# National Institute of Technology Agartala

# Department of Chemistry

## Curricula and Syllabi

for

## *BS MS Dual Degree Course in Chemistry*

**July-2019**

# First Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-I | DSCY21B01 | 3 | 1 | 0 | 4 |
| 2 | Physics-I | DSPH11B01 | 3 | 1 | 0 | 4 |
| 3 | Mathematics-I | DSMA31B01 | 3 | 1 | 0 | 4 |
| 4 | Language and Technical Writing | DSHU41B01 | 3 | 0 | 0 | 3 |
| 5 | Chemistry Laboratory-I | DSCY21P01 | 0 | 0 | 3 | 2 |
| 6 | Physics Laboratory-I | DSPH11P01 | 0 | 0 | 3 | 2 |
| **Total** | | | 12 | 3 | 6 | 19 |
| **Total contact hrs per week = 21** | | | **Total credit = 19** | | | |

# Second Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-II | DSCY22B02 | 3 | 1 | 0 | 4 |
| 2 | Basic Environmental and Atmospheric Science | DSCY22B03 | 3 | 0 | 0 | 3 |
| 3 | Physics-II | DSPH12B02 | 3 | 1 | 0 | 4 |
| 4 | Mathematics-II | DSMA32B02 | 3 | 1 | 0 | 4 |
| 5 | Chemistry Laboratory-II | DSCY22P02 | 0 | 0 | 3 | 2 |
| 6 | Physics Laboratory-II | DSPH12P02 | 0 | 0 | 3 | 2 |
| **Total** | | | 12 | 3 | 6 | 19 |
| **Total contact hrs per week = 21** | | | **Total credit = 19** | | | |

# Third Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-III | DSCY23B04 | 3 | 1 | 0 | 4 |
| 2 | General Chemistry-IV | DSCY23B05 | 3 | 1 | 0 | 4 |
| 3 | Physics-III Waves & Oscillations | DSPH13B10 | 3 | 0 | 0 | 3 |
| 4 | Computer Programming | DSMA33B06 | 2 | 0 | 0 | 2 |
| 5 | Computer Programming Lab | DSMA33P01 | 0 | 0 | 3 | 2 |
| 6 | Inorganic Chemistry Laboratory | DSCY23P05 | 0 | 0 | 9 | 6 |
| **Total** | | | 11 | 2 | 12 | 21 |
| **Total contact hrs per week = 25** | | | **Total credit = 21** | | | |

# Fourth Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-V | DSCY24B07 | 3 | 1 | 0 | 4 |
| 2 | General Chemistry-VI | DSCY24B08 | 3 | 1 | 0 | 4 |
| 3 | General Chemistry-VII | DSCY24B09 | 3 | 1 | 0 | 4 |
| 4 | Mathematics-III | DSCY24E01 | 3 | 1 | 0 | 4 |
| 5 | Organic Chemistry Laboratory | DSCY24P05 | 0 | 0 | 9 | 6 |
| **Total** | | | 12 | 4 | 9 | 22 |
| **Total contact hrs per week = 25** | | | **Total credit = 22** | | | |

## Fifth Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-VIII | DSCY25B10 | 3 | 0 | 0 | 3 |
| 2 | General Chemistry-IX | DSCY25B11 | 3 | 0 | 0 | 3 |
| 3 | General Chemistry-X | DSCY25B12 | 3 | 0 | 0 | 3 |
| 4 | Electrochemistry | DSCY25B13 | 3 | 0 | 0 | 3 |
| 5 | Physical Chemistry Laboratory | DSCY25P08 | 0 | 0 | 9 | 6 |
| 6 | Materials Chemistry Laboratory | DSCY25P09 | 0 | 0 | 3 | 2 |
| **Total** | | | 12 | 0 | 12 | 20 |
| **Total contact hrs per week = 24** | | | **Total credit = 20** | | | |

## Sixth Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-XI | DSCY26B14 | 3 | 0 | 0 | 3 |
| 2 | General Chemistry-XII | DSCY26B15 | 3 | 0 | 0 | 3 |
| 3 | General Chemistry-XIII | DSCY26B16 | 3 | 0 | 0 | 3 |
| 4 | Molecular Spectroscopy | DSCY26B17 | 3 | 0 | 0 | 3 |
| 5 | Advanced Inorganic Chemistry Laboratory | DSCY26P09 | 0 | 0 | 9 | 6 |
| **Total** | | | 12 | 0 | 9 | 18 |
| **Total contact hrs per week = 21** | | | **Total credit = 18** | | | |

## Seventh Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | General Chemistry-XIV | DSCY27B18 | 3 | 0 | 0 | 3 |
| 2 | General Chemistry-XV | DSCY27B19 | 3 | 0 | 0 | 3 |
| 3 | General Chemistry-XVI | DSCY27B20 | 3 | 0 | 0 | 3 |
| 4 | Instrumental Methods of Analysis | DSCY27B21 | 3 | 0 | 0 | 3 |
| 5 | Advanced Organic Chemistry Laboratory | DSCY27P10 | 0 | 0 | 9 | 6 |
| **Total** | | | 12 | 0 | 9 | 18 |
| **Total contact hrs per week = 21** | | | **Total credit = 18** | | | |

## Eighth Semester

| S.N. | Course Name | Code | Teaching hrs/week | | | Credit |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | Chemistry of Nanomaterials | DSCY28B22 | 3 | 0 | 0 | 3 |
| 2 | Elective-I | * | 3 | 0 | 0 | 3 |
| 3 | Elective-II | * | 3 | 0 | 0 | 3 |
| 4 | Elective-III | * | 3 | 0 | 0 | 3 |
| 5 | Advanced Physical Chemistry Laboratory | DSCY28P11 | 0 | 0 | 9 | 6 |
| 6 | Molecular Modeling Laboratory | DSCY28P12 | 0 | 0 | 6 | 4 |
| **Total** | | | 12 | 0 | 15 | 22 |
| **Total contact hrs per week = 27** | | | **Total credit = 22** | | | |

## *Eighth Semester Electives

**(To opt for any three courses from below)**

| ***S.N.*** | ***Course Name*** | ***Code*** |
|---|---|---|
| 1 | Solid State and Industrial Chemistry | DSCY28E07 |
| 2 | Advanced Organometallics and Supramolecular Chemistry | DSCY28E08 |
| 3 | Art in Organic Synthesis | DSCY28E04 |
| 4 | Organic Spectroscopy | DSCY28E09 |
| 5 | Principles and Applications of Fluorescence Spectroscopy | DSCY28E10 |
| 6 | Advanced Quantum Chemistry | DSCY28E11 |

## Ninth Semester

| ***S.N.*** | ***Course Name*** | ***Code*** | ***Teaching hrs/week*** | | | ***Credit*** |
|---|---|---|---|---|---|---|
| | | | ***L*** | ***T*** | ***P*** | |
| 1 | Elective-IV | # | 3 | 0 | 0 | 3 |
| 2 | Elective-V | # | 3 | 0 | 0 | 3 |
| 3 | Elective-VI | # | 3 | 0 | 0 | 3 |
| 4 | Project Work | DSCY29P12 | 0 | 0 | 15 | 10 |
| **Total** | | | 9 | | 15 | 19 |
| **Total contact hrs per week = 24** | | | **Total credit = 19** | | | |

## #Ninth Semester Electives

**(To opt for any three courses from below)**

| ***S.N.*** | ***Course Name*** | ***Code*** |
|---|---|---|
| 1 | Chemistry of Late Transition and f-Block Elements | DSCY29E10 |
| 2 | Advanced Bioinorganic Chemistry and Inorganic Molecular Spectroscopy | DSCY29E16 |
| 3 | Natural Products | DSCY29E14 |
| 4 | Heterocyclic Chemistry | DSCY29E15 |
| 5 | Molecular Spectroscopy in Chemistry | DSCY29E17 |
| 6 | Statistical Mechanics and Non-Equilibrium Thermodynamics | DSCY29E18 |

## Tenth Semester

| ***S.N.*** | ***Course Name*** | ***Code*** | ***Teaching hrs/week*** | | | ***Credit*** |
|---|---|---|---|---|---|---|
| | | | ***L*** | ***T*** | ***P*** | |
| 1 | Project-Dissertation | DSCY210P13 | 0 | 0 | 40 | 20 |
| **Total** | | | | | 40 | 20 |
| **Total contact hrs per week = 40** | | | **Total credit = 20** | | | |

# *First Semester*

**Course: General Chemistry-I** **Code: DSCY21B01**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of Chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to synthesize new compounds based on the elemental properties by utilizing knowledge of chemistry. |
| **PSO-2** | Successfully apply their knowledge to develop chemical compounds used for chelation therapy which have been learned as a part of this course. |
| **PSO-3** | Develop new synthetic rout for organic molecules and their impact in our society. |

## Course Objective

1. Objectives of inclusion of atomic structure is to give information to the students about the structure of atoms, electronic configuration, theoretical knowledge of atomic spectra and the ideas about the orbitals.
2. Periodic properties of elements and their general trends (eg.,atomic and ionic radii, ionization potential, electron affinity and electronegativity etc.) can be studied.
3. From coordination chemistry students may learn about complex compounds, their geometry, magnetic property, isomerism etc.
4. Basic knowledge of organic molecules, their reactions, bond formation, physical effects etc. can be studied.

## Course Content

**1) Atomic structure (15 L):**

Rutherford's model for atom, Bohr's model, Bohr's orbit, radii, energy, ionization potential, atomic spectra and atomic number; hydrogen atom: spectra, Balmer formula, Rydberg formula, Bohr's interpretation of atomic spectra, Bohr's correspondence principle, Moseley's experiment, fine structure of spectra and Somerfield's new energy states, Zeeman effect: magnetic quantum number, vector model of atom, quantum numbers, Pauli exclusion principle, Hund's rule for atomic spectra, Aufbau principle, coupling scheme and atomic states in the vector model, qualitative description of s-, p-, and d-orbitals, electronic configuration for many electron system, nature of bonding: covalent and ionic bonds.

**2) Periodic Table and Properties of Elements (12L):**

Long periodic table, extended periodic table: classification of elements: s-, p-, d- , and f-block elements, post actinides and super actinides, important properties of elements and their periodic trends: atomic and ionic radii, ionization potential, electron affinity and electronegativity, different electronegativity scales, screening effect, effective nuclear charge, Slater's rules, inert pair effect, melting points; boiling points; diagonal relationship.

**3) Coordination Chemistry-I (8L):**

Addition compounds: double salts and complex salts; Werner's theory; ligands and denticity, classification of ligands, pi-acidic ligands, macrocyclic ligands, chelates, chelate effects, chelation therapy, supercomplex, geometry, coordination number; IUPAC nomenclatures; isomerism: structural and stereoisomerism: geometrical and optical, facial amdmeridional isomers, chirality.

**4) Basic Organic Chemistry (10 L):**

Different classes of organic molecules and their mechanistic classification: ionic, radical and pericyclic reactions; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; nomenclature; IUPAC; physical effects; electronic displacements: inductive effect, electromeric effect, resonance and hyperconjugation; nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions, free radicals, carbenes and arenes.

## Course Outcome

| | |
|---|---|
| **CO-1** | Studying atomic structure students can gather knowledge about the structure of atoms, electronic configuration of multi electronic system, atomic spectra and different types of atomic orbitals. |
| **CO-2** | Students will understand the physical properties of elements (eg.,atomic and ionic radii, ionization potential, electron affinity and electronegativity etc.) and their periodic trends. |
| **CO-3** | Coordination chemistry will give information to the students about different types of ligands, complex compounds, their geometry, magnetic property, isomerism etc. |
| **CO-4** | Students will acquire knowledge about the organic molecules, their reaction mechanisms, bond formation and different physical effects etc. |

**Reference Books:**

**1.** J. D. Lee, Concise Inorganic Chemistry, 4th Ed., ELBS, 1991.
**2.** G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson, Delhi, india.
**3.** R. L. Dutta, Elementary Inorganic Chemistry, 5th Ed. The New Book Stall, Calcutta.
**4.** R. Sarkar, General Chemistry Part-I and Part-II, New Central Book Agency (P) Ltd.
**5.** A. K. Das, Fundamental Concepts of Inorganic Chemistry Part-I and Part-II, CBS Publishers & Distributors, New Delhi.
**7.** J. H. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principle of structure and reactivity, 4th Ed., Pearson, New Delhi.
**8.** Shriver & Atkins, Inorganic Chemistry, 4th Ed., Oxford University Press, Delhi
**9.** T. W. Graham Solomon, C. B. Fryhle, Organic Chemistry, John-Wiley and Sons.
**10.** J. March, Advanced Organic Chemistry: Reactions Mechanism and Structure John-Wiley and Sons
**11.** R. T. Morrison and R. N Boyd, 'Organic Chemistry', Prentice Hall.
**12.** Peter Sykes, 'A guide Book to Mechanism in Organic Chemistry,' Longman

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | - | 2 | - | - | - | - | - | - | - | - | - | - | 3 | - | - |
| CO-2 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | 3 | - |
| CO-3 | - | 2 | - | - | - | 3 | - | - | - | - | - | - | 2 | 2 | - |
| CO-4 | - | 2 | - | - | - | - | 3- | - | - | - | - | - | 2 | 3 | - |

**To establish the correlation between COs & PSOs**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | - | - | - |
| CO-2 | 3 | - | - |
| CO-3 | - | 3 | - |
| CO-4 | - | - | 3 |

**Course: Chemistry Laboratory-I** **Code: DSCY21P01**
**L-T-P: 0-0-3** **Credit: 2**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Learn the fundamental application of chemistry to set up modern experimental techniques. |
| **PEO-2** | Acquisition of skills to tackle the plant operations and process control instrumentation in an efficient manner. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Achieve confidence in handling chemicals, glassware and instruments professionally in chemical industries and develop the modern laboratory techniques. |
| **PSO-2** | Successfully apply their practical experience to determine analytical estimation of materials applicable in our daily life. |

## Course Objective

**1.** To develop the practical skill in chemistry lab, which includes activities such as handling of reagents, calibration of equipment, preparation of solutions, etc.

**2.** To understand the principles of volumetric/titrimetric analysis and procedure for preparation of standard and other solutions.

**3.** To get exposure to various analytical techniques in chemistry.

## Course Content

**1)** Preparation of primary standard solution (oxalic acid, $K_2Cr_2O_7$).

**2)** Standardization of secondary standard solution (NaOH, HCl, $KMnO_4$) against a primary standard solution.

**3)** Preparation of NaOH solution and its standardization using standard oxalic acid solution.

**4)** Standardization of hypo solution using standard potassium dichromate solution.

**5)** Determination of total hardness of supplied water sample by complexometric titration method using EDTA as a titre and EBT as indicator.

**6)** Determination of $Fe^{2+}$ ion from the given Mohr's salt solution by titrating against potassium dichromate ($K_2Cr_2O_7$) solution and using diphenylamine as an indicator.

**7)** Preparation of benzilic acid in solid state under solvent-free condition.

**8)** Estimate the amount of acetic acid in commercial vinegar using standard NaOH solution as titrant and phenolphthalein as an indicator.

**9)** Determination of total alkalinity (carbonate and bicarbonate ions) of a supplied water sample using phenolphthalein as an indicator.

**10)** Determination of alkali content in a given antacid tablet using standard HCl solution.

## Course Outcome

| | |
|---|---|
| **CO-1** | Coverage of basic experiments illustrating the principles in chemistry relevant to the study of science and engineering. |
| **CO-2** | Acquisition of skills in measuring, weighing, transferring chemicals, taking readings, while minimizing errors, etc. |
| **CO-3** | Develop the ability to test and generate soft water for domestic and industrial purposes. |

**Reference Books:**

**1.** S. Chawla, Essentials of Experimental Engineering Chemistry, Dhanpat Rai & Co., 3rd Edition, 2010.
**2.** A. I. Vogel, G. H. Jeffery, Vogel's Text Book of Quantitative Chemical Analysis, Longman Scientific & Technical, 5th Edition, 1989.
**3.** A. J. Elias, A Collection of Interesting General Chemistry Experiments, Universities Press, 2002.
**4.** A. K. Nad, B. Mahapatra and A. Ghoshal; An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd, 3rd Edition, 2011.

## Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | - | - | 3 | - | - | - | - | - | - | - |
| CO-2 | - | 2 | - | - | - | - | - | - | - | - | - | - |
| CO-3 | - | - | 2 | - | - | - | - | - | - | - | 2 | - |

## To establish the correlation between COs & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| CO-1 | 4 | - |
| CO-2 | - | 3 |
| CO-3 | 4 | - |

# *Second Semester*

**Course: General Chemistry-II** **Code: DSCY22B02**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of inorganic (nature of bonding) and physical (gaseous and liquid states, thermodynamic properties, reaction kinetics) chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge elsewhere relating with the practical implication of the subject in everyday life. |
| **PSO-2** | Successfully apply the principles of chemical bonding, laws of thermodynamics, and others, in different engineering disciplines, which have been learned as a part of this course. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Chemical bonding deals with the nature of chemical bonds present in chemical compounds. The topic will cover the bonding, structure and hybridization of chemical compounds and also the theoretical treatment of molecular structure determination**.**
**2.** To introduce to the students the role of hydrogen bonding which determines several physical properties of substances.
**3.** Studying this course the students will learn about the nature and behaviour of gaseous and liquid substances under different conditions.
**4.** The concept of thermodynamics is applicable almost everywhere, not just in our everyday life, but from academic point of view in understanding many intricate problems in engineering and science disciplines.
**5.** The topic chemical kinetics will make the student aware of the importance of reaction rates, mechanisms of reactions that dictate many complex chemical and biochemical reactions.
**6.** All in all, the course will give students relevant knowledge on formation of inorganic chemical compounds, the laws of physical phenomena which guide many chemical processes, to understanding behaviour of substances in their liquid or gaseous states.

## Course Content

**1) Chemical Bonding and Structure-I (10 L):**
Introduction to chemical bonding, ionic compounds: lattice energy: calculation and implications, solvation energy, Born-Haber cycle and its applications, Fajan's rules and its applications Covalent compounds: sigma and pi-bonds, hybridization, Bent's rule of hybridization, resonance, dipole moment, geometry: Qualitative description of VBT and MOT (diatomic homo and heteronuclear molecules), VSEPR theory, hydrogen bonding, hydrogen bridge bond, delta-bond, metal-metal bond.

**2) Gaseous and Liquid States (10 L):**
Gaseous state: gas laws, kinetic theory of gases, derivation of gas laws from kinetic theory; Maxwell's theory of velocity distribution; mean free path; viscosity of gases; real gases; van

der Waal's equation of state and its consequences; virial coefficients and equation of state. Liquid state: physical properties of liquids and their measurements; surface tension and viscosity. Numerical problems.

**3) Thermodynamics-I (15 L):**
Definitions: systems (open, closed and isolated) and surroundings, state of a system, state function, state variables, path function; intensive and extensive properties; thermodynamic processes: cyclic, reversible, irreversible, isothermal, adiabatic, isochoric, isobaric; concept of heat, work, energy, internal energy; thermal equilibrium and Zeroth law of thermodynamics; graphical explanation of work done during expansion and compression of an ideal gas; first law of thermodynamics; concept of enthalpy; Carnot's cycle; heat change at constant volume and constant pressure; relation between $C_p$ & $C_v$ using ideal gas and real gas equations; thermochemistry and Hess law; second law of thermodynamics; concept of entropy; Helmholtz free energy; Gibb's free energy; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Kirchhoff's equation; Maxwell's relations; Clausius-Clapeyron equation; Trouton's rule; Joule-Thomson coefficient: liquefaction of gases; third law and concept of residual entropy. Numerical problems.

**4) Chemical Kinetics and Chemical Equilibrium (10 L):**
Order and molecularity of a reaction; rate laws and rate equation for first order, second order, and zeroth order reactions; determination of order of reactions; energy of activation; catalytic reactions: general characteristics, homogeneous and heterogeneous reactions, enzyme catalyzed and auto catalyzed reactions: Michelis-Menten equation; law of mass action; equilibrium constants and their relations; reaction isotherms; reaction isochore; Le Chatelier's principle; ionic equilibria in solution, solubility product, common ion effect, salt hydrolysis, pH, buffer and their applications. Numerical problems.

## Course Outcome

| | |
|---|---|
| **CO-1** | To predict the structure-property relationship in different substances and engineering materials using the knowledge of chemical bonding. |
| **CO-2** | Draw the relationship between hydrogen bonding and associated physical properties, which is so relevant in our life. |
| **CO-3** | Develop the concept of thermodynamics from the very basics which will be useful in understanding advanced subjects in science and engineering and for its practical applications. |
| **CO-4** | Knowledge of thermodynamics and kinetics may help students think in the direction of contemporary environmental issues and ways to mitigate them. |
| **CO-5** | Relate the concepts of inorganic and physical chemistry to solving many pressing issues such as water purification, air pollution, among others. |
| **CO-6** | Get an idea about the applications of the physical laws of substances in gaseous and liquid states. |

**Reference Books:**


1. Concise Inorganic Chemistry, J. D. Lee, 4th Edn., ELBS, 1991.
2. Elementary Inorganic Chemistry, R. L. Dutta, 5th Edn., The New Book Stall, Calcutta.
3. General Chemistry Part-I and Part-II, R. Sarkar, New Central Book Agency (P) Ltd.
4. Fundamental Concepts of Inorganic Chemistry, Part-I and Part-II, A. K. Das, CBS Publishers & Distributors, New Delhi.
5. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, 47th Edn., Vishal Publishing Co., 2017.
6. Physical Chemistry G. M. Barrow, 6th Revised Edn. Tata McGraw-Hill, New Delhi, 1996.
7. Physical Chemistry, P. W. Atkins, 7th Edn. Oxford University Press, 2006.
8. Physical Chemistry G. W. Castellan, 4th Edn., Narosa, 2004.


## <u>Mapping with the POs/ PEOs: Matrix formation for attainments</u>

**1: Slight ( low)  2: Moderate (Medium)  3: Substantial (High) and for No Correlation “-“**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5** | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| **CO-6** | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

## <u>To establish the correlation between COs & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation “-“**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | - | 4 | - |
| **CO-2** | - | - | 3 |
| **CO-3** | 4 | - | - |
| **CO-4** | - | - | 2 |
| **CO-5** | 2 | - | - |
| **CO-6** | - | - | - |

**Course: Basic Environmental and Atmospheric Science Code: DSCY22B03**
**L-T-P: 3-0-0 Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | To acquire the fundamental principles of environmental chemistry with modern experimental and theoretical teaching skills. |
| **PEO-2** | Students will be able to analyse the problems in environmental analysis of pollutants in the context of practical significance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | To enhance their knowledge in environmental chemistry along with scientific facts through systematic education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop a scheme for water purification by utilizing the knowledge of chemistry. |
| **PSO-2** | Introduce environmental analysis of elements and to relate with the purification of gases in industry. |
| **PSO-3** | Evaluate the energy minimisation using green chemistry along with environment related issues in our society. |

## Course Objective

**1.** To introduce the importance of protecting our environment, concept of sustainable development and ecosystem.
**2.** To propagate the idea of environmental biodiversity and conservatism.
**3.** This course aims to establish a sound understanding of chemistry of the biosphere and the impact of natural and human induced events on local and global environments.
**4.** Upon completion of the course students will have depth knowledge and critical undrstanding of the theory and principle of biodiversity and the interrelationship of its levels with the basic effects from infrastructure development in nature conservation areas.
**5.** Students will learn the technical and analytical skills to quantify the level and effects of pollutant in environmental compartments (air, water, soil)
**6.** To introduce the idea of national and international standard for monitoring air quality,

## Course Content

**1) Introduction to Enviromental Sciences (10 L):**

**Introduction to the environment:** acquisition, transformation and utilization of energy, the geochemical, bio-geochemical and hydrological cycles, Concept of eco system.

**Biodiversity:** problems and issues in biodiversity and forestry, conservation and utilization of biodiversity, global warming and climate change. Recent records of climate change, impact of climate change on Indian environment. Major to cope with climate change.

Mineral and energy resources, Impact of mining and other human activities on the environment, Environmental impact assessment and environmental audit and introduction, Environmental policy matter and law.

**2) Green Chemistry (10 L):**

What is it?; need for green chemistry; inception and evolution of green chemistry; twelve principles of green chemistry with their explanations and examples; designing a green synthesis using these principles; green chemistry in day to day life.

**3) Environmental Pollution and Health (25 L):**

**Air pollution:** composition of pollutants and sources, disease associated with their pollutants, air quality monitoring, national and international standard for monitoring air quality, quality of indoor air and its effect on health, ventilation standards, methods and health hazards, analysis of gasses effluents $SO_2$, $NO_x$, $CO_2$ etc.

**Water Pollution:** Sources and types of water pollutants, ground water and surface water pollution, sampling and analysis and measurement of water, water quality standards, effects on aquatic echo system, heavy metal (arsenic, cadmium, lead, mercury, chloride, nitrate) analysis with respect to health significance. Diseases related to these pollutants, measurement of DO, BOD, COD.

**Soil Pollution:** Introduction, major root of soil pollution, some important pollutant in soil, diseases related to soil pollution.

## Course Outcome

| | |
|---|---|
| **CO-1** | To analyze the possible effects of the natural environment on the biodiversity element and also to propose measure to minimize the consequences with the priority given to the conservation of the national species, habitats and areas. |
| **CO-2** | It will help to develop solutions to a variety of chemical problems in identifying and analysing air pollutant from an analytical context. |
| **CO-3** | To apply successfully the principles of green chemistry for construction of eco-friendly and efficient products. |
| **CO-4** | Students can apply their knowledge of green chemistry for industrial waste treatment and management. |
| **CO-5** | To synthesize product using green methodology and apply this concepts to protect environment. |
| **CO-6** | Students will develop the Knowledge, skills and interactions between the ecosystem structure and their human impacts from one side with the sustanible management aiming at the conservation of species and habitats. |

**Reference Books:**

**1.** *Environmental Chemistry, 5th Edition,* 2005, De. A. K., New Age International Pvt. Ltd. New Delhi.

**2.** *Environmental Chemistry with Green Chemistry*, A. K. Das, Books and Allied Pvt. Ltd.

**3.** *A Textbook in Environmental Science*, Subramanian .V, 2002, Narosa Publishing House, New Delhi.

**4.** *Environmental Science, 8th Edition*, Wright R.T. and Nebel P.J. 2004, Prentice Hall India. Pvt. Ltd.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | | **2** | | **2** | **-** | **-** | **3** | **-** | **-** | **-** | **-** | **-** | **1** | **-2** | **-2** |
| **CO-2** | **-** | **2** | | **-** | **-** | **-** | **-2** | **-** | **-** | **-** | **-** | **-** | **1** | **-2** | **-2** |
| **CO-3** | **-** | **-2** | **-** | **-** | **-** | **-** | **3** | **-** | **-** | **-** | **-** | **-** | **2** | **-1** | **-2** |
| **CO-4** | **-** | **-2** | **-** | **-** | **-** | **2** | **3** | **-** | **-** | **-** | **-** | **-** | **-1** | **-** | **1** |
| **CO-5** | **-** | **2** | **2** | **-** | **-** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-2** | **2** | **-1** |
| **CO-6** | **-** | **-2** | | **-** | **1** | **-** | **2** | **-** | **-** | **-** | **-** | | **-** | **2** | **-1** |

**To establish the correlation between Cos & PSOs**

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

Table 2

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | **3** | **-** | **-** |
| **CO-2** | **-1** | **3** | **-** |
| **CO-3** | | **-2** | **-1** |
| **CO-4** | **-2** | **-** | **2** |
| **CO-5** | **2** | | **-** |
| **CO-6** | **-** | **3** | **-1** |

**Course: Chemistry Laboratory-II** **Code: DSCY22P02**
**L-T-P: 0-0-3** **Credit: 2**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Learn the fundamental application of chemistry to set up modern experimental techniques. |
| **PEO-2** | Attainment of laboratory management skills to tackle the plant operations and process control instrumentation in an efficient manner. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | To have hands-on experience on the basic principles involved in the preparation of organic compounds and qualitative identification of functional groups in their compounds. |
| **PSO-2** | Experiments are designed to deal with a pre-defined area of knowledge and also to assist students in learning a set of vital concepts, skills, ideas and techniques. |

## Course Objective

**1.** This course enables to understand the basic concepts in systematic methods of functional group detection in organic compounds.
**2.** To know the techniques of preparing different chemical compounds (organic/inorganic/ nanoparticle) with wide applications.
**3.** To have exposure to procedures for measuring physical properties of liquids.

## Course Content

**1)** Determination of non nitrogenous functional group of a supplied known organic compound.
**2)** Determination of non nitrogenous functional group of a supplied unknown organic compound.
**3)** Determination of nitrogenous functional group of a supplied known organic compound.
**4)** Determination of nitrogenous functional group of a supplied unknown organic compound.
**5)** Preparation of benzamide from benzoyl chloride.
**6)** Preparation of complex hexamine cobalt (III) chloride $[Co(NH_3)_6]Cl_3$
**7)** Synthesis of cuprous oxide (CuO) nanoparticle having variable color.
**8)** Determination of viscosity coefficient of a supplied solution using Ostwald viscometer.
**9)** Determination of surface tension of a supplied liquid using stalagmometer.
**10)** Estimation of copper from a cupric salt ($CuSO_4.5H_2O$) solution.

## Course Outcome

| | |
|---|---|
| **CO-1** | Acquisition of skills in measuring, weighing, transferring chemicals, taking readings etc., and understand safety related information. |
| **CO-2** | Comprehend idea about the synthesis and applications of chemical compounds. |
| **CO-3** | Confidence in handling chemical processes employed for scientific or technical purposes. |

**Reference Books:**


**1.** S. Chawla, Essentials of Experimental Engineering Chemistry, Dhanpat Rai & Co., 3rd Edition, 2010.

**2.** A. I. Vogel, G. H. Jeffery, Vogel's Text Book of Quantitative Chemical Analysis, Published by Longman Scientific & Technical, 5th Edition, 1989.

**3.** A. J. Elias, A Collection of Interesting General Chemistry Experiments, Universities Press, 2002.

**4.** A. K. Nad, B. Mahapatra and A. Ghoshal; An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd, 3rd Edition, 2011.


**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | - | - | 3 | - | - | - | - | - | - | - |
| CO-2 | - | - | - | 2 | - | - | - | - | - | - | - | - |
| CO-3 | - | - | 2 | - | - | - | - | - | - | - | 2 | - |

**To establish the correlation between COs & PSOs**

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "- "**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| CO-1 | 4 | - |
| CO-2 | 3 | - |
| CO-3 | - | 4 |

# *Third Semester*

**Course: General Chemistry-III** **Code: DSCY23B04**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of Chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to synthesize industrial chemical compounds and their uses for the benefit of society. |
| **PSO-2** | Successfully apply their knowledge to produce gaseous fuel as alternative energy source and their uses for pollution free atmosphere. |
| **PSO-3** | Identification of compounds and their symmetry operations for the theoretical treatment as a part of solid state chemistry can be understood. |

## Course Objective

1. Compounds of metal and non-metal and their uses as catalyst in industry and engineering have been included for beneficiary of engineering students.
2. Synthesis of aliphatic and aromatic hydrocarbons by different chemical reactions can be understood. Mechanism of organic reactions also included to make the topic interesting for the students.
3. Symmetry operations of elements, their optical activity, nomenclature and isomerism have been included which will give the students idea about the molecular dimension and symmetry operation of molecules.

## Course Content

**1) Chemistry of Main Group Elements (20 L):**

**Group 1 (1A):** Alkali metals and their ions and compounds, their solutions in liquid ammonia and other solvents, hydrides, oxides, peroxides, superoxides, oxy-acids, organometallics, complexes with crown ethers and cryptants,

**Group 2 (IIA):** Alkaline earth metals and their ions, different compounds: halides, hydrides, oxides, oxoacid salts, complexes of beryllium, magnesium and calcium with varieties of ligands, Grignard reagents and its applications.

**Group-13 (IIIA):** Elements, hydrides, diborane, higher boranes and carboranes, reactions of boranes, halides, oxides, salts of oxy-acids, nitrides, boron nitride, borazine, complexes, organometallics, Zieglar-Natta catalyst.

**Elements of Group 14 (IVA):** Allotropes, carbides, hydrides, silanes, alkanes, halides, freons and its detrimental effects in environment, oxides and oxy-acids, carbonyl as a ligand, nickel carbonyls, iron carbonyls, carbon dioxide as a green house gas, silicates, zeolites, cement, glass, ceramics, organometallics, chemistry of Fullerenes.

**Elements of Group 15 (VA):** Dinitrogen, hydrides, hydrazine, halides, oxides, oxy-acids and their salts, role of phosphate esters in biological processes, phosphazene, inorganic rubber, complexes and organometallics

**Elements of Group 16 (VIA):** Dioxygen, ozone, hydrides, hydrogen peroxide, oxides, oxides of other elements, air pollution by sulpher oxides, oxy-acids and their salts, halides, oxohalides, sulphur-nitrogen compounds, complexes of oxygen and sulphur,

**Chemistry of Halogens and Nobel Gases:** Colour of halogens in gaseous and solution states, hydrogen halides, HF as a solvent, halide ions as ligands, oxides, interhalogencompounds, polyhalides, pseudohalogens; fluorides of xenon and their structure and bonding, xenon oxofluorides, xenon oxides, chemistry of krypton and radon.

**2) Acyclic and Cyclic Hydrocarbons (15 L):**
Alkanes**:** Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Alkyl Halides: Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Williamson's ether synthesis: Elimination vs substitution. Cycloalkanes and its derivatives: Reactions. Alkenes (including dienes)**:** Preparation and reactions: Dehydration of alcohols and dehydro halogenation of alkyl halides (Saytzeff's rule and Hoffmann's rule); cis-alkenes (Partial catalytic hydrogenation of alkynes) and trans-alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration - demercuration, Hydroboration-oxidation. Alkynes: Preparation and Reactions. Aromatic hydrocarbons: Aromaticity, Huckels rule, Structure and reactions of benzene; Electrophilic substitution: nitration, halogenation and sulphonation. Friedel- Craft's reaction (alkylation and acylation).Aryl Halides: Preparations and reactions. Sandmeyer&Gattermann reactions; Benzyne mechanism.

**3) Basic stereochemistry (10 L):**
Elements of symmetry: simple axis, plane of symmetry, center of symmetry, alternate axis of symmetry, chirality, optical activity, specific rotation, optical purity. Configuration: Types of isomerism. Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). D and L; cis - trans nomenclature.

## Course Outcome

| | |
|---|---|
| **CO-1** | Studying the topic students will gather knowledge about the synthesis and applications of industrial chemical compounds and their application. |
| **CO-2** | Knowledge about the synthesis of gaseous fuels and their application as green fuel can be acquired. |
| **CO-3** | Students can get idea about the symmetric properties of chemical compounds. |

**Reference Books:**


1. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson, Delhi, India.
2. R. L. Dutta, Inorganic Chemistry Part-II, The New Book Stall. Calcutta
3. R. Sarkar, General Chemistry Part-I and Part-II, New Central Book Agency (P) Ltd.
4. J. H. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principle of structure and reactivity, 4th Ed., Pearson, New Delhi.
5. Shriver & Atkins, Inorganic Chemistry, 4thEd., Oxford University Press, Delhi
6. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced InorganicChemistry, 6th Edition, Wiley India (P.) Ltd., New Delhi.
7. Finar I. L., 'Organic Chemistry' volume 1, Longman, London.
8. R. T. Morrison and R. N Boyd, 'Organic Chemistry', Prentice Hall.
9. J. March, Advanced Organic Chemistry: Reactions Mechanism and Structure John-Wiley and Sons.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | - | - | 3 | 2 | - | - | - | - | - | - | - | - | 3 | 3 | - |
| CO-2 | - | 2 | 3 | - | - | - | 3 | - | - | - | - | - | 2 | 3 | - |
| CO-3 | - | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - | - |

**To establish the correlation between COs & PSOs**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 4 | 4 | - |
| CO-2 | 4 | 4 | - |
| CO-3 | - | - | 2 |

**Course: General Chemistry-IV** **Code: DSCY23B05**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Acquire the basic knowledge of organic chemistry, which is the backbone of the chemistry of natural products and medicinal chemistry that they will learn in their advanced organic chemistry courses. |
| **PSO-2** | Understand the concept of colligative properties which is one of the important properties that determine many other properties of solutions. |
| **PSO-3** | Apply their knowledge of the subject to practical problems in chemistry and other applications relevant to our day to day life. |

## Course Objective

**1.** This course will cover general methods of preparation, properties, and reactions of organic compounds containing oxygen atom.

**2.** The course will focus on general methods of preparation, properties, and reactions of nitrogen containing organic compounds.

**3.** The topics heterocyclic and organometallic compounds will involve the study of synthesis, properties and reactivity of such compounds.

**4.** In the topic colligative properties, the students will learn about such properties of solutions that depend on the number of solute particles rather than what their nature is like.

**5.** The course is designed to prepare the students to be able to apply their theory concepts to practical laboratory courses.

**6.** All in all the course is meant for students to relate the relevance of the topics in daily life.

## Course Content

**1) Chemistry of Oxygen Containing Organic Compounds (15 L):**

Alcohols: Preparation of 1º, 2º and 3º alcohols. Reactions: with sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. $HNO_3$). Oppeneauer oxidation, diols: oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: preparation: cumene hydroperoxide method, from diazonium salts. Reactions: electrophilic substitution: nitration, halogenation and sulphonation. Reimer–Tiemann reaction, Gattermann-Koch reaction, Houben–Hoesch condensation, Schotten–Baumann reaction. Ethers (aliphatic and aromatic): Korey synthesis, cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): preparation and reactions: iodoform test. Aldol condensation, Claisen condensation, Cannizzaro's reaction, Wittig reaction, benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff-Verley reduction. Carboxylic acids and their derivatives (acid chlorides, anhydrides, esters), preparation and reactions, Hell–Vohlard–Zelinsky reaction, Reformatsky reaction, Perkin condensation.

**2) Chemistry of Nitrogen Containing Organic Compounds (10 L):**
Amines (aliphatic and aromatic): structure and nomenclature; preparation and reactions: Hofmann vs Saytzeff elimination, carbylamine test, Hinsberg test, Schotten–Baumann reaction. Electrophilic substitution: nitration, bromination, sulphonation. Nitroalkanes and nitroarenes: Structure and nomenclature, preparation and reactions. Nitriles and isonitriles: Structure and nomenclature, preparation and chemical reactions. Diazomethane, diazoacetic ester and urea: structure, preparation and reactions. Diazonium salts: preparation and reactions.

**3) Heterocyclics and Grignard reagents (10 L):**
Introduction, structure and nomenclature. Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline. Organometallics: preparation of Grignard reagent and organo lithium. Reactions: addition of Grignard and organo lithium reagents to carbonyl compounds, acids, esters, acid chlorides etc. Limitations of Grignard reagents.

**4) Colligative Properties (10 L):**
Colligative property: What is it? Relative lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, measurements of colligative properties. Laws of osmotic pressure. Abnormal colligative property, van't Hoff factor, inter relation between colligative properties. Thermodynamic properties of colligative properties.

## Course Outcome

| | |
|---|---|
| **CO-1** | Be able to learn methods of preparation, properties, and reactions of organic compounds containing oxygen atom such as alcohols, aldehydes, ethers, etc. |
| **CO-2** | Be able to know about the methods of preparation, properties, and reactions of typical nitrogen containing organic compounds like amines, nitriles, etc. |
| **CO-3** | The topics heterocyclic and organometallic compounds will develop insight on the synthesis, properties and reactivity of important above mentioned compounds. |
| **CO-4** | Learn important concepts pertaining to properties of solutions, like boiling points, freezing points, osmotic pressure, etc, which depend invariably on the number of solute particles present in solution rather than the nature of solute particles. |

**Reference Books:**

**1.** March J, Advanced Organic Chemistry, John Wiley, 1992.
**2.** Gupta R; R, Kumar M, Gupta V, Heterocyclic Chemistry, Vols 1-3, Springer-Verlag.
**3.** Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, 47$^{th}$ Edn., Vishal Publishing Co., 2017.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-2 | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-3 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |

To establish the correlation between Cos & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | - | 4 | - |
| CO-2 | - | - | 3 |
| CO-3 | 4 | - | - |
| CO-4 | - | - | 2 |

**Course: Inorganic Chemistry Laboratory** **Code: DSCY23P05**
**L-T-P: 0-0-9** **Credit: 6**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Enable the students to learn the various fundamental chemical processes. |
| **PEO-2** | Attainment of laboratory management skills to tackle the plant operations and process control instrumentation in an efficient manner. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Achieve confidence in handling chemicals, glassware and instruments professionally in chemical industries and develop the modern techniques. |
| **PSO-2** | Successfully apply their practical experience to analytically determine materials applicable in our daily life. |

## Course Objective

**1.** To understand the basic concepts in systematic methods of qualitative chemical analysis of inorganic salt mixtures.
**2.** To provide the students with a clear and thorough understanding of quantitative estimation of major constituents in minerals and building materials.
**3.** To know the fundamentals and conditions to optimize the reaction in order to obtain a desirable precipitate for gravimetric analysis.

## Course Content

**I) Semimicro Qualitative Analysis**

Systematic qualitative analysis of inorganic salt mixtures containing four ions including the interfering anion (arsenates/phosphate/borate/fluoride).

**II) Redox Titrimetric Estimation**

**1.** Estimation of Ca in dolomite
**2.** Estimation of $Fe_2O_3$ cement
**3.** Estimation of CaO in cement
**4.** Estimation of Mn in pyrolusite

**III) Gravimetric Analysis**

**1.** Estimation of chloride as AgCl
**2.** Estimation of sulphate as $BaSO_4$
**3.** Estimation of water of crystallization of $BaCl_2.2H_2O$
**4.** Estimation of Ni as $Ni(DMGH)_2$

## Course Outcome

| | |
|---|---|
| **CO-1** | Development of practical skill in identification of components in salt mixture. |
| **CO-2** | Learning of the volumetric analytical methods to determine the amount of substances present in the test sample. |
| **CO-3** | Acquisition of skills in gravimetric methods of analysis which is among the most widely applicable of all the analytical procedures. |

**Reference Books:**

**1.** A. I. Vogel, Macro and Semicro Qualitative Inorganic Analysis, Orient Longman, 1969.
**2.** J. Basset, R.C. Denney, G.H. Jeffery and J. Memdham, Vogel's Text Book of quantitative Inorganic Analysis, ELBS, 4th Edn., 1978.
**3.** H. H. Willard, L. L. Merrit and J.A. Dean, Instrumental methods of analysis, East-West Press,4th Edn, 1974.
**4.** G. W. Parshall (Ed. In chief), Inorganic Synthesis, Vol 15, McGraw Hill, P. 48, 1974.
**5.** D. D. Sood, S. B. Mohaharand, A. V. R. Reddy, Experiments in Radiochemistry Theory and Practice, IANCAS Publications, 1994.
**6.** W.L. Jolly, Synthesis and characterization of inorganic compounds Prentice Hall Inc.
**7.** S. C. Das, Advanced Practical Chemistry for 3-Year Honours Course, 6th Edn., 2012.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | - | - | 3 | - | - | - | - | - | - | - |
| CO-2 | - | 2 | - | 2 | - | - | - | - | - | - | - | - |
| CO-3 | - | - | 2 | 2 | - | - | - | - | - | - | 2 | - |

**To establish the correlation between COs & PSOs**

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "- "**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| CO-1 | 4 | - |
| CO-2 | 3 | - |
| CO-3 | - | 4 |

# *Fourth Semester*

**Course: General Chemistry-V** **Code: DSCY24B07**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | To acquire the fundamental principles of coordination and nuclear chemistry with modern experimental and theoretical teaching skills. |
| **PEO-2** | Students will be able to analyse the problems of radioactive radiation in nuclear reactions in the context of practical significance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | To enhance their knowledge in chemical industry along with scientific information through systematic education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop the concept of transition metal coordination chemistry in chemical industry. |
| **PSO-2** | Provide environmental analysis of radioactive metal and to minimize environmental pollution. |
| **PSO-3** | Evaluate the energy release in nuclear reaction and their use in generation of power. |
| **PSO-4** | Learn the techniques used by the chemists to determine the composition of magnetic material and analyse for trace elements in the biological system. |
| **PSO-5** | Give better insight into the chemistry of late Transition Elements as well as to broaden their knowledge of the properties and behaviour of late Transition Elements in production of electronic device. |

## Course Objective

**1.** Introduce students to the real concept of transition metal coordination chemistry from the knowledge of crystal field theory and valance bond theory.

**2.** Students will learn the factors that determines the coordination number of complexes and identify common geometries

**3**. Students should be able to describe various types of isomerism which can occure in coordination compounds

**4.** To understand and calculate the mass defect for a nuclear reaction

**5.** Nuclear Chemistry will give you the depth knowledge about how the environment functions and how it is affected by human activities.

**6.** Nuclear chemistry and radiochemistry methods can be used to make issues more visible and solve problems, particularly in relation to environmental problems and metal production.

**7.** To give better insight into the chemistry of Late Transition Elements as well as to broaden their knowledge of the properties and behaviour of Late Transition Elements.

**8.** To impart knowledge of chemistry of late transition elements, their organometallic compounds and their catalytic application in industry.

## Course Content

**1) Coordination Chemistry-II (20 L):**

Valence bond theory, crystal field theory, molecular orbital theory, ligand design, variation of properties across transition series, metal-metal bonding and clusters.Experimental separation and identification of isomers, cotton effect, circular dichroism, stability Constants; determination of Complex Composition: molar ratio method, slope ratio method, and Job's method, Applications: complexometric titrations; natural coordination compounds.

**2) Nuclear Chemistry (10 L):**
Composition of the Nucleus; Classification; Isotopes; Isobers; Isotones; Detection and stability of Isotopes; Nuclear Stability; Mass defect; Packing fraction; Nuclear Binding Energy; Magic Numbers; Nuclear forces; Radioactive radiations; Radioactive decay; Decay kinetics; Disintegration series; Artificial Nuclear reactions; Nuclear fission, nuclear fusion, Applications of Radioisotopes in Chemistry and Biology; Cyclotrons; Nuclear Reactors.

**3) Late Transition Elements (15L):**
Classification; diamagnetism; Paramagnetism; Ferromagnetism; Antiferromagnetism and Ferrimagnetism; Magnetic Susceptibility and determination (Gouy Method); Orbital Contribution; Curie's Law; Superexchange Phenomenon
**Zirconium and Hafnium:** Compounds of +IV oxidation state, halides, aqueous chemistry, lower oxidation states;
**Niobium and Tantalum:** Compounds of +V oxidation state, halides, +IV oxidation states, lower oxidation states
**Molybdenum and Tungsten:** Compounds of +VI, V, IV and lower oxidation states;
**Technetium and Rhenium:** Compounds of VII, VI, V, IV and lower oxidation states;

## Course Outcome

| | |
|---|---|
| **CO-1** | Student can apply their knowledge of coordination chemistry to conduct research in coordination chemistry and to explain the properties of coordinated complexes |
| **CO-2** | The students will be able to know the stability of organometallic compounds and clusters, and their applications as a Industrial catalysts. |
| **CO-3** | Prepare students to interpret experimental separation and identification of isomers |
| **CO-4** | Prepare students to undertake final year project in coordination chemistry |
| **CO-5** | To interpret binding energy per nucleon plots in terms of nuclear stability, the energy changes associated with fission and fusion reactions for the production of nuclear energy |
| **CO-6** | Combining magnetic, structural and other experimental data to determine the identities of late transition elements, coordinated compounds and to rationalize their properties. |

**Reference Books:**
**1.** *General and Inorganic Chemistry Part II*, R Sarkar, New central book agency Pvt. Ltd.
**2.** *Advanced Inorganic Chemistry, 6th Edition*,F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann.
**3.** *Inorganic Chemistry*, Huheey, Keiter, Keiter, Medhi, Pearson education publisher Pvt. Ltd.
**4.** *Inorganic Chemistry*, R L Madan and G D Tuli, S Chand Publisher Pvt. Ltd.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 1 | -2 | | 2 | - | - | | - | - | - | - | - | 1 | -2 | -3 |
| **CO-2** | - | -2 | 3 | 2 | - | - | - | - | - | - | - | - | | 2 | -3 |
| **CO-3** | - | 2 | - | -2 | - | - | | - | - | 3 | - | - | 2 | -2 | -3 |
| **CO-4** | - | -2 | - | - | - | - | | - | - | - | - | - | -1 | -2 | 1 |
| **CO-5** | -1 | 2 | | 2 | - | - | | - | - | - | - | - | -1 | 2 | -1 |
| **CO-6** | - | -2 | | - | 2 | - | | - | - | - | - | | -2 | 2 | -1 |

**To establish the correlation between Cos & PSOs**

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 3 | 1- | - |
| CO-2 | -2 | 4 | - |
| CO-3 | 1 | -2 | - |
| CO-4 | - | - | 2 |
| CO-5 | 4 | - | -1 |
| CO-6 | - | 3 | -1 |

**Course: General Chemistry-VI** **Code: DSCY24B08**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquaint with the fundamentals related to macromolecules, and accuracy and precision in data collection, and types/nature of solvents that play role in Chemistry vis-à-vis modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop the concept of green chemistry for clean environment, use of polymers in everyday life and so on. |
| **PSO-2** | Successfully apply the principles and nature/properties of polymeric materials which have been learned as a part of this course. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** To get exposure on inorganic solvents, other than water, which are not organic compounds.

**2.** To educate on the need of non-aqueous solvents in chemical research and industry for reactions that do not occur in aqueous solutions or require a special environment.

**3.** The objective of introducing polymer is to provide an integrated view of the fundamentals of polymer science and engineering, including the chemical structure of various polymers, methods of measuring the molecular weight, polymerization kinetics and a variety of the engineering properties exhibited by polymers.

**5.** The purpose of incorporating error analysis is to make students learn scientific ways of collecting experimental data such as to minimise error and maximise accuracy in results.

## Course Content

**(1) Acids, Bases and Non-aqueous Solvents (10 L):**

Theories of acids and bases: Arrhenius; Brønsted-Lowry concept, differentiating and leveling solvents, superacids: Hammett Acidity Function, pH-calculations, buffer solutions, buffer capacity, acid-base Indicators, Lewis concepts, Lewis-base adducts, hydracids, oxyacids, factors affecting acid-base strength, Lux-Flood Concept, HSAB Theory and Applications.

Non-aqueous solvents: liquid ammonia, liquid hydrogen fluoride, liquid hydrogen cyanide, sulfuric scid, liquid sulphur dioxide, supercritical carbondioxide.

**(2) Polymer Chemistry (15 L):**

Introduction, definition and classification of polymers, resin, rubber, plastics; characterization: number average, molecular weight average and viscosity average molecular weight; concept of segment and segment length; effect of solvents; thermodynamics of dilute polymer solution; molecular weight of polymer: osmometry, viscosity, surface tension, light scattering and sedimentation equilibrium method; kinetics of polymerization; mechanistic aspect: addition, ionic, emulsion, aqueous, coordination, condensation polymerization processes; crystal structure of polymers: crystalline melting point ($T_m$), glass transition temperature ($T_g$ ); effect of different parameters on $T_m$ and $T_g$. Numerical problems.

**(3) Molecular Dimension (10 L):**

Average end-to-end distance and radius of gyration; interaction of polymer molecules with solvents; Flori Flox parameter; flexible parameters and Kuhn's statistical segments; emulsion, microemulsion, micelle formation, phase separation; conformation and configuration of polymer in solution; conformation and configuration of polymer in solution; crystallinity of macromolecules–factors influencing crystallinity; experimental methods of determination of crystallinity of polymers; properties of macromolecules and their uses.

**(4) Error Analysis (10 L):**

Error, accuracy and precision, mean, median, deviation, Student's t.

Titrimetric analysis: principles, classification; Principles and methods of redox-, complexometric, acid-base titrations; potentiometric methods of analysis. Spectrophotometry: Lambert-Beer Law, applications; atomic absorption spectrometry, basic conductimetric titrations.

## Course Outcome

| | |
|---|---|
| **CO-1** | Knowledge on appropriate use of solvents that would make the environment clean for a sustainable development. |
| **CO-2** | To predict the structure and properties of different polymeric materials using the knowledge of polymers |
| **CO-3** | Develop novel systems to generate polymeric materials for industrial and other uses at low cost. |
| **CO-4** | Knowledge of contemporary environmental issues and assessment of the effects of pollution. |
| **CO-5** | Comprehend idea about the synthesis and applications of polymers and other macromolecules. |
| **CO-6** | Relate the concepts in experimental techniques in laboratory. |

**Reference Books:**


**1.** Basic Principles of Polymer Chemistry, Archana Garg, 1st Ed. 2017(Atlantic Publishers and Distributors Pvt. Ltd.)

**2.** Textbook of Polymer Science, Fred W. Billmeyer, 3rd Ed. 2007 (Wiley)

**3.** Polymer Science, V. R. Gowariker, 2nd Ed. 2015 (New Age International Pvt. Ltd.)

**4.** Polymer Chemistry, Charles E. Carraher, 9th Ed. 2013 (CRC Press)

**5.** Plastics Materials, J. A. Brydson, 7th Ed. 1999 (Butterworth-Heinemann)

**6.** The Chemistry of Polymers, John W. Nicholson, 5th Ed. 2017 (Royal Society of Chemistry)

**7.** Concise Inorganic Chemistry, J. D. Lee, 4th Ed., ELBS, 1991.

**8.** Inorganic Chemistry, G. L. Miessler, D. A. Tarr, 3rd Edition, Pearson, Delhi, India.

**9.** Elementary Inorganic Chemistry, R. L. Dutta, 5th Ed. The New Book Stall, Calcutta.

**10.** General Chemistry Part-I and Part-II, R. Sarkar, New Central Book Agency (P) Ltd.

**11.** Fundamental Concepts of Inorganic Chemistry Part-I and Part-II, A. K. Das, CBS Publishers, New Delhi.

**12.** Inorganic Chemistry: Principle of Structure and Reactivity, J. H. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 4th Ed., Pearson, New Delhi.

## Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5** | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| **CO-6** | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

## To establish the correlation between COs & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | - | 4 | - |
| **CO-2** | - | - | 3 |
| **CO-3** | 4 | - | - |
| **CO-4** | - | - | 2 |
| **CO-5** | 2 | - | - |
| **CO-6** | - | - | - |

**Course: General Chemistry-VII** **Code: DSCY24B09**
**L-T-P: 3-1-0** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Understand the relevance of chemistry in biology and of statistical averaging methods in thermodynamics. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the subject. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge of chemistry to understand the intricate biological processes in our body and other living organisms, which may motivate them to pursue further studies in the field. |
| **PSO-2** | Successfully apply the principles of statistical methods in thermodynamics which have been learned as a part of this course. |
| **PSO-3** | Eventually evaluate the complex energy and environmental scenario along with other related issues in our society. |

## Course Objective

**1.** The objective of this course is to teach students the relevance of chemistry in biology through the topic chemistry of biological systems, on one hand, and statistical thermodynamics on the other.
**2.** To introduce the students to chemical biology - a scientific discipline spanning the fields of chemistry and biology so that they can relate with the complex biological processes occurring in living organisms.
**3.** Studying the subject the students will learn about the synthesis of biomolecules such as proteins, amino acids, nucleic acids, etc., and of the manipulation of biological systems.
**4.** Statistical thermodynamics is one of the pillars of modern physics that is necessary for the fundamental study of any physical system that has a very large number of degrees of freedom.
**5.** The approach to statistical mechanics is based on statistical methods, probability theory and the microscopic physical laws.
**6.** The students will be acquainted on the importance of realizing the behaviour of atoms and molecules at the microscopic level to understand the behaviour of macroscopic systems.

## Course Content

**(1) Chemistry of Biological Systems (20L):**
**Amino acids:** Synthesis (Strecker, Gabriel, Malonic ester, azalactone); isoelectric point, ninhydrin reaction and other reactions.
**Peptides:** Peptide linkage, synthesis of peptides using N-protection and C-protection, solid phase synthesis.
**Peptide sequence:** C-terminal and N-terminal unit determination (Edman, Sangar and dansyl chloride).
**Proteins:** Classification, primary, secondary, tertiary and quarternary structures.
Nucleic acids: Pyrimidine and purine bases (only structure and nomenclature), nucleosides and nucleotides.
**RNA and DNA:** Complementary base pairing; Watson-Crick model of DNA.

**(2) Statistical Thermodynamics (25L):**
Probability and entropy; ensembles; Boltzmann statistics; molecular and molar partition functions; translational, rotational, vibrational, and electronic partition functions; reference state of zero energy; equilibrium constant and partition function; partition function and thermodynamic parameters, Sackur-Tetrode equation; equations of state for ideal gas; equipartition theorem; specific heat capacity of solids (Einstein's model); ideal lattice gas (Langmuir adsorption isotherm); theory of absolute reaction rates; distribution laws : Fermi-Dirac and Bose-Einstein statistics. Numerical problems.

## Course Outcome

| | |
|---|---|
| **CO-1** | To predict the structure and properties of different biological molecules. |
| **CO-2** | Knowledge on chemical biology spanning the fields of chemistry and biology with a specific goal to relate biological processes occurring various organisms. |
| **CO-3** | Encourage further study on chemistry of biomolecules, which is one of highly important topics of research. |
| **CO-4** | Knowledge of contemporary health issues and assessment of the effects of scientific research on the subject. |
| **CO-5** | Relate the concepts of quantum mechanics and classical thermodynamics using statistical techniques. |
| **CO-6** | Comprehend the use of computational chemistry to understand the complex phenomena at the molecular level. |

**Reference Books:**

**1.** Lehninger Principles of Biochemistry, D. L. Nelson, M. M. Cox, 4$^{th}$ Edn., Macmillan Press, 2011.
**2.** Harpers Biochemistry, R. K. Murray, D. K. Granner, P. A. Mayes, V. W. Rodwell, 24$^{th}$ Edn., Wiley, 2006.
**3.** T. L. Hill, Statistical Thermodynamics Addision Wesley, 1960.
**4.** D. A. McQuarrie, Statistical Thermodynamics, Viva Books Pvt Ltd, 2003.
**5.** M. C. Gupta Statistical Thermodynamics WEL 1995, Company Ltd., New Delhi.
**6.** Physical Chemistry, P. W. Atkins, 7th Edn., 2000, Oxford University Press.

## Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-2 | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-3 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO-5 | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-6 | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

## To establish the correlation between COs & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | - | 4 | - |
| CO-2 | - | - | 3 |
| CO-3 | 4 | - | - |
| CO-4 | - | - | 2 |
| CO-5 | 2 | - | - |
| CO-6 | - | - | - |

**Course: Organic Chemistry Laboratory** **Code: DSCY24P05**
**L-T-P: 0-0-9** **Credit: 6**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | To focus on synthesis of organic compounds for reaction design and methodology development in the fields of synthetic organic chemistry. |
| **PEO-2** | To impart knowledge of separation techniques of organic compounds in the context of practical relevance in the Chemical industries |
| **PEO-3** | To analyse the professional needs in applied food and chemical industry technology through the knowledge of extraction of natural products and organic compounds |

**PSOs (Program Specific Objectives):**

| | |
|---|---|
| **PSO-1** | To apply the knowledge of various tools and synthetic methods used in organic synthesis. |
| **PSO-2** | Successfully apply modern and high-tech extraction techniques as a part of this course. |

## Course Objective

**(1)** To provide the knowledge of different synthetic techniques for designing organc molecules or processes that meet the specified needs with appropriate consideration for the demands of chemical industries.

**(2)** To impart the knowledge of identification of organic compounds using chromatographic techniques.

**(3)** To acquire the knowledge of extraction of different types of organic compounds for thier future applications in industrial chemistry.

## Course Content

**(1)** Single-step synthesis of organic compounds, determination of melting point and yield of the product.

**(2)** Identification of organic compounds using Thin Layer chromatography and Determination of $R_F$ value of unknown organic compound.

**(3)** Extraction of following organic compounds

a. Extraction of Lactose from milk

b. Extraction of Lycopene from Tomato

c. Extraction of citric acid from Lemon

d. Extraction Cinnamon oil from Cinnamon

e. Extraction of Caffeine from Tea

f. Extraction of Caffeine from Coffee

g. Extraction of Piperine from black pepper

## Course Outcome

| | |
|---|---|
| **CO-1** | Students will acquire the knowledge of synthesis of organic compounds for further application in the field of pharmaceutical and related sciences with a background in the field of organic molecules. |
| **CO-2** | Students will be able to identify the organic molecules in organic compounds by advance techniques. |
| **CO-3** | Students will acquire the knowledge of extraction of organic compounds and their importance in the field of drug chemistry, food chemistry, etc. |

**Reference Books:**

**1.** Vogel's Textbook of Practical Organic Chemistry 5th Edition, 2005, Pearson.
**2.** F.G. Mann, Practical Organic Chemistry 4th Edition, Pearson.

## Mapping with the POs/ PEOs: Matrix formation for attainments

**S- Strong, M-Moderate and W-Weak**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | | **S** | **S** | | | | | | | | | | **M** | **S** | |
| **CO-2** | | | | **M** | **S** | | | | | | | | | **S** | |
| **CO-3** | | | | | **S** | **S** | | | | | | | | | **S** |

# *Fifth Semester*

**Course: General Chemistry-VIII** **Code: DSCY25B10**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Understand the fundamental principles related to physical properties of molecules, colloidal solutions and surface chemistry, solid state chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge of the subject in fabricating such materials which may find use in water purification, environmental remediation, developing sensors, etc. |
| **PSO-2** | Educate the society at large with the knowledge they acquire from colloidal and surface science in maintaining clean and pollution free environment. |
| **PSO-3** | Assess quality of various materials in the context of energy scenario along with environment related issues in our society. |

## Course Objective

1. The topic dichroism will highlight on the behaviour of crystals and solutions on their interaction with plane polarized light.
2. To familiarise students on the importance of intermolecular forces in determining the physical properties of molecules.
3. The objective of solid state chemistry is to lay emphasis on the 3D arrangements of atoms and molecules to give rise to attractive structures with definite properties.
4. All in all, the course will cover broadly the nature of atoms, and molecules, the forces among them that play role which lead to various liquids and solids.
5. The objective of the course is to help students learn about the nature of formation of substances and their behaviour towards external factors and eventually draw analogy with nature, such as if it is possible to mimic nature and thus find solutions to many a problems facing mankind.

## Course Content

**(1) Dichroism and Intermolecular Forces (10L):**

Physical properties: additive and constitutive property; molar volume at boiling point; parachor, rheochor and molar refraction; optical activity; different consequences of optical activity; polar and non-polar molecules; molar polarization; induced and orientational polarization; dipole moment; determination of dipole moment based on different physical properties; Clausius-Mossotti equation: application and limitation; debye equation; orientation polarisation and Debye equation; effect of temperature on polarisation of polar and non-polar molecules.

Laws in intermolecular reactions; interaction energy; van der Waals force, H-bonding, and other intermolecular forces; explanation of some physicochemical peculiarities in terms of intermolecular forces. Numerical problems.

**(2) Colloids and Surface Chemistry (20 L):**

Colloids: classification (lyophilic and lyophobic), characteristics, preparation, purification, and kinetics: Brownian motion and translation diffusion, osmotic pressure; rotary Brownian motion; light scattering and Tyndall effect; liquid-gas and liquid-liquid interfaces; surface and interfacial tensions; adsorption and orientation at interfaces; Langmuir adsorption isotherm; BET equation for multimolecular adsorption; association colloids-micelle formation, spreading; surface films and Langmuir-Blodgett films; solid gas interface; capillary condensation; contact angles and wetting; adsorption from solution charged interfaces: electrical double layer and electro-kinetic phenomena; colloid stability; lyophobic sols; van der Waals forces between colloidal particles; rheology: introduction, viscosity, non-Newtonian flow; viscoelasticity; emulsions and foams: oil-in-water and water-in-oil emulsion.

**(3) Solid State Chemistry (15 L):**
Crystalline and amorphous solids; symmetry elements; lattices; unit cells; crystal systems; Bravais lattice; closed packed structure; octahedral and tetrahedral holes; structures of ionic solids: structures of AX, $AX_2$, $AX_3$ types and their derived species, sphalite, wurzite, fluorite, perovskite, ilmentite, rutile, silicate and layered structure, silicates; radius-ratio; lattice Energy and Madelung constant; lattice planes: Miller indices; Brag's equation; experimental methods; crystal density; band structure; semiconductors; defects; diodes; LED; photovoltaic cells; superconductivity.

## Course Outcome

| | |
|---|---|
| **CO-1** | At the end of the course, the students will gain insight on the fundamental aspects of molecule-molecule interaction, crystal growth, properties of colloidal solutions, among others. |
| **CO-2** | Broaden outlook on the importance of molecular substances in everyday life and of their relevance in society for a sustainable development. |
| **CO-3** | The knowledge of solid state chemistry will go on to motivate students to develop novel systems for water purification. |
| **CO-4** | Knowledge of contemporary environmental issues and assessment of the effects of pollution. |
| **CO-5** | Develop interest in the topic of solid state chemistry which is related to many other branches of engineering and science. |
| **CO-6** | Comprehend ideas about the properties and applications of surface science. |

**Reference Books:**


**1.** Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, 11th Edn., 2017 (OUP Oxford)
**2.** Physical Chemistry, R. L. Madan, G. D. Tuli, S. Chand Publisher.
**3.** Physical Chemistry, P. C. Rakshit, revised Edn. (2014), Sarat Book House.
**4.** Inorganic Chemistry, G. L. Miessler, D. A. Tarr, 3rd Edition, Pearson, Delhi, India.
**5.** General Chemistry Part-I and Part-II, R. Sarkar, New Central Book Agency (P) Ltd.
**6.** Fundamental Concepts of Inorganic Chemistry Part-I and Part-II, A. K. Das, CBS Publishers, New Delhi.

## Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight (Low)  2: Moderate (Medium)  3: Substantial (High) and for No Correlation "-"**

| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** | **PO-6** | **PO-7** | **PO-8** | **PO-9** | **PO-10** | **PO-11** | **PO-12** | **PEO-1** | **PEO-2** | **PEO-3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-2** | **-** | **2** | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-3** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-4** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **3** |
| **CO-5** | **-** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** |
| **CO-6** | **-** | **-** | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **3** | **-** | **2** | **-** |

## To establish the correlation between COs & PSOs

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

Table 2

| **CO** | **PSO-1** | **PSO-2** | **PSO-3** |
|---|---|---|---|
| **CO-1** | **-** | **4** | **-** |
| **CO-2** | **-** | **-** | **3** |
| **CO-3** | **4** | **-** | **-** |
| **CO-4** | **-** | **-** | **2** |
| **CO-5** | **2** | **-** | **-** |
| **CO-6** | **-** | **-** | **-** |

**Course: General Chemistry-IX** **Code: DSCY25B11**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**

Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | To acquire the fundamental principles of reaction mechanism of coordination compounds with modern experimental and theoretical teaching skills. |
| **PEO-2** | Students will be able to analyse the problem in extracting organic compounds occuring in foods and tissues in the context of practical significance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | To enhance their knowledge in metal coordination chemistry along with scientific facts through systematic education. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop a scheme for production of organic compounds occurring in foods and tissues by utilizing knowledge of chemistry. |
| **PSO-2** | Demonstrate the extraction of sugars, starch, and cellulose and to relate with industrial production. |
| **PSO-3** | Evaluate the energy source along with environment related issues in our society. |
| **PSO-4** | Learn the techniques used by the chemists to determine composition of metal complexes and analyse the structure for industrial importance |
| **PSO-5** | Introduce carbohydrates chemistry and the groups of saccharides in the chemical and descriptive terms. |

## Course Objective

**1.** To introduce carbohydrates and the groups of saccharides in the chemical and descriptive terms.
**2.** Students will learn the basic conversion of straight chain structure of any 5 or 6 carbon containing monosaccharides to its corresponding ring structure.
**3.** To introduce the role of saccharides in biology.
**4.** To introduce the role of mutarotation in interconversion between alpha and beta anomers.
**5.** To provide an overview of energy profile diagram of coordinated complexes and their reaction pathways.
**6.** Students will be able to learn the mechanisms for complex reactions and to predict the reactivity of coordinated complexes.

## Course Content

**Carbohydrate Chemistry (15 L):**
Classification and nomenclature of saccharides, Monosaccharides: Aldose up to 6 carbons, structure of D-glucose and D-fructose (configuration and conformation), anomeric effect and mutarotation. Reactions**:**Osazone formation, bromine water oxidation, stepping-up (Kiliani method) and stepping down (Ruff's and Wohl's method) of aldoses. Disaccharides: sucrose, lactose, maltose, inversion of sugars

**Reaction Mechanisms of Coordination Compounds (30 L):**
Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, reaction pathways, ligand substitution in octahedral and square planar complexes, mechanisms and kinetics, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, evidences in favour of conjugate mechanism, *trans* and *cis*-effect, racemization,

rearrangement; electron transfer in redox reactions: Outer-sphere and Inner sphere, cross reactions, Marcus-Hush theory, oxidative reactions, photochemical reactions.

## Course Outcome

| | |
|---|---|
| **CO-1** | Ability to formulate the mechanism for reactions of transition metal complexes. |
| **CO-2** | Ability to develop their logical and critical thinking through the discussion of possible reaction mechanism. |
| **CO-3** | To be able to recognize the structures of the modified sugars molecules. |
| **CO-4** | The ability to predict products and choose appropriate reaction condition to obtain the desired products |
| **CO-5** | To know how the ring structures of aldehyde and ketone sugars are formed |
| **CO-6** | To demonstrate the overview of energy profile diagram of coordinated complexes and their reaction pathways. |

**Reference Books:**

1. *Lehninger Principles of Biochemistry, Lehninger 7^TH edition*; D.L Nelson, M.M Cox, Lippincott willams and Wilkins
2. *General and Inorganic Chemistry part II*, R Sarkar, New central book agency Pv Ltd
3. *Organic Chemistry; Stereochemistry and The Chemistry of Natural Product* ,Volume-2 I.L. Finar,2002, 5th edition ,Person publishers Pv Ltd
4. *Shriver and Atkins' Inorganic Chemistry*, Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong.
5. *Advanced Inorganic Chemistry, A Comprehensive Test 4th Edition*, F. Albert Cotton and Geoffrey Wilkinson.

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 2 | 3 | | 2 | - | - | | - | - | - | - | - | 1 | 2 | -2 |
| **CO-2** | 1 | 3 | | - | - | 1 | | - | - | - | - | - | | 2 | -1 |
| **CO-3** | 1 | -3 | - | - | - | 2 | | - | 1 | - | - | - | 2 | -1 | -2 |
| **CO-4** | - | 3 | - | - | - | 1 | | - | 1 | - | - | - | -1 | - | 1 |
| **CO-5** | - | 3 | 2 | - | - | - | | - | - | - | - | - | -2 | 2 | -2 |
| **CO-6** | - | 2 | | - | 1 | - | | - | - | - | - | | -3 | 2 | -1 |

To establish the correlation between Cos & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 3 | 3- | -3 |
| CO-2 | - | 1 | - |
| CO-3 | 2 | -1 | - |
| CO-4 | - | - | 2 |
| CO-5 | 2 | - | -2 |
| CO-6 | - | 1 | -2 |

**Course: General Chemistry-X** **Code: DSCY25B12**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire with the fundamental principles of quantum mechanics and quantum chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop the behaviour of tiny particles and photo-physical properties of molecules. |
| **PSO-2** | Successfully apply the principles of quantum mechanics in various engineering materials which have been learned as a part of this course. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.
**2.** Understand and explain the differences between classical and quantum mechanics.
**3.** Solve Schrödinger equation for simple potentials.
**4.** Student identifies correctly the mathematical space that contains all possible states of a physical system, using Dirac's notation.
**5.** Student computes the probability of finding the system in a given state given that it was prepared in another given state.
**6.** Use the superposition principle to predict experimental outcomes for measurement of observables on simple quantum systems.

## Course Content

**(1) Quantum Chemistry (45 L):**

Black body radiation, Planck's quantum theory, photo electric effect, atomic spectra and Bohr's atomic model, four quantum numbers; Compton effect, de Broglie hypothesis, Heisenberg uncertainty principle, basic postulates, operators; time-independent and time-dependent Schrödinger wave equation; physical significance of wave function, exactly solvable systems; particle in a box of various dimensions and tunnelling; harmonic oscillator; rigid rotator; hydrogen atom-wave functions including shapes of atomic orbitals; orbital and spin angular momenta; Pauli exclusion principle, Zeeman effect, spin-orbit coupling.

Approximate methods of quantum mechanics: variation principle; perturbation theory; applications.

Chemical bonding in diatomic molecules; VB and MO theories; Huckel theory for $\pi$-electron systems.

## Course Outcome

| | |
|---|---|
| **CO-1** | Pinpoint the historical aspects of development of quantum mechanics. |
| **CO-2** | Understand the concept of wave function. |
| **CO-3** | Understand the uncertainty relations. |
| **CO-4** | Spot, identify and relate the eigen value problems for energy, momentum, angular momentum and central potentials explain the idea of spin. |
| **CO-5** | Student forms a mental picture on the meaning of linear combination of states within quantum mechanics. |
| **CO-6** | Student recognizes the expansion of wave functions in terms of special functions as casting vectors as the linear combination of the basis elements. |

**References Books:**

1. D. A. McQuarrie, Quantum Chemistry, OUP (1983).
2. P. W. Atkins et al Molecular Quantum Mechanics, OUP, 1998.
3. R. K. Prasad, Quantum Chemistry, New Age International, New Delhi, 4$^{th}$ Edn. 2010
4. Fundamentals of Molecular Spectroscopy, C.N. Banwell, E.M. McCash, 4$^{th}$ Edn., McGraw-Hill.
5. Chemical Applications of Group Theory, F. A. Cotton, 3$^{rd}$ Edn., Wiley.
6. Group Theory and Quantum Mechanics, M. Tinkham, McGraw Hill, 1964.
7. A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning Pvt. Ltd., 2008.
8. P. W. Atkins – Physical Chemistry, 7th Edn. Oxford (2000).
9. I. N. Levine, Physical Chemistry, 5th Edn., McGraw Hill, New Delhi, (1995).
10. Physical Chemistry, G.W. Castellan, 3$^{rd}$ Edn. Addison Wesley.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-2 | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-3 | - | - | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO-5 | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-6 | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

**To establish the correlation between Cos & PSOs**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | - | 4 | - |
| CO-2 | - | - | 3 |
| CO-3 | 4 | - | - |
| CO-4 | - | - | 2 |
| CO-5 | 2 | - | - |
| CO-6 | - | - | - |

**Course: Electrochemistry** **Code: DSCY25B13**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of electrochemistry with modern experimental and theoretical skills for, apart from other implications, some central biological mechanisms are known to occur by means of electrochemical reactions. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance of the subject to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to understand mechanisms involved in electrochemical cells and associated thermodynamic phenomena, which are important topics for both fundamental research and society. |
| **PSO-2** | Successfully apply the principles of electrochemistry and electrochemical phenomena, which have been learned as a part of this course, that lead to development of many a different engineering materials. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Electrochemistry dealing with electrochemical reactions will seek to cover the mentioned topics to acquaint the relevance of the subject in the context of chemistry and its applications elsewhere.
**2.** To introduce the students to the energy related issues at international, national and regional level so that they get exposure to the pressing problems.
**3.** Studying this subject the students will learn about the electrochemical means of energy conversion to meet energy needs as well as maintaining clean environment.
**4.** The objective of introducing redox reactions and thermodynamics is to provide an integrated view of the fundamentals of electrochemistry and engineering devices.
**5.** The topic will establish a correlation between theory and practical in electrochemistry.
**6.** The purpose of incorporating different type of cells, for example, commercial cells, fuel cells, etc. is to give knowledge to the students about their usefulness in research and industry.

## Course Content

**(1) Electrochemistry and Thermodynamics of electrolytic solution (30 L):**

Introduction to electrochemistry, electrolytic and metallic conduction, Ostwald's dilution law - its uses and limitations, specific and equivalent conductance, variation of equivalent and specific conductance with dilution. Kohlrausch's law of independent migration of ions, ionic mobilities, hydration of ions, ionic atmosphere, ionic strength, Debye-Huckel theory of dilute ionic solution, limiting law and Debye-Huckel-Onsagar equation. Transport number, Hittorf's rule, determination by moving boundary method. Applications of conductivity measurements: degree of dissociation, pKa, solubility product, and conductometric titrations.
Free energy and activity, Electrode-electrolyte interfaces, Electrical double layer at interface - Helmholtz, Gouy-Chapman and Stern models, Butler-Volmer equation-derivation and applications, and Tafel plot.

**(2) Redox reactions (15 L):**

Standard and formal electrode potentials, Nernst equation, different types of electrodes: normal, calomel, reversible, metal-metal ion, and oxidation-reduction electrodes. Emf of electrochemical cells and its measurement; potentiometric titration; electrode potential series and its application; concept of redox reactions, determination of standard electrode potential, effect of different factors on electrode potential: pH, precipitation, complexation, chemistry of aqua regia, redox titration, selection of redox indicators, potentiometric titrations; commercial cells, and fuel cells.

## Course Outcome

| | |
|---|---|
| **CO-1** | The concept of electrochemistry which could be understood by people from any background has its nucleus chiefly in energy conversion for a clean and green environment. |
| **CO-2** | Knowledge on conventional and non-conventional energy sources and future energy resources for sustainable development. Of the methods for energy conversion, the electrochemical one is the most advanced and seems most likely to become of considerable practical importance. |
| **CO-3** | Knowledge of contemporary environmental issues and assessment of the effects of pollution. As an example, the students should be able to know that the electrochemical means of conversion of energy (to electrochemically powered transportation systems) would be an important step by means of which the difficulties of air pollution and the effects of an increasing concentration of $CO_2$ in the atmosphere may be met. |
| **CO-4** | Fuel cells which is a sub-branch of electrochemistry shall be recognised for its technological and industrial implications. |
| **CO-5** | Relate the concepts in electrochemistry with other branches of science and technology. |
| **CO-6** | Comprehend idea about the basics and applications of electrochemistry. |

**Reference Books:**

**1.** Modern Electrochemistry-1 (Ionics), J. O. M. Bockris, A. K. N. Reddy, $2^{nd}$ Edn., 2018, Springer.
**2.** Modern Electrochemistry-2A (Fundamentals of Electrodics), J. O. M. Bockris, A. K. N. Reddy, $2^{nd}$ Edn., 2001, Springer.
**3.** An Introduction to Electrochemistry, Samuel Glasstone, 2016, EWP.
**4.** Electrochemical Methods-Fundamentals and Applications, A. J. Bard, L. R. Faulkner, $2^{nd}$ Edn., 2001, John Wiley & Sons.
**5.** Physical Chemistry, P. C. Rakshit, Revised Edn., 2014, Sarat Book House.
**6.** Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, $47^{th}$ Edn., 2017, Vishal Publishing Co.
**7.** Physical Chemistry, G. W. Castellan, $4^{th}$ Edn., 2004, Narosa.

## <u>Mapping with the POs/ PEOs: Matrix formation for attainments</u>

**1: Slight (Low)  2: Moderate (Medium)  3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5** | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| **CO-6** | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

## <u>To establish the correlation between COs & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | - | 4 | - |
| **CO-2** | - | - | 3 |
| **CO-3** | 4 | - | - |
| **CO-4** | - | - | 2 |
| **CO-5** | 2 | - | - |
| **CO-6** | - | - | - |

**Course: Physical Chemistry Laboratory** **Code: DSCY25P08**
**L-T-P: 0-0-9** **Credit: 6**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Adapt to work with new experiments, assimilate updated information, and be able to solve complex problems based on practical physical chemistry. |
| **PEO-2** | Learn the fundamental applications of physical chemistry through experimental techniques using modern state-of-the-art equipment. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Prepare themselves for their higher studies by learning good laboratory practices using the modern methods and techniques, while simultaneously develop professional skills to be able to work in chemical and other industries requiring knowledge/experience of practical chemistry. |
| **PSO-2** | Successfully apply their practical experience to analytically determine/estimate amount of substances in water, their physical properties, among others. |

## Course Objective

**1.** Students will learn the ethics and acquire training required for physical chemistry laboratory.

**2.** The practicals have been designed such that the students develop knack for learning physical chemistry in their theory courses. In addition, the concepts that they learn in theory could be augmented due to their laboratory experiments, data collection, and calculation.

**3.** To introduce the students to the modern experiments that not just help to enhance their knowledge on the laws of physical chemistry but seek to solve problems at international, national and regional level based on practical physical chemistry.

**4.** Eventually, the course should be able to make students think rationally in their encounter with problems requiring knowledge of physical chemistry laboratory experience and training.

## Course Content

**Experiments using Conductometer:**

**1.** To find out the strength of HCl by titrating it against standard NaOH solution conductometrically.

**2.** To find out the strength of $NH_4OH$ by titrating it against standard HCl solution conductometrically.

**3.** To find out the strength of $CH_3COOH$ by titrating it against standard NaOH solution conductometrically.

**4.** To find out the strength of HCl & $CH_3COOH$ mixture by titrating it against standard NaOH solution conductometrically.

**5.** To find out the solubility product ($K_{sp}$) of sparingly soluble salt (say $BaSO_4$) conductometrically.

**6.** To find out the CMC of soap solution (SDS) by means of conductometric experiments.

**7.** To determine the degree of hydrolysis and hydrolysis constant of $NH_4Cl$ at room temperature.

**8.** To determine the dissociation constant of a weak electrolyte conductometrically and verification of Ostwald's dilution law.

**9.** To determine the equivalent conductivity of strong electrolytes at different dilutions (HCl, NaCl, $CH_3COONa$) and hence to determine the equivalent conductivity of a weak electrolyte ($CH_3COOH$) at infinite dilution.

**Experiments using Potentiometer:**

**1.** To find out the strength of the given ferrous ammonium sulphate solution (approximate strength N/10) by titrating it against potassium dichromate solution potentiometrically. Also find the redox potential of the ferrous-ferric system.)

**2.** To determine the standard electrode potential of Cu and Ag electrodes and determination of the potential difference in a concentration cell.

**3.** To evaluate the thermodynamic parameters of a reaction from EMF measurement.

**4.** To find the activity of hydrogen ions using the hydrogen electrode.

**5.** To determine the hydrolysis constant and degree of hydrolysis of an electrolyte.

**6.** To determine the equilibrium constant for the formation of complex ion $[Ag(NH_3)_2]^+$ potentiometrically.

**7.** To determine the solubility product of AgCl and to determine the instability of $Ag(NH_3)_2^+$ complex.

**Experiments using pH Meter:**

**1.** To find out the strength of the given HCl solution by titrating it against NaOH.

**2.** To find out the strength of HCI and $CH_3COOH$ in a mixture of both by titrating it against NaOH solution.

**3.** To determine the pH of a given solution with indicators and compare it with pH meter value.

**4.** To determine the pH of a given solution by comparator method or buffer solution method.

**5.** To find out the strength of acetic acid by titrating it against sodium hydroxide.

**6.** To find out the strength of ammonia solution by titrating it against acetic acid.

**7.** To find out the strength of ammonia solution by titrating it against hydrochloric acid.

**8.** To find out the strength of borax solution by titrating it against hydrochloric acid.

**9.** To find out the strength of sodium carbonate solution by titrating it against hydrochloric acid.

**10.** To find out the dissociation constants of a polybasic acid, say phosphoric acid by titrating it against sodium hydroxide solution.

**11.** To determine the pH of a buffer solution.

## Course Outcome

| | |
|---|---|
| **CO-1** | By the end of the course, the student should have acquired hands-on training on physical chemistry practicals which would go on to help them in their career. |
| **CO-2** | They have acquired basic knowledge and mastered the art of handling modern equipment for advanced practicals and research. |
| **CO-3** | They should be able to apply their knowledge in other disciplines and for solving complex problems facing mankind in daily life. |

**Reference Books:**

**1.** Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan.

**2.** Advanced Physical Chemistry Experiments, Dr. J. N. Gurtu, A. Gurtu.

## Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |

## To establish the correlation between Cos & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| **CO-1** | - | 4 |
| **CO-2** | - | - |
| **CO-3** | 4 | - |

**Course: Materials Chemistry Laboratory** **Code: DSCY25P09**
**L-T-P: 0-0-3** **Credit: 2**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of materials synthesis chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop system for water purification, and other environment related issues by utilizing knowledge of materials chemistry. |
| **PSO-2** | Successfully apply the principles and materials properties of different engineering materials which have been learned as a part of this course. |

## Course Objective

**1.** The course would introduce students to the materials chemistry laboratory and lay emphasis on the need for practical knowledge of the subject vis-à-vis their theory knowledge.
**2.** To students should learn the art of synthesis of materials in micro and nano dimensions and compare their properties with that of bulk materials.
**3.** The relevance of the field of materials chemistry in industrial and technological arena shall be realized.

## Course Content

**1.** Synthesis of Ag nanoparticles and their characterization using UV-Vis, TEM, XRD.
**2.** Synthesis of Cu nanoparticles and characterization using UV-Vis, TEM, XRD.
**3.** Synthesis of nanoparticles of other metals (gold, rhodium, palladium, platinum) and their using UV-Vis, TEM, XRD.
**4.** Synthesis of quantum dots, nanowires and nanorods of oxides, sulphides of metals and their characterization using UV-Vis, TEM, XRD.
**5.** Synthesis of carbon dots and their characterization.
**6.** Handling of some minor equipment like UV-Vis, fluorimeter, DLS, TGA, ball milling, etc.

## Course Outcome

| | |
|---|---|
| **CO-1** | To predict the structure and properties of different materials using the knowledge of materials chemistry. |
| **CO-2** | Knowledge on conventional and non-conventional energy sources and future energy resources in sustainable development. |
| **CO-3** | Develop a knack for research in the field aiming to devise novel systems for solving common problems facing society such as access to clean water, clean environment, among others. |

**Reference Books:**

**1.** Experimental techniques in material and mechanics, C. Suryanarayana, CRC Press, 2011 by Taylor & Francis Group
**2.** Science and Engineering: An Introduction, William D. Callister, Jr. and David G. Rethwisch John Wiley & Sons, Inc.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-2 | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-3 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |

**To establish the correlation between Cos & PSOs**

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| CO-1 | - | 4 |
| CO-2 | - | - |
| CO-3 | 4 | - |

# *Sixth Semester*

**Course: General Chemistry-XI** **Code: DSCY26B14**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**.

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of Phase Rules and Reaction Dynamics with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Defines the importance of Phase Diagrams in the field of materials science and engineering |
| **PSO-2** | Successfully apply the principles of phase rule and reaction dynamics for various engineering materials which have been learned as a part of this course. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Explains the basic definitions and terms in a phase diagram

**2.** Interprets the stability regions in unary systems by using pressure and temperature diagrams.

**3.** Composes binary systems by using unary systems.

**4.** Explain the concept of activation energy and how it relates to the variation of reaction rate with temperature .

**5.** Be able to interpret potential energy profiles and use them to determine the activation energy and potential energy changes for a reaction.

**6.** Be able to use the Arrhenius equation to calculate a rate constant, activation energy, and frequency factor.

## Course Content

**Phase Rule (25):**

Elementary description of phase transition; phase, component, degree of freedom, phase equilibria; phase rule and its thermodynamic derivation and applications: thermodynamics of ideal and non-ideal gases and solutions.

One component system: water, carbon dioxide, sulphur, iodine, dry ice, etc.

Two component system: salt solutions: KI-water, $Fe_2Cl_6$–water systems, salt hydrate-$CuSO_4.5H_2O$ etc.

Binary alloys: antimony-lead, Al-Mg, Au-Sn system, etc.

Liquid- liquid mixture: Upper and lower critical solution temperature ($T_c$); phenol-water and water-triethylamine; their miscibilities; steam distillation; fractional distillation; fractional crystallization; partial miscibility of solid and liquid solution; thermal analysis and cooling curves; application of thermal analysis.

**Chemical Kinetics (20):**

Molecular basis of chemical reaction, potential energy surfaces and reaction dynamics; kinetics of different complex reactions; theories of reaction rates-Arrhenius, collision and TS theory; general features of reactions of different orders and molecularity, unimolecular, diffusion controlled, photochemical reactions and enzyme kinetics; dynamics of electron transfer and proton transfer processes; influence of solvents, dielectric constant and ionic strength on reaction rates, primary and secondary salt effects, kinetic isotope effect.

## Course Outcome

| | |
|---|---|
| **CO-1** | Identify and understand the principles of chemical equilibrium thermodynamics to solve multiphase equilibria and chemical reaction equilibria. |
| **CO-2** | Analyze the conditions associated with ideal and non-ideal vapour-liquid systems at equilibrium through the construction and interpretation of phase diagrams for ideal and non-ideal binary mixtures. |
| **CO-3** | Use empirical correlations and experimental data to evaluate thermodynamic quantities that relate to the vapour-liquid or liquid-liquid equilibria of ideal and non-ideal chemical mixtures. |
| **CO-4** | Determine equilibrium constants for chemical reactions and equilibrium point compositions for multiple reaction systems. |
| **CO-5** | Solve single- and multistage separation processes involving non-ideal chemical mixtures using numerical methods and simulations, and recommend appropriate operating conditions. |
| **CO-6** | To provide the student with principles and kinetic tools useful in analyzing the rates of chemical reactions for both homogeneous and heterogeneous reactions. And to increase the student's ability to do chemical reactor design by providing the knowledge and tools required to obtain, evaluate, and improve rate equations for use in design, operation and optimization of chemical reactors. |

**Reference Books:**

**1.** Fogler S.H., "Elements of Chemical Reaction Eng.", 3rd Ed., Prentice Hall,1999.
**2.** Levenspiel, O., "Chemical Reaction Eng." John Wiley & Sons 1972,
**3.** Froment G.F. and Bischoff K.B., "Chemical Reactor Analysis and Design" John Wiley, 1990.
**4.** Roberts, G.W., "Chemical Reactions and Chemical Reactors", Wiley, 2009.
**5.** P. W. Atkins – Physical Chemistry, 7th Edn. Oxford (2000).
**6.** I. N. Levine, Physical Chemistry, 5th Edn., McGraw Hill, New Delhi, (1995).
**7.** Physical Chemistry, G.W. Castellan, 3$^{rd}$ Edn. Addison Wesley.

### Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** | **PO-6** | **PO-7** | **PO-8** | **PO-9** | **PO-10** | **PO-11** | **PO-12** | **PEO-1** | **PEO-2** | **PEO-3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | | | | | | | | | | | **2** | | |
| **CO-2** | | **2** | | | | | | | | | | | **2** | | |
| **CO-3** | | | **2** | | | | | | | | | | **2** | | |
| **CO-4** | | | | | | | | | | | | | | | **3** |
| **CO-5** | | **2** | **2** | | | | | | | | | | | **2** | |
| **CO-6** | | | | | | | | | | | | **3** | | **2** | |

**Course: General Chemistry-XII** **Code: DSCY26B15**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | To acquire the fundamental principles of synthesis of natural product with modern experimental and theoretical teaching skills. |
| **PEO-2** | Students will be able to analyse the problems in synthesis of carbocyclic compounds in the context of practical significance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | To enhance their knowledge of coordination compounds in chemical synthesis along with scientific information through systematic education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop a scheme for synthesis of carbocyclic compounds for organic synthesis by utilizing knowledge of chemistry. |
| **PSO-2** | Introduce the different types of natural product and their medicinal importance. |
| **PSO-3** | Evaluate the regions of the electromagnetic spectrum corresponding to different molecular transitions. |
| **PSO-4** | learn the techniques used by the chemists to determine chemical composition and analyse the compounds spectroscopically for industrial production of dye |
| **PSO-5** | demonstrate the spectrospic properties of coordinated compounds with their selection rules. |

## Course Objective

**1.** To understand the basic chemical and structural features of carbocyclic chemistry, including naphthalene, anthracene, phenanthrene and benzoquinone.
**2.** Students will learn the different types of natural product and their chemstry and medicnal importance.
**3.** Students will learn general methods of structural elucidation of compounds of natural origin.
**4.** To understand how the *d* orbital of transition metal are split in the presence of a ligand field (Octahedral, tetrahedral and square planar).
**5.** To understand the observed colours of a coordinated complexes arise from absorption of visible light, which cause transitions of electrons between ligand- field-split *d* orbitals.
**6.** The major objectives of this course is to introduce the students the spectrospic properties of coordinated compounds and their selection rules for transition.
**7.** To provide the regions of the electromagnetic spectrum corresponding to different molecular transitions.

## Course Content

**Carbocyclic Chemistry (20L):**

Preparation and reactions of benzoquinone.Structure, synthesis and reactions of napthalene, anthracene and phenanthrene and their quinones.

**Elementary Natural Products (10L):**

**Terpenoids:** Classification, isoprene rule, monoterpenoids. Chemistry of citrala and b, geraniol, nerol, menthol, alpha terpineol, camphor.
**Alkaloids:**Definition , Classification, General methods of structure elucidation, chemistry of coniine, nicotine, piperine.

**Electronic Spectra of Coordination compounds (15 L):**
L-S coupling; J-J-coupling; determination of microstates and Russel-Saunders terms; Hunds rules and ground state terms; spectral selection rules; intensity rules; Fine Structure of the Spectral lines; Jahn Teller distortion; Nephelauxetic Effect: M-L Orbital Overlap; EPR; Ligand Field Theory; Effect of Pi-Bonding; Spectrochemical series; Russel-Saunders Terms: Ground Terms and Racah Parameters; Spin Multiplicity; Spin- Orbit Coupling; Electronic Spectra: Selection rules; Orgel and Tanabe-Sugano (T-S) diagrams; Applications of T-S diagrams; Charge Transfer Spectra.

## Course Outcome

| | |
|---|---|
| **CO-1** | Students will apply their knowledge of carbocyclic chemistry for preparation, purification and identification of organic compounds. |
| **CO-2** | One can apply the concept of natural chemistry in the identification of natural compounds. |
| **CO-3** | To analyze and interpret the structural elucidation of compounds of natural origin. |
| **CO-4** | The theory of ligand field and elecronic spectra of complexes are useful for predicting the spectroscopic and magnetic properties of coordination compounds. |
| **CO-5** | To identify the regions of the electromagnetic spectrum corresponding to different molecular transitions. |
| **CO-6** | To rationalize the multiplet structure of electronic spectra. |

**Reference Books:**

**1.** *Organic Chemistry; Stereochemistry and The Chemistry of Natural Product* ,Volume-2 I.L. Finar,2002, 5th edition ,Person publishers Pv Ltd
**2.** *General and Inorganic Chemistry part II,* R Sarkar, New central book agency Pv Ltd
**3.** *Shriver and Atkins' Inorganic Chemistry*, Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong.
**4.** *Fundamental Concepts of Inorganic Chemistry: Volume 7 and Volume 5* ,Asim K Das, CBS Publishers and Distributer Pvt Ltd
**5.** *A Second Year Course of Organic Chemistry for Technical Institutes: The Carbocyclic Compounds*,2016, F. B. Thol
**6.** *Topics in Carbocyclic Chemistry: Volume 1*, D. Lloyd.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 1 | 2 | | - | - | - | | - | - | - | - | - | 1 | -2 | -1 |
| **CO-2** | - | 2 | | - | - | - | | - | - | - | - | - | 1 | - | -1 |
| **CO-3** | - | -3 | - | - | - | - | | - | - | - | - | - | 2 | -1 | -2 |
| **CO-4** | - | -3 | - | - | - | - | | - | - | - | - | - | - | - | 1 |
| **CO-5** | | 2 | 2 | - | - | - | | - | - | - | - | - | -2 | 2 | - |
| **CO-6** | - | -2 | | - | 1 | - | | - | - | - | - | | - | 2 | -2 |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 1 | 3- | -2 |
| CO-2 | - | 1 | 1- |
| CO-3 | | -2 | - |
| CO-4 | - | - | 2 |
| CO-5 | 1 | -3 | - |
| CO-6 | - | 2 | -2 |

**Course: General Chemistry-XIII** **Code: DSCY26B16**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental knowledge of organic reaction mechanism and reaction intermediate. |
| **PEO-2** | Ability to analyse the organic reactions mechanism for understanding various important named reactions. |
| **PEO-3** | To Enhance their professional growth along with scientific knowledge through continuing education and further innovation in research in organic chemistry. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Enhance their knowledge to predict the probable reaction mechanisms of organic reactions which are important for synthetic chemistry. |
| **PSO-2** | To Apply the principles of organic reaction mechanism for the synthesis organic compounds which are relevant in modern synthetic chemistry and commercially important compounds. |
| **PSO-3** | Students can design the synthesis of new organic compounds from the basic knowledge of the various organic named reactions keeping the environmental safety and economic factors. |

## Course Objective

**(1)** To familiarize with knowledge and core concepts of the organic named reactions and to understand the mechanisms involved in the reactions.

**(2)** Students will learn the mechanistic pathway of the named reactions and their applications in synthesis of many important organic compounds.

**(3)** This course also aims to give concepts and importance of the reactive intermediate chemistry. Students will also learn the mechanistic pathways of various important reactive intermediates in organic chemistry.

**(4)** To provide a good platform with solid knowledge in reactive Intermediates which are responsible for many organic reactions.

## Course Content

### 1. Organic Reaction Mechanism and Rearrangement (30 L):

Name reaction in organic synthesis: Pinacol-pinacolone rearrangement, Favorski rearrangement, Fries rearrangement, Knoevenagel reaction, Mannich reaction, Michael reaction, Oppeananer oxidation, Wolf Kishner reaction, Wagner- Meerwein rearrangement, Benzil-Benzilic Acid rearrangement, Beckmann Rearrangement, Diels-alder reaction, Claisen rearrangement, Wittig rearrangement, Mc Murry reaction, Mitsunovo reaction ,Julia olifination Shapiro reaction, Swern oxidation, Baylis-Hilman reaction, Baeyer Villager reaction, Dienone-phenol rearrangement, Neber rearrangement and Stephen rearrangement.

### 2. Reactive Intermediates (15 L):

Carbocations: Classical and nonclassical, neighbouring group participation, ion-pairs molecular rearrangements in acyclic and cyclic systems involving carbocations; stability and reactivity of bridge head carbocation.

Carbanions: Generation, structure and stability, and their reactions.

Carbenes: Generation and structure, reactions involving carbenes and carbenoids.

Nitrenes: Generation , structure and their reactions.

Enamines: Generation, structure and applications in organic synthesis. Benzynes: General, structure and reactions; Ipso effect.

## Course Outcome

| | |
|---|---|
| **CO-1** | To understand the knowledge of important organic named reactions and reaction mechanisms for the understanding of various commercially important organic reactions in synthesis organic chemistry. |
| **CO-2** | To acquire the concept of reactive intermediate and their reaction mechanism and to familiarise the applications of these reactive intermediate in organic chemistry |

**Reference Books:**

**1.** Carey F.A. and Sundberg R. J. , Advanced Organic Chemistry, Parts A & B , Plenum, U.S. ,2004
**2.** March J., Advanced Organic Chemistry, John Wiley & Sons,1992
**3.** Christian M. Rojas., Molecular Rearrangements in Organic Synthesis, John Wiley & Sons, 2015.

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** | **PO-6** | **PO-7** | **PO-8** | **PO-9** | **PO-10** | **PO-11** | **PO-12** | **PEO-1** | **PEO-2** | **PEO-3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **2** | **2** | | **3** | **-** | **2** | **2** | **-** | **-** | **-** | **-** | **3** | **2** | **2** | **2** |
| **CO-2** | **2** | **3** | **-** | **3** | **-** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **2** |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| **CO** | **PSO-1** | **PSO-2** | **PSO-3** |
|---|---|---|---|
| **CO-1** | **-** | **3** | **2** |
| **CO-2** | **3** | **2** | **3** |

**Course: Molecular Spectroscopy** **Code: DSCY26B17**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the knowledge of Spectroscopy (viz. UV-Vis, IR and NMR) with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the samples in the context of practical characterisationof the synthesised molecule. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop system for characterisation of molecules, by utilizing knowledge of chemistry. |
| **PSO-2** | Successfully apply the principles and spectroscopic nature of different molecules which have been learned as a part of this course. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Molecular Spectroscopy deals with different types of spectroscopic features present in chemical compounds. The topic will cover the UV-Vis, IR, NMR and Raman spectroscopy and energy relations of chemical compounds and also the theoretical treatment of molecular structure determination**.**

**2.** The students will be able to explain what it means to use spectroscopic methods for qualitative and quantitative analysis.

**3.** The students will be able to explain qualitatively determine the relative error in absorbance measurements and determine the optimal range for measurement purposes.

**4.** The students will be able to describe the selection rule for infrared-active transitions.

**5.** The students will be able to determine the vibrations for a triatomic molecule and identify whether they are infrared-active.

**6.** The students will be able to determine whether the molecular vibrations of a triatomic molecule are Raman active.

## Course Content

**Electronic Spectroscopy (8 L):**

Absorption laws (Beer-Lambert law), molar absorptivity, presentation of UV spectra, electronic transitions (σ-σ*, σ-π*, n-σ*, and π-π*), relative positions of $\lambda_{max}$ on conjugation effect, solvent effect. Concept of chromophore, auxochrome, bathochromic, hypsochromic, hyperchromic and hypochromic shifts. Woodward and Fischer's rule of conjugated enes, enones and aromatic compounds.

**NMR Spectroscopy (15 L):**

Basic principle, nuclear spin active nucleus, magnetic property of nuclei; precessional motion and frequency in an external magnetic field; nuclear resonance, relaxation process, spin-lattice relaxation, electric quadruple relaxation, broadening of signals. Chemical shifts, factors affecting the chemical shifts, shielding and deshielding effects and anisotropic effect. Magnetic and nonmagnetic equivalence nuclei. Spin-spin splitting, coupling constant, first order and non-first order spectra, double resonance in NMR, Decoupling phenomenon, use of $^{1}H$ and $^{13}C$ NMR in structural elucidation.

**Infrared and Raman Spectroscopy (15 L):**
Basic principles of IR and Raman spectroscopy. Comparison of IR and Raman spectroscopy, application of vibrational spectroscopy ininvestigating symmetry and shapes of simple molecule $AB_2$, $AB_3$ and $AB_4$, $AB_5$ and $AB_6$molecules on the basis of spectral data; mode of bonding of ambidentate ligands, ethylenediamine, diketonato complexes, thiocyanate, nitrate, sulphate and urea, application ofresonance Raman spectroscopy particularly for the study of active sites ofmetalloprotiens,Transition moment, Fermi's Golden rule, Franck-Condon transition, Vertical transitions,selection rules.

**EPR (7 L):**
Basic principle of EPR spectroscopy, derivative curves; difference between ESR and NMR; hyperfine splitting, g-tensors, application to transition metal complexes, simple organic molecules including free radicals.

## Course Outcome

| | |
|---|---|
| **CO-1** | Student will know basic information on molecular methods UV-vis spectroscopy. |
| **CO-2** | To acquire the knowledge of NMR spectroscopy and to familiarize the principles of various NMR spectroscopy techniques which are relevant to chemical analysis of organic molecules and compounds |
| **CO-3** | To familiarise the basic principles of IR spectroscopy and their applications in characterization of functional groups of organic molecules |
| **CO-4** | Student will acquire basic information on molecular methods EPR spectroscopy. |

**Reference Books:**

**1.** C. N. Banwell, Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw-Hill, 1994.
**2.** G. Aruldhas, Molecular Structure and Spectroscopy, 2nd Edition,Prentice-Hall of India Pvt. Limited, 2004.
**3.** Rita Kakkar, Atomic and Molecular Spectroscopy: Basic Concepts and Applications,Cambridge University Press, 2015.
**4.** William Kemp, Organic Spectroscopy, 3rd Edition, ELBS with Macmillan, 1975.
**5.** Donald L. Pavia, Introduction to Spectroscopy.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**S- Strong, M-Moderate and W-Weak**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | | M | | | | | | | | | | | M | | |
| CO-2 | | S | | | | | | | | | | | M | | |
| CO-3 | | | M | | S | | | | | | | | M | | |
| CO-4 | | | | | S | | | | | | | | | | S |
| CO-5 | | | | | | | | | M | | | M | | M | |
| CO-6 | | | | M | | | | | | | | | | M | |

**Course: Advanced Inorganic Chemistry Laboratory Code: DSCY26P09**
**L-T-P: 0-0-9 Credit: 6**

**Program Outcomes (POs):**

Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Enable the students to learn the various fundamental chemical processes. |
| **PEO-2** | Attainment of laboratory management skills to tackle the plant operations and process control instrumentation in an efficient manner. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Gain confidence in handling chemicals, glassware and instruments profession-ally in chemical industries and develop the modern techniques. |
| **PSO-2** | Successfully apply their practical experience to analytically determine materials applicable in our daily life. |

## Course Objective

1. To understand the basic concepts in systematic methods of qualitative chemical analysis of inorganic salt mixtures.
2. To determine the amount of element or substance quantitatively in the test sample.
3. To know the fundamentals and conditions to obtain a desirable metal complexes and their preliminary characterization.

## Course Content

**I. Semimicro qualitative analysis**

Systematic analysis of inorganic salt mixtures containing six ions including one of the following rare elements: W, Mo, Au, Pt, Pd, Se, Te, V, Ti, Zr, U, Th and Ce and the interfering anion (arsenates/phosphate/borate/fluoride).

**II. Quantitative estimation** (involving volumetric-redox and complexometry) of constituents in two and three component mixtures.

1. Estimation of Fe(II) and Fe(III) in a mixture using standard (N/20) solution of $K_2Cr_2O_7$ as a titrant
2. Estimation of Cu and Zn in a mixture using standard (N/20) solution of $Na_2S_2O_3$ as titrant.
3. Estimation of Fe and Cu in a mixture using standard (N/20) solution of $K_2Cr_2O_7$ and $Na_2S_2O_3$ as titrant.
4. Estimation of Fe and Mn in a mixture using standard (N/20) solution of $K_2Cr_2O_7$ as titrant.
5. Estimation of Fe and Cr in a mixture using standard (N/20) solution of $K_2Cr_2O_7$ as titrant.

**III. Preparation of inorganic compounds:** following the allied reactions and physical studies includes melting point and conductance measurements, UV-Visible spectroscopy Fluorescence spectroscopy and determination of CFSE value.

**i)** Hexamminecobalt(III) chloride
**ii)** Tris(ethylenediamine)cobalt(III) chloride
**iii)** Dichlorobis(ethylenediamine)nickel(II)
**iv)** Hexamminenickel(II) chloride
**v)** Tris(acetylacetonato)iron(III)
**vi)** Manganese(III)acetylacetonate

## Course Outcome

| | |
|---|---|
| **CO-1** | Students will have hands-on experience on basic principle in separation and identification of components in inorganic salt mixture. |
| **CO-2** | Learning of the volumetric analytical methods to determine the amount of substance present in the test sample. |
| **CO-3** | Training in synthesis of complexes and basic instrumental methods of analysis for their preliminary characterization will pave the way to future research work. |

**Reference Books:**

**1.** A.I. Vogel, Macro and Semicro qualitative Inorganic Analysis, Orient Longman, 1969.
**2.** J. Basset, R.C. Denney, G.H. Jeffery and J. Memdham, Vogel's Text Book of quantitative Inorganic Analysis, ELBS, 4th Edn., 1978.
**3.** H. H. Willard, L. L. Merrit and J.A. Dean, Instrumental methods of analysis, East-West Press, 4th Edn, 1974.
**4.** G.W. Parshall (Ed. In chief), Inorganic Synthesis, Vol 15, McGraw Hill, P. 48, 1974.
**5.** D. D. Sood, S. B. Mohaharand, A. V. R. Reddy, Experiments in Radiochemistry Theory and Practice, IANCAS Publications, 1994.
**6.** W.L. Jolly : Synthesis and characterization of inorganic compounds Prentice Hall Inc.
**7.** S.C.Das, Advanced Practical Chemistry for 3-Year Honours Course, $6^{th}$ Edn., 2012.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | - | - | 3 | - | - | - | - | - | - | - |
| **CO-2** | - | 2 | - | 2 | - | - | - | - | - | - | - | - |
| **CO-3** | - | - | 2 | 2 | - | - | - | - | - | - | 2 | - |

To establish the correlation between COs & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "- "**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| **CO-1** | 4 | - |
| **CO-2** | 3 | - |
| **CO-3** | - | 4 |

# *Seventh Semester*

**Course: General Chemistry-XIV** **Code: DSCY27B18**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of Pericyclic and photochemistry with modern computational and theoretical skill. |
| **PEO-2** | Ability to analyse the organic reactions involving pericyclic and photochemical problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education and further innovation in research. |

**PSOs (Program Specific Objectives):**

| | |
|---|---|
| **PSO-1** | Enhance their knowledge to predict feasibility of various pericyclic and photochemical reactions. |
| **PSO-2** | Apply the principles of pericyclic and photochemicals reactions under different reaction conditions. |
| **PSO-3** | Students can design the synthesis of organic compounds involving pericyclic and photochemical reactions under suitable reaction conditions. |

## Course Objective

**(1)** To familiarize with knowledge and core concepts of the Chemistry of pericyclic reactions which are very important and relevant branch of organic chemistry.
**(2)** Students will learn the mechanistic pathway of pericyclic reactions and its applications in the synthesis of many important organic compounds.
**(3)** This course also aims to give concepts and importance of photochemistry in organic chemistry. Students will also learn the mechanistic pathways of various photochemical reactions which are important in organic chemistry.

## Course Content

### Pericyclic and Photochemical Reactions (25 L):

Molecular orbital symmetry, Frontier orbital of ethylene, 1,3- butadiene;1,3,5-hexatriene and allyl systems, classification of pericyclic reactions (electrocyclic, cyloaddition, sigmatropic), Woodward Hoffman’s rule and correlation diagram, FMO and aromatic approach, transition states, Hiickel systems.

**Electro cyclic reactions:**

Conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems (thermal and photochemical).

**Cycloadditions:**

Antarafacial and suprafacial additions, 4n, 4n+2 systems, (2+2)-cycloaddition of ketones, (4n+2) cyclo additions (Diels-Alder, retro-Diels-Alder, heteroatom Diels-Alder and intramoleculer Diels-Alder reactions). 1,3-dipolar cycloadditions, cheletropic (addition and elimination) reactions.

**Sigmatropic rearrangements:**

Suprafacial and antarafacial shifts of hydrogen and carbon moieties. [3,3], [1,5], [5,5], [3,3], [2,3]-sigmatropic rearrangements. Claisen, Cope, Oxy-Cope, Aza-Cope, degenerate Cope and Sommlet-Houser rearrangements. Ene reactions.

**Photochemistry (20 L):**
Photochemical process, Franck-Condon principle, Jablonski diagram, photo sensitization, quantum yield, Stern-Volmer plot, delayed fluorescence, photochemistry of alkenes and dienes, *cis-trans*isomerisation, photochemical additions reactions of 1,3;1,4 (di-pi-methane rearrangement) and 1,5-dienes, dimerisation.

**Photochemistry of carbonyl compounds:**
Norrish type I and II reactions (cyclic and acyclic), α, β- unsaturated ketones; β, γ- unsaturated ketones, cyclohexenones (conjugated); cyclohexadienones (cross-conjugated and conjugated), Paterno-Buchi reaction, photo reductions, photochemistry of aromatic compounds; isomerisation, skeletal isomerisation, Dewar and Prismanes in isomerisation, singlet oxygen reactions; Photo Fries rearrangement, Barton reaction, Hofmann-Loffler Freytag reaction.

## Course Outcome

| | |
|---|---|
| **CO-1** | To predict the feasibility of organic reactions involving pericyclic and photochemical reactions under different reaction conditions. |
| **CO-2** | To develop and design for the synthesis of various organic photochemical reactions which are very important for understating mechanism of photochemical reactions. |

**Reference Books:**

1. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Edn., Oxford University Press, 2016.
2. S.M. Mukherjee, S.P. Singh, R.P. Kapoor, Organic Chemistry Volume III, New Age International Ltd. Publisher, New Delhi.
3. J. Singh and J. Singh, Photochemistry and Pericyclic Reactions, 4$^{th}$ Edition, New Age International Publisher.
4. K. C. Majumder, P. Biswas, Textbook of Pericyclic Reactions, Medtech, 2015.
5. Dipak K. Mondal, Pericyclic Chemistry, Orbital Mechanisms and Stereochemistry, Elsevier.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 2 | 2 | | 3 | - | - | 2 | - | - | - | - | 3 | 2 | 2 | 2 |
| **CO-2** | 2 | 3 | - | 3 | - | - | 2 | - | - | - | - | - | 2 | - | - |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | 3 | 4 | 3 |
| **CO-2** | 2 | - | 2 |

**Course: General Chemistry-XV** **Code: DSCY27B19**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of Symmetry Elements and Symmetry Operations and its applications. |
| **PEO-2** | Acquire the fundamental principles of molecular spectroscopy with modern experimental and theoretical skills. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop the behaviour of tiny particle and photo-physical properties of molecules. |
| **PSO-2** | Successfully apply the principles of group theory for various engineering materials which have been learned as a part of this course. |
| **PSO-3** | Understanding of these concepts is fundamental in understanding how molecules interact with light. |

## Course Objective

**1.** Connect the historical development of symmetry, symmetry elements and symmetry operations with our day to day knowledge. and learn the basic properties of quantum world.
**2.** Learn the basic properties of group theory.
**3.** Solve the Schrodinger equations for atoms and molecules with the help of group theory.
**4.** The course provides an introduction to molecular spectroscopy.
**5**. Student will know the basic physical chemistry law that govern molecular spectroscopy
**6.** Understanding of these concepts is fundamental in understanding how molecules interact with light.

## Course Content

**(1) Group Theory and its Application in Chemistry (25 L):**

Symmetry and group theory: Properties of group, subgroup and class, symmetry elements and operations, point groups, matrix representation of groups, operators and basis functions, similarity transformation, reducible and irreducible representations, Great orthogonality theorem and its consequences, character table, Projection operators and its applications. Hybridization schemes for σ-orbital, hybridization schemes for π-bonding for $AB_n$ type molecules.

Molecular rotational and vibrational spectroscopy: Rotations and vibrations of diatomic and polyatomic molecules, internal coordinates, normal modes and their symmetry, selection rules for fundamental vibrational transition.

**(2) Atomic and Molecular Spectroscopy (20 L):**

Vector model of atom; Stern-Gerlach experiment; atomic term symbol; many electron system and antisymmetry principle; atomic spectra; pure rotational and vibrational spectra of diatomic and polyatomic molecules; vibrational-rotational coupling; Raman spectroscopy of molecules; electronic spectra of molecules; selection rules for vibrational, electronic and Raman spectra; introduction to resonance spectroscopy: NMR, ESR, hyperfine interaction, photoelectron spectroscopy, Auger spectroscopy, Mössbauer spectroscopy.

## Course Outcome

| | |
|---|---|
| **CO-1** | Pinpoint the historical aspects of development of group theory. |
| **CO-2** | Understand the idea of symmetry. |
| **CO-3** | Understand the Great Orthogonality Theorem. |
| **CO-4** | Student forms a mental picture on the meaning of linear combination of atomic orbitals. |
| **CO-5** | Molecular Spectroscopy course provides an introduction to the knowledge of the spectroscopy methods about structure of the chemistry compounds, as well as experimental usage of chosen methods (IR, NMR, UV- VIS). |
| **CO-6** | Understanding of these concepts is fundamental in understanding how molecules interact with light. |

**Reference Books:**


**1.** D.A. McQuarrie, Quantum Chemistry, OUP (1983).
**2.** P.W. Atkins et al Molecular Quantum Mechanics, OUP, 1998.
**3.** R. K. Prasad, Quantum Chemistry, New Age International, New Delhi, 19974
**4.** Fundamentals of Molecular Spectroscopy, C.N. Banwell, E.M. McCash, 4$^{th}$ Edn., McGraw-Hill.
**5.** Chemical Applications of Group Theory, F.A.Cotton, 3ed, Wiley.
**6.** Group Theory and Quantum Mechanics, M. Tinkham, McGraw Hill, 1964.
**7.** A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning Pvt. Ltd., 2008.
**8.** P. W. Atkins – Physical Chemistry, 7th Edn. Oxford (2000).
**9.** I. N. Levine, Physical Chemistry, 5th Edn., McGraw Hill, New Delhi, (1995).
**10.** Physical Chemistry, G.W. Castellan, 3$^{rd}$ Edn. Addison Wesley.


**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation “-“**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | | | | | | | | | | | **2** | | |
| **CO-2** | | **2** | | | | | | | | | | | **2** | | |
| **CO-3** | | | **2** | | | | | | | | | | **2** | | |
| **CO-4** | | | | | | | | | | | | | | | **3** |
| **CO-5** | | **2** | **2** | | | | | | | | | | | **2** | |
| **CO-6** | | | | | | | | | | | | **3** | | **2** | |

**Course: General Chemistry-XVI** **Code: DSCY27B20**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the knowledge on synthesis, structure and bonding, properties and reactivity of main group organometallics. |
| **PEO-2** | Acquire the knowledge about cluster compounds, cage compounds and transition metal cluster complexes and their physical and chemical properties. |
| **PEO-3** | Enhancing their scientific knowledge about the specific role of metal ion biological system. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop system for organometallic catalysis by utilizing knowledge of chemistry. |
| **PSO-2** | Successfully apply the principles about basic concepts of active site structure function of iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity. |
| **PSO-3** | Evaluate the correlation between bonding with physical and chemical properties of cage and cluster compounds of main groups as well as transition and late transition elements. |

## Course Objective

**1.** The focus of this course is on the synthesis, structure and bonding, properties and reactivity of main group organometallics (including Grignard reagents, organolithium reagents, organophosphorus compounds, etc), organotransition metal chemistry and organometallic catalysis.
**2.** The laboratory component of the course will aim to develop skills in the handling of air-sensitive compounds using the Schlenk technique and the purification of compounds using chromatographic techniques.
**3.** To learn about cluster compounds, cage compounds and transition metal cluster complexes and their physical and chemical properties.
**4.** Studying this subject the students will learn about the specific role of metal ion biological system.
**5.** To introduce the students about basic concepts of active site structure function of iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity.
**6.** In the topic the attention also paid to metal ion and their coordination complex which are employed in chemotherapy, magnetic resonance imaging agents or as radiopharmaceutical.

## Course Content

**Organometallic Chemistry (15 L):**
Definition, acid ligands, hapticity (s) of ligands, 18-electron rule, application of 18-electron rule to carbonyl, nitrosyl, cyanide and hydrido complexes. Preparation, Properties and bonding of carbonyl, nitrosyl and cyanide complexes, metal carbonylates, carbonyl hydrides, metal olefin, alkynes and cyclopentadienyl complexes, Ziese's salt (preparation, structure and bonding), Ferrocene (preparation, Structure, bonding and reactions). Metal-metal bonded compounds and metal culsters (simple examples).
Simple examples of fluxtional molecules, coordinative unsaturation, oxidative addition and insertion reactions, homogeneous catalysis by organometallic compounds: hydrogenation, hydroformylation and polymerization of alkenes (Ziegler Natta Catalyst).

**Cage and Cluster Compounds (15 L):**
Bonding in boranes, styx numbers, synthesis and reaction of boron hydrides, carborane, borazine and boron nitride complexes. Cluster and catalysis, molecular structure of cluster, stereochemical rigidity of clusters, electronic structure of clusters with pi-acid ligands, capping principle, halide cluster, synthesis of metal clusters.

**Bioinorganic Chemistry (15 L):**
Essentials and trace elements of life, basic reactions in the biological systems and the role of metal ions specially $Na^+$, $K^+$, $Mg^{2+}$, $Fe^{3+/2+}$, $Cu^{2+}$ & $Zn^{2+}$. Transport across biological membrane-$Na^+$ ion pump, ionophores. Bio-function of hemoglobin and myoglobin, cytochromes and ferridoxins, photosynthesis: photo system I and II, Carbonate-bicarbonate buffering system and carbonic anhydrase. Biological nitrogen fixation. Toxic metal ions and their effects, chelation Therapy, metal dependent diseases and Pt and Au complexes as drugs (examples only).

## Course Outcome

| | |
|---|---|
| **CO-1** | Upon successful completion, students will have the knowledge and skills to explain and rationalize the synthesis, structure, bonding, properties and reactivity of both main group and transition metal organyls. |
| **CO-2** | On satisfying the requirements of this course, students will have the knowledge and skills to explain and rationalize industrially important catalytic processes through the application of organometallic principles. |
| **CO-3** | Know the concept and structural basis of cluster formation from the elements and Relate the physical characteristics of metals to their chemical reactivities. |
| **CO-4** | Knowledge on the importance of inorganic elements in biology with the special emphasis on how they function in*vivo*. |
| **CO-5** | Relate the structure of dioxygen binding protein: haemoglobin and myoglobin on the basis of cooperative interactions. |
| **CO-6** | Acquire the knowledge about the role of chelating agents as de-toxifying agent in metal poisoning and the mechanism of cisplatin as anticancer drug. |

**Reference Books:**

**1.** J. H. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry: Principle of structure and reactivity*, 4th Ed., Pearson, New Delhi.
**2.** Shriver & Atkins, *Inorganic Chemistry*, 4th Ed., Oxford University Press, Delhi
**3.** G. L. Miessler, D. A. Tarr, *Inorganic Chemistry*, 3rd Edition, Pearson, Delhi, India.
**4.** M. N. Hughes, *Inorganic Chemistry of Biological Processes*, 2nd Ed.(1981), John-Wiley & Sons, New York.
**5.** W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide*, Wiley, New York (1995).
**6.** S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, (1994).
**7.** I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, *Bioinorganic Chemistry*, Viva Books.

Table 1

**Mapping with the POs/ PEOs:**

**Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | - | - | 2 |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - |
| **CO-4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5** | - | 2 | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-6** | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

**To establish the correlation between Cos & PSOs**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

Table 2

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | - | 4 | - |
| CO-2 | - | - | 3 |
| CO-3 | 4 | - | - |
| CO-4 | - | 3 | - |
| CO-5 | 2 | - | - |
| CO-6 | - | - | - |

**Course: Instrumental Methods of Analysis** **Code: DSCY27B21**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the knowledge about the fundamental and application of existing chemical and scientific theories. |
| **PEO-2** | Apply the theoretical knowledge in practical field of work. |
| **PEO-3** | Proficiency to discover new field of research in both chemistry and allied fields of science and technology. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | To understand basic principles of characterization techniques for different materials and be familiar with practical aspect of each technique. |
| **PSO-2** | Ability to understand elementary knowledge and fundamentals application microscopic and spectroscopic analysis to analyze characteristic of inorganic compound. |
| **PSO-3** | Prospects to excel in higher studies or Industry. |

## Course Objective

**(i)** To relate the conceptual understanding of the basic principles and application of some separation methods in Chemistry

**(ii)** To understand about the phases of thermal degradation outlines of materials using various types of thermal systems like TGA, DTA, DSC, etc. and basic conception about different theoretical concept and their applications

**(iii)** Explore the electrochemical perception to be applied in analytical techniques such as polarography , amperometry, cyclic voltametry etc

**(iv)** To understand principles of several materials characterization techniques.

## Course Content

**(1) Separation and Thermal Analysis (15L):**

**Solvent Extraction**: Liquid-Liquid Extraction, principle, operation technique, successive extraction, different inorganic extraction system, various factors, counter-counter distribution.

**Chromatography:** general principles, methods and applications of column (adsorption and partition), paper chromatography, paper electrophoresis, thin layer chromatography, gas chromatography, high performance liquid chromatography, supercritical fluid chromatography, size-exclusion chromatography and ion chromatography

**Thermal Analysis:** Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods

**(2) Electroanalytivcal Techniques (15L):**

**Polarography:** Origin of polargraphy, Current-voltage relationship, Theory of polarographic waves (DC and sampled DC (tast) polarograms), Instrumentation, Ilkovic equation, Qualitative and quantitative applications.

**Cyclic Voltammetry:** Instrumentation, current-potential relation applicable for Linear Sweep Voltammetry (LSV) and Cyclic Voltammetry (CV), interpretation of cyclic voltammograms and parameters obtainable from voltammogram. Basic principle of Amperometric Titration and Coulometric analysis.

**(3) X-ray diffraction and Microscopy techniques (15L):**
**(i) X-ray diffraction:** Basics principle of powder-XRD, Phase identification, indexing, crystallite size, lattice parameter determination.
**(ii) Microscopy techniques:** Optical microscopy, Basic Concepts of resolution, TEM, SEM, AFM
**(iii) Electron Spectroscopy:** Theory, Instrumentation and applications of Electron spectroscopy (XPS, XRF and Auger).

## Course Outcome

| | |
|---|---|
| **CO-1** | Understand the basic principles associated with chromatography and discuss how these are applied to the various specific applications of chromatography. |
| **CO-2** | Resolve the problems established on numerous thermal concepts, design experiments with accurate data handling and analysis, and analyze several thermodynamic parameters. |
| **CO-3** | To understand the use of electrochemistry for analytical purpose. |
| **CO-4** | Students will familiar with the comprehensive subject of different types of method to analyze samples and it will help them with their project/ research purpose. |

**Reference Books:**

**1.** G. D. Christian, *Analytical Chemistry*, 5th Edition (1994), John Wiley & Sons, New York.
**2.** D. A. Skoog, *Principles of Instrumental Analysis*, 5th Edition (1998), Saunders College Publishing, Philadelphia, London.
**3.** G.W. Ewing, *Instrumental Methods of Chemical Analysis*, 5th Edition (1978), McGraw Hill Books Co., New York.
**4.** J. H. Kennedy, *Analytical Chemistry: Principles*, 2nd Edition (1990), Saunders Holt, London.
**5.** R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
**6.** F. W. Fifield and W. P. J. Hairens, Environmental Analytical Chemistry, 2nd Edition (2000), Black Well Science Ltd.
**7.** A. K. Das and M. Das *Environmental Chemistry with green Chemistry* 1$^{st}$ Edition (2015), Books and allied(P) Ltd.
**8.** S. K. Banerji, *Environmental Chemistry*, 1st Edition (1993), Prentice-Hall of India, New Delhi.
**9.** S. M. Khopkar, *Environmental Pollution Analysis*, 1st Edition (1993), Wiley Estern Ltd., New Delhi.
**10.** A. K. De, *Environmental Chemistry*, 4th Edition (2000), New Age International Private Ltd., New Delhi.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-2** | **3** | **2** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-3** | **3** | **2** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-4** | **3** | **-** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **3** |

To establish the correlation between COs & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | **3** | **4** | **-** |
| **CO-2** | **3** | **-** | **3** |
| **CO-3** | **4** | **-** | **-** |
| **CO-4** | **4** | **3** | **2** |

## Course: Advanced Organic Chemistry Laboratory    Code: DSCY27P10
## L-T-P: 0-0-9    Credit: 6

**Program Outcomes (POs):**

Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | To focus on reaction design and methodology development in the fields of synthetic organic chemistry and provide knowledge of multi-step synthesis. |
| **PEO-2** | To impart knowledge of chromatographic techniques for separation of organic compounds in the context of practical relevance in the Chemical industries. |
| **PEO-3** | To analyse the professional needs in applied chemical industry technology through the knowledge of quantitative estimation of natural products and organic compounds. |

**PSOs (Program Specific Objectives):**

| | |
|---|---|
| **PSO-1** | To apply the knowledge synthetic methods of organic synthesis for the development of new drug candidates, drug delivery concepts and nano-molecular devices. |
| **PSO-2** | Successfully apply modern and high-tech estimation techniques as a part of this course. |

# Course Objective

**(1)** To provide the knowledge of different synthetic techniques for designing organic molecules or processes that meet the specified needs with appropriate consideration for the demands of chemical industries.

**(2)** To impart the knowledge of creation, selection and application of appropriate techniques, resources and modern scientific and engineering tools.

**(3)** To acquire the knowledge of quantitative estimation of different types of organic compounds for their future applications in industrial chemistry.

# Course Content

**(1)** Multistep synthesis of organic compounds, determination of organic compounds and separation using column chromatography and characterization using UV-Vis spectroscopy and IR.

**(2)** Column Chromatography

a. Separation of leaf pigments

b. Separation of a mixture of organic compounds.

**(3)** Quantitative analysis

a. Estimation of sucrose

b. Estimation of Vitamin C

c. Estimation of Phenol

d. Estimation of Aniline

e. Estimation of glycine

## Course Outcome

| | |
|---|---|
| **CO-1** | Students will acquire the knowledge of multi-step synthesis of organic compounds for further application in the field of pharmaceutical and related sciences with a background in the field of organic molecules |
| **CO-2** | Students will be able to separate the organic molecules in organic compounds by advance techniques. |
| **CO-3** | Students will acquire the knowledge of quantitative analysis of organic compounds and their importance in the field of drug chemistry, food chemistry, etc. |

**Reference Books:**

**1.** Vogel's Textbook of Practical Organic Chemistry 5th Edition, 2005, Pearson.

**2.** F.G. Mann, Practical Organic Chemistry 4th Edition, Pearson.

### Mapping with the POs/ PEOs: Matrix formation for attainments

**S- Strong, M-Moderate and W-Weak**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | | **S** | **S** | | | | | | | | | | **M** | **S** | |
| **CO-2** | | | | **M** | **S** | | | | | | | | | **S** | |
| **CO-3** | | | | | **S** | **S** | | | | | | | | | **SS** |

# *Eighth Semester*

**Course: Chemistry of Nanomaterials** **Code: DSCY28B22**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Obtain the fundamental principles of chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Familiar with all the different types of newly discovered carbon structures, known as fullerenes, nanotubes and graphene. |
| **PSO-2** | Understanding the importance of basic chemistry behind the properties of materials at the nanometre range. |
| **PSO-3** | Enhancing their professional growth along with the knowledge through continuing education the fundamental principles nanoscience and nanotechnology. |

## Course Objective

**1.** Basic approaches to synthesize inorganic colloidal nanoparticles and their self-assembly in solution and surfaces

**2.**Acquire knowledge about theproperties chemical reactions of fullerenes, especially $C_{60}$, andidea about how carbon nano tubes is synthesized by different method and their properties.

**3**.To deliver a broad knowledge of synthetic methodologies for the synthesis of graphene oxide and basic concepts about properties of graphene and oxidised product graphene oxide.

**4.** To advance usage of chemistry for modern technology and to introduce students to inter- and multi-disciplinary science and engineering.

## Course Content

**Introduction to Nanomaterials (15 L):**

Scientific revolution; atomic structures-molecular and atomic size; Bohr radius; emergence of nanomaterials; synthesis of zero, one, two, three dimensional nanostructured materials; size effects on properties; surface plasmon resonance, quantum confinement; synthesis and fabrication: top-down and bottom-up; solution based synthesis, vapour-phase synthesis, sol-gel method, lithography method, synthesis using frameworks, supports and substrates.

**Chemistry of Carbon Nanomaterials (20 L):**

(i) Fullerenes: discovery of fullerenes, synthesis of fullerenes, structural feature of fullerenes, properties of fullerenes, chemical reactivity of fullerenes, Osmylation reaction, addition reaction, substitution reaction, photo chemical reaction polymerisation reaction, classification of fullerenes: exohedral and endohedral fullerenes, application of fullerenes.

(ii) Carbon nanotubes: synthesis of carbon nanotubes by arc discharge method, laser ablation method and chemical vapour disposition method**,** role of transition metal catalyst in the growth of CNTs Vapour-liquid-solid (VLS) growth and solution-liquid-solid (SLS) growth of the carbon nano tubes and its application in various field.

(iii) Graphene and graphene oxide: discovery of graphene, preparation of graphene oxide by Hummer’s Method, formation mechanism of graphene oxide, top-down approach of synthesis of graphene oxide, bottom-up approach to synthesis of graphene oxide, comparison among graphene, graphene oxide and reduced graphene oxide, properties of graphene and graphene oxide, reaction of graphene oxide with acid and base, reduction reaction, non-covalent chemistry of graphene oxide, Raman spectra and optical properties of graphene oxide, photoluminescence property of graphene oxide, graphene oxide, quantum dots.

**Application of Nanomaterials (10 L):**
Waste water treatment by using nanoparticles, catalytic oxidation of CO to $CO_2$ at lower temperature by nanoparticles, nano composite materials for photochemical water splitting, for solar cell and lithium-ion batteries, drug delivery; bio-conjugation; sensing.

## Course Outcome

| | |
|---|---|
| **CO-1** | Student will learn about various techniques to synthesis of scalable nano domain materials and usage of chemistry for modern technology |
| **CO-2** | Students will learn about the importance of nano carbon materials like CNTs, graphene etc in modern science |
| **CO-3** | Students should be able to recognise application of fullerenes, CNTs, graphene in energy harvesting system |
| **CO-4** | Student can be able to join a research group in nanoscience nanotechnology as a student researcher having prior knowledge in chemistry of nanomaterials. |

**Reference Books:**

**1.** C. N. R. RAO, A. MÜLLER and A. K. CHEETHAM, *Nanomaterials chemistry: recent developments and new directions*, John Wiley & Sons, 2007.
**2.** A. M. DIMIEV and S. EIGLER, *Graphene oxide: fundamentals and applications*, John Wiley & Sons, 2016.
**3.** A. K. Das, *An introduction to nanomaterials and nanoscience*, CBS Publishers &distributors Pvt.Ltd.2017.
**4.** T. PRADEEP, *Nano: The Essentials*, Tata McGraw-Hill Education, 2007.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | - | - | - | - | - | - | - | - | - | 2 | 2 | 2 | - |
| **CO-2** | 2 | - | 2 | - | 2 | - | - | - | - | - | - | 2 | 2 | 2 | - |
| **CO-3** | 2 | 2 | - | - | - | - | - | - | - | 2 | - | | 2 | - | 2 |
| **CO-4** | 2 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | - | S |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | - | 4 | - |
| **CO-2** | - | - | 3 |
| **CO-3** | 4 | - | - |
| **CO-4** | 4 | - | 2 |

**Course: Solid State and Industrial Chemistry** **Code: DSCY28E07**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of chemistry with modern experimental and theoretical skills on solid state chemistry. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the wide range of materials and physical properties that currently available. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge to know basic methods for the synthesis and purification of reagents and inorganic compounds. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Characterise solid matter using electron microscopy and diffraction, x-ray diffraction, thermal analysis, spectroscopic methods. |
| **PSO-2** | Apply their knowledge to develop solar cell and super conducting material by utilizing knowledge of solid state chemistry. |
| **PSO-3** | Understand the factors involved and specify the challenges faced in the production of inorganic compounds. |

## Course Objective

**1.** To provide an introduction to the concepts of solid state chemistry.
**2.** To illustrate the wide range of materials and physical properties that currently available.
**3.** To learn synthesis design and planning, different processing techniques and their chemical-physical fundamentals as well as basic method of characterisation of solids.
**4.** To know basic methods for characterization of solid matter – electron microscopy and diffraction, x-ray diffraction, thermal analysis, spectroscopic methods.
**5.** To study the preparation of inorganic solvents and compounds.
**6.** To understand the factors involved and specify the challenges faced in the production of inorganic compounds.

## Course Content

**Solid State Chemistry (30 L):**

***Electronic Properties and Band Theory:***

Electronic structure of solids- band theory, Refinement to simple band theory- k-space and Brillouin Zones, Band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, Doped semiconductors, p-n junctions.

***Magnetic Properties:***

Classification of materials: Quantum theory of paramagnetics. Cooperative phenomena. Magnetic domains. Hysteresis. Temperature dependent magnetic properties.

***Solid State Reactions:***

General Principles, Experimental procedure, Co-precipitation, Kinetics of solid state reactions, Crystallization of solutions, melts glasses and gels. Growth of single crystals: Czochralski method, Bridgman and Stockbarger methods. Zone Melting.

**Industrial Chemistry (15 L):**
Some important industrial products (manufacture and application): Polymer (PVC, polyethylene, Bakelite, nylon-66, terylene, natural rubber, buna and neoprene rubber), vulcanization of rubber, Detergents (dodecylbenzene sulphonates), Pesticides (DDT, BHC and few others commonly used in agriculture), Dyes and Pigments (methyl orange, phenolphthalein, mercurochrome, ultramarine, zinc-white, litho phone, carbon black), Fertilizers (superphosphate of lime, urea, ammonium sulphate), Ceramics (only glass and cement).

## Course Outcome

| | |
|---|---|
| **CO-1** | The student should be able to describe the principles concerning solid state structures. |
| **CO-2** | To obtain the knowledge on design and development of materials with pre-required properties based on understanding the structure of solids in its influence on physical-chemical properties. |
| **CO-3** | Understanding of phase relations, chemical synthesis, reaction kinetics as well as characterisation methods. |
| **CO-4** | Students will be expected to be able to outline the preparation of some important inorganic products. |
| **CO-5** | Understand the usefulness of industrial inorganic chemistry and think how this industry can be improved. |
| **CO-6** | Have knowledge of the experimental factors involved in preparations of inorganic compounds. |

**Reference Books:**
1. A. R. West, Solid State Chemistry and Its Applications, Wiley (1990).
2. L. V. Azaroff, *Introduction to Solids*, Tata McGraw-Hill, New Delhi (1977).
3. C. N. R. Rao, J. Gopalakrishnan, New Directions in Solid State Chemistry, Cambridge University Press, 2nd Ed. (1997).
4. V. I. Dyabkov, Reaction Diffusion and Solid State Chemical Kinetics, IPMS Publications (2002).

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5** | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| **CO-6** | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

**<u>To establish the correlation between Cos & PSOs</u>**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

<u>Table 2</u>

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | - | 4 | - |
| **CO-2** | - | - | 3 |
| **CO-3** | 4 | - | - |
| **CO-4** | - | - | 2 |
| **CO-5** | 2 | - | - |
| **CO-6** | - | - | - |

## Course: Advanced Organometallics and Supramolecular Chemistry
## Code: DSCY28E08 L-T-P: 3-0-0 Credit: 3

**Program Outcomes (POs):**

Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the knowledge on synthesis, structure and bonding, properties and reactivity of main group organometallics. |
| **PEO-2** | Acquire the knowledge on organotransition metal chemistry and organometallic catalysis. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge on the principles of supramolecular chemistry and host-guest chemistry using "lock and key" analogy. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to develop system for organometallic catalysis by utilizing knowledge of chemistry. |
| **PSO-2** | Successfully apply the principles to develop skills in the handling of air-sensitive compounds using the Schlenk technique and the purification of compounds using chromatographic techniques. |
| **PSO-3** | Study the synthesis and structure of various supramolecular system such as crown ethers, coronads, cryptands, spherands, rotaxanes etc. |

## Course Objective

**1.** The focus of this course is on the synthesis, structure and bonding, properties and reactivity of main group organometallics (including Grignard reagents, organolithium reagents, organophosphorus compounds, etc), organotransition metal chemistry and organometallic catalysis.
**2.** The laboratory component of the course will aim to develop skills in the handling of air-sensitive compounds using the Schlenk technique and the purification of compounds using chromatographic techniques.
**3.** To Study the principles of supramolecular chemistry and host-guest chemistry using "lock and key" analogy.
**4.** To determine the nature of supramolecular interactions, cation binding hosts, anion binding, ion pairs receptors, molecular guests in solution, self-assembly
**5.** To study the synthesis and structure of various supramolecular system such as crown ethers, coronads, cryptands, spherands, rotaxanes etc.
**6.** The focus of this course is to demonstrate effective report writing, experimental design and data analysis.

## Course Content

**Advanced Organometallics (15 L):**
**Alkene and alkyne complexes:** Preparation, bonding and structure of alkene, alkyne, allyl, dienyl, and trienylcomplexes; Fischer and Schrock carbene and carbyne complexes, fluxionally and dynamic equillibria,
**Arene complexes:** Synthesis, structure, bonding and reactivities, Agostic interactions, cyclometallation reactions and applications.
**Reactions of transition metal complexes:** Reaction of organometallic compounds by oxidative addition, reductive elimination, insertion, hydrogenation, carbonylation, hydroformylation and polymerization.

**Applications in catalysis:** Hydrogenation, Zeigler-Natta polymerization, hydrocarbonylation, hydroformylation of olefins using cobalt or rhodium catalysts (Oxo process). Fischer-Tropsch synthesis and Wacker Process catalyst, Grubbs catalyst, Vaska's complex

**Supramolecular Chemistry (30 L):**
**Macrocycles Complexes:** Types of macrocyclic ligands – design and synthesis by coordination template effect, di- and poly-nuclear macrocyclic complexes; applications of macrocyclic complexes.
**Supramolecular Chemistry:** Definition, supramolecular building block and spacer, molecular recognition and host-guest interactions, spherical recognition, receptors, co-receptor molecules and multiple recognition, organometallic/macrocyclic receptors, catenane, rotaxane, catenand, catenate, coronand, ferrocene, cobaltocenium and other metallocene receptors, molecular and supramolecular devices, self organization and self assembly of inorganic architectures.

**Metal-Organic Framework (MOF):** Design, synthesis, structure and applications

## Course Outcome

| | |
|---|---|
| **CO-1** | Upon successful completion, students will have the knowledge and skills to explain and rationalize the synthesis, structure, bonding, properties and reactivity of both main group and transition metal organyls. |
| **CO-2** | On satisfying the requirements of this course, students will have the knowledge and skills to explain and rationalize industrially important catalytic processes through the application of organometallic principles. |
| **CO-3** | Upon successful completion, students will have the knowledge and skills to Work to a professional level of skills in a chemical synthesis laboratory demonstrating effective laboratory safety and etiquette especially in the areas of handling of air sensitive reagents, chromatographic techniques and spectroscopic characterization. |
| **CO-4** | Have a good overview of the core concepts in supramolecular chemistry and explain non covalent interactions,molecularrecoginition and self-assembly. |
| **CO-5** | Be able to describe some of the applications of supramolecular chemistry including industrial applications and supramolecular catalysis. |
| **CO-6** | Understand fundamentals of photochemistry and laws governing it such as Beer Lambert law. |

**Reference Books:**

1. J. H. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, ***Inorganic Chemistry: Principle of structure and reactivity***, 4th Ed., Pearson, New Delhi.
2. Shriver & Atkins, ***Inorganic Chemistry***, 4th Ed., Oxford University Press, Delhi.
3. G. L. Miessler, D. A. Tarr, ***Inorganic Chemistry***, 3rd Edition, Pearson, Delhi, India.
4. M. N. Hughes, *Inorganic Chemistry of Biological Processes*, 2nd Ed.(1981), John-Wiley & Sons,New York.
5. Jean-Marie Lehn, *Supramolecular Chemistry*, VCH, Weinheim (1995).
6. J. L. Serrano, *Metallomesogens*, VCH, Weinheim (1996).
7. Oliver Kahn, *Molecular Magnetism*, VCH, Weinheim (1993).
8. F.A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, *Advanced Inorganic Chemistry*, 6th Edn., John Wiley & Sons (Asia), Singapore (2003).

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5** | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| **CO-6** | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

**<u>To establish the correlation between Cos & PSOs</u>**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

Table 2

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | - | 4 | - |
| **CO-2** | - | - | 3 |
| **CO-3** | 4 | - | - |
| **CO-4** | - | - | 2 |
| **CO-5** | 2 | - | - |
| **CO-6** | - | - | - |

**Course: Art in Organic Synthesis** **Code: DSCY28E04**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental knowledge of art of synthesis of various organic reagents and compounds. |
| **PEO-2** | Ability to analyse the organic reactions and to predict their possible reaction mechanisms while maintaining environmental safety and economic factors. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education and further innovation for further research. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Enhance their knowledge of the art of synthesis of organic compounds and the use of appropriate reagents. |
| **PSO-2** | Apply the principles of catalysis for the synthesis of industrially important organic compounds keeping the safely of environment and commercial requirement. . |
| **PSO-3** | Students can design the synthesis of organic compounds and apply the knowledge of art of synthesis for the synthesis of commercially important organic compounds relevant to our day to life requirement. |

## Course Objective

(1) To familiarize with the knowledge of the art for the synthesis of important organic compounds and their application in our day to day life.
(2) To give fundamental idea to the students for the synthesis and uses of catalytic reactions.
(3) Students will also learn the methodoly for the synthesis of various important reagents and their uses for the synthesis of organic compounds which are very important in the synthetic and industrial chemistry.

## Course Content

**UNIT-I: Reagents in Organic Synthesis (35 L)**

**a) Reagents containing phosphorus, sulphur, silicon, and boron containing reagents:**

Phosphorus containing reagents: Wittig reagents, stereoselectivity and applications.
Sulphur containing reagents: preparation of sulphur ylides and its application, Sommelet rearrangement, umpolung of carbonyl compounds.
Silicon containing reagents: Peterson reagents and its applications.
Boron containing reagents: diborane, di-isoamylborane, thexylborane, 9-BBN, isopinocamphenyl and diisopinocampheyl borane-their applications in reduction, oxidation and carbonylation.

**b) Organotransition metal reagents:**

Preparation and application of organotitanium, organorhodium, organopalladium complexes, Wilkinson’s catalyst, Zigler Natta catalyst, Stille, Suzuki and Sonogashira coupling, Heck reaction, Kumuda reaction, Negishi coupling and Gillman reagent.

**c) Selected oxidizing reagents with relevant applications and mechanisms:**

DDQ, PCC, $SeO_2$, $HIO_4$, Sharpless epoxidation, Dess Martin Periodinane (DMP)

**d) Selected reducing agents with relevant applications and mechanism:**

Catalytic hydrogenation, metal-liquid ammonia reduction, $NaBH_4$, LAH, DIBAL

**UNIT-II: Asymmetric Synthesis and Retro Synthesis (10 L)**
Development of methodologies for asymmetric synthesis, regioselectivity, stereoselectivity, diastereoselectivity and stereospecificity. Retrosynthesis, synthons, disconnections, 1, 1 and 1, 2 C-C disconnections.

## Course Outcome

| | |
|---|---|
| **CO-1** | To familiarise the use of phosphorous, sulphur, silicon and boron containing reagents for the synthesis important organic compounds reagents. |
| **CO-2** | To acquire the fundamental knowledge and the applications of organotransition metal reagents for the synthesis of commercially important compounds keeping the safety of environment and economic factors. |
| **CO-3** | To familiarize with some important oxidizing agents and their relevant mechanisms and applications. |
| **CO-4** | To acquire the knowledge of some important reducing agents and their relevant mechanisms and applications. |
| **CO-5** | Students will acquire the idea of retrosynthetic and disconnection approach for the synthesis of various target organic molecules. |

**Reference Books:**

**1)** House H. O., Modern synthesis Reactions, W.A.Benjamin , London, 1972.
**2)** Carruthers .W, Modern Methods of Organic Synthesis , Cambridge University press,2004.
**3)** March J, Advanced Organic Chemistry, John Wiley , 1992.
**4)** Norman R. O. C., Coxon J.M., Principles of organic synthesis, 3rd Ed; ELBS, 1993.
**5)** Warren S., Organic Synthesis: The Disconnection Approach, Johe Wiley, 2004.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **2** | **2** | | **3** | **-** | **-** | **3** | **-** | **-** | **-** | | **3** | **2** | **2** | **2** |
| **CO-2** | **2** | **-** | **-** | | **-** | **-** | **2** | **-** | **-** | **-** | | **-** | **2** | **2** | **3** |
| **CO-3** | **2** | **2** | **-** | **-** | **-** | | **2** | | | | | | **2** | **3** | **2** |
| **CO-4** | **2** | **2** | **-** | **-** | **-** | | **2** | **-** | **-** | **-** | | | **2** | **3** | **2** |
| **CO-5** | **2** | **2** | **-** | **3** | **-** | | **2** | **-** | **-** | **-** | | | **2** | **3** | **2** |
| **CO-6** | **2** | **2** | **-** | **3** | **-** | | **2** | **-** | **-** | **-** | | | **2** | **3** | **2** |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| **CO-1** | **3** | **3** | **2** |
| **CO-2** | **2** | **3** | **-** |
| **CO-3** | **3** | **2** | **2** |
| **CO-4** | **2** | **-** | **4** |
| **CO-5** | **2** | **2** | **2** |
| **CO-6** | **2** | **3** | **3** |

**Course: Organic Spectroscopy** **Code: DSCY28E09**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental knowledge of various spectroscopic techniques. |
| **PEO-2** | Ability to analyse the spectroscopic data for elucidation of structures of organic molecules. |
| **PEO-3** | Enhancing their professional growth and skill along with scientific knowledge through continuing education and further innovation for their future research. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Enhance their knowledge for the interpretation of spectroscopic data for the analysis of organic molecules. |
| **PSO-2** | Apply the fundamental principles of various spectroscopic theory for the structural elucidation of various organic compounds and molecules which are relevant for modern chemical applications.. |
| **PSO-3** | Students can interpret spectroscopic data and apply the knowledge of spectroscopy for the analysis of important organic compounds relevant to our day to life requirement. |

## Course Objective

**1.** To familiarize with the basic knowledge of IR, EPR, NMR spectroscopy and Mass spectrometry.
**2.** To give fundamental idea of molecular spectroscopy and their applications for structure elucidation of simple organic molecules.
**3.** Students will also learn the interpretations of various spectroscopic data for the structure elucidation of unknown simple organic molecules. This will enhance the fundamental knowledge of various spectroscopic techniques essential for the students in understanding synthetic chemistry.

## Course Content

**IR Spectroscopy (10 L):**
IR spectroscopy in organic chemistry, characteristic absorption frequencies for common organic functional groups: carboxylic acids, esters, aldehydes, amides, ketones, amines, hydroxyl, nitro, cyanide, aromatic groups etc. Factors affecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size); overtones, combination, Fermi resonance. Applications of IR spectroscopy in organic chemistry.
**NMR Spectroscopy (20 L):**
Natural abundance of $^{1}H$, $^{13}C$, $^{19}F$ and $^{31}P$ nuclei ; First and non-first order (complex)spectra. Relative peak positions of different kind of protons. Simplification of complex spectra (solvent effect, field effect, and double resonance and lanthanide shift reagents) and NOE signal enhancements. Resolution and multiplicity of $^{13}C$-NMR; H-decoupling, noise decoupling, broad band decoupling; DEPT and INEPT experiments; Calculation of chemical shift values of simple organic compounds; Introduction to 2D-NMR: COSY, HMQC (HSQC) and HMBC spectra. NOESY, HOESY and ROESY correlation spectra.
**MASS Spectrometry (15 L):**
Theory, instrumentation and modification; Unit mass and molecular ions; singly/doubly charged ions; metastable peak, base peak, isotopic mass peaks, relative intensity. Ionization methods (EI, CI and FAB); General fragmentation rules; α, β-allylic and benzylic cleavages;

McLafferty rearrangement; Fragmentation of various classes of organic compounds; other techniques of mass spectra (ESI, APCI and MALDI, etc). Combined problems in structure elucidation of organic compounds based on UV, IR, NMR and mass spectra.

## Course Outcome

| | |
|---|---|
| **CO-1** | To familiarise the basic principles of IR spectroscopy and their applications in characterization of functional groups of organic molecules. |
| **CO-2** | To acquire the knowledge of NMR spectroscopy and to familiarize the principles of various NMR spectroscopy techniques which are relevant to chemical analysis of organic molecules and compounds. |
| **CO-3** | Students will acquire the basic principles of mass spectrometry and applications of various spectroscopic techniques for the structural elucidation of molecules and compounds. |

**Reference Books:**


**1.** Kemp W., Organic Spectroscopy, 3$^{rd}$ Ed., W. H Freeman & Co.

**2.** Silverstein R.M. ,Bassler G.C and Morrill T.C., Spectroscopic Identification of Organic Compounds, John Wiley & Sons,1981.

**3.** Williams D.H. and Fleming I., Spectroscopic Methods in Organic Chemistry 4$^{th}$ Ed., Tata - McGraw Hill Publishing co. Ltd. 1988.

**4.** Silverstein R.M. and Webster F.X., Spectrometric Identification of Organic compounds, 7$^{th}$ Ed., Academic Press, 2008.

**5.** Kalsi P.S., Spectroscopy of Organic Compounds, 6$^{th}$ Ed., New Age International (P) Ltd., 2004.

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 2 | | 3 | - | | | - | - | - | | 3 | 2 | 2 | 2 |
| CO-2 | 2 | 3 | - | 3 | - | | | - | - | - | | 3 | 2 | 2 | 3 |
| CO-3 | 2 | 2 | - | 3 | - | | | | | | | 3 | 2 | 3 | 3 |
| CO-4 | 2 | 2 | - | 3 | - | | | - | - | - | | 3 | 2 | 3 | 2 |
| CO-5 | 2 | 2 | - | 3 | - | | | - | - | - | | 3 | 2 | 3 | 2 |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 2 | 3 | 2 |
| CO-2 | - | 4 | 3 |
| CO-3 | 3 | 2 | 4 |
| CO-4 | 2 | - | - |
| CO-5 | 3 | 3 | 3 |

**Course: Principles and Applications of Fluorescence Spectroscopy**
**Code: DSCY28E10 L-T-P: 3-0-0 Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of molecular spectroscopy with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Molecular Spectroscopy course provides an introduction to the knowledge of the spectroscopy methods about structure of the chemistry compounds, as well as experimental usage of Fluorescence Spectroscopy. |
| **PSO-2** | Understanding of these concepts is fundamental in understanding how molecules interact with light. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Understand quantum chemical principles

**2.** Student will know the basic physical chemistry law that govern molecular spectroscopy

**3.** Student will be able to interpret fluorescence spectroscopy.

**4.** Theory and application to chemical research problems on will be discussed for fluorescence spectroscopy.

5. Student will be trained to interpret spectra and to design experiments to address questions related to selectivity, reactivity, kinetics.

6. Finally the course provides specific study of the application of molecular spectroscopy to different areas of science.

## Course Content (45 L)

***Introduction***

Phenomenon of fluorescence: Jablonski diagram; characteristics of fluorescence emission – Stokes shift, mirror-image rule; lifetimes and quantum yields; Fluorescence quenching: mechanism & dynamics; Fluorescence anisotropy; Fluorescence standards.

***Solvent and Environmental Effects on Fluorescence***

Solvent polarity effect; Derivation and application of Lipper-Mataga (LM) equation, effect of viscosity, temperature effects; Additional factors that effect fluorescence emission; effect of solvent mixtures: specific and non-specific interactions. Biochemical applications of environment sensitive fluorescent probes.

***Instrumentation for Fluorescence Spectroscopy***

Spectrofluorimeters: light source, monochromator, optical filters, photomultiplier tube, polarizers; Time domain measurements: importance.

Basics of time correlated single photon counting, data collection, analysis based on non-linear least square (NLSS) and maximum entropy method (MEM).

***Applications of Fluorescence Phenomena***

Fluorescence sensing: Mechanism of sensing; sensing techniques based on (i) collisional quenching, (ii) energy transfer, (iii)electron transfer; examples of (i) pH sensors, (ii) glucose sensors & (iii) protein sensors.

Novel fluorophores: (i) quantum dots, (ii) lanthanides and (iii) long-lifetime metal-ligand complex. Radiative decay engineering – metal enhanced fluorescence; DNA technology – sequencing, high sensitivity DNA stains, DNA hybridization.

## Course Outcome

| | |
|---|---|
| **CO-1** | Student will know basic information on molecular methods Fluorescence spectroscopy. |
| **CO-2** | Student will be able to select molecular spectroscopy methods suitable for solving given scientific problem |
| **CO-3** | Student will be able to analyze results of measurements using molecular spectroscopy methods |
| **CO-4** | Student shows interest in the phenomenon of the interaction of light with matter in terms of the relationship with the molecular structure |
| **CO-5** | Explain basic principles of fluorescence spectroscopy |
| **CO-6** | Explain working principles, taking spectrum and outline of fluorescence spectroscopy device |

**Reference Books:**

1. B. Valeur. *Molecular Fluorescence: Principles and Applications*, Wiley-VCH (2001).
2. J. R. Lakowicz. *Principles of Fluorescence Spectroscopy*, Springer (2006).
3.D. L. Andrews & A.A. Demidov, *Resonance Energy Transfer*, John Wiley & Sons (1999).

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** | **PO-6** | **PO-7** | **PO-8** | **PO-9** | **PO-10** | **PO-11** | **PO-12** | **PEO-1** | **PEO-2** | **PEO-3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | | | | | | | | | | | **2** | | |
| **CO-2** | | **2** | | | | | | | | | | | **2** | | |
| **CO-3** | | | **2** | | | | | | | | | | **2** | | |
| **CO-4** | | | | | | | | | | | | | | | **3** |
| **CO-5** | | **2** | **2** | | | | | | | | | | | **2** | |
| **CO-6** | | | | | | | | | | | | **3** | | **2** | |

**Course: Advanced Quantum Chemistry** **Code: DSCY28E11**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**.

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of Quantum Mechanics and Quantum Chemistry with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Students will be able to demonstrate basic facility with the methods and approaches of scientific inquiry and problem solving. |
| **PSO-2** | Successfully apply the principles of quantum mechanics for various engineering materials which have been learned as a part of this course. |
| **PSO-3** | Students will be able to explain how the concepts and findings of science in general, or of particular sciences, shape our world. |

## Course Objective

**1.** Connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.
**2.** Students will be in the position to have a basic understanding of Hartree-Fock theory
**3.** Student will be able to apply restricted, unrestricted, and restricted open shell methods
**4.** Student will learn about basic Hartree-Fock theory, how it is realized in a computer prorgam, and how Hartree-Fock calculations are carried out.
**5.** The student will learn about Many-electron wave functions; electron distributions and densities
**6.** The student will learn about The Hohenberg–Kohn theorems and the Kohn–Sham approach

## Course Content (45 L)

***Many Electron Theory***
(a) Indistinguishability of particles; Antisymmetry principle and many electron wave function; Hartree-Fock theory; Roothaan equations, Koopman's theorem; Population analysis; Basis set.
*(b) Density Functional Theory*: Hohenberg-Kohn theorem; Kohn-Sham theory; exchange correlation functional
*(c)* Time-independent perturbation theory, Electron correlation, Moller-Plesset Perturbation theory, Configuration interaction.
***Radiation-Matter Interaction***: Time-dependent perturbation theory; semi-classical treatment of radiation-matter interaction; Transition probabilities and rates; Einstein's A and B coefficients, selection rules.
**Molecular Simulation Techniques**
Molecular Mechanics method, Coulomb and non-bonded interactions, Potentials: Lennard-Jones, FENE, EAM potentials, Verlet Algorithms, Periodic boundary condition, molecules in solution, modeling the solvents.

**Applications**
Potential energy surfaces; weak interactions; thermochemistry and kinetics of simple chemical reactions; spectroscopy.

## Course Outcome

| | |
|---|---|
| **CO-1** | Pinpoint the historical aspects of development of quantum mechanics |
| **CO-2** | Basic understanding of Hartree-Fock theory |
| **CO-3** | How HF theory is realized in a computer program |
| **CO-4** | Account for the fundamental background of Density Functional Theory (DFT). |
| **CO-5** | Explain how electron correlation is defined and how it is approximated within DFT and compare these approximations to other correlated methods. |
| **CO-6** | Account for the Kohn-Sham equations and density functionals, such as Slater's X-alpha and the Local Density Approximation (LDA). |

**Reference Books:**


1. D.A. McQuarrie, Quantum Chemistry, OUP (1983).
2. P.W. Atkins et al Molecular Quantum Mechanics, OUP, 1998.
3. R. K. Prasad, Quantum Chemistry, New Age International, New Delhi, 19974
4. Fundamentals of Molecular Spectroscopy, C.N. Banwell, E.M. McCash, 4$^{th}$ Edn., McGraw-Hill.
5. A. Szabo & N.S. Ostlund. *Modern Quantum Chemistry*, ELBS (1996).
6. . F. L. Pilar. *Elementary Quantum Mechanics*, Tata McGraw-Hill (1990).
7. P. W. Atkins – Physical Chemistry, 7th Edn. Oxford (2000).
8. I. N. Levine, Physical Chemistry, 5th Edn., McGraw Hill, New Delhi, (1995).
9. Physical Chemistry, G.W. Castellan, 3$^{rd}$ Edn. Addison Wesley.


### Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | | | | | | | | | | 2 | | |
| CO-2 | | 2 | | | | | | | | | | | 2 | | |
| CO-3 | | | 2 | | | | | | | | | | 2 | | |
| CO-4 | | | | | | | | | | | | | | | 3 |
| CO-5 | | 2 | 2 | | | | | | | | | | | 2 | |
| CO-6 | | | | | | | | | | | | 3 | | 2 | |

**Course: Advanced Physical Chemistry Laboratory** **Code: DSCY28P11**
**L-T-P: 0-0-9** **Credit: 6**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Adapt to work with new experiments, assimilate updated information, and be able to solve complex problems based on practical physical chemistry. |
| **PEO-2** | Learn the fundamental applications of physical chemistry through experimental techniques using modern state-of-the-art equipment. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Prepare themselves for their higher studies by learning good laboratory practices using the modern methods and techniques, while simultaneously develop professional skills to be able to work in chemical and other industries requiring knowledge/experience of practical chemistry. |
| **PSO-2** | Successfully apply their practical experience to analytically determine/estimate amount of substances in water, their physical properties, among others. |

## Course Objective

**1.** Students will learn the ethics and acquire training required for physical chemistry laboratory.
**2.** The practicals have been designed such that the students develop knack for learning physical chemistry in their theory courses. In addition, the concepts that they learn in theory could be augmented due to their laboratory experiments, data collection, and calculation.
**3.** To introduce the students to the modern experiments that not just help to enhance their knowledge on the laws of physical chemistry but seek to solve problems at international, national and regional level based on practical physical chemistry.
**4.** Eventually, the course should be able to make students think rationally in their encounter with problems requiring knowledge of physical chemistry laboratory experience and training.

## Course Content

**1)** Determination of rate constant of alkaline hydrolysis of ethyl acetate, and determination of activation parameters, effect of ionic strength.
**2)** Determination of partition coefficient of iodine between water and organic solvent.
**3)** Determination of partition coefficient of benzoic acid between water and benzene.
**4)** To study the kinetics of the acid hydrolysis of an ester.
**5)** Determination of the order of saponification for the reaction of ethyl acetate with sodium hydroxide, conductometrically.
**6)** To determine the heat of neutralization between HCl and NaOH.
**7)** Solvent effect and salt effect on the kinetics of alkaline hydrolysis of crystal violet.
**8)** Determination of standard electrode potential of AgCl-Ag electrode and evaluation of mean activity coefficient of HCl.
**9)** Cyclic voltametry for ferrocyanide-ferricyanide system.
**10)** Determination of catalytic constant for mutarotation of glucose in presence of perchloric acid.
**11)** To titrate potentiometrically a standard solution of KCl against $AgNO_3$ solution and to determine the concentration of $AgNO_3$ solution and the solubility product of AgCl.
**12)** Determination of specific rotation of cane sugar and determination of composition of a sugar solution of unknown strength.

**13)** Determination of pKa value of a weak acid by pH-metric method.
**14)** To determine the rate constant for the acid catalyzed inversion of cane sugar using the supplied solution and its half diluted solution at the room temperature.
**15)** Solvent and micelle effect on the fluorescence of 1-naphthol and determination of CMC of a surfactant.
**16)** To titrate potentiometrically the given ferrous ammonium sulphate using $KMnO_4/K_2Cr_2O_7$ as standard and to find the redox potential of $Fe^{3+}/Fe^{2+}$ system on the hydrogen scale.
**17)** To study the kinetics of reaction $I^- + S_2O_8^{2-}$ by colorimetric method.
**18)** To study the adsorption of acetic acid on charcoal and to prove the validity of Frendlich's adsorption isotherm.
**19)** To determine the order of reaction for the peroxide-iodide clock reaction.
**20)** To determine the order of reaction of the saponification of ethyl acetate by NaOH.
**21)** Conductometric titration of triple mixture KCl, $NH_4Cl$, HCl by NaOH and $AgNO_3$.
**22)** To determine the formula of cuproammonium ion.
**23)** Verification of Beer-Lambert's law and determination of pKa of an indicator, spectrophotometrically.
**24)** Spectrophotometric determination of pKa of an indicator in micellar and microemulsion media.

## Course Outcome

| | |
|---|---|
| **CO-1** | By the end of the course, the student should have acquired hands-on training on physical chemistry practicals which would go on to help them in their career. |
| **CO-2** | They have acquired basic knowledge and mastered the art of handling modern equipment for advanced practicals and research. |
| **CO-3** | They should be able to apply their knowledge in other disciplines and for solving complex problems facing mankind in daily life. |

**Reference Books:**

**1.** Experiments in Physical Chemistry J. C. Ghosh, Bharati Bhavan 1974, New Delhi.
**2.** Advanced experimental chemistry (Physical) J. N. Gurtu, & N. R. Kapoor, S. C. Company 1980.
**3.** Laboratory Manual in Physical chemistry W. J. Popiel, ELBS 1970.
**4.** Advanced Practical in Physical Chemstry J. B. Yadav, Pragati Prakasan Meerut.
**5.** Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
**6.** D. P. Shoemaker, C. W. Garland & J. W. Nibler. Experiments in Physical Chemistry ($5^{th}$ edn.), McGraw Hill (1989).

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-2** | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **CO-3** | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| **CO-1** | - | 4 |
| **CO-2** | - | - |
| **CO-3** | 4 | - |

**Course: Molecular Modeling Laboratory** **Code: DSCY28P12**
**L-T-P: 0-0-6** **Credit: 4**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Adapt to work with new computational tecniques, assimilate updated information, and be able to solve complex problems based on the concept of advanced physical chemistry. |
| **PEO-2** | Learn the fundamental applications of theoretical chemistry through molecular modeling techniques using modern state-of-the-art equipment. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Prepare themselves for their higher studies by learning good laboratory practices using the modern methods and techniques, while simultaneously develop professional skills to be able to work in chemical and other industries requiring knowledge/experience of computational chemistry. |
| **PSO-2** | Successfully apply their theoretical experience by both analytically and numerically for the development of drug design. |

## Course Objective

It explores a wide range of techniques and applications in molecular modelling and computational chemistry, including ab initio quantum mechanics, semi-empirical MO theory, molecular mechanics, molecular dynamics simulation, coarse-grained models, electrostatic methods and biomolecular structure prediction.

## Course Content

**Molecular mechanics calculations:** Concept of short range and long range interactions. Modelling of interactions involving macrobodies like planar surfaces, macrospheres, etc.
Potential energy surfaces and optimization methods using Gaussian.
Structure optimization and conformational analysis using *ab initio* molecular orbital theory, thermochemistry in different QM model chemistries. Tautomeric preferences and solvent effects. Stereoselectivity in Diels-Alder reactions.

**Water and small organic molecules:** Non-polarizable and polarizable rigid models. Flexible models and calculation of force constants. Structural and dielectric properties of a polar medium: Continuum models versus molecular models. Calculation of structure, energy and free energy through simulations using molecular models.

**Macromolecules:** Study of self-organized assemblies, biomolecules like peptides, proteins, membranes and ion channels through simulations. Concept of hydrophobic and hydrophilic interactions. Use of molecular modeling in drug design.

## Course Outcome

| | |
|---|---|
| **CO-1** | By the end of the course, the student should have acquired hands-on training on theoretical chemistry laboratory which would go on to help them in their career. |
| **CO-2** | They have acquired basic knowledge and mastered the art of handling modern quantum chemistry packages. |
| **CO-3** | They should be able to apply their knowledge in other disciplines and for solving complex problems facing mankind in daily life. |

**Reference Books:**


1. A.R. Leach, *Molecular Modelling : Principles and Applications*, Longman (1996).
2. T. Schlick, *Molecular Modelling and Simulation*, Springer (2006).
3. P.W. Atkins, *Molecular Quantum Mechanics*, Oxford (1997).
4. J. Israelachvili, *Intermolecular and surface Forces*, Academic (1991).
5. M. P. Allen and D. J . Tildesley, *Computer Simulation of Liquids*, Clarendon Press (1987)
6. D. Frenkel and B. Smit, *Understanding Molecular Simulation: From Algorithms to Applications*, Academic Press (1996).
7. C.L. brooks III, M.Karplus, B.M. Pettitt, *Proteins: A theoretical Perspective of Dynamics, Structure and Thermodynamics*, John Wiley (1988).


## Mapping with the POs/ PEOs: Matrix formation for attainments

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-2** | **-** | **2** | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |
| **CO-3** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **-** | **-** |

<u>To establish the correlation between Cos & PSOs</u>

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 |
|---|---|---|
| **CO-1** | **-** | **4** |
| **CO-2** | **-** | **-** |
| **CO-3** | **4** | **-** |

# *Ninth Semester*

**Course: Chemistry of Late Transition and f-Block Elements**
**Code: DSCY29E10 L-T-P: 3-0-0 Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire knowledge of the positions of the d– and f-block elements in the periodic table. |
| **PEO-2** | Ability to understand the general characteristics of the d– and f–block elements. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**
Students will be able to

| | |
|---|---|
| **PSO-1** | Apply their knowledge to understand the physical and chemical properties of the d– and f–block elements. |
| **PSO-2** | Successfully apply the principles and bonding nature of different compounds of the d– and f–block elements which have been learned as a part of this course. |
| **PSO-3** | Evaluate the application scenario of the compounds along with environment related issues in our society. |

## Course Objective

**1.** To learn the positions of the d– and f-block elements in the periodic table
**2.** To know the electronic configurations of the transition (d-block) and the inner transition (f-block) elements.
**3.** To appreciate the relative stability of various oxidation states in terms of electrode potential values.
**4.** To describe the preparation, properties, structures and uses of some important compounds of late transition and f-block elements.
**5.** To understand the general characteristics of the d– and f–block elements and the general horizontal and group trends in them.
**6.** To describe the properties of the f-block elements and give a comparative account of the lanthanoids and actinoids with respect to their electronic configurations, oxidation states and chemical behaviour.

## Course Content

**Chemistry of Late Transition Elements and Magnetism (30 L):**
Zirconium and Hafnium: Compounds of +IV oxidation state, halides, aqueous chemistry, lower oxidation states;
Niobium and Tantalum: Compounds of +V oxidation state, halides, +IV oxidation states, lower oxidation states
Molybdenum and Tungsten: Compounds of +VI, V, IV and lower oxidation states; isopoly and heteropoly acids
Technetium and Rhenium: Compounds of VII, VI, V, IV and lower oxidation states;
Platinum metals (Ru, Rh, Pd, Os, Ir, Pt): Extraction, Complex compounds of different oxidation states of ruthenium and osmium; rhodium and iridium, palladium and platinum; platinum and ruthenium compounds in cancer chemotherapy,
Chemistry of silver and gold: Complex compounds of +I, +II and +III oxidation states, organometallics

Diamagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism and Ferrimagnetism; Magnetic Susceptibility and determination (Gouy Method); Orbital Contribution; Curie's Law; Superexchange Phenomenon.

**f-Block Elements (15 L):**

Lanthanides: positioning in the periodic table. Electronic configuration, lanthanide contraction general methods of extraction, oxidation states, spectral and magnetic moments. Lanthanum shift reagents, MRI contrast agent, Superparamagnetism.

Actinides: Electronic structure, ionic radii, oxidation state, spectra and paramagnetic properties of actinides elements, actinide hypothesis, Chemistry of uranium and thorium, isolation of neptunium, plutonium and americium and their aqueous chemistry.

Super heavy elements, Island of stability.

## Course Outcome

| | |
|---|---|
| **CO-1** | By the end of this section, student will be able to outline the general approach for the isolation of transition metals from natural sources. |
| **CO-2** | Student will be able to describe typical physical and chemical properties of the transition metals. |
| **CO-3** | Acquire the skill of extracting these elements from its ores. |
| **CO-4** | Acquire the knowledge of the relationship between the electronic structure and physical and chemical properties of the transition elements. |
| **CO-5** | Student will have basic information on the various important uses of medical and industrial for these transition elements. |
| **CO-6** | Knowledge to define the role of transition elements in oxidation-reduction reactions of biochemistry. |

**Reference Books:**


1) F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, ***Advanced Inorganic Chemistry***, 6th Edition, Wiley India (P.) Ltd., New Delhi.
2) G. L. Miessler, D. A. Tarr, ***Inorganic Chemistry***, 3rd Edition, Pearson, Delhi, India.
3) R. Sarkar, ***General Chemistry Part-I and Part-II***, New Central Book Agency (P) Ltd.
4) J. H. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, ***Inorganic Chemistry: Principle of structure and Reactivity***, 4th Ed., Pearson, New Delhi.
5) Shriver & Atkins, ***Inorganic Chemistry***, 4th Ed., Oxford University Press, Delhi

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-2 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 |
| CO-3 | - | 3 | - | - | - | - | - | - | - | - | - | - | - | 3 | - |
| CO-4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO-5 | - | 2 | - | - | 2 | - | - | - | - | - | - | - | - | 2 | - |
| CO-6 | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

**<u>To establish the correlation between COs & PSOs</u>**
**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 4 | - | - |
| CO-2 | - | - | 3 |
| CO-3 | - | 4 | - |
| CO-4 | - | - | 2 |
| CO-5 | 2 | - | - |
| CO-6 | - | 3 | - |

## Course: Advanced Bio-Inorganic Chemistry and Inorganic Molecular Spectroscopy

**Code: DSCY29E16**

**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**

Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire knowledge of the fundamental principles nature selectivity to choose Zn in hydrolytic enzyme and Fe in the redox process etc. on the basis of principle of inorganic chemistry. |
| **PEO-2** | Ability to analyse the problems such as construction of artificial leaf, used of metal ion in drug in the context of practical relevance to the socio-economical and environmentally being system. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**
**Students will be able to**

| | |
|---|---|
| **PSO-1** | Successfully apply the principles of chemistry of coordination complexes to understand functions of biological systems. |
| **PSO-2** | To interpret the chemistry of natural photosynthesis for development of artificial leaf for sustainable development |
| **PSO-3** | Become familiar inorganic complex based medicine as anticancer agent and detoxification of excess metal ion. |

## Course Objective

**1.** To introduce the students about basic concepts of active site structure function of iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity.
**2.** In the topic the attention also paid to metal ion and their coordination complex which are employed in chemotherapy, magnetic resonance imaging agents or as radiopharmaceutical.
**3.** The purpose of incorporating the course is to provide a thorough knowledge of bioinorganic chemistry as the current areas of research interest.
**4.** To introduce the theory of the various instruments and the signals produced when analysing compound.
**5.** To equip the students with enough information to be able to interpret signals from spectroscopic instruments.
**6.** The students will be able to explain basic principles of UV-Visible, FT-IR, NMR spectroscopy and relevant terms of that spectroscopy.

## Course Content

**Advanced Bioinorganic Chemistry (25L):**

Calcium signalling molecules, effect of metal ions in neuro-transmission.

Electron transport proteins: cytochromes, Fe-S proteins, Metalloproteins catalysing oxygen atom transfer reaction: Blue copper proteins: Type 1, Type 2, and Type 3 copper centers in O2 activating proteins iron containing enzymes such as methane monoxygenase, ribonucleotide reductase, nitric oxide reductase; Molybdenum containing enzymes such as xanthane, sulphite oxidase and nitrate, trimethylamine-N-oxide, DMSO reductase. Nitrate and nitrite reduction $NO_3$- and $NO_2$- reductase, alcohol dehydrogenase and vitamin $B_{12}$, molybdo-enzymes – molybdenum cofactors (molybdenum-pterin complexes); Ferritin, transferritin and hemosiderin; DNA probe and chemotherapeutic agents, Other selected metalloproteins of various metal ions. Structure/function analogue of above mentioned systems.

**Inorganic Molecular Spectroscopy (20L):**
Raman and IR spectroscopy, Molecular luminescence spectrometry: theory, instrumentation and applications, light scattering techniques including nephelometry . Flame spectrometric techniques: atomic absorption, atomic emission and atomic fluorescence - theory, instrumentation and applications of these techniques.
Electron paramagnetic resonance spectroscopy: principle and applications.
Mössbauer spectroscopy: Principles and Applications-Hyperfine- Magnetic Interactions - NQR spectroscopy – Principles and Applications to Fe-NO complexes, Sn- complexes etc.
Application of NMR in inorganic complexes- $^{31}$P, $^{19}$F, $^{119}$Sn NMR.
Combined spectroscopic techniques case studies and structural identification of inorganic compounds

## Course Outcome

| | |
|---|---|
| **CO-1** | Knowledge on the importance of inorganic elements in biology with the special emphasis on how they function *in vivo*. |
| **CO-2** | Learn the significant elements such as Iron, Copper and Zinc as metallo enzyme. |
| **CO-3** | Acquire the knowledge about the role of chelating agents as de-toxifying agent in metal poisoning and the mechanism of cisplatin as anticancer drug. |
| **CO-4** | Student will have basic information on molecular methods (IR, Raman, UV-VIS, NMR and EPR). |
| **CO-5** | Student will be able to select molecular spectroscopy methods suitable for solving given scientific problem. |
| **CO-6** | Student shows interest in the phenomenon of the interaction of light with matter in terms of the relationship with the molecular structure. |

**Reference Books:**

1. M. N. Hughes, *Inorganic Chemistry of Biological Processes*, 2nd Ed.(1981), John-Wiley & Sons,New York.
2. W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide*, Wiley, New York (1995).
3. S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, (1994).
4. I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, *Bioinorganic Chemistry*, Viva Books.
5. C. N. Banwell, Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw-Hill, 1994.
6. G. Aruldhas, Molecular Structure and Spectroscopy, 2nd Edition,Prentice-Hall of India Pvt. Limited, 2004.
7. Rita Kakkar, Atomic and Molecular Spectroscopy: Basic Concepts and Applications,Cambridge University Press, 2015.
8. William Kemp, Organic Spectroscopy,3rd Edition, ELBS with Macmillan, 1975.

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation “-“**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-2 | - | 2 | | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-3 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| CO-4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO-5 | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-6 | - | - | | - | - | - | - | - | - | - | - | 3 | - | 2 | - |

**<u>To establish the correlation between COs & PSOs</u>**

**2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation “-“**

<u>Table 2</u>

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | - | 4 | - |
| CO-2 | - | - | 3 |
| CO-3 | 4 | - | - |
| CO-4 | - | - | 2 |
| CO-5 | 2 | - | - |
| CO-6 | - | - | - |

**Course: Natural Products** **Code: DSCY29E14**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental knowledge natural product chemistry. |
| **PEO-2** | Ability to design the synthesis of natural product compounds and aquire the applications of natural products in daily life. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education and to innovate for further research. |

**PSOs (Program Specific Objectives):**

| | |
|---|---|
| **PSO-1** | Enhance their knowledge of the natural product compounds and the importance of natural products in daily life. |
| **PSO-2** | Apply the principles of synthetic knowledge of natural product compounds which are relevant and important in present chemistry keeping the commercial requirement. |
| **PSO-3** | Students can design the synthesis of natural product compounds which are relevant practically in the present organic chemistry and to enhance their practical skill for the synthesis of natural products which are commercially important. |

## Course Objective

**(1)** To familiarize the knowledge and importance of Natural Product chemistry in organic chemistry and their applications in our day to life.

**(2)** To give fundamental idea to the students for the isolation, extraction and synthesis of natural product compounds.

**(3)** Students will also learn the chemistry of natural products and will be highlighted various applications of natural products in industry and medicinal chemistry.

## Course Content

**Unit-I: Terpenoids and Steroids (25 L):**

**Terpenoids:**

Classification, Occurrence, isolation and biosynthesis of terpenoids. Structure determination, stereochemistry and synthesis of the following representative compounds: caryophyllene, isocaryophyllene, santonin, abietic acid.

**Steroids:**

Classification, isolation, structure determination and biosynthesis of cholesterol. Bile acids. Classification of hormones and synthesis of testosterone, androsterone, progesterone and estrone.

**Unit-II: Alkaloids and Polyphenols (20 L):**

**Alkaloids:** Definition, classification, occurrence, isolation and biosynthesis of alkaloids. Structure determination, stereochemistry, synthesis and reactions of the following representative alkaloids: ephedrine, papaverine, morphine, quinine, reserpine.

**Flavonoids:** Classification and biosynthesis of flavonoids and related polyphenols. Structure and synthesis of apigenin, luteolin, quercetin, diadzein and cyanidin chloride.

## Course Outcome

| | |
|---|---|
| **CO-1** | To familiarise with the classification, isolation and structure determination of terpenoids. |
| **CO-2** | To acquire the knowledge of classification, isolation, synthesis and structure determination of steroids. |
| **CO-3** | Students will acquire the fundamental knowledge for the classification, isolation, biosynthesis and structure determination of alkaloids which are commercially important compounds keeping the economic factors. |
| **CO-4** | To familiarize with the classification and biosynthesis of flavonoids. |

**Reference Books:**


1. Finar I. L. and Final A. L., Organic Chemistry, Vol. 2, ELBS, London.
2. Mann J., Devidson R. S. , Hobbs J.B. , Banthrope D.V., Harborne J.B. , Natural Products, their chemistry and biological significance, Longmann , Essex , 1994.
3. Bohm B. A., Introduction to Flavonoids, Harwood Academic Publications.
4. Rahman Ata –ur , Choudhary M. L., New Trends in Natural Product Chemistry, Harwood Academic Publications.
5. Pelletier S. W., Chemistry of the Alkaloids, Van Nostrand Reinhold Company, N.Y.


**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** | **PO-6** | **PO-7** | **PO-8** | **PO-9** | **PO-10** | **PO-11** | **PO-12** | **PEO-1** | **PEO-2** | **PEO-3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | 2 | 2 | - | | - | - | - | - | - | - | 2 | 2 | 2 | 2 | 2 |
| **CO-2** | 2 | 3 | - | | - | - | | - | - | - | | 3 | 2 | 2 | 3 |
| **CO-3** | 2 | 2 | - | | - | - | - | | | | | 2 | 2 | 3 | 2 |
| **CO-4** | 2 | 2 | - | | - | - | - | - | - | - | | 2 | 2 | 3 | 2 |

**<u>To establish the correlation between COs & PSOs</u>**

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| **CO** | **PSO-1** | **PSO-2** | **PSO-3** |
|---|---|---|---|
| **CO-1** | - | - | 1 |
| **CO-2** | 2 | - | 2 |
| **CO-3** | 2 | 2 | 1 |
| **CO-4** | - | - | 2 |

**Course: Heterocyclic Chemistry** **Code: DSCY29E15**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Acquire the fundamental knowledge heterocyclic chemistry. |
| **PEO-2** | Ability to design the synthesis of heterocyclic compounds and to acquire the applications of heterocyclic compounds in daily life. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education and to innovate for further research in heterocyclic chemistry. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Enhance the knowledge of the heterocyclic compounds and their importance in daily life. |
| **PSO-2** | Apply the synthesis knowledge of heterocyclic compounds which are relevant and important in present chemistry keeping the commercial requirement. |
| **PSO-3** | Students can also design for the synthesis of heterocyclic compounds which are relevant practically in the present organic chemistry and to enhance their practical skill for the synthesis of heterocyclic compounds which are commercially important. |

## Course Objective

**(1)** To introduce the knowledge of heterocyclic chemistry and the importance of heterocyclic compounds in our day to life.

**(2)** To give fundamental idea to the students for the synthesis of heterocyclic compounds and their various applications.

**(3)** Students will also learn the chemistry of heterocyclic compounds and various reaction mechanism and their uses as drugs.

## Course Content (45 L)

Introduction to heterocycles: Nomenclature and aromaticity. Synthesis and reactions of three and four memberd heterocycles: Aziridine. Azirine, azetidine, oxiranes, oxetanes, thiarines and thietanes

Synthesis and reactions of five membered heterocycles with one heteroatom: Pyrroles,furans, thiophenes , indoles ,benzofurans, benzopyrroles, benzothiophenes.

Synthesis and reactions of five membered heterocycles with two heteroatoms: Pyrazoles, imidazoles, oxazoles, thiazoles, isothiazoles.

Synthesis and reactions of six membered heterocycles with one heteroatom: Pyridines, quinolines, isoquinolines, acridines.

Synthesis and reactions of six membered heterocycles with two or more heteroatoms: Pyrimidines, purines, diazines ,triazines ,tetrazines, pteridines.

Synthesis and reactions of seven and large membered heterocycles: Azepines, oxepines, thiepines. Chemistry of porphyrins and spiroheterocycles.

## Course Outcome

| | |
|---|---|
| **CO-1** | To familiarise with the nomenclature and aromaticity nature of heterocyclic compounds and To acquire the knowledge for the synthesis of three and four membered heterocyclic compounds |
| **CO-2** | Students will acquire the fundamental knowledge for the synthesis and reactions of five membered heterocyclic compounds.. |
| **CO-3** | To familiarize with synthesis and reactions of six membered heterocyclic compounds with one heteroatom. |
| **CO-4** | To acquire the knowledge for synthesis and reactions of six membered heterocyclic compounds with two or more heteroatoms. |
| **CO-5** | Students will familiarize with the synthesis and reactions of seven and large membered heterocyclic compounds. |

**Reference Books:**


1. Gilchrist T. L. Heterocyclic Chemistry, Longman Scientific.
2. Joule J.A, Mills K., Smith G. F., Heterocyclic Chemistry, 3$^{rd}$ Ed. Chapman & Hall, N.Y.
3. Gupta R; R, Kumar M, Gupta V, Heterocyclic Chemistry, Vols 1-3, Springer-Verlag.
4. Eicher T, Hauptmann S, The Chemistry of Heterocycles, Thieme.

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 2 | - | - | - | - | - | - | - | - | 2 | 2 | 2 | 2 | 2 |
| CO-2 | 2 | 2 | - | - | - | - | - | - | - | - | 2 | 2 | 2 | 2 | 3 |
| CO-3 | 2 | 2 | - | 2 | - | - | - | | | | 2 | - | 2 | 3 | 2 |
| CO-4 | 2 | 2 | - | 2 | - | - | - | - | - | - | 2 | - | 2 | 3 | 2 |
| CO-5 | 2 | 2 | - | 2 | - | - | - | - | - | - | 2 | - | 2 | 3 | 2 |

To establish the correlation between Cos & PSOs

**2: Slight (low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"**

| CO | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|
| CO-1 | 3 | 3 | 3 |
| CO-2 | - | - | 2 |
| CO-3 | - | 2 | |
| CO-4 | 3 | - | 2 |
| CO-5 | 2 | 3 | 3 |
| CO-6 | - | 2 | 3 |

**Course: Molecular Spectroscopy in Chemistry** **Code: DSCY29E17**
**L-T-P: 3-0-0** **Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**.

| | |
|---|---|
| **PEO-1** | Acquire the fundamental principles of molecular spectroscopy with modern experimental and theoretical skills. |
| **PEO-2** | Ability to analyse the problems in the context of practical relevance to the society. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Molecular Spectroscopy course provides an introduction to the knowledge of the spectroscopy methods about structure of the chemistry compounds, as well as experimental usage of chosen methods (IR, NMR, UV- VIS). |
| **PSO-2** | Understanding of these concepts is fundamental in understanding how molecules interact with light. |
| **PSO-3** | Evaluate the energy scenario along with environment related issues in our society. |

## Course Objective

**1.** Understand quantum chemical principles
**2.** Student will know the basic physical chemistry law that govern molecular spectroscopy
**3.** The course provides an introduction to molecular spectroscopy.
**4.** Some of the fundamental concepts used in understanding molecular spectroscopy will be discussed in detail.
**5.** Understanding of these concepts is fundamental in understanding how molecules interact with light.
**6.** Finally the course provides specific study of the application of molecular spectroscopy to different areas of science.

## Course Content (45 L)

**Electron Spin Resonance (ESR/EPR):**

Classical and quantum mechanical description of resonance. Features of e.s.r. spectra : g-factor, hyperfine structure, fine structure, line shapes and line width; simple theory of π – radical; Krammer's theorem; ESR of transition metal ions: d1 and d9 system.

**Nuclear Magnetic Resonance (NMR):**

**NMR of Solids:** dipolar coupling tensors, NMR spectra of two coupled protons, second moment of NMR absorption line, structural studies by the method of oments, Nuclear Quadrapole resonance. Nuclear spin commutation and shift operators. Analysis of NMR spectra in liquids: AB spectrum.

Illustration of e.s.r. spectra of isotropic spectra e.g. $C_2H_5$-, $C_6H_6$-, $C_{14}H_{10}$-, Ag+ in KCl, $Co^{2+}$ in MgO etc. ELDOR and ENDOR technique, Electron spin angular momentum: commutation and shift operators.

**Some preliminary concepts in pulse magnetic resonance (emphasis on minimum Mathematical treatment):** Time and frequency (fourier transform), free induction decay (FID), spin echoes, the Carr-Purcell sequence, the phase alternation and Meiboom-Gill methods, spin-flip narrowing, a brief note on NOE some terminology in pulse NMR: WAHUA, MREV, MLEV, DANTE, WALTZ, INEPT, DEPT, INADEQUATE, COSY, COSY-45, COSY-90, E.COSY, NOESY.

**Photo-electron spectroscopy:**
**(A) Core binding energies and chemical shifts:** Valence electron spectra of small Molecules and large molecules, molecular orbital models, vibrational structure and lone pair, photo electron spectra of benzene, application of X-PES (or ESCA) in material sciences.
**(B) Laser Raman:** Laser as a source, simple systematic diagram of a Raman spectrometer, some applications in Chemistry, a brief note on NIR-FT Raman spectroscopy.

## Course Outcome

| | |
|---|---|
| **CO-1** | Student will know basic information on molecular methods (IR, Raman, UV-VIS, NMR, EPR) |
| **CO-2** | Student will be able to select molecular spectroscopy methods suitable for solving given scientific problem |
| **CO-3** | Student will be able to analyze results of measurements using molecular spectroscopy methods |
| **CO-4** | Student shows interest in the phenomenon of the interaction of light with matter in terms of the relationship with the molecular structure |
| **CO-5** | Explain why atomic spectra consist of lines whereas molecular spectra at room temperature are broad and continuous. |
| **CO-6** | Explain the difference between a 3- and 4-level laser and why it is not possible to have a 2-level laser. |

**Reference Books:**
**1.** Fundamentals of Molecular Spectroscopy, C.N. Banwell, E.M. McCash, $4^{th}$ Edn., McGraw-Hill.
**2.** Modern Spectroscopy, J. Michael Hollas, 4th Edn., Wiley.
**3.** Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, George S. Kriz, Cengage Learning India Pvt. Ltd.
**4.** Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
**5.** I. N. Levine, Molecular Spectroscopy, Wiley
**6.** G. Herzberg, Molecular Spectra and Molecular Structure I,II,III

**Mapping with the POs/ PEOs: Matrix formation for attainments**
**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | | | | | | | | | | 2 | | |
| CO-2 | | 2 | | | | | | | | | | | 2 | | |
| CO-3 | | | 2 | | | | | | | | | | 2 | | |
| CO-4 | | | | | | | | | | | | | | | 3 |
| CO-5 | | 2 | 2 | | | | | | | | | | | 2 | |
| CO-6 | | | | | | | | | | | | 3 | | 2 | |

**Course: Statistical Mechanics and Non-Equilibrium Thermodynamics**
**Code: DSCY29E18 L-T-P: 3-0-0 Credit: 3**

**Program Outcomes (POs):**
Programs must validate that their students achieve the following outcomes

| | |
|---|---|
| **PO - 1** | **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO - 2** | **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO -5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**PEOs (Program Educational Objectives):**

| | |
|---|---|
| **PEO-1** | Apply the theory to understand gases and crystals and in addition be able to construct microscopic models and from these derive thermodynamic observables |
| **PEO-2** | Describe the importance and consequences of quantum mechanics for macroscopic particle systems. |
| **PEO-3** | Enhancing their professional growth along with scientific knowledge through continuing education. |

**PSOs (Program Specific Objectives):**

Students will be able to

| | |
|---|---|
| **PSO-1** | Understand the strength and limitations of the models used and be able to compare different microscopic models |
| **PSO-2** | Show an analytic ability to solve problems relevant to statistical mechanics |
| **PSO-3** | Student uses the appropriate normalization for the Boltzmann factor and the appropriate degeneracies and densities of states. |

## Course Objective

**1.** Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics.
**2.** Apply the principles of statistical mechanics to selected problems.
**3.** Apply techniques from statistical mechanics to a range of situations.
**4.** Learn relationship between equilibrium distributions and kinetic processes leading to equilibrium.
**5.** Become aware of the richness and complexity of statistical behavior exhibited by interacting systems and various approaches (phenomenological and microscopic) developed to comprehend such systems.
**6.** Student can recover the laws of thermodynamics and the equipartition theorem from the statistical description using microstates.

## Course Content (45 L)

Phase space and Liouvville's theorem; Major Postulates of statistical Mechanics. Concept of various and averaging procedures. Quantum in distinguishablility. Bose-Einstein and Fermi-Dirac statistics, Classical limits of FD and BE statistics. Ideal Fermi gas, Imperfect gas, Non Equilibrium systems.

**Irreversible Thermodynamics:** Postulates and methodologies, linear flow Gibbs equation, Onsager reciprocal theory.

**Nonequilibrium Thermodynamics:** Non-equilibrium thermodynamics, postulates and methodologies, forces and fluxes, linear laws, Gibbs equation, Onsager reciprocal theory. Curie-Prigogine principle, diffusion, effusion, sedimentation, thermoelectric effect, membrane property, Stationary state: time variation of entropy production, minimum entropy production, stability of stationary state, fluctuation.

## Course Outcome

| | |
|---|---|
| **CO-1** | Learn different statistical ensembles, their distribution functions, ranges of applicability and the corresponding thermodynamic potentials. |
| **CO-2** | Apply classical and quantum distributions in circumstances varying from standard examples to statistics of charge carriers in semiconductors, chemical reactions and ions in electrolyte solutions. |
| **CO-3** | Can explain the procedures for deriving the relation between thermodynamic parameters such as pressure, temperature, entropy and heat capacity from the distribution functions. |
| **CO-4** | Can explain phase transitions and magnetization in magnetic systems. |
| **CO-5** | Can apply the theory on different types of gasses: ideal classic, diatomic, quantum Fermi gasses such as quarks, electrons or baryons, quantum Bose gases such as photons, gluons or mesons. |
| **CO-6** | Can apply the methods of statistical physics in other fields of physics and related fields. |

**Reference Books:-**

**1.** T. L. Hill *Statistical Thermodynamics*, Addision Wesley 1960
**2.** D.A. Mcquarie *Statistical Thermodynamics*, Viva Books Pvt Ltd 2003
**3.** JM Seddon and JD Gale *Thermodynamical and statistical mechanics*, RSC 2001
**4.** LK Nash *Elements of Classical and Statistical Thermodynamics* Addision –Wesley 1970
**5.** M. C. Gupta *Statistical Thermodynamics* WEL 1995.
**6.** C. Kalidas and M. V. Sanganarayana. *Non-Equilibrium Thermodynamics – Principles and Applications*, Macmillan India (2002).
**7.** Robert H Gasser, N. Graham Richards *An introduction to Statistical Thermodynamics* WSC, 1995.
**8.** I. Prigogine. *Introduction to Thermodynamics of Irreversible Processes*, Interscience (1960).

**Mapping with the POs/ PEOs: Matrix formation for attainments**

**1: Slight ( low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation “-“**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PEO-1 | PEO-2 | PEO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-1** | **3** | **2** | | | | | | | | | | | **2** | | |
| **CO-2** | | **2** | | | | | | | | | | | **2** | | |
| **CO-3** | | | **2** | | | | | | | | | | **2** | | |
| **CO-4** | | | | | | | | | | | | | | | **3** |
| **CO-5** | | **2** | **2** | | | | | | | | | | | **2** | |
| **CO-6** | | | | | | | | | | | | **3** | | **2** | |