 | T. Engel and P. Reid, <i>Quantum Chemistry and Spectroscopy, 3rd Edition, Pearson, 2018.</i> |
| 2 | D. A. McQuarrie, <i>Quantum Chemistry, 2nd Ed., University Science Books, California, 2008.</i> | 7 | Peter Atkins and Ronald Friedman, <i>Molecular Quantum Mechanics, 5th Edition, Oxford</i> |
| 3 | A.K. Chandra, <i>Introductory Quantum Chemistry, 4th edition, Tata McGraw Hill education, 1994.</i> | 8 | C. N. Banwell and E. M. McCash, <i>Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw Hill Education, 2006</i> |
| 4 | Ira. Levine, <i>Quantum Chemistry, 7th Ed., Prentice Hall, 2013</i> | 9 | Gurdeep Raj, <i>Advanced Physical chemistry, 32nd edition, Goel Publishing house, Krishna Prakashan Media (P) Ltd, 2006</i> |

| | | | |
|---|--|----|--|
| 5 | J.E.House, <i>Fundamentals of Quantum Mechanics, Paperback, Academic Press Inc., 3rd Edition, 21 April 2017.</i> | 10 | Walter S. Struve, <i>Fundamentals of Molecular Spectroscopy, John Wiley & Sons, Wiley-Interscience publication, USA, 1989.</i> |
|---|--|----|--|

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------|------------|--|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------------------|--------------|----------------------------|---------------------|----------------------|---|--------------------------|---|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* (10%) | | | | Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| | | | | | | | | | | | | Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| 1 | Remember | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | Debate | - | | | |
| 2 | Understand | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | Interactive Lecture | ✓ | | | |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | Brainstorming | ✓ | | | |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | |
| 5 | Evaluate | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| 6 | Create | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | | | | | | | |
|----------------------|--|--|--|----------------------------|---|--|--|------------------|--|--|--|
| Professional Experts | | | | Higher Institution Experts | | | | Internal Experts | | | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | | | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | | | 1 | Dr. Tumpa Sadhukhan, Department of Chemistry, SRMIST Email id: tumpas@srmist.edu.in | | |
| | | | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | | | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in | | |

| Course Code | PCY25D01T | Course Title | Analytical Chemistry | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|----------------------|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Understand the fundamental concepts of analytical chemistry, data analysis, and separation techniques | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Understand electroanalytical methods of sample analysis | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Learn the theory and applications of spectroscopic techniques | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Understand different thermal analysis methods | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Learn the working principle of X-ray and microscopic techniques | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Apply the analytical chemistry knowledge to investigate the properties of samples | ✓ | ✓ | ✓ | - | 3 | - | - | 3 | - | 3 | - | - | - | 1 | - | - | - | - | - |
| CLO-2 | Understand and interpret the electroanalytical data of different samples | ✓ | ✓ | ✓ | - | 3 | - | - | 3 | - | 3 | - | - | - | 1 | - | - | - | - | - |
| CLO-3 | Implement the suitable spectroscopic method for different sample analysis | ✓ | ✓ | ✓ | ✓ | 4 | - | - | 3 | - | 3 | - | - | - | 2 | - | - | - | - | - |
| CLO-4 | Perform thermo-analytical methods for analyzing different samples | ✓ | ✓ | ✓ | ✓ | 4 | - | - | 3 | - | 2 | - | - | - | 1 | - | - | - | - | - |
| CLO-5 | Demonstrate the working steps of X-ray and microscopic techniques | ✓ | ✓ | ✓ | ✓ | 4 | - | - | 1 | - | 2 | - | 3 | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|---|---|--|
| | Fundamentals of Analytical Chemistry | Electroanalytical Methods | Spectroscopic Techniques | Thermal Analysis - Principle and Instrumentation | X-ray and Microscopic Techniques |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Data Analysis and Separation Techniques: Introduction. Analytical chemistry lab practices and basics of data analyses. | Electroanalytical Methods: Introduction. Electrochemical cells. | Spectrometric Methods: Introduction. Spectrometric methods: classification. | Emission and Thermoanalytical Methods: Introduction. Emission techniques for sample analysis: theory and types. | Microscopic and X-ray Methods: Introduction. Types and sample preparation methods. |

| | | | | | |
|---------------|--|---|--|--|---|
| SLO-2 | Classification of errors: systematic and random. Accuracy and precision calculation. | Potentials in electroanalytical cells and electrode potentials. Calculation of cell potentials with examples. | UV-Vis molecular absorption Spectrometry. Beer's/lambert's Law. | Flame photometry (FP): theory. Instrumentation and a few important applications of FP. | Scanning electron microscope (SEM): theory and instrumentation. SEM: data interpretations. |
| SLO-3 | Significant figures, mean, median, and standard deviation calculations. Comparison of methods: Q-test, F-test, and T-test. Sampling methods. | Potentiometry: principle and methodology. Potentiometric titrations: current-voltage relationships. | Measurement of transmittance and absorbance. Application of UV-vis spectrophotometer. | Plasma emission spectrometry: instrumentation. Applications with examples. | Transmission electron microscope (TEM): theory, instrumentation, bright and dark field analyses. |
| SLO-4 | Tutorial: Errors calculations | Tutorial: Potentiometry | Tutorial: Spectrometric methods | Tutorial: Emission and Thermal Analytical Methods | Tutorial: SEM and TEM |
| SLO-5 | Chromatography: classification. The concept of plate and rate theories, efficiency, resolution, selectivity, and separation capability. | pH meter: working principle. pH meter calibration procedure and application. | Infrared spectrometry (IR): basics, Theory, and instrumentation of IR spectrophotometer. | Thermogravimetric Methods analysis (TGA): theory and Instrumentation. | Selective area electron diffraction (SAED) analysis and EDS analyses. Electron energy loss spectroscopic analysis (EELS). |
| SLO-6 | Thin-layer chromatography (TLC): Principle. Methodology and Application. | Conductometry: principle. Acid-base titrations. | Infrared sources and transducers in IR spectrophotometers. Infrared absorption and transmittance analyses. | Functional features of TGA and applications. | Atomic force microscopy (AFM): basic principle and instrumentation. |
| SLO-7 | Paper chromatography (PC): theory, procedure, and applications. | Redox titrations: theory. Formal and standard potential in various media. | Raman spectroscopy: theory, instrumentation, and applications of Raman spectrophotometer. | Differential Thermal Analysis (DTA): theory and working principle. | AFM: analysis procedure, data interpretation, and application |
| SLO-8 | Tutorial: TLC | Tutorial: Redox titrations. | Tutorial: IR and Raman Spectroscopy | Tutorial: TGA | Tutorial: AFM |
| SLO-9 | Gas chromatography (GC): Introduction and Instrumentation. | Theories and choice of indicators. pH-indicators. | Mass spectrometry: Applications of Mass spectrometer. | DTA: Instrumentation and applications. | X-ray photoelectron spectroscopy (XPS): principle and instrumentation. |
| SLO-10 | Features of a chromatographic column, gas chromatograph detector (GCD). GC: analysis and applications. | Cyclic Voltammetry (CV): principle and instrumentation. | Nuclear Magnetic Resonance (NMR) spectroscopy: Theory and NMR Instrumentations. | Differential Scanning Calorimetry (DSC): Principles and applications. | XPS: depth profile analysis and Deconvolution of XPS peaks. |
| SLO-11 | High-pressure liquid chromatography (HPLC). sample analysis and product identification. | Linear sweep voltammetry (LSV) techniques. Differential pulse voltammetry (DPV) technique. | Chemical shift and environmental effects, coupling and splitting pattern | Functional features of DSC and applications. | X-ray absorption spectroscopy (XAS): Introduction and Synchrotron-XAS applications. |
| SLO-12 | Tutorial: GC and HPLC | Tutorial: CV and LSV | Tutorial: NMR | Tutorial: DSC, DTA | Tutorial: XAS |

| Resources | |
|-----------|--|
| 1 | <i>D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, Fundamentals of Analytical Chemistry, 9th Ed., Brooks Cole, 2013.</i> |
| 2 | <i>D. A. Skoog, F. J. Holler and S. R. Crouch, Principles of Instrumental Analysis, Thomson Learning, 2007.</i> |
| 3 | <i>H. H. Willard, L. Jr. Merritt, J. A. Dean and F. A. Settle, Instrumental Methods of Analysis, 7th Ed., CBS Publishers, 2007.</i> |
| 4 | <i>Donald L Pavia, Gary M. Lampman, George S. Kriz: Introduction to spectroscopy, 5th edition. Cengage Learning Publishers, 2003.</i> |

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|---|----------------------------|---------------------|----------------------|---|--------------------------|---|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | | Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | | Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | | | Learning Management System | - | Hands-on Practice | - | Gender Equality | - |
| 1 | Remember | 20 | - | 20 | - | 20 | - | 20 | - | 20 | - | | Debate | - | | | |
| 2 | Understand | 20 | - | 20 | - | 20 | - | 20 | - | 20 | - | | Interactive Lecture | ✓ | | | |
| 3 | Apply | 40 | - | 40 | - | 40 | - | 40 | - | 40 | - | | Brainstorming | ✓ | | | |
| 4 | Analyze | 20 | - | 20 | - | 20 | - | 20 | - | 20 | - | | | | | | |
| 5 | Evaluate | - | - | - | - | - | - | - | - | - | - | | | | | | |
| 6 | Create | - | - | - | - | - | - | - | - | - | - | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|---|---|--|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. N. Clament Sagaya Selvam, Department of Chemistry, SRMIST Email id: clamentn@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25D02T | Course Title | Materials Chemistry | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|---------------------|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|--|--|
| CLR-1 | Introduce the science of materials chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Deepen the knowledge of crystalline materials with a focus on their synthesis methods | | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Improve the understanding of amorphous, electronic materials and their applications | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Understand the fundamentals of nanomaterials and their applications | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Gain knowledge about mechanical, magnetic, and electrical properties of materials along with their technological relevance and enlighten with basic principles of various analytical techniques for the characterization of materials | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLO-1 | Understand different types of materials, their properties, characterization and applications | ✓ | ✓ | ✓ | - | 2 | 75 | 60 | 3 | - | 3 | - | - | - | 3 | 3 | 3 | - | - | 3 | | |
| CLO-2 | Well aware of various chemical, and physical methods of crystalline materials synthesis | ✓ | ✓ | ✓ | - | 2 | 80 | 70 | 3 | - | 3 | - | - | 2 | - | 3 | 3 | - | - | 3 | | |
| CLO-3 | Gain knowledge about amorphous materials, polymer materials and band theory of solids | ✓ | ✓ | ✓ | ✓ | 2 | 65 | 65 | 3 | - | 2 | - | - | - | 3 | 3 | 3 | - | - | 3 | | |
| CLO-4 | Acquaint with the fundamental concepts of nanomaterials and their importance | ✓ | ✓ | ✓ | ✓ | 2 | 80 | 70 | 3 | - | 2 | - | - | - | 3 | 3 | 3 | - | - | 3 | | |
| CLO-5 | Familiar with the mechanical, magnetic, and electrical properties of the materials and their technological relevance Identify suitable analytical techniques and perform the characterization of materials | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | 3 | - | 2 | - | 3 | - | - | 3 | 3 | - | - | 3 | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---------------------------------------|---|---|--|---|
| | Introduction to Crystalline Materials | Classification of Solids | Chemistry of Nanomaterials | Functional Properties of Solids | Characterization of Solids |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Crystalline materials: Introduction | Amorphous solids: Introduction, a comparison of crystalline and amorphous materials in terms of properties and applications | Nanomaterials: Introduction, examples of a variety of nanomaterials | Mechanical properties: Introduction, various mechanical properties, and their importance | Spectroscopic methods: Introduction |
| SLO-2 | Fundamentals of lattice and unit cell | Oxide and Chalcogenide glasses | Quantum confinement and quantum nanostructures | Ductile and Brittle fracture | UV-Vis: Instrumentation, basic working principles, and examples in analysis |

| | | | | | |
|------------------|--|--|---|--|---|
| SLO-3 | Atomic coordinates and Bravais lattices | Amorphous carbon, diamond, graphite, alkaline graphite | Surface energy and Surface area of nanomaterials | Toughness and Impact testing | IR: Instrumentation, basic working principles, and examples in analysis |
| SLO-4 | Tutorial: Crystalline materials | Tutorial: Amorphous carbon | Tutorial: Nanomaterials | Tutorial: Impact testing | Tutorial : UV-Vis and IR |
| SLO-5 | Point defects, Line defects: line | Polymer compounds: Introduction, examples and applications | Fabrication methods of nanomaterials: Top-down and Bottom-up approaches | Magnetic properties of materials: Introduction, para magnetic properties | X-ray diffraction: Instrumentation, basic working principle, and examples in analysis |
| SLO-6 | Surface defects and bulk defects | Band theory of solids | Classification of nanomaterials: 0D, 1D, and 2D. 0D nanomaterials examples and applications | Ferromagnetic and anti-ferromagnetic properties | Electron microscopy: SEM, instrumentation, basic working principles, and examples in analysis |
| SLO-7 | Synthetic approaches for crystalline functional materials: Chemical methods | Insulators and Semi-Conductors | 1D and 2D nanomaterials examples and applications | Ferri magnetic properties. Technological relevance of magnetic properties of materials with a few examples | Electron microscopy: TEM, instrumentation, basic working principles and examples in analysis |
| SLO-8 | Tutorial: Types of Defects | Tutorial: Polymer compounds | Tutorial: Synthesis of nanomaterials | Tutorial: Ferromagnetic and Ferri magnetic materials | Tutorial : XRD, SEM and TEM |
| SLO-9 | Synthetic approaches for crystalline functional materials: Chemical methods with applications | Superconductivity and optical properties of materials | Porous and Soft materials | Thermoelectric properties: Introduction and dielectric properties | XPS: Instrumentation, basic working principles, and examples in analysis |
| SLO-10 | Synthetic approaches for crystalline functional materials: Physical methods | Band gap of materials and its correlation with optical properties. Concept of doping and different types of dopant materials | Amorphous and Luminescent materials | Piezoelectric properties and pyroelectric properties | Probe analysis, AFM: Instrumentation, basic working principles, and examples in analysis |
| SLO-11 | Synthetic approaches for crystalline functional materials: Physical methods with applications | Effect of doping on optical properties of materials and devices based on optical properties of materials | Discussion on a few examples of technologies developed using nanomaterials | ferroelectric effect and technological relevance of electrical properties of material with a few examples | Peculiar examples of materials characterization |
| SLO-12 | Tutorial: Physical methods and Chemical methods for synthetic approaches for crystalline functional materials | Tutorial: Doping and types of dopant materials | Tutorial: Porous and Soft materials | Tutorial: Thermoelectric properties | Tutorial: XPS and AFM |
| Resources | | | | | |
| 1 | A.R. West, <i>Basic Solid State Chemistry</i> , 2 nd Ed., John Wiley & Sons Ltd., 1999. | | | | |
| 2 | K.J. Klabunde, <i>Nanoscale Materials in Chemistry</i> , Wiley Interscience, New York, 2001. | | | | |
| 3 | C. Giacovazzo, <i>Fundamentals of Crystallography</i> , Oxford University Press, 2002. | | | | |
| 4 | W.D. Callister and D.G. Rethwisch, <i>Materials Science and Engineering: An Introduction</i> , 9 th Ed., Wiley, 2013. | | | | |
| 5 | D.J. Ward, <i>Materials Science</i> , Lerner Classroom, 2008. | | | | |

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|------------|--|----------------------|--|-------------------------|--|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | | | | | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | | | | | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | | | | | | |
| 1 | Remember | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | | | | | |
| 2 | Understand | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | | | | | |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | |
| 5 | Evaluate | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| 6 | Create | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | |
|----------------------|---|----------------------------|--|------------------|---|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. N. Clament Sagaya Selvam, Department of Chemistry, SRMIST Email id: clamentn@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25D03T | Course Title | Advanced Polymer Science | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|--------------------------|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|--|------------------------|---------------|------------------------------|--------------------|--|--|
| CLR-1 | Gain knowledge about advanced polymer systems, their structure-property relationships and applications. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Understand the concept of liquid crystallinity and the properties of different types of LCPs. | | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Gain knowledge on the synthesis, properties and applications of ionic polymers. | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Acquire skills on the synthesis of conducting polymers and understand the significance and applications of conducting polymers. | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Enrich the knowledge on biopolymers/biodegradable polymers, basic concepts of stimuli responsive polymers and their multi-applications. | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices&SocialResponsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLO-1 | Gain knowledge on advanced polymer science and different polymer systems. | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | - | 3 | - | - | - | 3 | - | - | - | - | - | | |
| CLO-2 | Learn about main-chain and side chain LCPs and their properties. | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | 3 | - | - | - | - | - | 2 | - | - | - | | |
| CLO-3 | Gain knowledge on ionic polymers for the preparation of ion exchange materials. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 3 | - | - | - | 3 | - | - | - | - | - | | |
| CLO-4 | Understand the structural and electronic properties of conducting polymers. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | 3 | - | 3 | - | - | - | - | - | - | - | - | 3 | | |
| CLO-5 | Design stimuli responsive polymer systems based on the skills and knowledge acquired. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | 3 | - | - | - | 2 | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|--|---|--|---|--|
| | Liquid crystalline polymers | Ionomers and ion exchange materials | Conducting polymers | Biopolymers and biodegradable polymers | Stimuli responsive polymers |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Introduction to LCPs, and structural requirements to exhibit liquid crystallinity. | Synthesis of ionic polymers. Properties and applications of ionic polymers. | Synthesis and properties of conducting polymers. | Introduction to biopolymers and biodegradable polymers. | Introduction and classification of smart polymers. |
| SLO-2 | Main-chain LCPs: thermotropic and lyotropic liquid crystals. | Ionic crosslinking and ion exchange process. | Polyacetylene | Polymers in medicines and drug delivery. | Temperature and pH responsive polymers. |

| | | | | | |
|---------------|---|--|---|---|---|
| SLO-3 | Synthesis of LC main-chain polymers. | Ionomers based on polyethylene. | Poly (p-phenylene vinylene) (PPV) | Biodegradable polymers: starch-based polymers, poly(glycolic acid) (PGA) and polylactic acid (PLA). | Photo responsive and redox-responsive polymers. |
| SLO-4 | Tutorial: Properties of Main-chain LCPs. | Tutorial: Properties and application of Ionomers based on polyethylene. | Tutorial: Discuss why polyacetylene is a conducting polymer and the applications of polyacetylene and PPV. | Tutorial: Discuss the importance of biodegradable polymers compare to conventional plastics and the mechanism of biodegradation. | Tutorial: Application of temperature, pH, photo- and redox responsive polymers. |
| SLO-5 | Structural features of side-chain LC polymers. | Ionomers based on polystyrene Ionomers based on polytetrafluoroethylene. | Polyheterocyclic and polyaromatic conducting polymers: | Poly(lactic-co-glycolide) (PLGA), and polycaprolactone (PCL). | Magnetic field responsive polymers. Shape memory polymers. |
| SLO-6 | Properties and applications of side-chain LC polymers. | Elastomeric ionomers and aromatic ionomers. | Polyaniline, polypyrrole and polythiophene. | Applications of pharmaceutical polymers: vinyl polymers, cellulose ethers and polyesters. | Smart polymer hydrogels. |
| SLO-7 | Nematic and cholesteric LCPs. | Polymers with integral ions Halatotelechelic polymers (HTP's) | Poly(3,4-ethylenedioxythiophene) (PEDOT). | Silicones, polysaccharides and related polymers. | Self-healing polymers and their applications. |
| SLO-8 | Tutorial: Difference between cholesteric, nematic and smectic phases and their applications | Tutorial: Comparison of properties of PS, PTFE, elastomeric ionomers, and aromatic ionomers. | Tutorial: Comparison of properties of polyaniline, polypyrrole, and polythiophene. Application of polyaniline, polypyrrole, polythiophene, and PEDOT. | Tutorial: Revise the preparation, properties and applications of PLGA, PCL, and pharmaceutical polymers. | Tutorial: Application of magnetic field responsive polymers, shape memory polymers and smart polymer hydrogels. |
| SLO-9 | Different types of LCPs: Photochromic LCPs, chiral-photochromic LCPs, ionogenic LCPs. | Polyethyleneimine (PEI) and ion exchange materials. | Poly(p-phenylene sulfide), Poly(vinyl carbazole). Polypyrene and polyphenylene. | An overview of polymer nanomaterials – nanoparticles, nanostructures & nanocomposites. Synthesis, processing, and characterization of polymer nanocomposites. | Bioseparation, Biomedical applications of smart polymers – drug delivery, tissue engineering, medical devices, etc. |
| SLO-10 | LC elastomers. Photomechanical LC polymers. | Polyelectrolytic complexes Biological ionic polymers. | Applications of conducting polymers: polymer rechargeable batteries. | Polymer nanocomposites for high-temperature applications. | Optoelectronics applications of smart polymers. |
| SLO-11 | LC block copolymers and LC composites. | Inorganic ionic polymers. | Sensors – electrochemical actuators and electroluminescence | Current status, trends, and future Applications of polymer nanocomposites. | Recent advances and future perspectives of smart polymers. |
| SLO-12 | Tutorial: Modern tools to evaluate the properties of LC polymers. | Tutorial: Estimate the degree of crosslinking in ionic polymers. | Tutorial: Methods to coat conducting polymer thin films on substrates. | Tutorial: Assess the degree of biodegradability of biopolymers. | Tutorial: Estimate the surface functionality of stimuli-responsive polymers. |

| Resources | |
|-----------|--|
| 1 | X. Wang, Q. Zhou, <i>Liquid Crystalline Polymers</i> . N.J World Scientific: Singapore, 2004. |
| 2 | B.N. Hendy, <i>Ionic polymers</i> . In: Dyson R.W. (eds) <i>Specialty Polymers</i> . Springer, Boston, MA 1987. |
| 3 | Matrin. T. Goosey, <i>Plastics for Electronics</i> , Elsevier Applied Science Publishers, 1985. |
| 4 | M.J. Bowden and S.R. Turner, <i>Polymers for High Technology, Electronics and Photonics</i> , American Chemical Society 1987. |
| 5 | T.A. Skotheim, J. Reynolds, <i>Conjugated Polymers: Theory, Synthesis, Properties, and Characterization</i> , 3rd Edition, CRC Press, 2006. |
| 6 | David Jones, <i>Pharmaceutical Applications of Polymers for Drug Delivery</i> , iSmithers Rapra Publishing, 2004. |
| 7. | A. Steinbüchel, <i>Biopolymers</i> , Institute of Microbiology, University of Münster, WILEY-VCH, 2004. |
| 8. | J. H. Koo, <i>Polymer Nanocomposites, Processing, Characterization, and Applications</i> , 2nd Edn., Mc Graw Hill, 2019. |
| 9. | Marek W. Urban, <i>Handbook of Stimuli-Responsive Materials</i> , John Wiley and Sons, Inc 2011 |
| 10. | A. A. Zagorodni, <i>Ion Exchange Materials: Properties and Applications</i> , Elsevier, 2006/ |
| 11. | J. R. Reynolds, B. C. Thompson, T. A. Skotheim, <i>Handbook of Conducting Polymers</i> , 4th Edition - 2 Volume Set, Taylor and Francis Group, 2019. |
| 12. | S. Ahmed, R. A.M. Osmani, <i>Handbook of Biodegradable Polymers Applications in Biomedical Sciences, Industry, and the Environment</i> , Taylor and Francis Group, 2025. |

| Assessment | | | | | | | | | | | | Strategies | | | | | |
|---------------------------|------------|--|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------------------|--------------|----------------------------|---------------------|----------------------|---|--------------------------|---|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | | Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* (10%) | | | | Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| | | | | | | | | | | | | | | | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| 1 | Remember | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | Debate | - | | | |
| 2 | Understand | 15 | - | 15 | - | 15 | - | 15 | - | 15 | - | | Interactive Lecture | ✓ | | | |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | Brainstorming | ✓ | | | |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - | | | | | | |
| 5 | Evaluate | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| 6 | Create | 15 | - | 10 | - | 10 | - | 10 | - | 10 | - | | | | | | |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|---|---|---|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. Samarendra Maji, SRMIST and Dr. Arun Prakash P, Department of Chemistry, SRMIST Email id: arunprap1@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | POC25301T | Course Title | Modern Synthetic Reagents and Rearrangements | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|--|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | enable them to learn about different types of Organic reagents and methods used in modern organic synthesis. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Develop the skills in designing synthetic strategies for various targets. | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | explore the use of several important reagents and their implication in the modern organic transformations. | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | get a significant exposure in research and development for future development. | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Develop capabilities as an organic chemist in pharmaceutical industries. | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Gain knowledge about various molecular rearrangement reactions. | ✓ | ✓ | ✓ | - | 2 | 70 | 65 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - |
| CLO-2 | Acquaint students with the use of protecting groups in organic synthesis. | ✓ | ✓ | ✓ | - | 2 | 80 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Gain knowledge about various important reagents and methods in organic Synthesis. | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 65 | - | 3 | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-4 | Understand the principles of asymmetric synthesis. | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | - | 3 | - | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Gain knowledge about the in multistep organic synthesis. | ✓ | ✓ | ✓ | ✓ | 2 | 80 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|--|--|--|---|
| | Functional group transformations and organic reactions | Coupling reactions in organic synthesis | Introduction to Protecting group in organic synthesis | Rearrangement in organic synthesis | Asymmetric transformations in organic synthesis |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Functional group transformations using various oxidizing reagents (PCC, PDC, PFC, CTAP, RuO ₄ , KBrO ₃) | Role of Palladium and Nickel catalyst in organic reactions | Introduction to Protecting group in organic synthesis, Qualities of a Good Protecting Group in Organic Synthesis | Wagner-Meerwein Rearrangement, Nametkin Rearrangement | Principles of asymmetric synthesis, Introduction, the chiral pool in Nature |
| SLO-2 | Functional group transformations using Reducing reagents (NaCNBH ₃ , Bu ₃ SnH, Et ₃ SiH and Hydrazine) | Heck, Negishi reaction, Suzuki- Miyaura, Kumada, Buchwald-Hartwig coupling for the carbon-heteroatom bond formation reaction | Qualities of a Good Protecting Group in Organic Synthesis, Protecting groups for N. | Pinacol Pinacolone Rearrangement and retropinacol, Benzil-Benzilic acid rearrangements | Methods of asymmetric induction, Substrate controlled reactions |

| | | | | | |
|---------------|--|---|--|---|---|
| SLO-3 | Functional group transformations using the reagents SOCl ₂ , PBr ₃ , PPh ₃ -CCl ₄ , LiBr, NaI, NBS, PPh ₃ -X ₂ | Organocatalysis: Lewis base catalysis, iminium catalysis, enamine catalysis, Lewis acid catalysis, Brønsted acid and base catalysis. Carbenes as organocatalysts, | Protecting groups for O, Protecting groups for Sulphur like alcohol | Rearrangement involving diazomethane | Reagent and catalyst controlled reactions, Synthesis of L-DOPA [Knowles's Monsanto process] |
| SLO-4 | Tutorial : oxidizing and reducing reagents | Tutorial : Organocatalysis | Tutorial : Give the topic of the session | Tutorial : Pinacol Pinacolone Rearrangement and retropinacol, Benzil-Benzilic acid rearrangements | Tutorial : Reagent and catalyst controlled reactions |
| SLO-5 | Lawesson's reagent, Mitsunobu reagent, Use of CH ₂ N ₂ , TMSCHN ₂ , | Different NHCs and their synthesis, NHC catalyzed umpolung, NHC catalyzed transesterification reactions | Use of TMSI, TBAF, TBDMS, BnBr, DHP, CbzCl | Baker-Venkataraman rearrangement, Bamberger rearrangement, Carroll rearrangement, Chapman Rearrangement | Asymmetric reactions with mechanism: Aldol and related reactions, Cram's rule, Felkin-Anh model |
| SLO-6 | Barbier-Weiland degradation, Conversion of aldehyde to ketone and vice versa | Homo and cross benzoin type reactions, Stetter reaction | Use of Boc. anhydride, Fmoc-Cl, acetals as protecting | Overman Rearrangement | Sharpless enantioselective epoxidation and Sharpless enantioselective hydroxylation |
| SLO-7 | Conversion of aldehyde to cyanide, Conversion of cyanide to ester | Enolate chemistry, homo enolate derived reactions, Addition to ketenes and analogues | Protection of carbonyl groups in aldehydes and ketones | Gabriel-Colman rearrangement | Amino-hydroxylation |
| SLO-8 | Tutorial : Lawesson's reagent, Mitsunobu reagent | Tutorial : Enolate chemistry | Tutorial : Give the topic of the session | Tutorial : Baker-Venkataraman rearrangement, Bamberger rearrangement | Tutorial : Sharpless enantioselective synthesis |
| SLO-9 | Conversion of ketone/aldehyde to phenol, Conversion of ketone to enone | Oxidative NHC catalysis | Protection of the carboxyl group, Protection of double and triple bonds. | Stevens rearrangement | Diels-Alder reaction, Use of chiral auxiliaries in diastereoselective reductions, |
| SLO-10 | Synthetic utility of Samarium iodide in organic synthesis, Synthetic utility of Samarium Ruthenium in organic synthesis (Ring closure reaction | Cooperative catalysis with metal catalysts | Applications of the protection and deprotection of the hydroxyl, carbonyl functional group in organic synthesis | Sommelet rearrangement | Use of chiral BINOLs, BINAPs and chiral oxazolines |
| SLO-11 | Continued (Metathesis-RCM) , Synthetic utility of Samarium Cobalt in organic, synthesis (Pauson-Khand reaction and Nicholas reaction). | Cooperative catalysis with other organo catalysts | Applications of the protection and deprotection of the amino and carboxyl functional groups in organic synthesis | Wittig rearrangements | Asymmetric transformations |
| SLO-12 | Tutorial : RCM and Synthetic utility of Samarium iodide in organic synthesis | Tutorial : Cooperative catalysis with metal catalysts | Tutorial : Give the topic of the session | Tutorial : Stevens and Sommelet rearrangement | Tutorial : Asymmetric transformations |

| Resources | |
|-----------|--|
| 1 | J. Clayden, N. Greeves, S. Warren and P. Wothers, <i>Organic Chemistry</i> , 1st Ed., Oxford University Press, 2001. |
| 5 | Peter Sykes, <i>A Guide book to Mechanism in Organic Chemistry</i> , 6th Ed., Orient Longman Ltd., New Delhi, 1997. |

| | | | |
|---|---|---|--|
| 2 | M.B. Smith & J. March, <i>March's Advanced Organic Chemistry, 5th Ed.</i> , John Wiley & Sons, New York, 2001. | 6 | <i>Modern Methods of Organic Synthesis, Fourth edition by William Carruthers and Iain Coldham.</i> |
| 3 | F.A. Carey and R.A. Sundberg, <i>Advanced Organic Chemistry, Part A and Part B, 5th Ed.</i> , Kluwer Academic/Plenum Publishers, New York, 2004 | 7 | T.H. Lowry and K.S. Richardson, <i>Mechanism and Theory in Organic Chemistry, 3rd Ed.</i> , Addison-Wesley |
| 4 | P. G. M. Wuts, <i>Greene's Protective Groups in Organic Synthesis, 5th Ed.</i> , Wiley, 2014. | | |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|-------------------|--------------|-------------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* | | | |
| | | | | | | | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

| Strategies | | | | |
|----------------------------|---|----------------------|---|----------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality ✓ |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|----------------------|---|---|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in |
| | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | Dr. Priyadip Das, Department of Chemistry, SRMIST, Email: priyadip@srmist.edu.in |
| | | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25D05T | Course Name | Supramolecular Chemistry and Crystal Engineering | | | | Course Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|-------------|--|--|--|--|-----------------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Enable them to learn the underlying principles of supramolecular chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Strengthen the knowledge of the students in supramolecular chemistry | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Explore noncovalent interactions to form supramolecular assembly. | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Get a significant exposure in emerging field crystal engineering | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Express their capabilities to find applications in molecular devices including smart actuators and molecular switches | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical Practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand the basic principles of supramolecular chemistry | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | - | 2 | - | - | 3 | - | - | - | - | - |
| CLO-2 | Acquaint students with the fundamental concepts of Molecular recognitions in supramolecular chemistry | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | - | 3 | - | - | - | - | - | - | - | 2 |
| CLO-3 | Gain knowledge about various noncovalent interactions to form supramolecular assemblies | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 3 | - | - | 3 | - | - | - | - | - |
| CLO-4 | Understand the concept of crystal engineering | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | - | 2 | - | - | - | - | - | - | - | 3 |
| CLO-5 | Gain knowledge about the Host-guest chemistry | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | - | 3 | - | - | - | - | - | - | - | - |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|--|--|---|--|
| | Introduction to supramolecular chemistry | Design and synthesis of receptors | Crystal engineering | Supramolecular self-assembly | Applications of supramolecular systems |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Definition of supramolecular chemistry Various examples of supramolecular assemblies | Basic understanding of Host-guest chemistry, Synthetic strategies of macrocycles and cages | Basic understanding of crystal engineering | Self-assembly by covalent bonding: Design, synthesis and applications | Molecular electronic devices |

| | | | | | |
|---------------|---|---|--|---|---|
| SLO-2 | Terminology and nomenclature in supramolecular chemistry | Design and synthesis of cation receptors: crown ethers, lariat ethers, podands, cryptands | Role of H-bonding, halogen bonding and other weak interactions | Self-assembly by covalent bonding: Design, synthesis and applications | Molecular wires and rectifiers |
| SLO-3 | Chemical interactions leading to supramolecular assemblies | lariat ethers, podands, cryptands, Spherands, calixarenes, | Co-crystals, salts, polymorphs and their physico-chemical properties | Self-assembling by H-bonding, Design, synthesis and applications | Molecular switches and logic gates |
| SLO-4 | Tutorial Session, Question answer session | Tutorial Session, Question answer session | Tutorial Session, Question answer session | Tutorial Session, Question answer session | Tutorial Session, Question answer session |
| SLO-5 | Nature of binding interactions in supramolecular structures, Ion-ion, ion-dipole interactions | Cyclodextrins, cyclophanes, cryptophanes | Design of molecular crystals towards achieving targeted applications | metallomacrocycles | Relevance of supramolecular chemistry to mimic biological systems |
| SLO-6 | Ion-ion, ion-dipole interactions, Dipole-dipole, H-bonding | carcerands, and hemicarcerands | Mechanical properties of molecular crystals | catenanes | cyclodextrins as enzyme mimics |
| SLO-7 | cation-pi, anion-pi interactions | Host-guest interactions, pre-organization and complementarity | Binary and Ternary cocrystals | rotaxanes | ion channel mimics |
| SLO-8 | Tutorial Session, Question answer Session | Tutorial Session, Question answer Session | Tutorial Session, Question answer Session | Tutorial Session, Question answer Session | Tutorial Session, Question answer Session |
| SLO-9 | pi-pi and Van der Waals interactions | Lock and key analogy, Design and synthesis of anion receptors | Various applications of crystal engineering | helicates and knots | supramolecular catalysis |
| SLO-10 | Halogen bonding, definition, and examples, Solvation effect, Hoffmeister effect | Design and synthesis of anion receptors | Coordination polymers | Examples of recent developments in supramolecular chemistry. | supramolecular catalysis |
| SLO-11 | Supramolecular assemblies for various applications | Design and synthesis of neutral molecule receptors | Metal organic frameworks | Examples of recent developments in supramolecular chemistry. | Question answer Session |
| SLO-12 | Tutorial Session, Question answer session | Tutorial Session, Question answer session | Tutorial Session, Question answer session | Tutorial Session, Question answer session | Tutorial Session, Question answer session |

| Resources | | |
|-----------|---|---|
| 1 | <i>J.M. Lehn, Supramolecular Chemistry-Concepts and Perspectives, Wiley-VCH, 1995.</i> | 6 <i>G. R. Desiraju, J. J. Vittal and A. Ramanan, Crystal Engineering: A Textbook, World Scientific, 2011.</i> |
| 2 | <i>P. D. Beer, P. A. Gale and D. K. Smith, Supramolecular Chemistry, Oxford University Press, 1999.</i> | 7 <i>T. W. G. Solomons and C. B. Fryhle, Organic Chemistry 10th Ed., John Wiley and Sons, Inc 2011</i> |
| 3 | <i>J. W. Steed and J. L. Atwood, Supramolecular Chemistry, 1st Ed., Wiley, 2000.</i> | 8 <i>D. N. Nasipuri, Stereochemistry of Organic Compounds: Principles & Applications, 3rd edition, South Asia Books 2012</i> |
| 4 | <i>J. W. Steed, Core Concepts in Supramolecular Chemistry and Nanochemistry, 1st Ed., John Wiley & Sons, 2007.</i> | 9 <i>B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Practical Organic Chemistry, 5th Ed., Pearson, 2012</i> |
| 5 | <i>J.D. Seader, I. W. Hamley, Introduction to soft mater Synthetic and Biological self-assembly materials, Separation process principles, 2nd Ed., Wiley, 2010.</i> | 10 <i>V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press 2000.</i> |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|------------|--------------|------------|--------------|------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | | |
| | | (10 %) | | (10 %) | | (20 %) | | (10%) | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 2 | Understand | 15 | - | 15 | - | 10 | - | 10 | - | 15 | - |
| 3 | Apply | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 4 | Analyze | 20 | - | 25 | - | 25 | - | 25 | - | 25 | - |
| 5 | Evaluate | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| 6 | Create | 15 | - | 10 | - | 15 | - | 15 | - | 10 | - |
| Total (%) | | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - |

| Strategies | | | | |
|----------------------------|---|----------------------|---|--------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|--|---|---|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. Jayanta Samanta, SRMIST Email: jayantas@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25D06T | Course Title | Advanced Electrochemistry | | | | Category | D | Discipline Elective Course | L | T | P | C |
|-------------|-----------|--------------|---------------------------|--|--|--|----------|---|----------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|--|------------------------|---------------|------------------------------|--------------------|---|---|
| CLR-1 | Understand the theories and concepts of electrode-electrolyte interface | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Learn about the electrode kinetics in the electrochemical systems | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Respons abilities | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLR-3 | Understand the various electrochemical techniques | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Gain knowledge about energy conversion and storage systems | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Applications of photoelectroncatalysis, electrochemical sensors, and biofuel cells | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | ✓ | | | | | | | | | | | | | | | | | | | ✓ | ✓ |
| CLO-1 | Explain the fundamental concepts of electrochemistry and the structure of the electrical double-layer | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 | | |
| CLO-2 | Explain the kinetic equations used in the electrochemical systems | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 | | |
| CLO-3 | Explain the principle, operation, and data interpretation of the electrochemical techniques | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 | | |
| CLO-4 | Apply the knowledge to develop the electrolyzers, fuel cells, and future energy devices | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | | |
| CLO-5 | Explore new horizons of electrochemical processes in the photoelectrocatalysis, sensors, and bioelectrodics | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|-------------------------------------|---|---|--|--|
| | Basic Electrochemistry Concepts | Electrode Kinetics | Electrochemical techniques | Energy conversion and Storage | Photoelectroncatalysis, Electrochemical Sensors, and Biofuel cells |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | Electrochemical cells and reactions | Overpotential, Activation overpotential & Concentration overpotential | Voltammetry (Cyclic, linear sweep, differential pulse, and square wave) | Electrochemical water splitting – Oxygen Evolution Reaction (OER), Key steps involved in the mechanism | Photoelectrochemistry – introduction and working principle |

| | | | | | |
|---------------|---|---|---|--|--|
| SLO-2 | Ideally polarizable and non-polarizable electrodes | Butler-Volmer equation derivation and approximations | Reversible, irreversible, and quasi-reversible reactions, Adsorption phenomena at the electrode | Electrochemical water splitting – Hydrogen Evolution Reaction (OER), key steps involved in the mechanism | Photoelectrochemical water splitting |
| SLO-3 | Reference electrodes | Butler-Volmer equation derivation and approximations | Rotating electrodes (RDE, RRDE) | Oxygen Reduction Reaction (ORR), key steps involved in the mechanism | Photoelectrochemical reduction of CO ₂ to a value-added product |
| SLO-4 | Tutorial: Fundamentals of electrode reactions | Tutorial: Kinetics of electrode reactions | Tutorial: Electroanalytical methods | Tutorial: Electrochemical energy conversion reactions | Tutorial: Photoelectrocatalysis |
| SLO-5 | Electrical double-layer structure | Exchange current density, Symmetry factor | Voltammetry - microelectrodes | Fuel cells and Electrolyzers | Electrochemical sensors, Types of electrochemical sensors |
| SLO 6 | Helmholtz –Perrin model of Electrical double layer | Tafel equation, Nernst equation | Amperometry, Chrono-amperometry, Potentiometry Chrono-potentiometry | Supercapacitor, Classification of supercapacitors | Chemically modified electrodes for healthcare and environmental monitoring |
| SLO-7 | Guoy-Chappman and stern model of Electrical double-layer | Butler-Volmer equation for a multi-step reaction | Spectroelectrochemistry | Metal-ion supercapacitor, Flexible and wearable supercapacitors | Bioelectrochemistry, introduction, membrane potential |
| SLO-8 | Tutorial: Theories related to electrode-electrolyte interface | Tutorial: Electrochemical kinetic equations and derivations | Tutorial: Time-dependent electroanalytical methods | Tutorial: Electrochemical energy conversion and storage devices. | Tutorial: Sensors and modified electrodes. |
| SLO-9 | Mode of mass transport (migration, diffusion, and convection) | Cottrell equation | Electrochemical Impedance spectroscopy | Metal-ion battery (e.g. Li, Na, etc.) Metal-Sulfur battery | Interfacial electron transfer process in biological systems |
| SLO-10 | The role of supporting electrolytes | Problems related to Butler-Volmer | Scanning Electrochemical microscopy (SECM) | Metal-air battery and Solid-state battery | Introduction to Biofuel cells |
| SLO-11 | Ohmic and non-ohmic behavior in electrochemistry | Problems related to Tafel, Nernst, and Cottrell equations. | Substrate generation (SG)-tip collection modes of SECM. | Redox flow battery | Applications of biofuel cells |
| SLO-12 | Tutorial: Understanding the interfacial electrochemistry | Tutorial: Important equations used in electrode kinetics | Tutorial: Electrochemical techniques and data interpretation | Tutorial: Performance evaluation of catalysts, and energy storage materials | Tutorial: Electroactive material synthesis and performance evaluation |

| Resources | | |
|-----------|---|----|
| 1. | <i>A.J.Bard and L.R. Faulkner, Electrochemical methods –Fundamentals and Applications, 2nd Ed., John Wiley and Sons, 2001</i> | 6 |
| 2. | <i>J.O.M. Bockris and A.K.N. Reddy, Modern Electrochemistry, Volumes 1 & 2, Plenum Press, New York. 1988</i> | 7 |
| 3. | <i>S. Glasstone, Electrochemistry, Affiliated East-West Press, Pvt., Ltd., New Delhi, 1974.</i> | 8 |
| 4. | <i>J. Wang, Analytical Electrochemistry, Second Edition, 2000.</i> | 9 |
| 5. | <i>C.Hamann, A. Hamnett and W. Vielstich, Electrochemistry, Wiley, 2007</i> | 10 |
| | | 6 |
| | | 7 |
| | | 8 |
| | | 9 |
| | | 10 |

| | |
|------------|------------|
| Assessment | Strategies |
|------------|------------|

| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | Final Assessment (50 % weightage) |
|---------------------------|------------|--|------------|------------|------------|-----------------------------------|
| | | CLA – 1 | CLA – 2 | CLA – 3 | CLA – 4* | |
| | | (10 %) | (10 %) | (20 %) | (10%) | |
| | | Theory (%) | Theory (%) | Theory (%) | Theory (%) | |
| 1 | Remember | 15 | 15 | 10 | 10 | 15 |
| 2 | Understand | 15 | 15 | 10 | 10 | 15 |
| 3 | Apply | 20 | 25 | 25 | 25 | 25 |
| 4 | Analyze | 20 | 25 | 25 | 25 | 25 |
| 5 | Evaluate | 15 | 10 | 15 | 15 | 10 |
| 6 | Create | 15 | 10 | 15 | 15 | 10 |
| Total (%) | | 100 | 100 | 100 | 100 | 100 |

| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | |
|----------------------|--|----------------------------|--|------------------|--|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. Anandhakumar S, Department of Chemistry, SRMIST Email id: anandhas2@srmist.edu.in Dr. Arun Prakash P, Department of Chemistry, SRMIST Email id: arunprap1@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 | Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Course Code | PCY25S02L | Course Title | Instrumental Methods of Analysis - Practical | | | | Category | S | Skill Enhancement Course | L | T | P | C |
|-------------|-----------|--------------|--|--|--|--|----------|---|--------------------------|---|---|---|---|
| | | | | | | | | | | 0 | 0 | 6 | 3 |

| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|-------|---|---|---|------------|---|---|---|-----------------------|---|---|---|---|---|---|---|----|----|----|--|
| | | | | | | | | | | | | | | | | | | | | | |
| CLR-1 | Gain exposure to the practical knowledge of Instruments and their handling. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| CLR-2 | Gain insight into the principle, instrumentation, and interpretation of simple compounds in UV spectroscopy | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Learn about the analysis of samples using electroanalytical methods | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Gain knowledge about the characterization of simple compounds using XRD | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Know how to maintain the record of experiments conducted and Learn strategies for the green synthesis of simple molecules-Demonstration | | | | | | | | | | | | | | | | | | | | |

| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
|----------------|--|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLO-1 | Understand different characterization techniques used in simple molecules - UV-vis and IR-analysis | ✓ | ✓ | ✓ | - | 2 | 75 | 60 | 2 | - | 3 | 2 | - | - | 3 | 3 | 3 | - | - | 3 |
| CLO-2 | Get awareness of safety techniques and handling of chemicals. – UV-vis and IR-analysis | ✓ | ✓ | ✓ | - | 2 | 80 | 70 | 2 | - | 1 | 3 | 2 | - | - | 3 | 3 | - | - | 3 |
| CLO-3 | Understand the applications of electroanalytical techniques | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 65 | 2 | - | 1 | 3 | - | - | 3 | 3 | 3 | - | - | 3 |
| CLO-4 | Apply the techniques for structure determination of simple molecules. Using XRD | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | 2 | - | 3 | 2 | 1 | - | - | 3 | 3 | - | - | 3 |
| CLO-5 | Acquire insight into the principles and handling of various instruments through demonstrations | ✓ | ✓ | ✓ | ✓ | 2 | 70 | 70 | 2 | - | 1 | 3 | 2 | - | - | 3 | 3 | - | - | 3 |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|-----------|--|---|---|---|---------------------------------|
| | Introduction to Instrumental Methods of Analysis | Spectroscopic Techniques | Electroanalytical Methods | Chromatographic Techniques and XRD Analysis | Demonstration/Practical session |
| | 18 | 18 | 18 | 18 | 18 |
| SL: 1-6 | Introduction to Instrumental Methods of Analysis | Validating Beer – Lamberts law by finding the absorbance of a dye in a UV-visible spectrophotometer | Determination of a concentration of an acid by pH meter | Paper chromatography: Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by reporting the Rf values | Demonstration Practical Session |
| SLO: 7-12 | IR Absorption Spectra (Study of Aldehydes and Ketones) | Determination of concentration of mixture of acids by conductometric method | Determination of the isoelectric pH of a protein | Chromatographic separation of the active ingredients of plants, flowers, and juices by TLC | Repeat Class -1 |

| | | | | | |
|-------------------|---|---|---|---|-----------------|
| SLO: 13-18 | Determination of a Mixture of Cobalt and Nickel using a UV-visible Spectrophotometer. | Estimation of chloride by potentiometric titration (precipitation reaction) | Cyclic Voltammetry analyses: Ferrocyanide/Ferricyanide Couple | Synthesis of zinc oxide nanoparticle by sol-gel method: XRD analysis and interpretation | Repeat Class -2 |
|-------------------|---|---|---|---|-----------------|

| Resources | |
|-----------|---|
| 1 | Vogel, A Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall, 1996. |
| 2 | Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7) |
| 3 | Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle. |
| 4 | Y.R. Sharma, Elementary Organic Spectroscopy: Principles and Chemical Applications, 5th edition, S. Chand and company Ltd., Ram Nagar, New Delhi, 2010. |
| 5 | D.A. Skoog, D.M. West and F.J. Holler, Analytical Chemistry: An Introduction, 5th edition, Saunders college publishing, Philadelphia, 1990 |

| Assessment | | | | | | | | | | | |
|---------------------------|------------|--|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------------------|--------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | | | | | Final Assessment (50 % weightage) | |
| | | CLA – 1 (10 %) | | CLA – 2 (10 %) | | CLA – 3 (20 %) | | CLA – 4* (10%) | | | |
| | | | | | | | | | | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) |
| 1 | Remember | - | 15 | - | 15 | - | 15 | - | 15 | - | 15 |
| 2 | Understand | - | 15 | - | 15 | - | 15 | - | 15 | - | 15 |
| 3 | Apply | - | 20 | - | 25 | - | 25 | - | 25 | - | 25 |
| 4 | Analyze | - | 20 | - | 25 | - | 25 | - | 25 | - | 25 |
| 5 | Evaluate | - | 15 | - | 10 | - | 15 | - | 10 | - | 10 |
| 6 | Create | - | 15 | - | 10 | - | 15 | - | 10 | - | 10 |
| Total (%) | | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 |

✓

| Strategies | | | | |
|----------------------------|---|----------------------|---|--------------------------|
| Technology | | Pedagogy / Andragogy | | Sustainable Development |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education |
| Learning Management System | - | Hands-on Practice | ✓ | Gender Equality |
| | | Debate | - | |
| | | Interactive Lecture | ✓ | |
| | | Brainstorming | ✓ | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| Strategies | | | | |
|----------------------------|------------------------|-------------------------|--------------------------|---|
| Technology | Pedagogy / Andragogy | Sustainable Development | | |
| Simulations | - Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | - Hands-on Practice | ✓ | Gender Equality | - |
| | Debate | - | | |
| | Interactive Lecture | ✓ | | |
| | Brainstorming | ✓ | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|---|---|--|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 1 Dr. N. Clament Sagaya Selvam, Department of Chemistry, SRMIST Email id: clamentn@srmist.edu.in 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| Code | PPY25G01T | Title | LASER Physics | | | | Category | G | Generic Elective Course | L | T | P | C |
|------|-----------|-------|---------------|--|--|--|----------|---|-------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 1 | 0 | 4 |

| Offering Department | Physics and Nanotechnology | Pre-requisite Courses | - | Co-requisite Courses | - | Progressive Courses | - | Data Book / Codes/Standards | - |
|---------------------|----------------------------|-----------------------|---|----------------------|---|---------------------|---|-----------------------------|---|
|---------------------|----------------------------|-----------------------|---|----------------------|---|---------------------|---|-----------------------------|---|

| Rationale (CR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|----------------|--|----------|--------|-----------|---------|-------------------|--------------------------|-------------------------|-----------------------|---|---|---|---|---|---|---|---|----|----|----|
| CR-1 | acquire the knowledge on laser beam characteristics | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CR-2 | acquire knowledge for solving problems in laser physics | | | | | | | | | | | | | | | | | | | |
| CR-3 | analyze Fabry-Perot cavity to understand laser resonator | | | | | | | | | | | | | | | | | | | |
| CR-4 | gain knowledge on Q-switched and mode-locked lasers | | | | | | | | | | | | | | | | | | | |
| CR-5 | acquire the knowledge on advanced topic of random lasers | | | | | | | | | | | | | | | | | | | |
| Outcomes (CO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | | | | | | | | | | | | |
| CO-1 | use the basic characteristics of a laser | ✓ | ✓ | - | - | 5 | 85 | 75 | 3 | - | 3 | - | 3 | - | - | - | - | - | - | - |
| CO-2 | analyse Fabry Perot cavity to understand a laser resonator | ✓ | ✓ | - | - | 4 | 85 | 75 | 3 | - | 3 | - | 3 | - | - | - | - | - | - | - |
| CO-3 | apply Rate equations to understand the dynamics of a laser | ✓ | ✓ | - | - | 6 | 85 | 75 | 3 | - | 3 | - | 3 | - | - | - | - | - | - | - |
| CO-4 | implement the conditions of stable resonators | ✓ | ✓ | - | - | 3 | 85 | 75 | 3 | - | 3 | - | 3 | - | - | - | - | - | - | - |
| CO-5 | work with the physics of various types of lasers | ✓ | ✓ | - | - | 2 | 85 | 75 | 3 | - | 3 | - | 3 | - | - | - | - | - | - | - |

| Title & Session Outcomes | Basic concepts on lasers | Cavity modes | Stable resonators and four level laser system | Q-switching and mode locking | Types of lasers |
|--------------------------|--|---|--|--|---|
| Duration (hour) | 12 | 12 | 12 | 12 | 12 |
| SO-1 | General Introduction to lasers, Spontaneous and stimulated emission, Stimulated absorption | Cavity life time and Quality factor, Ultimate line width of a laser | Geometrical optics analysis of optical resonators, Condition for stable resonators | Introduction to Q-switching, Dynamics of the Q-switching process | Coherence properties of laser light |
| SO-2 | The laser idea, Gain medium, pumping scheme and optical feedback, | Einstein's A and B Coefficients | Stability diagram for optical resonators | Electro-optical Q-switching | Temporal coherence, Michelson Interferometer, First-order correlation function |
| SO-3 | Properties of laser beams, Monochromaticity, Directionality, coherence, | Introduction to resonators, Fabry-Perot cavity | Sources of resonator loss | Introduction to mode locking, Mathematical interpretation for mode locking | Spatial coherence, Young's double slit experiment to understand spatial coherence |

| | | | | | |
|--------|---|--|--|---|---------------------------------------|
| SO - 4 | Demonstration | Demonstration | Demonstrations | Demonstration | Demonstration |
| SO-5 | Modes of a cavity, Black body radiation | Elementary theory of Fabry-Perot cavity, Transmission spectrum | Laser rate equations, Mathematical formulation of rate equations for four level laser system | Passive and active mode locking | He-Ne laser (CW) |
| SO-6 | Calculation of mode density for black body | Coefficient of finesse/Quality factor Fundamental Gaussian beam | Condition for population inversion, Threshold condition for four level system | Gain saturation, Spatial hole burning | Nd:YAG laser (Pulsed) |
| SO-7 | Comparison of black body radiation with laser radiation | Gaussian beam in homogeneous medium | Calculating threshold for He-Ne laser, Integrating cavity rate equation | Longitudinal and transverse mode selection, Single mode operation | Introduction to random laser |
| SO-8 | Problem solving | Problem solving | Problem solving | Problem solving | Problem solving |
| SO-9 | Line shape functions, Line-broadening mechanisms | Gaussian beam focusing | Rate equations under steady state condition | Multi-mode lasers | Emission properties of a random laser |
| SO-10 | Homogeneous and inhomogeneous broadening | Higher order Hermite Gaussian beams | Variation of laser power around the threshold | Gain competition | Modes of a random laser |
| SO-11 | Natural, Doppler and Collision broadening | Analysis of higher order Hermite Gaussian beams | Optimum output coupling, Laser spiking | Optical amplifiers | Applications of random lasers |
| SO-12 | Practice | Practice | Practice | Practice | Practice |

| Assessment | | | | | |
|-------------------|---|---------|---------|----------|----------------------------|
| Level of Thinking | Continuous Learning Assessment (CLA) (50 % weightage) | | | | Final Exam (50% Weightage) |
| | CLA – 1 | CLA – 2 | CLA – 3 | CLA – 4* | |
| | (10%) | (10%) | (20%) | (10%) | |
| | Theory | Theory | Theory | Theory | |
| 1 Remember | 20% | 20% | 20% | 20% | 20% |
| 2 Understand | 20% | 20% | 20% | 20% | 20% |
| 3 Apply | 30% | 30% | 30% | 30% | 30% |
| 4 Analyze | 30% | 30% | 30% | 30% | 30% |
| 5 Evaluate | | | | | |
| 6 Create | | | | | |
| Total | 100 % | 100 % | 100 % | 100 % | 100 % |

| Strategies | | | | |
|------------------------------|----------------------|------------------------|-------------------------|---------------------------|
| Technology | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | ✓ | Case Studies | ✓ | No Poverty |
| Emulations | ✓ | Group Discussion | ✓ | Zero Hunger |
| Prototypes | | Hands-on Practice | | Good Health & Well Being |
| Hands-on Practice Tools | | Inquiry Learning | ✓ | Quality Education |
| Mathematical Computing Tools | | Interactive Lecture | ✓ | Gender Equality |
| Field Visit | | Leading Question | ✓ | Clean Water & Sanitation |
| | | Mind Map | | Affordable & Clean Energy |
| | | Minute Paper | | |
| | | Peer Review | | |
| | | Problem Based Learning | ✓ | |

*The evaluation can be done based on one or more parameters that include, i) Seminars, ii) Mini-project, iii) Case-studies, iv) MOOC Certifications, v) Publication of Articles, vi) Presentation of research work in Conferences, vii) Assignments.

| Resources | | | |
|-----------|--|---|---|
| 1 | K. Thyagarajan and A.K. Ghatak, Lasers Theory and Applications, 1st Ed., Macmilan Publishers, 2010 | 2 | O. Svelto, Principles of lasers, 4th Ed., Springer, 1998. |
| 3 | A. Yariv, Quantum Electronics, 3rd Ed., John Wiley, New York, 1989 | 4 | Seigman, Lasers, 3rd Ed., Oxford Univ. Press, 1986 |
| 5 | B.E.A. Saleh and M.C. Teich, Fundamentals of Photonics, 2nd Ed., Wiley, 2012. | 6 | D. Wiersema, The physics and applications of random lasers, Nature Physics, vol.4, pp 359-367, (2008) |

| Designers | | | |
|----------------------|---|----------------------------|--|
| Professional Experts | | Higher Institution Experts | |
| 1 | Dr. N Vijayan, NPL, nvijayan@nplindia.org | 1 | Prof. Maruthi Manoj Brundavanam, IIT Kharagpur, bmmanoj@phy.iitkgp.ac.in |
| 2 | Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in | 2 | Prof. M Bala Murali Krishna, IIT Jodhpur, bmkrishna@iitj.ac.in |
| | | | Internal Experts |
| | | 1 | Dr. K Shadak Alee, SRMIST, shadakk@srmist.edu.in |
| | | 2 | Dr. Junaid M Laskar, SRMIST, junaidmb@srmist.edu.in |

| Code | PPY25G02J | Title | Semiconductor Virtual Nanofabrication | | | | Category | G | Generic Elective Course | L | T | P | C |
|------|-----------|-------|---------------------------------------|--|--|--|----------|---|-------------------------|---|---|---|---|
| | | | | | | | | | | 3 | 0 | 2 | 4 |

| Offering Department | Physics and Nanotechnology | Pre-requisite Courses | - | Co-requisite Courses | - | Progressive Courses | - | Data Book / Codes/Standards | - |
|---------------------|----------------------------|-----------------------|---|----------------------|---|---------------------|---|-----------------------------|---|
|---------------------|----------------------------|-----------------------|---|----------------------|---|---------------------|---|-----------------------------|---|

| Rationale (CR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | | | | | |
|----------------|---|-------|---|---|---|--|-------------------|--------------------------|-------------------------|---|---|---|---|---|---|---|---|---|----|----|----|--|--|--|
| CR-1 | Know what semiconductor process technology is and acquire special skillset for a fab engineer semiconductor industry demand | 1 | 2 | 3 | 4 | Conceive Design Implement Operate | Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| CR-2 | Prepare yourself to meet with the requirement of highly trained workforce to nurture the India Semiconductor Mission | | | | | | | | | | | | | | | | | | | | | | | |
| CR-3 | Understand the basic physics of CMOS devices and various processes and tools involved in CMOS micro/nano fabrication | | | | | | | | | | | | | | | | | | | | | | | |
| CR-4 | Become familiarize with the CMOS processing through virtual training using SEMulator3D | | | | | | | | | | | | | | | | | | | | | | | |
| CR-5 | Study the fundamentals of Nanofabrication and Microfabrication | | | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CO) | At the end of this course, learners will be able to: | | | | | | | | | | | | | | | | | | | | | | | |
| CO-1 | Apply CMOS device physics and differentiate between design, fabrication, packaging, system manufacturing and product | ✓ | ✓ | ✓ | ✓ | | 4 | 85 | 75 | - | - | 3 | - | 3 | - | - | 3 | - | - | - | | | | |
| CO-2 | Develop integral skills in semiconductor microfabrication unit processes | ✓ | ✓ | ✓ | ✓ | | 4 | 85 | 75 | - | - | 3 | - | 3 | - | - | 3 | - | - | - | | | | |
| CO-3 | Develop module-level understanding of advanced CMOS FinFET process | ✓ | ✓ | ✓ | ✓ | | 4 | 85 | 75 | - | - | 3 | - | 3 | - | - | 3 | - | - | - | | | | |
| CO-4 | Demonstrate ability to use SEMulator3D to design CMOS devices and solve integration challenges | ✓ | ✓ | ✓ | ✓ | | 4 | 85 | 75 | - | - | 3 | - | 3 | - | - | 3 | - | - | - | | | | |
| CO-5 | Use Statistical Process Control | ✓ | ✓ | ✓ | ✓ | | 4 | 85 | 75 | - | - | 3 | - | 3 | - | - | 3 | - | - | - | | | | |

| Title & Session Outcomes | Introduction To Semiconductors | Unit Processes | Module Processes | Contact Module and BEOL Processes | Statistical Process Control |
|--------------------------|--|--|--|--|--|
| Duration (hour) | 15 | 15 | 15 | 15 | 15 |
| SO-1 | Semiconductor Ecosystem | Silicon – From crystal growth to wafer preparation | Isolation module – Advantages and challenges of STI verses LOCOS | Contact module – Metal/semiconductor contacts | Introduction and importance of SPC, |
| SO-2 | Overview of semiconductor logic, memory, display, and MEMS | Wafer orientation and Doping (Diffusion and ion implantation) | Device architecture – Planar to FinFET | contact resistance issues of simple metal/silicon contact | Basic Concepts of Statistical Distribution |
| SO-3 | MOS transistor and CMOS Logic Inverter | Wafer cleaning and oxide growth process | Use of SiGe and strain | metal silicides, silicidation process, evolution from Ti to Co to Ni | Hypothesis Testing |
| SO-4-5 | Practice: Demo on SEMulator3D software | Practice: Familiarize with SEMulator3D using basic tutorial on STI | Practice: LOCOS isolation verses Shallow Trench Isolation (STI) | Practice: Ion implantation and Silicidation | Practice: PlanarFET vs FinFET inverter |

| | | | | | |
|------------------|--|---|---|--|---|
| SO-6 | MOSFET device physics | Deposition technologies - CVD, PVD, ALD, Cu electroplating | Gate module – SiO ₂ versus high-k dielectrics | Interconnect module – Need for multiple metal layers | Theory of z-test, t-test |
| SO-7 | Moore's Law and Scaling | Optical lithography – Exposure system, resolution, light source | Polysilicon versus metal gate | RC delay | ANOVA |
| SO-8 | CMOS fabrication Layout design rules | Photoresist materials | Gate-first versus gate last | challenge of electromigration | Sample size estimation |
| SO-9--10 | <i>Practice: Learn to use the Layout editor of SEMulator3D & Create a layout of NMOS or PMOS using SEMulator3D</i> | <i>Practice: Visit to Process Lab</i> | <i>Practice: Gate-First versus Gate-Last</i> | <i>Practice: Damascene process</i> | <i>Practice: Module-level understanding of CMOS 14-nm process</i> |
| SO-11 | Manufacturing ecosystem - difference between design, fabrication, packaging, system manufacturing and product | Advanced lithography tools and concepts (immersion lithography and multiple patterning) | Integration challenges of replacement metal gate | Evolution from Al verses Cu | Theory of DOE, Screening test, RSM |
| SO-12 | Manufacturing ecosystem cont. | Dry and wet etching – Etch chemistry and etch tools | Well & junction module – Basics of implantation | Damascene and dual-damascene process, W plugs and via | Fractional and Full-factorial tests |
| SO-13 | Semiconductor manufacturing process overview (FEOL verses BEOL) | Semiconductor metrology | Source-drain and well implants, other implants | Intermediate dielectric – materials and integration challenges | Paired Means |
| SO-14--15 | <i>Practice: Building NMOS or PMOS using SEMulator3D</i> | <i>Practice: Simulate the spacer fabrication and multiple patterning</i> | <i>Practice: Building CMOS inverter using SEMulator3D</i> | <i>Practice: Dual-Damascene process</i> | <i>Practice: Build your own device</i> |

| Assessment | | | | | | | | | | |
|-------------------|------------|---|--------------|------------|--------------|------------|--------------|------------|--------------|-------------------------------|
| Level of Thinking | | Continuous Learning Assessment (CLA) (50 % weightage) | | | | | | | | Final Exam (50% Weightage) |
| | | CLA – 1 | | CLA – 2 | | CLA – 3 | | CLA – 4* | | |
| | | (10%) | | (10%) | | (20%) | | (10%) | | |
| | | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) | Practice (%) | Theory (%) |
| 1 | Remember | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 20 |
| 2 | Understand | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 20 |
| 3 | Apply | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 30 |
| 4 | Analyze | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 30 |
| 5 | Evaluate | | | | | | | | | |
| 6 | Create | | | | | | | | | |
| Total (%) | | 100 | | 100 | | 100 | | 100 | | 100 |

| Strategies | | | |
|------------------------------|------------------------|----------------------------|---|
| Technology | Pedagogy / Andragogy | Sustainable Development | |
| Simulations | ✓ Case Studies | ✓ No Poverty | ✓ |
| Emulations | ✓ Group Discussion | ✓ Zero Hunger | |
| Prototypes | Hands-on Practice | ✓ Good Health & Well Being | |
| Hands-on Practice Tools | ✓ Inquiry Learning | ✓ Quality Education | ✓ |
| Mathematical Computing Tools | ✓ Interactive Lecture | ✓ Gender Equality | ✓ |
| Field Visit | Leading Question | ✓ Clean Water & Sanitation | |
| | Mind Map | Affordable & Clean Energy | |
| | Minute Paper | | |
| | Peer Review | | |
| | Problem Based Learning | ✓ | |

*The evaluation can be done based on one or more parameters that include, i) Seminars, ii) Mini-project, iii) Building device designs using SEMulator3D software, iv) MOOC Certifications, v) Publication of Articles, vi) Presentation of research work in Conferences, vii) Assignments.

| Resources | | | |
|-----------|---|---|--|
| 1 | J. S. M. Sze and M. K. Lee. "Semiconductor Devices: Physics and Technology" – John Wiley & Sons Inc., 3 rd edition, 2012. | 2 | Stephen A. Campbell, "The Science and Engineering of Microelectronic Fabrication" – Oxford university Press, 2001 |
| 3 | Yoshio Nishi and Rober Doering (Eds.), "Handbook of Semiconductor Manufacturing Technology"- CRC Press, 2 nd Edition, 2007. | 4 | Marc J.Madou. "Fundamentals of Microfabrication and Nanotechnology – Volume II" – CRC Press, 3 rd Edition, 2011. |
| 5 | Gary S. May and Costas J. Spanos "Fundamentals of Semiconductor Manufacturing and Process Control" IEEE A JOHNWILEY&S ONS, INC., Publication. | 6 | Gary S. May and Costas J. Spanos "Fundamentals of Semiconductor Manufacturing and Process Control" IEEE A JOHNWILEY&S ONS, INC., Publication |
| 7 | https://onlinecourses.nptel.ac.in/noc20_bt37/preview | 8 | https://onlinecourses.nptel.ac.in/noc20_bt17/preview |

| Designers | | | |
|----------------------|---|----------------------------|--|
| Professional Experts | | Higher Institution Experts | |
| 1 | Dr. Joseph Ervin, LAM Research, Joseph.Erwin@lamresearch.com | 1 | Dr. Sushobhan Avasthi, Centre for Nano Science and Engineering (CENSE), Indian Institute of Science, Bangalore. savasthi@iisc.ac.in |
| 2 | Mr. Kulanthaivelu Ramaswamy, Technical Staff Engineer-Analog Design, Micochip Technology Inc. Kulanthaivelu.Ramasamy@microchip.com | 2 | |
| | | | 3 |
| | | | Dr. S. Chandramohan, SRMIST |
| | | | Prof. Sarin Sundar, SRMIST |
| | | | Dr. Shailendra K. Saxena, SRMIST |

| | | | | | | | | | | | | | | | | |
|------------|-----------|------------|------------------------------|--|--|--|-----------------|---|-------------------------|--|--|--|---|---|---|---|
| CourseCode | PCY25G01T | CourseName | Research Skills and Learning | | | | Course Category | G | Generic Elective Course | | | | L | T | P | C |
| | | | | | | | | | | | | | 3 | 1 | 0 | 4 |

| | | | | | | | | | |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|
| Course Offering Department | Chemistry | Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil | Data Book / Codes/Standards | Nil |
|----------------------------|-----------|-----------------------|-----|----------------------|-----|---------------------|-----|-----------------------------|-----|

| Rationale (CLR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | | | Program Outcomes (PO) | | | | | | | | | | | |
|-----------------|---|----------|--------|-----------|---------|---------------------------|--------------------------|-------------------------|------------------------|-----------------|-----------------------|----------------------------|-------------------|-------------------|------------------------------|---------------------------------------|------------------------|---------------|------------------------------|--------------------|--|--|
| CLR-1 | Understand the concept of research and differenttypes of research in the context of chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| CLR-2 | Evaluate the different methods of scientific writingand reporting | | | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Impart the knowledge about the statisticaldistribution and applications | | | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Develop the skill of technical writing | | | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Inculcate the knowledge of intellectual property andrights | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| Outcomes (CLO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Bloom's Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethicalpractices&SocialResponsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning | | |
| CLO-1 | Understand the key areas of research | ✓ | ✓ | ✓ | - | 4 | 85 | 75 | - | 3 | 2 | 3 | - | - | - | - | - | - | - | - | | |
| CLO-2 | Develop experimental skills and documentation | ✓ | ✓ | ✓ | - | 4 | 85 | 70 | - | 3 | 3 | - | - | - | - | - | 3 | - | - | - | | |
| CLO-3 | Develop competence on data collection andprocess of scientific documentation | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | 3 | 3 | - | - | - | - | - | - | - | - | | |
| CLO-4 | Understand the research ethics | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 70 | - | 3 | 2 | 3 | - | - | - | - | - | - | - | 3 | | |
| CLO-5 | Submit proposals for funding agencies | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 60 | - | 3 | 3 | 2 | - | - | - | - | - | - | - | - | | |

| Sessions | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|----------|---|---|---|---|---|
| | Literature review, DOI and other indices | Online data base and data analysis | Statistical Data | Scientific writing | Research ethics |
| | 12 | 12 | 12 | 12 | 12 |
| SLO-1 | What is Research? Introduction – Motivation of Research - Objectives of research, Research methods and methodologies-Overview | Online databases, E-journals. Journal access – open access - subscription | Analysis and Presentation of Data, Descriptive statistics | Technical writing, technical writing - Activity | Ethics in research, authors Acknowledgement |

| | | | | | |
|---------------|--|---|---|--|---|
| SLO-2 | types of research- Descriptive vs analytical types of research - applied vs fundamental | Citation index, Impact factor, H-index, E-consortium | Choosing and using statistical tests Data-Sample-purpose | Technical presentation -Activity | Group discussion on ethics in research Outcome of group discussion |
| SLO-3 | types of research- quantitative vs qualitative types of research- conceptual vs empirical | UGC Infonet, E-book Preprint servers – advantages and risks | Sample test - Different types of T-test - problems F- test , χ^2 - test | Creativity in research Basic idea Creativity in research - Activity | Plagiarism Tools to avoid plagiarism |
| SLO-4 | Tutorial: Activity based on Literature Survey | Tutorial: Activity based on data analysis | Tutorial: Activity based on T-test | Tutorial: Seminar presentation | Tutorial: Plagiarism check for assignment |
| SLO-5 | Literature review vs. literature report Basic steps while conducting Literature and its Consolidation | Search engines, Scirus, Google Scholar ChemIndustry, Wiki-Databases | Chemometrics Analysis of variance(ANOVA), | Good practical Units,numbers Reproducibility | Presentations - Power-point presentation. Poster presentation |
| SLO-6 | Sources of information Primary, secondary, and tertiary sources of literature | ChemSpider, Science Direct SciFinder, Scopus | Correlation and regression Curve fitting | Scientific writing – Abbreviations – standards rules nomenclature in chemistry and other fields | Elements of excellent presentation Communication skills |
| SLO-7 | Journal abbreviations, abstracts, reviews, monographs, dictionaries | Internet resources for Science, Library research, | fitting of linear equations, analysis of residuals | justification for scientific contributions, description of methods | Activity based on research presentation |
| SLO-8 | Tutorial: Activity based on Literature Survey | Tutorial: Activity based on data analysis | Tutorial: Activity based on chemometrics | Tutorial: Assignments on technical writing | Tutorial: Seminar on research topics |
| SLO-9 | Introduction to Chemical Abstracts Author Index | field research Laboratory research | General polynomial fitting linearizing transformations | conclusions the need for illustration, style | Proposal submission for funding agencies Knowledge of funding agencies |
| SLO-10 | Formula Index Subject Index | Data Analysis Making, and Recording Measurements | exponential function fit, r and its abuse | Writing references Research report writing | Intellectual property rights |
| SLO-11 | Doi and other Indices with examples, Substance Index | Tabulation and generation of graphs, Maintaining a laboratory record | Basic aspects of multiple linear regression analysis | Activity-based on scientific writing | Patent rights, Copyrights |
| SLO-12 | Tutorial: Activity based on Literature Survey | Tutorial: Activity based on tabulation and generation of graphs | Tutorial: Activity based on linear fit and regression analysis | Tutorial: Assignment on report writing | Tutorial: Drafting project proposal |

| Resources | |
|-----------|---|
| 1 | Dawson, C.. Practical research methods. UBS Publishers, New Delhi, 2002 |
| 2 | Walpole R.A., Myers R.H., Myers S.L. and Ye King: Probability and statistics for engineers and scientist, Pearson Prentice Hall, Pearson Education, Inc. 2007 |
| 3 | Kothari C.K., Research Methodology-Methods and Techniques (New Age International, New Delhi), 2004 |

| Assessment | | | | | | |
|---------------------------|------------|--|------------|------------|------------|-----------------------------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | Final Assessment (50 % weightage) |
| | | CLA – 1 | CLA – 2 | CLA – 3 | CLA – 4* | |
| | | (10 %) | (10 %) | (20 %) | (10%) | |
| | | Theory (%) | Theory (%) | Theory (%) | Theory (%) | |
| 1 | Remember | 15 | 15 | 10 | 10 | 15 |
| 2 | Understand | 15 | 15 | 10 | 10 | 15 |
| 3 | Apply | 20 | 25 | 25 | 25 | 25 |
| 4 | Analyze | 20 | 25 | 25 | 25 | 25 |
| 5 | Evaluate | 15 | 10 | 15 | 15 | 10 |
| 6 | Create | 15 | 10 | 15 | 15 | 10 |
| Total (%) | | 100 | 100 | 100 | 100 | 100 |

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | | | | |
|----------------------|---|----------------------------|---|------------------|---|
| Professional Experts | | Higher Institution Experts | | Internal Experts | |
| 1 | Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 | Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 | Dr. T. Pushpa Malini, Department of Chemistry, SRMIST Email: pushpamt@srmist.edu.in |
| | | 2 | Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iiservm.ac.in | 2 | Dr. M. R. Ganesh, SRMIST Email: ganeshm1@srmist.edu.in |
| | | | | 3 | Prof. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |

| | | | | | | | | | | |
|--------------------|------------------|--------------------|-------------------|------------------------|----------|---|----------|----------|----------|----------|
| Course Code | PCY25I01L | Course Name | Internship | Course Category | P | Project Work, Internship In Industry / Higher Technical Institutions | L | T | P | C |
| | | | | | | | 0 | 0 | 0 | 2 |

| | | | | | |
|-----------------------------------|------------------|------------------------------------|------------|----------------------------|------------|
| Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil |
| Course Offering Department | Chemistry | Data Book / Codes/Standards | Nil | | |

| Course Learning Rationale (CLR): | | The purpose of learning this course is to: | | | Learning | | | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|----------------------------------|---|--|-------------------|-----------------|---------------------------|--------------------------|-------------------------|---------------------------------|-----------------|-----------|----------------------|---------------------|------------------------|--------------------------|------------|--------------------|---------|---------|---------|----|----|----|
| CLR-1: | gain experience | 1 | 2 | 3 | Level of Thinking (Bloom) | Expected Proficiency (%) | Expected Attainment (%) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| CLR-2: | have a better understanding | Disciplinary Knowledge | Critical Thinking | Problem Solving | | | | Analytical Reasoning | Research Skills | Team Work | Scientific Reasoning | Reflective Thinking | Self-Directed Learning | Multicultural Competence | ICT Skills | Life Long Learning | PSO - 1 | PSO - 2 | PSO - 3 | | | |
| CLR-3: | have the opportunity to learn and watch. | | | | | | | | | | | | | | | | | | | | | |
| CLR-4: | gain the ability to put new things into practice. | | | | | | | | | | | | | | | | | | | | | |
| CLR-5: | Build confidence | | | | | | | | | | | | | | | | | | | | | |
| Course Learning Outcomes (CLO): | | At the end of this course, learners will be able to: | | | | | | | | | | | | | | | | | | | | |
| CLO-1: | Improve the communication skill | 2 | 80 | 75 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | |
| CLO-2: | recognise parallel relationship between words | 2 | 80 | 70 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| CLO-3: | Improve Professional behavior and/or knowledge | 2 | 75 | 70 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| CLO-4: | Improve the Project-related skills | 2 | 80 | 75 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| CLO-5: | Improve employability-enhancing activities | 2 | 80 | 70 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |

| | Continuous Learning Assessment (50% weightage) | | Final Evaluation (50% weightage) | |
|-------------------|---|------------|---|-----------|
| | Review – 1 | Review – 2 | Project Report | Viva-Voce |
| | 20% | 30% | 30% | 20% |
| Internship | | | | |

Semester-IV

| Course Code | PCY25P01L | Course Name | Project Work | Course Category | P | Project Work, Internship In Industry / Higher Technical Institutions | L | T | P | C |
|-------------|-----------|-------------|--------------|-----------------|---|--|---|---|----|----|
| | | | | | | | 0 | 0 | 20 | 10 |

| Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil |
|----------------------------|-----------|-----------------------------|-----|---------------------|-----|
| Course Offering Department | Chemistry | Data Book / Codes/Standards | | | |

| Rationale (CR) | The purpose of learning this course is to: | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|----------------|--|----------|--------|-----------|---------|-------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLR-1 | Produce competent, creative and imaginative graduates with a strong scientific acumen | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CLR-2 | Apply of the acquired knowledge, skills, and tools pertinent to the field of Chemistry | | | | | | | | | | | | | | | | | | | |
| CLR-3 | Promote independent and collaborative research work in the domain of chemistry | | | | | | | | | | | | | | | | | | | |
| CLR-4 | Inculcate the ethical responsibility of the graduate in the scientific society | | | | | | | | | | | | | | | | | | | |
| CLR-5 | Identify the challenges and solutions pertinent to the field of Chemistry | | | | | | | | | | | | | | | | | | | |
| Outcomes (CO) | At the end of this course, learners will be able to: | Conceive | Design | Implement | Operate | Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| CLO-1 | conduct thorough research on a given topic | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 3 | - | - | - | 3 | - | - | - | - | - | - | 2 |
| CLO-2 | critically analyze data, and draw relevant conclusions | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | - | 3 | 3 | 3 | - | - | - | - | - | - | - |
| CLO-3 | identify complex problems and develop feasible solutions, | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | 3 | - | 3 | 3 | - | - | - | - | - | - | 3 |
| CLO-4 | understand and applies problem solving skills learned, and implement them effectively in a project setting | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 2 | 3 | - | 3 | 2 | - | - | - | - | - | - | - |
| CLO-5 | inculcate professional communication through Interviews & Group Discussions | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | - | - | - | - | 3 | - | 1 | 2 | 3 | - | - |

| | Continuous Learning Assessment (50% weightage) | | Final Evaluation (50% weightage) | |
|--------------|--|-------------|----------------------------------|-----------|
| | Review – 1* | Review – 2* | Project Report* | Viva-Voce |
| Project Work | 20% | 30% | 30% | 20% |

* includes submission of project work in the form of paper for presentation/publication in a conference/journal and/or preliminary filing of a patent with proof.

GENERIC ELECTIVES OFFERED BY THE CHEMISTRY DEPARTMENT

| Course Code | PCY25G02T | Course Name | Chemistry of Biomolecules | Course Category | G | Generic elective course | L | T | P | C |
|-------------|-----------|-------------|---------------------------|-----------------|---|-------------------------|---|---|---|---|
| | | | | | | | 3 | 1 | 0 | 4 |

| | | | | | |
|----------------------------|-----------|-----------------------------|-----|---------------------|-----|
| Pre-requisite Courses | Nil | Co-requisite Courses | Nil | Progressive Courses | Nil |
| Course Offering Department | Chemistry | Data Book / Codes/Standards | NIL | | |

| | | |
|---|----------|---------------------------------|
| Course Learning Rationale (CLR): The purpose of learning this course is to: | Learning | Program Learning Outcomes (PLO) |
|---|----------|---------------------------------|

| Rationale (CR) | | Depth | | | | Attainment | | | Program Outcomes (PO) | | | | | | | | | | | |
|----------------|--|----------|--------|-----------|---------|-------------------|--------------------------|-------------------------|------------------------|-----------------|----------------------|----------------------------|-------------------|-------------------|------------------------------|---|------------------------|---------------|------------------------------|--------------------|
| CLR-1 | Provide basic understanding about the biomolecules like amino acids, proteins, nucleic acids, lipids and carbohydrates | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CLR-2 | appreciate the role of these biomolecules in biology. | | | | | | | | | | | | | | | | | | | |
| CLR-3 | gain knowledge about enzymes and coenzymes | | | | | | | | | | | | | | | | | | | |
| CLR-4 | apply the information gained about enzymes and coenzymes into organic chemistry applications like molecule synthesis | | | | | | | | | | | | | | | | | | | |
| CLR-5 | gain knowledge about amino acids and proteins and their structural features | | | | | | | | | | | | | | | | | | | |
| Outcomes (CO) | | Conceive | Design | Implement | Operate | Level of Thinking | Expected Proficiency (%) | Expected Attainment (%) | Disciplinary Knowledge | Problem Solving | Design & Development | Analysis, Design, Research | Modern Tool Usage | Society & Culture | Environment & Sustainability | Ethical practices & Social Responsibility | Individual & Team Work | Communication | Project Management & Finance | Life Long Learning |
| CLO-1 | apply the information gained about enzymes and coenzymes into organic synthesis. | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 3 | - | - | 3 | 3 | - | - | - | - | - | - | 2 |
| CLO-2 | understand the importance of nucleic acid in bioorganic chemistry | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | - | 3 | 3 | 3 | - | - | - | - | - | - | - |
| CLO-3 | understand the importance of carbohydrate chemistry | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | - | 3 | - | 3 | 3 | - | - | - | - | - | - | 3 |
| CLO-4 | understand the significant role of amino acid, peptides and proteins in bioorganic chemistry | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 2 | 3 | - | 3 | 2 | - | - | - | - | - | - | - |
| CLO-5 | understand interactions between amino acids, peptides, nucleic acids and their role in biomolecule structure | ✓ | ✓ | ✓ | ✓ | 4 | 85 | 75 | 3 | - | - | 2 | 3 | - | - | - | - | - | - | - |

| Session | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 |
|---------|--|----------------------------------|---|------------------------|---|
| | Properties of Amino acids, Peptides and proteins | Importance Enzymes and coenzymes | Introduction to Nucleotides and nucleosides | Fatty Acids and Lipids | Structures and properties Carbohydrates |
| | (12) | (12) | (12) | (12) | (12) |

| | | | | | |
|---------------|---|---|---|--|---|
| SLO-1 | Classification and structure of amino acids | Enzymes, Classification | Nature of genetic material | Fatty acids classification | Classification of carbohydrates |
| SLO-2 | Configuration of amino acids, acid-base properties and isoelectric point | Kinetics, inhibition | Structure of purine and pyrimidine | Nomenclature, structure of fatty acids | Stereo isomerism of sugars |
| SLO-3 | Separation of amino acids | Mechanisms of enzyme action | Nucleotides and nucleosides | Properties of fatty acids | Optical isomerism of sugars |
| SLO-4 | Tutorial: Question answer session | Tutorial: Question answer session | Tutorial: Question answer session | Tutorial: Question answer session | Tutorial: Question answer session |
| SLO-5 | Peptide bonds, disulfide linkages | Cofactors as derived from vitamins, co-enzymes | Types of nucleic acids | Structure and function of prostaglandins, tri-acyl glycerol | Mutarotation, occurrence, |
| SLO-6 | Proteins classification based on solubility, shape, composition and function, | Prosthetic, prosthetic group and apoenzymes | Structure of DNA | Structure and functions of phospholipids, | Structure of mono and di saccharides |
| SLO-7 | Structure of polysaccharides | Structure and biological functions of coenzyme-A | Properties of nucleic acids | Spingomyelin | Biological importance of mono, di and polysaccharides |
| SLO-8 | Tutorial: Problem solving | Tutorial: Problem solving | Tutorial: Problem solving | Tutorial: Problem solving | Tutorial: Problem solving |
| SLO-9 | Structure of proteins, Determination of the primary structure of a protein, secondary, tertiary and quaternary structures | Thiamine pyrophosphate, pyridoxal phosphate | Hypo and hyperchromicity | Plasmalogens | An introduction to mucopolysaccharides |
| SLO-10 | Determination of the primary structure of a protein, secondary, tertiary and quaternary structures, | NAD ⁺ , NADP ⁺ , FAD, lipoic acid | Transcription and translation | Structure and function of glycolipids, | Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups. |
| SLO-11 | Protein denaturation. | Overview of reactions catalysed by the above cofactors | Determination of the base sequence of DNA | Cholesterol. | Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups. |
| SLO-12 | Tutorial: Practice | Tutorial: Practice | Tutorial: Practice | Tutorial: Parctice | Tutorial: Practice |

| | |
|---------------------------|---|
| Learning Resources | 1.D. 1. Nelson, 2. 2. Cox, Lehninger Principles of Biochemistry, 5thEd., W. 3. Freeman; New York, USA, 2005. 2. R. K. Murray, D. K. Grammer, Harper's Biochemistry, 29th Ed., McGraw Hill, Lange Medical Books, United Kingdom, 2009. 3. J.1. Jain, S. Jain, N. Jain, Fundamentals of Biochemistry, S. Chand & Company. India, 2013. 4. P. Y. Bruice, Organic Chemistry, 5th Ed., Pearson, 2014. |
|---------------------------|---|

| Assessment | | | | | | |
|---------------------------|------------|--|------------|------------|------------|-----------------------------------|
| Bloom's Level of Thinking | | Continuous Learning Assessment (CLA) (50% weightage) | | | | Final Assessment (50 % weightage) |
| | | CLA – 1 | CLA – 2 | CLA – 3 | CLA – 4* | |
| | | (10 %) | (10 %) | (20 %) | (10%) | |
| | | Theory (%) | Theory (%) | Theory (%) | Theory (%) | |
| 1 | Remember | 15 | 15 | 10 | 10 | 15 |
| 2 | Understand | 15 | 15 | 10 | 10 | 15 |
| 3 | Apply | 20 | 25 | 25 | 25 | 25 |
| 4 | Analyze | 20 | 25 | 25 | 25 | 25 |
| 5 | Evaluate | 15 | 10 | 15 | 15 | 10 |
| 6 | Create | 15 | 10 | 15 | 15 | 10 |
| Total (%) | | 100 | 100 | 100 | 100 | 100 |

| Strategies | | | | | |
|----------------------------|---|----------------------|---|--------------------------|---|
| Technology | | Pedagogy / Andragogy | | Sustainable Development | |
| Simulations | - | Clarification/Pauses | ✓ | Good Health & Well Being | ✓ |
| Presentation Tools | - | Group Discussion | ✓ | Quality Education | ✓ |
| Learning Management System | ✓ | Hands-on Practice | - | Gender Equality | ✓ |
| | | Debate | - | | |
| | | Interactive Lecture | ✓ | | |
| | | Brainstorming | ✓ | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

* The evaluation can be done on one or more parameters that include, (i) Seminars, (ii) Mini-Project, (iii) Case-Studies, (iv) MOOC Certification, (v) Publication of Article, (vi) Presentation of Research Work in Conferences, (vii) Assignments

| Designers | | |
|--|---|--|
| Professional Experts | Higher Institution Experts | Internal Experts |
| 1 Dr. Ravikiran Allada, Head Analytical R&D and ASAT (AVP) Steriscience (Strides), Bengaluru, Karnataka, Email Id: Ravikiran.Allada@Steri-science.com | 1 Prof. G. Sekar, Department of Chemistry, IIT Madras Email: gsekar@iitm.ac.in | 1 Dr. Priyadip Das, Department of Chemistry, SRMIST Email id: priyadip@srmist.edu.in |
| | 2 Prof. Sukhendu Mandal, Department of Chemistry, IIISER, Thiruvananthapuram Email: sukhendu@iisertvm.ac.in | 2 Prof. Dr. M. Arthanareeswari, Department of Chemistry, SRMIST Email id: arthanam@srmist.edu.in |