
VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

# SCHOOL OF ADVANCED SCIENCES
# DEPARTMENT OF CHEMISTRY

# M.Sc Chemistry

# (MSH)

# Curriculum & Syllabi

# (2024-2025 Admitted students)

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

## VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

## MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

## VISION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

To be an internationally renowned science school in research and innovation by imparting futuristic education relevant to the society.

## MISSION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

- To nurture students from India and abroad by providing quality education and training to become scientists, technologists, entrepreneurs and global leaders with ethical values for a sustainable future.

- To enrich knowledge through innovative research in niche areas.

- To ignite passion for science and provide solutions for national and global challenges.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

# M.Sc Chemistry

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be practitioners and leaders in their chosen field.
2. Graduates will function in their profession with social awareness and responsibility.
3. Graduates will interact with their peers in other disciplines in their work place and society and contribute to the economic growth of the country.
4. Graduates will be successful in pursuing higher studies in their chosen field.
5. Graduates will pursue career paths in teaching or research.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

# M.Sc Chemistry

## PROGRAMME OUTCOMES (POs)

PO_01: Having a clear understanding of the subject related concepts and of contemporary issues.

PO_02: Having problem solving ability to address social issues.

PO_03: Having a clear understanding of professional and ethical responsibility.

PO_04: Having cross cultural competency exhibited by working in teams.

PO_05: Having a good working knowledge of communicating in English.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

# M.Sc Chemistry

## PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M.Sc. Chemistry programme, graduates will be able to

PSO1: Apply advanced concepts of organic, analytical, physical and inorganic chemistry to solve complex problems to improve human life.

PSO2: Design experiments, analyze, synthesize and interpret data to provide solutions to different industrial problems by working in the pure, inter and multi-disciplinary areas of chemical sciences.

PSO3: Able to independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

# M.Sc Chemistry

## CREDIT STRUCTURE

### Category-wise Credit distribution

| S. No. | Description | Credit | Maximum Credit |
|---|---|---|---|
| 1 | DC – Discipline Core | **28** | **28** |
| 2 | DE – Discipline Elective | **21** | **21** |
| 3 | PI – Projects and Internship | **20** | **20** |
| 4 | OE – Open Elective | **06** | **06** |
| 5 | SE – Skill Enhancement | **05** | **05** |
| | **Total credits** | **80** | |

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

# M.Sc. Chemistry

## DETAILED CURRICULUM

| Discipline Core | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Course Code** | **Course Title** | **Course Type** | **Version** | **L** | **T** | **P** | **J** | **Credit** |
| 1 | PCHY501L | Physical Chemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 2 | PCHY501P | Physical Chemistry Lab-I | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 3 | PCHY502L | Inorganic Chemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 4 | PCHY502P | Inorganic Chemistry Lab-I | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 5 | PCHY503L | Organic Chemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 6 | PCHY503P | Organic Chemistry Lab-I | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 7 | PCHY504L | Group Theory and Molecular Spectroscopy | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 8 | PCHY505L | Organic Synthesis and Methodologies | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 9 | PCHY506L | Organometallics and Industrial Applications | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |

| Discipline Elective | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Course Code** | **Course Title** | **Course Type** | **Version** | **L** | **T** | **P** | **J** | **Credit** |
| 1 | PCHY601L | Analytical Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 2 | PCHY602L | Advanced Organic Chemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 3 | PCHY603L | Chemistry of Heterocyclic Compounds | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 4 | PCHY604L | Chemistry of Natural Products | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 5 | PCHY605L | Photochemistry and Pericyclic Reactions | Theory Only | 1.0 | 4 | 0 | 0 | 0 | 4.0 |
| 6 | PCHY606P | Organic Chemistry Lab-II | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 7 | PCHY607P | Organic Chemistry Lab-III | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 8 | PCHY608L | Electroanalytical and Separation Techniques | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 9 | PCHY609L | Environmental and Industrial Analytical Chemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 10 | PCHY610L | Bioanalytical and Forensic Analysis | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 11 | PCHY611L | Analytical Quality Assurance for Process Industry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 12 | PCHY612P | Analytical / Physical Chemistry Lab-II | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 13 | PCHY613P | Analytical Chemistry Lab-III | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 14 | PCHY614L | Advanced Inorganic Chemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 15 | PCHY615L | Materials Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 16 | PCHY616L | Nanomaterials and Characterization Techniques | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 17 | PCHY617L | Inorganic Photochemistry | Theory Only | 1.0 | 4 | 0 | 0 | 0 | 4.0 |
| 18 | PCHY618P | Inorganic Chemistry Specialization Lab-II | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 19 | PCHY619P | Inorganic Chemistry Specialization Lab-III | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 20 | PCHY620L | Process Chemistry in Pharmaceutical Industry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 21 | PCHY621L | Pharmacognosy and Phytochemistry | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 22 | PCHY621P | Pharmacognosy and Phytochemistry Lab | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 23 | PCHY622L | Pharmaceutical Quality Control and Qaulity Assurance | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 24 | PCHY623L | Medicinal Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 25 | PCHY623P | Medicinal Chemistry Lab | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 26 | PCHY624L | Advanced Physical Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 27 | PCHY625P | General Organic and Inorganic Chemistry Lab | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 28 | PCHY626P | Analytical Chemistry Practical I | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |

| Projects and Internship | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Course Code** | **Course Title** | **Course Type** | **Version** | **L** | **T** | **P** | **J** | **Credit** |
| 1 | PCHY698J | Internship I/ Dissertation I | Project | 1.0 | 0 | 0 | 0 | 0 | 4.0 |
| 2 | PCHY699J | Internship II/ Dissertation II | Project | 1.0 | 0 | 0 | 0 | 0 | 12.0 |
| 3 | PSET695J | Project Work | Project | 1.0 | 0 | 0 | 0 | 0 | 4.0 |

| Open Elective | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Course Code** | **Course Title** | **Course Type** | **Version** | **L** | **T** | **P** | **J** | **Credit** |
| 1 | PCHY627L | Drug Design | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 2 | PCHY628L | Polymer Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 3 | PCHY629L | Biophysical Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 4 | PCHY630L | Computational Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 5 | PCHY631L | NMR, EPR and Mass Spectrometry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 6 | PCHY632L | Bioorganic Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 7 | PCHY633L | Nanomaterials | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 8 | PCHY634L | Green Chemistry | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |

| Skill Enhancement | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Course Code** | **Course Title** | **Course Type** | **Version** | **L** | **T** | **P** | **J** | **Credit** |
| 1 | PENG501P | Technical Report Writing | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 2 | PSTS501P | Qualitative Skills Practice | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 |
| 3 | PSTS502P | Quantitative Skills Practice | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 |

# Discipline Core

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY501L | Physical Chemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Enriching the understanding of the significance of laws of thermodynamics and understand the calculations of absolute entropy and fugacity.
2. Appreciating the significance of the kinetics of complex reactions, theories of unimolecular gaseous reactions, homogeneous and heterogeneous catalysis and enzyme catalysis.
3. Understanding mathematical aspects of quantum chemistry and their applications.
4. Recalling Nernst equation and understand Debye-Huckel theory of electrolytic conductance, Kohlrausch's law and understand the theory of conductometric and potentiometric titrations.

**Course Outcomes**

1. Recall the concepts of a Carnot theorem for heat engines.
2. Solve problems related to thermodynamic properties of ideal & real gases and entropy of a system.
3. Analyze kinetics of complex, unimolecular and chain reactions.
4. Relate the requirements of quantum mechanics for chemical systems.
5. Apply Nernst equation, Debye-Huckel theory and Kohlrausch's law.
6. Interpret electronically excited state dynamics and kinetic behavior of chemical systems.
7. Recall the concepts on adsorption isotherms, kinetics and thermodynamics of surface reactions.
8. Explain properties of surface active agents and their thermodynamics of micellazation.

| Module:1 | Classical Thermodynamics I | 5 hours |
|---|---|---|

Review of laws of thermodynamics- Carnot cycle, Efficiency of heat engine, Entropy, entropy calculations – Free energy, criteria for spontaneity, Free energy as function of Temperature and Pressure. Chemical potential – Fugacity - Activity coefficient – Applications of free energy. 3$^{rd}$ law of thermodynamics – Absolute entropy.

| Module:2 | Chemical Kinetics I | 7 hours |
|---|---|---|

Empirical Rate Laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants - Lindemann and Rice-Ramsperger- Kassel (RRK); unimolecular reactions; Kinetics of parallel – opposing reactions - chain reactions (hydrogen-halogen reactions).

Catalysis-Homogeneous catalysis-heterogeneous catalysis-enzyme catalysis-Michaelis-Menton kinetics, salt effects – Inhibition effects - Autocatalysis.Catalysis-

| | | |
|---|---|---|
| Homogeneous catalysis- heterogeneous catalysis-enzyme catalysis-Michaelis-Menton kinetics, salt effects – Inhibition effects - Autocatalysis. | | |
| **Module:3** | **Quantum Chemistry I** | **6 hours** |
| Wave-particle dualism, Uncertainty principle. Operators for dynamic variables – Eigen values and Eigen functions; Postulatory basis of quantum mechanics; Schrödinger wave equation. | | |
| **Module:4** | **Quantum Chemistry II** | **7 hours** |
| Particle in a box, one and three-dimensional, quantum numbers, zero point energy, orthogonalisation and normality, finite potential barrier – tunneling. The Rigid Rotator, One Dimensional Harmonic Oscillator, Solutions to hydrogen atom. Variation theorem – Time dependent wave function. | | |
| **Module:5** | **Electrochemistry I** | **5 hours** |
| Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; Electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric andpotentiometric titrations. | | |
| **Module:6** | **Photophysical Chemistry I** | **7 hours** |
| Review of concepts and laws of photochemistry- Brief review of electronic transition, Frank- Condon principle, selection rules, construction of Jablonski diagram, electronic transitions andintensity of absorption bands;<br>Excited state kinetics, quantum yield expressions, excimer and exciplex, kinetics of luminescence quenching: Phosphorescence, fluorescence quenching: concentration quenching, static and dynamic,deviation from Stern-Volmer kinetics. | | |
| **Module:7** | **Surface Chemistry and Colloids** | **6 hours** |
| Surface tension, adsorption on solids, Thermodynamics of surfaces, Gibbs Adsorption Isotherm, Heat and Entropy of adsorption. Study of surfaces – Freundlich, Langmuir and BET adsorption isotherms - study of kinetics of surface reactions.<br>Properties and stability of colloids, surface active agents, reverse micelles, critical micellar concentration (CMC), factors affecting CMC of surfactants, thermodynamics of micellazation, microemulsions. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |
| **Text Book(s)** | | |
| 1. | P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, 2018, International 11$^{th}$ Edition,Oxford University Press, United Kingdom. | |
| 2. | Ira N. Levine, Quantum Chemistry, 7$^{th}$ Edition, 2014, Pearson Prentice Hall, London. | |
| **Reference Books** | | |
| 1. | K. J. Laidler, Chemical Kinetics, 1987, 3$^{rd}$ Edition, Harper & Row, New York. | |
| 2. | R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry, 2015, 4$^{th}$ Ed., Wiley, India. | |

| | | | | |
|---|---|---|---|---|
| 3. | R. S. Berry, S. A. Rice and J Ross, Physical Chemistry, 2001, 3rd Edition, Wiley, New York. | | | |
| 4. | A.K. Chandra, Quantum Chemistry, 4th edition, McGraw Hill Education, 2017, India. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY501P | Physical Chemistry Lab-I | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Training in operating different instruments used in the analysis of various chemical Constituents.

**Course Outcomes**

1. Experiment with potentiometry, conductometry, fluorimetry, colorimetry, kinetics and chromatography.
2. Apply concepts of physical and analytical chemistry through experiments.

**Indicative Experiments**

| | | |
|---|---|---|
| 1. | Estimation of Ferrous ion by Potentiometry | 6 hours |
| 2. | Construction of phase diagram of three component system. | 6 hours |
| 3. | Conductometric titration of mixture of acids against a strong base. | 6 hours |
| 4. | Adsorption of acetic acid on charcoal - Verification of Freundlich | 6 hours |
| 5. | Evaluation of Arrhenius parameters: Activation Energy and Frequency | 6 hours |
| 6. | Kinetics of oxidation of Iodide by Persulphate. | 6 hours |
| 7. | Determination of the distribution coefficient for iodine between different immiscible solvents. | 6 hours |
| 8. | Determination of concentrations of potassium and calcium in real samples using Flame Photometry | 6 hours |
| 9. | Estimation of chlorophyll in leaves by colorimetry | 2 hours |
| 10. | Determination of quinine by Fluorimetry and comparison of quantum efficiencies | 2 hours |
| 11. | Determination of stoichiometry of metal complexes using spectrophotometry (Job's method) | 4 hours |
| 12. | Separation of (a) mixture of Azo dyes by TLC (b) mixture of metal ions by Paper chromatography (demo) | 4 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Advanced Physical Chemistry Practical Guide, Charu Arora, Sumantra Bhattacharya, Bentham Science Publishers, 2022. |
| 2. | Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000. |

**Reference Books**

| | |
|---|---|
| 1. | Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan, Viva Books Private Limited, 2015. |

| | | | | |
|---|---|---|---|---|
| | | | | |
| 2. | Analytical Chemistry, International Adaptation, Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, 7th Edition, Wiley, 2020. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY502L | Inorganic Chemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Explaining structure, bonding and reaction mechanism involved in inorganic solids and metal complexes.
2. Applying concepts of inorganic chemistry in research and development.

**Course Outcomes**

1. Compare the trends in the properties of main group elements and discuss thechemistry of Si, B, C- based compounds.
2. Explain the structural arrangement in metals, ionic, covalent compounds and inorganic solids.
3. Discuss theories of coordination chemistry.
4. Interpret the reaction mechanism in metal complexes.
5. Outline the concepts of organometallics.
6. Justify the importance of nuclear chemistry in energy generation.

| Module:1 | Chemistry of p-block elements | 6 hours |
|---|---|---|

Introduction-Periodic trends- Silicones, silicates, silanes, phosphazenes. Boranes: Synthesis, bonding and structure. Carboranes and borazines. Sulfur Nitride $(SN)_x$, Carbon Nitride $(CN)_x$, Boron Carbon Nitride $(BCN)_x$, HSAB Theory.

| Module:2 | Structure and bonding | 6 hours |
|---|---|---|

Close packing: Types of close packing in metals, packing in ionic crystals. Ionic solids: Pauling's rules for ionic crystals - ionic radii and covalent radii. Metal Clusters. Metallic bonding and Hydrogen bonding.

| Module:3 | Inorganic solids | 5 hours |
|---|---|---|

Ionic solids - NaCl, CsCl, $TiO_2$, $CaF_2$ and ZnS – 3D structure -polyhedral approach**.** Defects inCrystal: Frenkel, Schottky and other defects.
Covalently bonded compounds - $CdI_2$, NiAs, $MoS_2$.

| Module:4 | Coordination chemistry-I | 9 hours |
|---|---|---|

Introduction-CFT: splitting of d orbitals under various geometries, factors affecting splitting- spectrochemical series – Jahn-Teller distortion - application to spinels - limitations of CFT. Ligand Field Theory and MO theory: types of complexes - sigma - pi bonding of complexes, back bonding(carbonyls) - Nephelauxetic effects.

| Module:5 | Coordination chemistry-II | 6 hours |
|---|---|---|

Reaction mechanisms: Labile and inert complexes - ligand displacement reactions in octahedral and square planar complexes. Trans effect: theory and applications. Electron transfer reactions: Innersphere and outer sphere process.

| Module:6 | Organometallic Chemistry | 6 hours |
|---|---|---|

Types of ligands in organometallic compounds - eighteen Electron rule, alkyl compounds, metalcarbonyls, isolobal concepts. Metallocenes: Ferrocene.

| Module:7 | Nuclear chemistry | 5 hours |
|---|---|---|

| | | |
|---|---|---|
| Stability of nuclides, nuclear energy, isotope separation (specific to U), Types of decay, radioactive equilibrium, different types of nuclear reactions, q value and nuclear reaction cross section, neutronactivation analysis. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |
| **Text Book(s)** | | |
| 1. | D.F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edition, 2010. | |
| 2. | J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, 2014. | |
| 3. | F.A. Cotton and G. Wilkinson Advanced inorganic Chemistry, John Wiley & Sons, 6th Ed.,1999. | |
| **Reference Books** | | |
| 1. | J.E. Huheey, E.A. Kelter and R.L. Kelter, Principles of structure and reactivity, Inorganic Chemistry, Harper Collins College Publishers, 4th Edition, 2011. | |
| 2. | C.N.R. Rao, Muller and A. K. Cheetham, Chemistry of Nanomaterials, Vol. I & II, WileyVCH Verlag GmbH KGaA, 2014. | |
| 3. | Lesley E. Smart, Elaine A. Moore, Solid State Chemistry: An Introduction, CRC Press, 4thEdition, 2012. | |
| 4. | Walter D. Loveland, David J. Morrissey, Glenn T. Seaborg, Modern Nuclear Chemistry, Wiley-Interscience, 1st edition, 2001. | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | |
| Recommended by Board of Studies | 26-02-2024 | |
| Approved by Academic Council | No. 73 | Date 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY502P | Inorganic Chemistry Lab I | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Applying the concepts of qualitative and quantitative analyses of inorganic samples
2. Developing skills for synthesis and characterization of inorganic materials

**Course Outcomes**

1. Recall and apply the principle of analysis of salt mixture.
2. Estimate the metal content in alloy specimens.
3. Develop the skill of nanomaterial synthesis.
4. Adapt methodologies for real time sample analysis

| | **Indicative Experiments** | |
|---|---|---|
| 1. | Qualitative analysis of inorganic cations - Semi-micro qualitative analysis of<br>a mixture of salts containing two common cations (Pb, Bi, Ca, Cd, Fe, Cr, Al, Co, Ni,Mn, Zn, Ba, Sr, Mg) and less common cations (W, Se, Mo, Ce, Th, Zr, V, Li): simple salt mixtures | 30 hours |
| 2. | Quantitative Analysis of Inorganic Materials<br>1. Determination of copper and nickel in an alloy<br>2. Simultaneous spectrometric determination of chromium and manganese in an alloysteel. | <br>6 hours<br>6 hours |
| 3. | Synthesis and Characterization of<br>1. Prussian blue<br>2. Silver nanoparticles | <br>6 hours<br>6 hours |
| 4. | Challenging Experiment<br>Synthesize a chalcogenide or oxide based phosphor material used in displays.<br>(i) Confirm the composition by appropriate techniques<br>(ii) Prove the phosphorescence of the material | 6 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

1. Vogel's Qualitative Inorganic Analysis, G. Svehla and B. Sivasankar, 7th edition, Pearson, 2012.

**Reference Books**

1. Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000.

Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY503L | Organic Chemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Explaining the basic concepts on organic reactions and mechanism including stereochemical and conformational aspects.
2. Application of spectroscopic techniques for characterization of organic compounds.

**Course Outcomes**

1. Recall the fundamental principles of organic reactions and mechanism.
2. Illustrate nomenclature, isomerism and stereochemistry in organic molecules.
3. Analyze the stereochemistry of products in organic reactions.
4. Apply chemoselectivity, regioselectivity and enantioselectivity for organic reactions of industrial significance.
5. Determine the influence of the substituents on substrate molecules and nature of solvent.
6. Interpret the structure of organic molecules using spectroscopy.

| Module:1 | Art of arrow pushing and reactive intermediates | 9 hours |
|---|---|---|

Flow of electrons – electron source (nucleophile) and electron sink (electrophile), bond making and bond breaking. Common mistakes in arrow pushing – Backward arrow, not enough arrow, hyper valency, mixed media error, conservation of charge, oxidation state and delocalization. General aspects, structure, stability and fate of the intermediates and chemical reactions involving classical and non-classical carbocations, carbanions, free radicals, carbenes, nitrenes and arynes.

| Module:2 | Introduction to Stereochemistry and conformational analysis | 9 hours |
|---|---|---|

Assigning *R* & *S* configuration at chiral centers – one & two chiral center, *meso* compounds. Illustrations of erythro and threo nomenclature.

Atropisomerism in $sp^2$ and $sp^3$ carbons with specific example. Racemic mixture, optical purity - enantiomeric excess, Cis-Trans geometrical isomerism and E, Z notations. Introduction to akamptisomerism. Conformational analysis of acyclic, mono cyclic and bicyclic system: simple 1,2 disubstituted ethane derivatives, cyclohexane, mono, di and tri-substituted cyclohexane, cis and trans decalins. s-cis and s-trans conformations in butadiene.

| Module:3 | Substitution and elimination reactions | 8 hours |
|---|---|---|

Mechanism - Effect of substrate, nucleophile and solvents on - $S_N1$, $S_N2$, $S_Ni$, $S_N1'$, $S_N2'$, $S_Ni'$ reactions with specific examples. Aromatic Nucleophilic Substitution ($S_NAr$) - Vicarious mechanism – Nucleophilic substitution involving diazonium ions – Balz Schimann reaction-Von-Richter rearrangement. Elimination reactions - 1,2; 1,3, 1,4 and pyrolytic–eliminations- E1, E1cB, E2 mechanism, stereo- selectivity in E2 reaction, Saytzeff vs. Hoffmann elimination.

| Module:4 | Electrophilic and nucleophilic addition reaction to C-C double bond | 5 hours |
|---|---|---|

Syn and anti-additions. Reaction mechanisms in hydroboration, addition of

| | | |
|---|---|---|
| alcohols, dienes, thiols, hydrogen cyanide, bisulphite anions and hydride ions. Conversion of alkenes to diols (Manganese, Osmium based), Prevost reaction and Woodward modification. | | |
| **Module:5** | **Aromatic Electrophilic substitution** | **5 hours** |
| Electrophilic substitution in mono and disubstituted aromatic systems : Nitration, bromination and Friedel Crafts reaction | | |
| **Module:6** | **Addition to carbon-hetero atom multiple bond** | **5 hours** |
| Aldol and Knoevenagel reactions and its stereoselectivity (syn- & anti-), reactions of enamine, Mannich reaction, Perkin reaction, Addition of Grignard reagent, and Stobbe reactions, Claisen ester condensation, Benzoin condensation, Darzens glycidic ester condensation, Reformatsky reaction, McMurry coupling, Michael addition and Robinson annulation. | | |
| **Module:7** | **Structural elucidation using spectroscopic techniques** | **7 hours** |
| Fundamental principles of the following spectroscopic techniques can be discussed: UV- Vis, IR, NMR and Mass spectrometer. Application of these spectroscopic techniques in problem solving for organicmolecules. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Ernest L.Eliel, Stereochemistry of carbon compounds, Tata McGrawhill Edition, 2001. |
| 2. | J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, andStructure, 6th Edition, Wiley, 2013. |
| 3. | Peter Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Edition, Pearson EducationLtd., England, 2013. |

**Reference Books**

| | |
|---|---|
| 1. | I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011. |
| 2. | W. Carruthares, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition,Cambridge University Press, Fourth Edition, 2015. |
| 3. | F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part A & B: Reaction and Synthesis,Springer, 5th Edition, 2010. |
| 4. | R. M. Silverstein, G. C. Bassler, T. C. Morril, Spectrometric identification of OrganicCompounds, John Wiley & Sons, Inc, 2010. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY503P | Organic Chemistry Lab I | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Developing skills in organic synthesis
2. Creating knowledge in separation, analysis and spectroscopic interpretation of organic compounds

**Course Outcomes**

1. Analyze organic mixtures and functional groups of molecules using various reagents.
2. Evaluate product distribution based on reaction conditions and spectroscopic techniques.

| Indicative Experiments | | |
|---|---|---|
| 1. | Separation and qualitative Organic analysis of binary mixture I | 6hours |
| 2. | Separation and qualitative Organic analysis of binary mixture II | 6hours |
| 3. | Separation and qualitative Organic analysis of binary mixture III | 6hours |
| 4. | Separation and qualitative Organic analysis of binary mixture IV | 6hours |
| 5. | Separation and qualitative Organic analysis of binary mixture V | 6hours |
| 6. | Training on separation/purification techniques (TLC, column and distillation) | 6hours |
| 7. | Training on separation/purification techniques (recrystallization, extraction, Soxhlet extraction, etc.) | 6hours |
| 8. | Synthesis and characterization of Endo-cis-1,4- endoxo -2,3-dicarboxylic acid (IR , UV , GCMS, NMR). | 6hours |
| 9. | Synthesis and characterization of 3-Pyridyl-4(3H) quinazolone (IR, UV, GCMS, NMR ). | 4hours |
| 10. | Synthesis and characterization of Flavone using Baker-Venkatraman Synthesis(IR, UV, GCMS, NMR ). | 4 hours |
| 11. | Synthesis and characterization of Anthracene-Maleic anhydride adduct (IR, UV, GCMS, NMR ). | 4 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India; 5th edition, 2003. |
| 2. | Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000. |

**Reference Books**

| | |
|---|---|
| 1. | Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Private Limited, 2008. |

| | | | | |
|---|---|---|---|---|
| 2. | The Systematic Identification of Organic Compounds, R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson, 7th edition, John Wiley & Sons, New York, 1997 | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY504L | Group Theory and Molecular Spectroscopy | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Applying practical aspects of quantum chemistry, spectroscopy, symmetry, and group theory indifferent research problems.
2. Explaining the concepts of rotational, vibrational, electronic and NMR spectroscopy.

**Course Outcomes**

1. Define symmetry and symmetry operations in molecules.
2. Make use of group theory in molecular spectroscopy.
3. Demonstrate the practical implementation of quantum chemistry in spectroscopy.
4. Apply the quantum chemistry, group theory and molecular spectroscopy to solve real world problems.
5. Outline the basic physical aspects of NMR spectroscopy.

| Module:1 | Fundamentals of Group Theory | 6 hours |
|---|---|---|

Symmetry elements and symmetry operations-group multiplication table-subgroups, similarity transformations and classes- identifications of symmetry operations and determination of point groups- reducible and irreducible representations-Mullikan symbols.

| Module:2 | Applications of Group Theory | 7 hours |
|---|---|---|

Orthogonality theorem and its consequences - construction of character table for linear ($CO_2$, HCl, $N_2$) and non- linear molecules ($H_2O$, $CH_4$, $XeF_4$, $BF_3$, $SF_6$ and $NH_3$). Determination of representations of vibrational modes in linear and non-linear molecules.

Symmetry adapted linear combinations, symmetry aspects of MO theory, sigma- and pi-bonding in $AB_4$(tetrahedral) molecule.

Symmetry selection rules of infra-red and Raman spectra - application of group theory for the electronic spectra of ethylene and formaldehyde.

| Module:3 | Fundamentals of molecular spectroscopy | 6 hours |
|---|---|---|

The basis of absorption and emission of radiation by molecular species, the wave properties of the light, the quantum theory of light, quantum theory of matter, molecular energies and the Born Oppenheimer approximation, the types of molecular motion and spectroscopy associated with each.

| Module:4 | Rotational Spectroscopy | 6 hours |
|---|---|---|

Classical description of molecular rotation, quantum mechanics of molecular motion, rotational spectra, determination of the bond length from rotational constants, vibrational stretching and vibrational satellites, no-rigid rotor, centrifugal distortion, degeneracies and intensities, Stark effect, selection rules, rotational spectra of polyatomic molecules.

| Module:5 | Vibrational Spectroscopy | 6 hours |
|---|---|---|

| | | |
|---|---|---|
| Interaction of Electromagnetic radiation with matter - The Vibrating Diatomic Molecule - harmonic and anharmonic oscillators- Diatomic Vibrating Rotator - Vibrations of polyatomic molecules-Molecular vibrations, types of molecular vibrations. Fundamentals, overtones, combination bands and Fermi resonance, fingerprint region. Application of IR - characteristic group frequencies in organic molecules and metal carbonyls. | | |
| **Module:6** | **Electronic Spectra of molecules** | **6 hours** |
| The Born-Oppenheimer Approximation, Vibrational Coarse structure: Progressions, Intensity of vibrational-Electronic spectra: Franck-Condon Principle, Dissociation Energy, Dissociation Products and Predissociation. The Woodward Fisher rules – calculation of $\lambda_{max}$ for dienes, enones and polyenes – Use of UV spectroscopy in distinguishing geometrical isomers. Effect of solvents on spectra - solvatochromism. Applications of electronic spectra. | | |
| **Module:7** | **Magnetic resonance spectroscopy** | **6 hours** |
| Nuclear Spin Origins, Spin and Magnetic Properties, Nuclear Spin Angular Momentum and Quantum Numbers, Magnetic Moment of a Nucleus Nuclear Energy Levels in a Magnetic Field, Classical Description of the NMR Experiment and the principle, Experimental Verification of Quantized Angular Momentum and of the Resonance Equation, Types of NMR spectroscopy, applications. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Colin N Banwell, Elaine M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw-HillPublishing Co. Ltd., 5th Edition, 2013. |
| 2. | P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, International 11th Edition, Oxford University Press, United Kingdom, 2018. |
| 3. | Understanding NMR Spectroscopy, James Keeler, Wiley India Pvt Ltd; Second edition, 2013. |
| 4. | F.A. Cotton, Chemical Applications of Group Theory, 3rd Edition, Wiley India Edition, 2009. |
| | |

**Reference Books**

| | |
|---|---|
| 1. | D. A. McQuarrie, Quantum Chemistry, 2nd Edition, University Science Books, 2008. |
| 2. | Hollas J. Michael Hollas, Modern Spectroscopy, John Wiley & Sons Inc. 4th Edition, 2003. |
| 3. | A.K. Chandra, Introduction to Quantum Chemistry, Tata Mc Graw Hill Publishing Company,New Delhi, 4th Edition, 2009. |
| 4. | P. S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition. New Age International Publishers,6th Edition, 2006. |

| | | | | |
|---|---|---|---|---|
| 5. | F. Hammer, Inorganic Spectroscopy and Related Topics, Sarup & Sons, 1st Edition, 2008. | | | |
| 6. | P. K Bhattacharya, Group theory and its applications, 3rd Edition, Himalaya Publishing House, 2007. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY505L | Organic Synthesis and Methodologies | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Acquainting various methodologies used in organic synthesis, which enable the student to think different possible ways to synthesis an organic compound
2. Knowing various metallic reagents used in chemical transformations in the production natural and synthetic drugs and materials.

**Course Outcomes**

1. Recall the fundamental principles of organic reactions.
2. Outline the concepts related to synthesis, mechanisms and the functions of various reagents.
3. Apply their understanding about the retrosynthetic approaches involved in organic reactions of industrial significance.
4. Analyze the product distribution and the stereochemistry of various organic products through spectroscopic data.
5. Evaluate the organic reactions and methodologies based on the influence of the substituents on substrate molecules and nature of solvent and the parametric conditions.
6. Propose new organic reactions to achieve the required retro- synthesis products.

| Module:1 | C-C & C-X Disconnection approach | 3 hours |
|---|---|---|

An introduction to synthons and synthetic equivalents, disconnection approach, functionalgroup inter conversions. One group and two group C-X disconnections in 1,2-, 1,3-, 1,4- and 1,5-difunctional compounds. One group and two group C-C Disconnections; Alcohols and carbonyl compounds regioselectivity, Diels-Alder reaction, 1,3-di functional compounds.

| Module:2 | Planning and execution of retrosynthesis | 5 hours |
|---|---|---|

Retro synthesis of alkenes, acetylenes, nitro and amine compounds with specific example tosynthesis of simple molecule for each functional group

| Module:3 | Strategies of alcohols and carbonyl disconnections | 4 hours |
|---|---|---|

Alcohols and carbonyl compounds with specific example to synthesis of simple molecule foreach functional group

| Module:4 | Retro-synthesis of carbonyl and heterocyclic compounds | 5 hours |
|---|---|---|

Unsaturated carbonyl compounds, control in carbonyl condensations, Michael addition and Robinson annulation. Retro synthesis of aromatic heterocycles of 5 and 6 membered rings.

| Module:5 | Types of Asymmetric synthesis | 6 hours |
|---|---|---|

Asymmetric synthesis – Substrate, auxiliary, reagent, catalyst controlled methods (organo and metal catalysis)

| Module:6 | Heterocycles with fused 6 membered rings | 7 hours |
|---|---|---|

Dicyclohexylcarbodiimide (DCC), EDCI, DDQ, Organozinc (Reformatsky reaction), Organo lithium (Shapiro reaction, LDA), Organocopper (Gillman reagent,

| | | |
|---|---|---|
| Ullmann), organopalladium (Sonogashira and Stille), organosilicon (Peterson's synthesis), organotin (tributyl tinhydride) | | |
| **Module:7** | **Protection, deprotection and total synthesis** | **10 hours** |
| Alcohol, acid, amine, ketone and aldehyde. Total synthesis of Camptothecins, Longifolene and Cubane – chemoselectivity. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Stuart Warren and Paul Wyatt, Organic synthesis, the disconnection approach, 2nd edition,Wiley, 2012. |
| 2. | Jie Jack Li, E. J. Corey, Total Synthesis of Natural Products: At the Frontiers of OrganicChemistry, First Edition, Springer, 2012. |
| 3. | Rainer Mahrwald, Enantioselective Organocatalyzed Reactions, 322 & 386 Pages, 1stEdition, Springer, 2011. |
| 4. | K. C. Nicolaou, E. J. Sorensen-Classics in total synthesis- 4th edition, Wiley-VCH (1996) |
| 5. | Michael B Smith, Organic synthesis, 4th Edition, Academic Press (2016) |
| **Reference Books** | |
| 1. | I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011. |
| 2. | W. Carruthares, Lain Coldham, Modern Methods of Organic Synthesis South Asia Edition,Cambridge University Press, Fourth Edition, 2015. |
| 3. | Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, andStructure.7th Edition, Wiley, 2017. |
| 4. | L. S. Starkey, Introduction to Strategies for Organic synthesis. Wiley & Sons, Inc., Hoboken, New Jersey and Canada. 2012 |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY506L | Organometallics and Industrial Applications | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Explaining the basic concepts of organometallics, their reactions and reaction mechanisms
2. Imparting knowledge on applications of various organometallic reagents.

**Course Outcomes**

1. Explain synthesis, mechanism and functions of organometallic reagents and catalysts.
2. Demonstrate the importance of organometallic compounds.
3. Analyse the spectral data of organometallic compounds.

| Module:1 | Introduction | 5 hours |
|---|---|---|

Energy, Polarity, Lability & Reactivity aspects of main group organometallic chemistry; Transition metal compounds – The 18 valence electron rule, nomenclature of organometallic compounds, Significance of metal - carbon bonds in catalysis.

| Module:2 | Preparation methods, stability | 5 hours |
|---|---|---|

Bonding theory, synthesis and reactivity of sigma-bonded alkyls and aryls, metal carbonyls and pi-bonded organic ligands such as alkenes, alkynes, allyls, and arenes, applications.

| Module:3 | Metal carbonyls, metallocenes, carbenes and carbynes | 5 hours |
|---|---|---|

Metal Carbonyls – Preparation methods, Properties, important reaction types – Nature of carbonyl metal hydrides; Metallocenes and other sandwich - inverted and half- sandwich compounds; Metal carbenes and carbynes (alkylidenes, alkylidynes). Nucleophilic and electrophilic carbene complexes.

| Module:4 | Olefin complexes, homoalkene and heteroalkene complexes | 5 hours |
|---|---|---|

$C_3R_3^+$, $C_4H_4$ and $C_5H_5$ – ligands – Cyclopentadienyl metal carbonyls, halides and their special applications; Multi metal clusters – Formation and criteria for M-M bonds; isolobal analogy.

| Module:5 | Important synthetic routes and properties | 9 hours |
|---|---|---|

Organosilanes, organoboranes and organometallic complexes of platinum group metals (Ru, Rh, Pd, Os, Ir and Pt), β-Hydride elimination, Oxidative addition, Reductive elimination, ligand substitution, migratory insertion, trans metalation, nucleophilic attack on the ligand. Agostic interactions in organometallic complexes; Organometallic polymers – synthesis, important properties and applications.

| Module:6 | C-C Coupling reactions | 9 hours |
|---|---|---|

Pd catalyzed cross-coupling reactions; Boron- Suzuki reaction; Tin- Stille reaction; Lithium & Magnesium- Kumada coupling; Zinc- Negishi reaction; Silicon- Hiyama reaction; Copper-Sonogashira reaction; Heck Reaction. Activation & functionalization of sp, $sp^2$ and $sp^3$ hybridized molecules (CO, $CO_2$ and $CH_4$).

| | | |
|---|---|---|
| **Module:7** | **Structural elucidation** | **5 hours** |
| Structural elucidation of organometallic complexes, fluxional molecules. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |

| **Text Book(s)** | |
|---|---|
| 1. | Basic Organometallic Chemistry: Concepts, Syntheses, and Applications of Transition Metals, B.D. Gupta, Anil J. Elias, Universities Press, 2nd edition, 2013. |
| 2. | A Text Book on Organometallics, Christoph Elschenbroich, 3rd revised edition, WILEY- VCH, Germany, 2006. |
| 3. | The Organometallic Chemistry of the Transition Metals Robert H. Crabtree, 6th edition, John Wiley & Sons, Inc., 2014. |
| | |

| **Reference Books** | |
|---|---|
| 1. | Organic Synthesis Using Transition Metals, Roderick Bates, 2nd Edition, John Wiley & Sons, Ltd., 2012 |
| 2. | Applied Homogeneous Catalysis with Organometallic Compounds: A Comprehensive Handbook in Four Volumes, Boy Cornils, Wolfgang A. Herrmann, Matthias Beller, Rocco Paciello (Eds), Wiley-VCH Verlag GmbH & Co. KGaA, 2017. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

# Discipline Elective

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY601L | Analytical Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Making students understand the insights of statistical methods in qualitative and quantitative analysis and usage of different analytical instruments for chemical analysis.
2. Realizing the importance of thermal analysis, absorption and emission spectroscopy, surface analytical, electroanalytical, and chromatographic techniques.

**Course Outcomes**

1. Analyze different errors using statistical methods in Chemical analysis.
2. Evaluate errors in chemical analysis through statistical treatment of data through F- test, T-test and Q-test.
3. Relate thermal behavior of different organic and inorganic materials using TGA, DTA and DSC
4. Apply absorption and emission techniques for trace element analysis from different matrices.
5. Utilize diffraction and microscopic techniques to characterize nanomaterials.
6. Analyze electroactive species using different voltammetric techniques.
7. Make use of TLC and Paper chromatographic techniques for monitoring and detection of important organic and inorganic materials.
8. Determine organic compounds using GC and HPLC techniques.

| Module:1 | Errors and Statistical treatment | 8 hours |
|---|---|---|

Errors in chemical analysis. Classification of errors- systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Calculations involving significant figures. Confidence limit, correlation coefficient and regression analysis. Comparison of methods: F-test and T-test. Rejection of data based on Q-test. Least squares method for deriving calibration graph. Fitting of data to hypothesis.

| Module:2 | Thermoanalytical methods | 6 hours |
|---|---|---|

Types – Thermogravimetric Analysis (TGA) – Factors influencing TGA – Instrumentation of TGA - Applications of TGA for analysis of inorganic compounds and polymers. Differential thermal analysis (DTA) – Theory - instrumentation and applications in food and pharmaceutical industry. Differential Scanning Calorimetry (DSC) –Theory – instrumentation and applications in polymer and pharmaceutical industries.

| Module:3 | Atomic Absorption, Flame Emission and Inductively coupled plasma Analysis | 5 hours |
|---|---|---|

Atomic Absorption spectroscopy and Flame Emission Spectroscopy - Basic

| | | |
|---|---|---|
| principles– Instrumentation – analytical applications. ICP-MS/OES - Basic principles- sources of radiation – instrumentation – analytical applications. | | |
| **Module:4** | **Material Characterization Techniques** | **6 hours** |
| XRD, SEM, TEM, EDAX, AFM - Basic Principles, instrumentation and their utility in characterization of nanomaterials | | |
| **Module:5** | **Electroanalytical Techniques** | **6 hours** |
| Polarography - Introduction, Dropping mercury electrode (DME), Instrumentation, Ilkovic equation and its verification, Determination of half wave potential, applications.<br>Voltammetry – A three electrode system concept – diffusion-controlled and adsorption-controlled electron-transfer reactions; Single sweep voltammetry, cyclic voltammetry – Randles-Sevcik equation, Criteria for reversible and irreversible processes - applications. | | |
| **Module:6** | **Basics of TLC and Paper Chromatography** | **6 hours** |
| Thin-layer chromatography (TLC): Principle, methodology selection of stationary and mobile phases- preparation of plates, spotting, development, identification and detection, measurement of RF values, Qualitative and quantitative applications.<br>Paper chromatography (PC): Theory and principle; techniques: one, two-dimensional and circular PC, mechanism of separation, structure of cellulose and types of paper, methodology, sample preparation, choice of solvents, location of spots and measurement of RF value, factors affecting RF values, advantages and applications | | |
| **Module:7** | **Introduction to HPLC and GC** | **6 hours** |
| Gas chromatography (GC): Principle, instrumentation columns - packed and tubular, factors affectingseparation, applications.<br>High pressure liquid chromatography (HPLC)*:* Apparatus, pumps, column packing, detectors-UV, IRand fluorescence detectors, advantages and applications. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Gary D. Christian, Purnendu (Sandy) Dasgupta, Kevin Schug, Analytical Chemistry, Wiley & sons, 7th Edition, 2013. |
| 2. | Douglas A Skoog, Donald M West, F James Holler, Stanley R.Crouch, Fundamentals of Analytical Chemistry, Wadsworth Publishing Co Inc., 9th Edition, 2014. |
| 3. | H.A. Willard, L.L.Merrit, J.A. Dean, Von Nostrand, Instrumental Methods of Analysis, 7th Edition,CBS Publishers, 1986. |
| | |

**Reference Books**

| | |
|---|---|
| 1. | S.M. Khopkar, Analytical Chemistry: Problems and Solutions, New Age International Pvt. Ltd.,2nd Edition, 2010. |

| | | | | |
|---|---|---|---|---|
| 2. | J. Basset, R.C. Denny, C.H. Jaffery and J. Mendhan, Vogel's Text Book of Quantitative Chemical Analysis, ELBS, Longman Group Publishers, $6^h$ Edition, 2009. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY602L | Advanced Organic Chemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Explaining the basic concepts on organic reactions and mechanism including stereochemical and conformational aspects.
2. Application of spectroscopic techniques for characterization of organic compounds.

**Course Outcomes**

1. Recall the fundamental concepts related to organic reactions.
2. Explain synthesis, mechanism and the functions of reagents and catalysts.
3. Apply the organic reactions to make industrially important molecules.
4. Analyze product distribution and stereochemistry of products using spectroscopy.
5. Relate the influence of substituents on substrate molecules, nature of solvent and reaction parameters.
6. Propose organic reactions to achieve the required products.

| Module:1 | Classical to modern oxidation methods | 7 hours |
|---|---|---|

Oxidation of alcohols - Chromium, Manganese, Aluminum, Silver, Ruthenium. Swern, Dess-Martin periodinane and TEMPO based reagents, N-hydroxypthalimide reagent. Alkene to epoxides - Sharpless, Jacobsen and Shi epoxidation (chiral). Ketones to ester and lactones.

| Module:2 | Oxidative cleavage and addition | 6 hours |
|---|---|---|

Oxidative cleavage of alkenes - Manganese, Osmium, Ruthenium, Lead, Ozone Oxidative addition of alkenes - hydroboration, Wacker oxidation, Selenium, Chromium based allylic oxidation.

| Module:3 | Reduction by metals | 8 hours |
|---|---|---|

Heterogeneous - Palladium/Platinum/Rhodium/Nickel Homogeneous: Wilkinson; Noyori asymmetric hydrogenation Reduction by alkali metals – Li / Na in liquid ammonia – Birch reduction Reduction by transition metals: Zinc and Titanium reagents, $SmI_2$ (Acyloin formation, dehalogenation and deoxygenations) Reduction by metal catalyst - Meerwein-Pondorff-Verley reduction Enantioselective reductions - Chiral Boranes, Corey-Bakshi-Shibata reduction

| Module:4 | Reduction by metal hydrides | 6 hours |
|---|---|---|

Reduction by metal hydrides - $NaBH_4$, triacetoxyborohydride, $LiAlH_4$, L-selectride, K-selectride, Luche reduction; DIBAL-H, and Red-Al, Trialkylsilanes and Trialkylstannane

| Module:5 | Rearrangement reactions | 5 hours |
|---|---|---|

Carbocation - Pinacol-pinacalone, Wagner Meerwin, Demjanov Carbanion – Favorskii (5-9 membered ring systems), Stevens, Neber Carbene – Wolff rearrangement; Nitrene - Hoffman, Curtius, Schmidt. N-Heterocyclic Carbenes in Metal Catalysis and organo catalysis.

| Module:6 | Carbohydrates and peptides in organic synthesis | 7 hours |
|---|---|---|

| | | |
|---|---|---|
| Reactivity at carbon center - reactions at anomeric carbon and epimeric carbons, ring expansions and contractions. Protection and deprotection methods in carbohydrate.<br>Chemical and enzymatic glycosylations to oligosaccharides - Modification of sugars into carbocycles and heterocycles and their applications in medicinal chemistry (one example each). Peptides: Synthesis of peptides, protection and deprotection methods in peptide synthesis. | | |
| **Module:7** | **Modern Synthetic Methods** | **4 hours** |
| Baylis-Hillman reaction, Henry reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction. Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Suzuki, Negishi | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |

| **Text Book(s)** | |
|---|---|
| 1. | F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5th Edition, 2010. |
| 2. | J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and structure, 6th Edition, Wiley, 2013. |
| 3. | L. Kuerti and B. Czako, Strategic Applications of named Reactions in Organic Synthesis, Elsevier Academic Press, 2005. |
| **Reference Books** | |
| 1. | I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011. |
| 2. | W. Carruthares, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition, Cambridge University Press, Fourth Edition, 2015. |
| 3. | F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5th Edition, 2010. |
| 4. | R.M. Silverstein, G. C. Bassler, T. C. Morril, Spectrometric identification of Organic Compounds, John Wiley & Sons, Inc, 2010. |
| 5. | Nolan, S. P. N-Heterocyclic Carbenes in Synthesis; Wiley-VCH; Weinheim, 2006. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY603L | Chemistry of Heterocyclic Compounds | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Explaining synthesis methods, and applications of heterocyclic compounds.
2. Learning the physical and chemical behaviour of heterocyclic compounds and their reaction mechanisms.

**Course Outcomes**

1. Recall fundamental aspects of heterocyclic compounds.
2. Explain nomenclature, structure, reaction mechanisms and functions of heterocyclic compounds.
3. Make use of organic reactions to synthesize heterocyclic molecules of industrial importance.
4. Analyze product distribution and stereochemistry of heterocyclic derivatives using spectroscopic tools.
5. Relate the influence of substituents on substrate molecules, nature of solvent and reaction parameters.

| Module:1 | Systematic nomenclature of heterocycles | 3 hours |
|---|---|---|

Hantzsch-Widman system for monocyclic, fused and bridged heterocycles

| Module:2 | Aliphatic and carbocylic aromatic heterocyclic compounds | 8 hours |
|---|---|---|

Carbocyclic aromatic system-six members and fused, tautomerism in heterocycles-spectroscopic properties of heterocyclic systems (any two).

Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, oxetanes, thietanes. Corey-Chaykovsky epoxidation. Darzen, Aza Darzen condensation, DeKimpe - thiranes, azetidines.

| Module:3 | Five membered Heterocyles | 5 hours |
|---|---|---|

Synthesis and reactions of Furans: Fiest Benary furan synthesis, Knorr and Paal-Knorr pyrrole synthesis, Pyrroles and pyrrolidines-Barton. Zard reaction. Hofmann-Loffler-Freytag reaction.

Thiophenes-Hinsberg synthesis of thiophene derivatives. Oxazoles and isoxazoles- Robinson- Gabrial ring closure. Cornforth rearrangement. Larock synthesis.

| Module:4 | Six and Large Membered Heterocycles | 8 hours |
|---|---|---|

Pyridines- Hantzsch (Dihydro)-pyridine synthesis, Doebner von Miller reaction, pyrimidines- Biginelli reaction, Chichibabin (Tschitschibabin) pyridine synthesis. Synthesis and reactions of azepines, oxepines, thiepines, diazepines (1,2 and 1,4), thiazepines, azocines.(any four)

| Module:5 | Heterocycles with fused 5 membered rings | 6 hours |
|---|---|---|

Synthesis and reactions of heterocycles with fused 5 membered ring benzopyrroles, benzofurans and benzothiophenes, Indoles: Fischer, Madelung, Nenitzescu syntheses.

| Module:6 | Heterocycles with fused 6 membered rings | 7 hours |
|---|---|---|

| | | |
|---|---|---|
| Heterocycles with fused 6 membered ring Quinolines and isoquinolines- Bischler-Napieralski reaction. Friedlander synthesis. Meth-Cohn quinolone synthesis. Pfitzinger quinoline synthesis., Skraup synthesis, Coumarins, chromones, quinolizinium ions | | |
| **Module:7** | **Industrial and Medicinal Applications of Heterocyclic Compounds** | **6 hours** |
| PEDOT and polypyrroles as conducting polymers, Bipyridine in dye sensitized solar cells (DSC). Nicotinic acid (Lipid modulating drug), 3,5-pyrazolidinedione (anti-inflammatory drug),Captopril (anti-hypertensive agent) and Ciprofloxacin (antibiotic). | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| **Text Book(s)** | |
|---|---|
| 1. | Heterocyclic Chemistry At A Glance, John A. Joule, Keith Mills, 2nd revised edition Wiley-Blackwell, 2012. |
| 2. | The Chemistry of Heterocycles, Theophil Eicher, Siegfried Hauptmann, 3rd edition, Wiley-VCH, Weinheim, 2012. |
| 3. | An Introduction to the Chemistry of Heterocyclic Compounds, Acheson, R. M. 3rd Edition, WileyIndia Pvt Ltd, 2008. |
| 4. | Heterocyclic Chemistry, Gilchrist, T. L. , 3rd Edition, Prentice Hall, 2005. |
| **Reference Books** | |
| 1. | Organic Chemistry, Jonathan Clayden, Nick Greeves, and Stuart Warren, Oxford University Press, 2014. |
| 2. | The essence of Heterocyclic Chemistry, Arun R Parikh, Hansa Parikh and Ranjan Khunt, New Age International, 2017. |
| 3. | Heterocyclic Chemistry, V. K. Ahluwalia, Alpha Science International, 2012. |
| 4. | Advanced Organic Chemistry: Structure and Mechanisms (Part A &B). Frances A Carey and Richard J Sundberg, Springer, 2015. |
| 5. | Heterocyclic chemistry, R. K. Bansal, 5th edition, New Age International Private Limited, 2017. |
| 6. | Name reactions in heterocyclic chemistry, Jie Jack Li, Wiley India Pvt Ltd, 2012. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY604L | Chemistry of Natural Products | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Explaining synthesis, properties, medicinal applications, metabolic activities and biological functions of natural products.
2. Acquainting the students with steroids and their biological functions.

**Course Outcomes**

1. Relate the structural difference between different natural products.
2. Outline chemical synthesis and biosynthesis of natural products like steroids, alkaloids, terpenoids, flavonoids and pigments.
3. Determine the structure of natural products using structural elucidation methods.
4. Demonstrate the importance of natural products based on their bioactivities.

| Module:1 | Steroids | 5 hours |
|---|---|---|

Classification, general structural elucidation and identification tests- Synthesis, structural elucidation, stereo chemistry and conformational aspects of cholesterol.

| Module:2 | Synthesis of Steroids | 5 hours |
|---|---|---|

Synthesis and structural elucidation of oestrone. Conversion of cholesterol into androsterone, testosterone, progesterone and bile acids.

| Module:3 | Alkaloids | 9 hours |
|---|---|---|

Classification, general structural elucidation and identification tests-Structural elucidation and chemistry of the following alkaloids: quinine, morphine, reserpine, mosembrine.

| Module:4 | Terpenoids | 5 hours |
|---|---|---|

Classification, mevalonic lactose, structural elucidation and synthesis of bisabolene, longifolene and caryophyllene.

| Module:5 | Flavanoids and Pigments | 9 hours |
|---|---|---|

Anthocyanins and anthocyanidines, general methods of synthesis. Synthesis and structure of flavonols, isoflavonols, isoflavones.

Introduction to pigments, classification, isolation and synthesis of apigenin, quercetin, diadzein, cyanidin and cyanin.

| Module:6 | Vitamins | 5 hours |
|---|---|---|

Chemistry and synthesis of Vitamin B complexes, Vitamin C and Vitamin D

| Module:7 | Carbohydrates | 5 hours |
|---|---|---|

Pyranose and furanose forms of aldohexose and ketohexose – methods used for the determination of ring size - conformation of aldohexopyranose – structure and synthesis of maltose, lactose, sucrose and cellobiose – A brief study of starch and cellulose.

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

Industry Expert Lecture

| | Total Lecture hours: | 45 hours |
|---|---|---|

**Text Book(s)**

| | | | | |
|---|---|---|---|---|
| 1. | Natural Products in the Chemical Industry, Bernd Schaefer, 2nd ed. Springer,New York, 2014. | | | |
| 2. | Organic Chemistry, Vol II, Stereochemistry and the Chemistry of Natural Products, I. L. Finar, 5th edition, Pearson, 2009. | | | |
| **Reference Books** | | | | |
| 1. | Advanced Organic Chemistry, Part-A and B, F. A. Carey and R. J. Sundberg, 5th edition, Springer, 2008. | | | |
| 2. | Strategies and Tactics in Organic Synthesis, Michael Harmate, Ist Edition, Elsevier, 2013. | | | |
| 3. | Organic Chemistry of Natural Products, Volume II, O. P. Aggarwal, 38th edition,Krishna Prakashan Media (P) Ltd, 2014. | | | |
| 4. | Medicinal Natural Products, P. M. Dewick, 3rd edition, John Wiley, 2011. | | | |
| 5. | Chemistry of Natural Products, Sujata V. Bhat, Bhimsen A. Nagasampagi, MeenakshiSivakumar, Narosa Publishing House, 2013. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY605L | Photochemistry and Pericyclic Reactions | 4 | 0 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Imparting knowledge on theory and applications of photochemistry and pericyclic reactions.
2. Explaining mechanisms of reactions involved in organic synthesis using cycloaddition and photochemistry.

**Course Outcomes**

1. Recall the fundamental principles of photochemical reactions.
2. Relate the concepts related to light induced organic synthesis, mechanisms and functions of reagents.
3. Apply photochemical reactions for synthesising molecules of industrial significance.
4. Analyse product distribution and stereochemistry of products derived from photochemical reactions.
5. Evaluate the photochemical reactions based on the influence of the substituents on substrate molecules.
6. Propose photochemical reactions to achieve the required products.

| Module:1 | Principles of photochemical reactions | 11 hours |
|---|---|---|

Molecular energies and Jablonski diagram. Photochemical reactions and their applications in organic synthesis; Hund's and Frank Condon principle, Photochemistry of carbonyl compounds, Paterno- Buchi reaction, Norrish type I and II reaction, Photoreduction, Photochemistry of α,β unsaturated compounds, olefins and isomerization.

| Module:2 | Photo rearrangements | 5 hours |
|---|---|---|

Di-π-methane, oxa di-π-and aza di-π-methane, aromatic hydrocarbons, Wolf and Friesrearrangements.

| Module:3 | Significant photoreactions | 11 hours |
|---|---|---|

Photocycloaddition, Photochemical aromatic substitution reaction; Reactions with singlet oxygen, ene reactions (ene with oxygen, alkenes, carbonyl, alkynes, amines etc.); Photochemical methods for protection and deprotection.-Barton reaction and Hoffman-Loffler-Freytag reactions, The mechanisms of reactions involving free radicals- Sandmayer, Gomberg- Bachmann, Pschorr and Hunsdiecker reactions. Photo-elimination reactions

| Module:4 | Aromaticity and cross-conjugated Systems | 6 hours |
|---|---|---|

Aromaticity in benzenoid and non-benzenoid compounds. Huckel's (4n+2) and 4n rules, annulenes, anti-aromaticity and homo-aromaticity. Annulenones, Annulenequinones, Fulvenes. Polycyclic Systems-Cyclopropenyl Aromatic Systems-Pentalenes, Heptalenes, Azulenes, Other Systems-Cyclobutadiene and cyclooctateraene.

| Module:5 | Molecular orbital symmetry | 7 hours |
|---|---|---|

Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system, Wood-

| | | |
|---|---|---|
| ward Hoffman correlation diagrams, FMO and PMO approach, electrocyclic reactions, - conrotatory and dis rotatorymotions, 4n , 4n+2 and allyl systems | | |
| **Module:6** | **Sigma-tropic rearrangement** | **7 hours** |
| Supra and antarafacial shifts of H Sigmatropic shifts involving carbon moieties,3,3 and 5,5 sigmatropic rearrangement and Claisen and Cope , Oxa and Aza Cope rearrangement- HOMO-LUMO orbital symmetry analysis. Cheletropic Reactions | | |
| **Module:7** | **Cycloaddition** | **11 hours** |
| Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes, 1,3-dipolarcycloaddition and chelotropic reactions. Ene reaction.<br>**Diels-Alder reactions**: retro Diels-Alder reaction- FMO mechanism for *endo*- and *exo*-selectivity, stereochemistry, inter- and intramolecular reactions. Correlation diagrams and FMO method, Allowed and forbidden reactions. Nazarov and Iso Nazarov reactions | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Orbital interactions in chemistry, Thomas A Albright, Jeremy Burdett, Myung –Hwan Whangbo, 2nd edition, John Wiley & Sons, Inc., 2013 |
| 2. | Pericyclic reactions-A Textbook: Reactions Applications and Theory, S. Sankararaman, Wiley-VCH, 2015. |
| 3. | Organic Photochemistry and Pericyclic Reactions, S. Kalaivanai, MJP Publishers, 2011. |

**Reference Books**

| | |
|---|---|
| 1. | Pericyclic reactions, Sunil Kumar, Vinod Kumar, S.P. Singh, Elsevier, 2016. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY606P | Organic Chemistry Lab-II | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Imparting training in analysis of organic compounds using chemical and instrumental methods.
2. Developing skills in organic synthesis.
3. Demonstrating the importance of different instrumental methods in chemical analysis of materials.

**Course Outcomes**

1. Recall synthetic utility of organic molecules and reagents.
2. Outline the preparation methods of organic molecules and reaction mechanisms.
3. Analyse the structure of synthesized organic molecules and their derivatives using chemical analysis and spectroscopic tools.

| | **Indicative Experiments** | |
|---|---|---|
| 1. | Estimation of Phenol | 6 hours |
| 2. | Estimation of Aniline | 6 hours |
| 3. | Estimation of Glucose | 6 hours |
| 4. | Estimation of Methyl Ketone | 6 hours |
| 5. | Estimation of carbonyl group (percentage purity of carbonyl compound) | 6 hours |
| 6. | Synthesis, characterization of phenytoin from benzoin- two step reactions(IR, UV, GCMS, NMR) | 6 hours |
| 7. | Synthesis, characterization of 2,3-diphenyl quinoxaline (from benzil) (IR,UV, GCMS, NMR) | 6 hours |
| 8. | Synthesis characterization of 2-phenylindole from acetophenone – two stepreactions (IR, UV, GCMS, NMR) | 6 hours |
| 9. | Synthesis, characterization of tetrahydrocarbazole from cyclohexanone-(Fischer Indolization) (IR, UV, GCMS, NMR) | 6 hours |
| 10. | Synthesis, characterization of methyl cinnamate from malonic acid throughcinnamic acid two step reactions (IR, UV, GCMS, NMR) | 6 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India; 5th edition, 2003. |
| 2. | Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000. |
| 3. | An advanced course in practical chemistry, Nad A. K., Mahapatra B, and Ghoshal A. New Central Book Agency (P) Ltd, 2011. |
| 4. | Instrumental techniques for Analytical Chemistry, Frank Settle, Prentice Hall PTR, New Jersey, USA, 1997. |

**Reference Books**

| | |
|---|---|
| 1. | Techniques and Experiments for Organic Chemistry, Addison Ault, University |

| | | | | |
|---|---|---|---|---|
| | Science Book, USA, 1998. | | | |
| 2. | The Systematic Identification of Organic Compounds, R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson, 7th edition, John Wiley & Sons, New York, 1997 | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY607P | Organic Chemistry Lab-III | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Developing skills in organic synthesis.
2. Demonstrating the art of extraction and separation of organic molecules.
3. Imparting training in analysis of organic compounds using chemical and instrumental methods

**Course Outcomes**

1. Apply organic synthesis mythologies to prepare important organic molecules.
2. Demonstrate preparation methods, functions of various reagents and reaction mechanisms.
3. Analyse product distribution and the influence of reaction conditions in terms ofyields.
4. Evaluate the properties of synthesized molecules and their derivatives using spectroscopic tools.

| Indicative Experiments | | |
|---|---|---|
| 1. | Synthesis, characterization of methyl salicylate from salicylic acid: one-step(IR, UV, GCMS, NMR) | 6 hours |
| 2. | Synthesis, characterization of methyl red from anthranilic acid: two-step process(IR, UV, GCMS, NMR) | 6 hours |
| 3. | Synthesis, characterization of α, β -Unsaturated acid from anisaldehyde – two stepKnoevenagel condensation/hydrolysis (IR, UV, GCMS, NMR) | 6 hours |
| 4. | Synthesis, characterization of Poly Halo-arene (1-iodo-2,4,6-tribromo benzenefrom aniline) – two step (IR, UV, GCMS, NMR) | 6 hours |
| 5. | Synthesis, characterization of trimethylquinoline from p-toluidene-two step(IR, UV, GCMS, NMR) | 6 hours |
| 6. | Multi step synthesis: 2-aminobenzophenone-2-methyl-3-aceylquinoline-2-methylquinoline chalcone | 6 hours |
| 7. | Multi step synthesis: Cinnamaldehyde- cinnmamyl alcohol-cinnamylbromide – allylaryl ether | 6 hours |
| 8. | Extraction and characterization of Lactose from Milk | 5 hours |
| 9. | Extraction and characterization of Lycopene from Tomatoes | 5 hours |
| 10. | Separation of binary mixture by column chromatography - non-polar and polarcompounds | 8 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India; 5th edition, 2003. |
| 2. | Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000. |
| 4. | An advanced course in practical chemistry, Nad A. K., Mahapatra B, and |

| | | | | |
|---|---|---|---|---|
| | Ghoshal A. New CentralBook Agency (P) Ltd, 2011. | | | |
| 5. | Instrumental techniques for Analytical Chemistry, Frank Settle, Prentice Hall PTR, New Jersey, USA, 1997. | | | |
| **Reference Books** | | | | |
| 1. | Techniques and Experiments for Organic Chemistry, Addison Ault, University Science Book, USA, 1998. | | | |
| 2. | The Systematic Identification of Organic Compounds, R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson, 7th edition, John Wiley & Sons, New York, 1997. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY608L | Electroanalytical and Separation Techniques | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Getting insight into advanced voltammetric and amperometric technique in analysis of electroactive species.
2. Understanding the working principle and applications of ion-selective electrodes.
3. Explaining theoretical principles and practical applications of chromatographic techniques.

**Course Outcomes**

1. Apply advanced voltammetric techniques.
2. Analyse toxic metal ions and anions using ion selective electrodes.
3. Make use of GC and GC-MS techniques for the analysis of volatile organic compounds.
4. Evaluate different chiral and bio molecules by separating them using HPLC, UPLC and LC-MS.
5. Apply super critical fluid chromatography for extraction.
6. Interpret separation of biological molecules using affinity chromatography.
7. Apply the principles of capillary electrophoresis for biological applications.

| Module:1 | Advanced Voltammetric Techniques | 6 hours |
|---|---|---|

Normal pulse voltammetry, Differential pulse voltammetry, Square wave voltammetry & Stair casevoltammetry – Principle, procedure and applications.
Stripping voltammetry – Anodic & Cathodic stripping – Applications.
Amperometry: Basic principles, instrumentation, nature of titration curves, and analytical applications.

| Module:2 | Ion Selective Electrodes | 6 hours |
|---|---|---|

Working principles and applications– theoretical considerations - types of ion-selective electrodes – properties of ion-selective electrodes – sources of errors – construction and working of cation specific electrodes for analysis of cadmium, lead, arsenic and anion specific electrodes for fluoride, chloride and sulphide ions.

| Module:3 | Gas Chromatography | 7 hours |
|---|---|---|

Instrumentation - Carrier Gas – Packed and Capillary Column, Types of Stationary Phases and Column Selection). Injection Methods (On-column, Split/Split-less and Programmed Temperature Vaporizer) Temperature Control - Common detector systems.
Sampling Methods - Sample Selection & Preparation and Injection -. GC Method Development - Troubleshooting - Quantitative and Qualitative Applications – Hyphenated Systems (GC/MS).

| Module:4 | Liquid Chromatography | 8 hours |
|---|---|---|

HPLC Columns - Types, Packing Characteristics and Modern Column Trends of HPLC Columns - Specialty Columns (Chiral and Bio-Separation). Stationary Phases (Normal and Reverse-phase) - Mobile Phases (Selection of Mobile Phase,

| | | |
|---|---|---|
| Isocratic and Gradient Elution) - Sample Preparation and Introduction- HPLC Method Development – Preparative HPLC - Troubleshooting – Quantitative and Qualitative Applications – Hyphenated Systems (LC/MS). | | |
| **Module:5** | **UPLC and Super critical fluid chromatography** | **7 hours** |
| UPLC: Ultra performance liquid chromatography, stationary phases for UPLC, specific applications. Supercritical Fluid chromatography: Principle - super critical fluids, properties of supercritical fluids- Instrumentation, detectors, injection techniques, pressure restrictors, specific applications. Ion Chromatography: principle, applications in qualitative and quantitative analysis. | | |
| **Module:6** | **Affinity Chromatography** | **4 hours** |
| Definitions, separation mechanism-matrices, matrix activation, role of spacer arms and applications inpurification of biological molecules. | | |
| **Module:7** | **Capillary Electrophoresis** | **5 hours** |
| Overview, types, the basis for electrphoretic separations, migration rates and plate heights, electroosmotic flow, instrumentation, capillary zone electrophoresis, capillary gel electrophoresis, capillary isoelectrophoresis, capillary isoelectric focusing, applications. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Richard G. Compton and Craig E. Banks, Understanding Voltammetry, 2nd Revised Edn., WorldScientific Publishers, 2011. |
| 2. | Konstantin N. Mikhelson, Ion-Selective Electrodes, Springer-Verlag, 2013. |
| 3. | Gary D. Christian, Purnendu K. Dasgupta and Kevin A. Schug, Analytical Chemistry, 7th edition, John Wiley & Sons, Inc., 2014. |
| 4. | Daniel C. Harris and Chucky Lucy, Quantitative Chemical Analysis, 9th Edn., W.H. Freeman,2015. |
| 5. | Mark F. Vitha, Chromatoraphy: Principles and Instrumentation, John Wiley & Sons, Inc., 2017. |
| 6. | A. Braithwaite and F.J. Smith, Chromatographic Methods, 5th Edition, Blackie Academic &Professional (Chapman & Hall), 2009. |
| | |
| **Reference Books** | |
| 1. | Danilo Corradini, Handbook of HPLC, CRC Press Taylor and Francis, 2011. |
| 2. | C.F. Poole, Gas Chromatography, Elsevier Inc., 2012. |
| 3. | Yuki Saito and Takumi Kikuchi, Voltammetry – Theory, Types and Applications, Nova SciencePublishers, Inc. 2014. |
| 4. | M. Anderson, A. Fitch and J. Stickney, Chemically Modified Electrodes, Electrochemical Society,2015 |

| | | | | |
|---|---|---|---|---|
| 5. | Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, 7th Edn., Cengage Learning Publishers, 2018. | | | |
| 6. | C.F. Poole S.K. Poole, Chromatography Today, 5th Edition, Elsevier Science, 1991. | | | |
| 7. | Hans-Joachim Hubschmann, Hand Book of GC-MS, Fundamentals and Applications, Wiley-VCH,2009. | | | |
| 8. | Robert E. Ardrey, Liquid Chromatography-Mass Spectrometry-An Introduction, Wiley, 2003. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY609L | Environmental and Industrial Analytical Chemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding soil analysis and waste management.
2. Learning the effects of pollutants in water, air and food and their analysis.
3. Identifying the different industrial pollutants and prevention methods.

**Course Outcomes**

1. Analyze trace elements in soil by chemical analysis.
2. Evaluate parameters to be controlled in solid waste and adopt methods for reduction and recycling of solid waste.
3. Analyze water quality through different analytical methods.
4. Apply absorption and emission spectroscopy and chemical analysis for water pollutants.
5. Analyze air quality and adopt methods for reduction of air pollutants.
6. Evaluate industrial pollutants, understand their effects and adopt methods to reduce them.
7. Identify contaminants present in food and water such as pesticides and additives.

| Module:1 | Chemical analysis of soil | 5 hours |
|---|---|---|

Soil/Sediment analysis: a brief idea of chemistry of soil. Trace element analysis in soil - B, Cd,Cu, Fe, Mn, Mo, Zn, Pb. Standard specifications for soil

| Module:2 | Soil based Waste Management | 5 hours |
|---|---|---|

Waste Management: waste management approaches - waste reduction, recycling, disposal. Management of hazardous wastes, household waste, municipal and industrial wastes-collection, transportation and disposal options.

| Module:3 | Water quality assessment | 6 hours |
|---|---|---|

Determination of pH, EC, TDS, DO, colour, turbidity, total solids, conductivity, acidity, alkalinity hardness, chloride, fluoride, sulphate, nitrite, nitrate, phosphorous (total inorganic and organic),BOD, COD, TOC, pesticides.

| Module:4 | Water pollutants & their Impact | 6 hours |
|---|---|---|

Sources of water pollution - domestic, industrial, agricultural, soil and radioactive wastes as sources of pollution. Contamination by inorganic and organic materials - parameters for analysis. Impact of heavy metal pollution- Assessment of toxic metal ions in water; Impact of organic pollutants - Assessment of dyes and other organic pollutants in water.

| Module:5 | Air quality monitoring | 6 hours |
|---|---|---|

Air quality; Air Analysis: atmospheric pollution, classification of air pollutants, sources of air pollution and methods of control, sampling of aerosols, sampling of gaseous pollutants, analysis of $SO_2$, $NO_2$, CO-$CO_2$, hydrocarbons, particulates, effects of air pollutants on animals, ozone layer, chlorofluorocarbons, acid rain and greenhouse effect.

| Module:6 | Industrial pollutants and prevention | 7 hours |
|---|---|---|

Pollutants from Pigment and paint, textile industries, tannery, cosmetics,

| | | |
|---|---|---|
| ceramics and glass, chemical and pharmaceutical, explosives, electroplating industries, food processing industries. Pollution prevention strategies in industrial processes. | | |
| **Module:7** | **Food ingredients, additives and contaminants** | **8 hours** |
| Water in food, crude protein and amino acids - functional properties; lipids - classification and use of lipids in food - physical and chemical properties, nutritive value; carbohydrates-functional properties in food; minerals, vitamins, ash content. Pesticide analysis in food products. Food additives; chemistry, role and application of preservatives; emulsifying, stabilizing, buffering, bleaching, maturing agents and starch modifiers, food color, flavors, anti-caking agents. Common adulterants in food, contamination of food stuffs. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Pradyot Patnaik, Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil and Solid Wastes, 3rd Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2018. |
| 2. | Timothy J. Sullivan, Alan T. Herlihy and James R. Webb, Air Pollution and Freshwater Ecosystems: Sampling, Analysis, and Quality Assurance, CRC Press, Boca Raton, FL, Taylor & Francis Group, LLC, 2015. |

**Reference Books**

| | |
|---|---|
| 1. | Eugene W. Rice, Rodger B. Baird, Andrew D. Eaton, Lenore S. Clesceri, Standard Methods for Examination of Water and Wastewater, 22nd Edition, American Public Health Association, 2012. |
| 2. | Leo M.L. Nollet, Leen S. P. De Gelder, Handbook of Water Analysis, 3rd Edition CRC Press, Taylor & Francis Group, Boca Raton, FL, 2013. |
| 3. | Leo M.L. Nollet and Fidel Toldra, Handbook of Analysis of Active Compounds in Functional Foods, CRC Press, Boca Raton, FL, Taylor & Francis Group, 2012. |
| 4. | Sadhana Chaurasia, Anand Dev Gupta, Hand Book of Water, Air and Soil Analysis,International E- Publication, 2014. |
| 5. | Bernie Goldman, Air Pollution and Environmental Analysis, Callisto Reference, 2017. |
| 6. | Paul Mac Berthouex, Linfield C. Brown, Chemical Processes for Pollution Prevention and Control, 1st Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2018. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY610L | Bioanalytical and Forensic Analysis | 4 | 0 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the principles of antigen-antibody interactions, immunoanalytical techniques, Immunodiffusion and immunofluorescent assays.
2. Getting insight into forensic toxicology and biochemical, physical and chemical methods of forensic analysis.

**Course Outcomes**

1. Demonstrate Antigen-Antibody interactions and apply them in biological analysis.
2. Analyze samples using immunodiffusion and electrophoresis techniques
3. Apply radioisotope dilution techniques in tracer analysis.
4. Evaluate biological samples through ELISA, ELISPOT and Western Blotting techniques
5. Analyze biological samples using fluorescent immunoassays using DELFIA, SLFIA, FACS and PACIA techniques.
6. Demonstrate fundamental aspects of forensic toxicology.
7. Analyze narcotics, stimulants, depressants, hallucinogens, alcohol, metabolites in blood and other matrices.

| Module:1 | Antigen-Antibody/Protein-ligand Interactions: Principles and Applications | 10 hours |
|---|---|---|

Structure and characteristics of antibodies, polyclonal and monoclonal antibodies, Concepts and applications of Antigen-Antibody Interactions, Strength and Characteristics of Antigen - Antibody Interaction; Zone of Equivalence and its significance in analysis- Antibodies and Enzymes as analytical reagents. Cross-Reactivity - quantitative and qualitative analysis of antigens.

| Module:2 | Immunoanalytical Techniques | 8 hours |
|---|---|---|

The principle of single and double immunodiffusion. Electrophoresis - Gel, SDS-PAGE, Immuno and Capillary. Isotope dilution techniques - Principles and applications- radioisotope dilution techniques - Use of radioisotope tracer techniques in biochemical experiments and their detection.

| Module:3 | Immunodiffusion and Immunoassays | 6 hours |
|---|---|---|

Principles of Enzyme-linked immunoassays – types - direct, indirect, sandwich and competitive ELIS techniques - use of Chemiluminescence in ELISA - ELISPOT Assay; Western blotting – principles, procedures and applications.

| Module:4 | Fluorescence Immunoassays | 6 hours |
|---|---|---|

Principles of fluorescence immunoassays - substrate labelled fluorescent immunoassay (SLFIA) - delayed enhanced lanthanide fluorescence immunoassay (DELFIA)- flow cytofluorimetry and fluorescence-activated cell sorting (FACS) - particle counting immunoassays (PACIA).

| Module:5 | Introduction to Forensic Analysis and Forensic | 10 hours |
|---|---|---|

| | | |
|---|---|---|
| | **Toxicology** | |
| Introduction to forensic science, role of a forensic scientist, theory of forensic analysis: comparative analysis, Classification of poisons based on physical states; study of common poison; mode of action, chemical properties; methods of administration and their action in the body. Analysis of drug of abuse: opiates, hallucinogens, depressants, stimulants and club drugs; breath testing of alcohol, collection and preservation of drug evidence, qualitative and quantitative analysis by colour tests, microcrystalline tests. Simultaneous analysis of multianalytes. | | |
| **Module:6** | **Forensic Analysis of Biological Samples** | **8 hours** |
| Analysis of biological samples (Qualitative and Quantitative): Blood, semen, urine and saliva. Blood spatter analysis, DNA analysis. Hairs and fiber analysis, fingerprint analysis; Isolation, sample preparation. | | |
| **Module:7** | **Physical and Chemical Methods of Analysis in Forensic Science** | **10 hours** |
| Forensic analysis of explosives and gunshot residues, paints, arsons, and questioned documents. Lie detection – introduction, process, merits and demerits. Application of mass, GC-MS, FT-IR, SEM in forensic analysis. Applications of non-destructive testing probes including radiography, Xera– radiography Surface penetrations methods (SEM and Laser Probes), application of spectroscopic, chromatographic techniques such as GC-MS, FT-IR, UV-Visible spectroscopy, Atomic absorption spectroscopy for forensic sample analysis. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **60 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Howard Harris, Henry C Lee, Introduction to forensic science and criminalistics, Second edition, 2019, CRC Press. |
| 2. | Anil K Sharma, Immunology: An Introductory Textbook, 2019, Pan Stanford Publishing Ltd. |
| **Reference Books** | |
| 1. | A Lucas, Forensic Chemistry, 2017, Forgotten Books. |
| 2. | Max M. Houck, Forensic Chemistry (Advanced Forensic Science Series), 2015 Academic Press. |
| 3. | Richard Saferstein, Criminalistics: An Introduction to Forensic Sciences, 2015, Pearson Education. |
| 4. | Judith A. Owen, Jenni Punt, Sharon A. Stranford, Patricia P. Jones, Kuby Immunology, 7 edition, 2013), W H Freeman & Co. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY611L | Analytical Quality Assurance for Process Industry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the importance of different methods that are used for assuring qualityin different process industries.
2. Getting inputs on existing Quality Assurance methods used in different processindustries including good manufacturing practices.
3. Knowing the significance of Quality assurance in automated process industries

**Course Outcomes**

1. Evaluate the parameters to be maintained to achieve consistent quality in process industry.
2. Apply the principles of ISO 9000 for management of quality in industry.
3. Compose SOPs and GLPs in setting up Quality Management System
4. Propose appropriate sampling methods for chemical analysis.
5. Apply Statistical Quality control methods to solve quality issues in industry.
6. Create flow sheets for automated processes and quality assurance

| Module:1 | Basic concepts of Quality Assurance | 5 hours |
|---|---|---|

Basic concepts, Principles or prescription; Needs, requirements and expectations; The characteristics of quality; Achieving, sustaining and improving quality; Quality dimensions and costs of quality.

| Module:2 | Quality Assurance | 6 hours |
|---|---|---|

Elements of quality Assurance, Quality Management System Quality management concepts andprinciples: ISO 9001:2000

QMS Case studies on ISO 9001: 2000 in chemical industries. ISO 14000 Series of Standards

| Module:3 | TQM and Six sigma | 8 hours |
|---|---|---|

TQM in Chemical Industry. Six Sigma Approach to Quality: Applying Six Sigma to chemical Industries. - Good Laboratory Practices: Principles of GLP, GMP in Drugs and Pharmaceutical Industries - Standard operating procedure (SOP) Accreditation of QC laboratories: Requirements of QMS; Establishing a QMS; Validation of methods and related case studies. Tools and Mechanisms ICH Guidelines on Drug substances and Products.

| Module:4 | Sampling | 5 hours |
|---|---|---|

Measurement, analysis and methods of improvement; Basics of sampling; Sampling procedures; Sampling based on physical state and hazards in sampling pre-concentration methods.

| Module:5 | Statistical Quality Control | 6 hours |
|---|---|---|

Statistical Quality Control Techniques: Statistical treatment of data. Control charts, Performance Evaluation uncertainties in measurement. Validation of analytical methods- Role of SQC in QCQA ofprocess industry.

| | | |
|---|---|---|
| **Module:6** | **Industrial QA** | **6 hours** |
| Outlines of QA in chemical industries; Flow sheet preparations; Principles of process selection and unit operation. Outlines of QA in chemical industries; Flow sheet preparations; Principles of process selection and unit operation. | | |
| **Module:7** | **Quality Assurance and Automation** | **7 hours** |
| Automated and Automatic Process control; Automation in chemical process industry; Methods of automation: Flow injection and Sequential Injection; Quality assurance through automation. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | R. Pannerselvam, Production and Operations Management, Prentice Hall India Learning Pvt. Ltd3rd Edition, 2012. |
| 2. | Mehmet Savsar, Quality Assurance and management, InTech-Croatia, 2012. |
| 3. | D.C. Montgomery, Statistical Quality Control, John Wiley & Sons, 5th edition, 2005. |
| 4. | M. K. Starr, Production and Operations Management, Biztantra, Delhi, 2004. |
| 5. | D.H. Shah, QA Manual, Business Horizons, 2000 |
| 6. | D.H. Besterfield, C. Besterfield-Michna, G.H. Besterfield, M. Besterfield -Sacre, Total QualityManagement, Pearson Education, Inc., 3rd Edition, 2003. |
| | |
| **Reference Books** | |
| 1. | Piotr Konieczka and Jack Namiesnik Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach, Ist Edition, CRC press 2009. |
| 2. | David Hoyle, ISO 9000 Quality Systems Handbook, Fifth Edition, Butterworth-Heinemann-Elsevier, New York, 2006. |
| 3. | Elizabeth Prichard and Victoria Barwick, Quality Assurance in Analytical Chemistry, John Wiley& Sons, 2007. |
| 4. | Y. Anjaneyulu and R. Marayya, Quality Assurance and Quality Management in PharmaceuticalIndustry, Pharma Book Syndicate, 2005. |
| 5. | A. K. Chakraborty, P. K. Basu, S.C. Chakravarty, Guide to ISO 9001: 2000, Asian Books Pvt. Ltd.,2005. |
| 6. | B.W. Wenclawiak, M.Koch and E. Hadjicostas (Eds.), Quality Assurance in Analytical Chemistry, Springer, 2004. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY612P | Analytical & Physical Chemistry Lab II | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

Analyzing various chemical constituents using instrumental techniques.

**Course Outcomes**

1. Apply standard addition method in titrimetric analysis.
2. Propose experiments for analysis of inorganic and organic materials.
3. Analyze constituents in materials using emission and absorption techniques.
4. Apply electrochemical methods for analysis of electroactive species.

| | **Indicative Experiments** | |
|---|---|---|
| 1. | Standard addition method for estimation of Ascorbic acid in fruit juice | 6 hours |
| 2. | Estimation of chromium in steel sample by spectrophotometry | 6 hours |
| 3. | Determination of sodium carbonate in washing soda by pH titration | 6 hours |
| 4. | Determination of Indicator constant by spectrophotometry | 6 hours |
| 5. | Determination of dissociation constant ($K_a$) of weak electrolyte and verification of Debye-Huckel Onsager equation using strong electrolyte. | 6 hours |
| 6. | Estimation of sulphide in effluent using potentiometric titration | 6 hours |
| 7. | Determination of Stern-Volmer constant of Iodine quenching by fluorimetry | 6 hours |
| 8. | Cyclic Voltammetry | 6 hours |
| 9. | Determination of ascorbic acid in real samples using Differential Pulse Voltammetry and comparing with specifications | 6 hours |
| 10. | Determination of protein concentration using Bradford's method | 6 hours |
| | | |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Advanced Physical Chemistry Practical Guide, Charu Arora, Sumantra Bhattacharya, Bentham Science Publishers, 2022. |
| 2. | Kissinger, Laboratory Techniques in Electroanalytical Chemistry, Second edition, CRC Press, 2016. |

**Reference Books**

| | |
|---|---|
| 1. | R. Holze, Experimental Electrochemistry: A Laboratory Textbook, Second edition, Wiley-VCH, 2019. |
| | |

Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY613P | Analytical Chemistry Lab III | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding analysis of organic and inorganic compounds present in real life samples by instrumental methods.
2. Demonstrating analysis of different contaminants in water and other matrices

**Course Outcomes**

1. Propose experiments for determination of metals in different matrices using instrumental methods.
2. Analyze real samples and effluent samples for knowing the levels of different contaminants.
3. Evaluate drugs and soft drinks using different titrimetric and instrumental methods of analysis.

| **Indicative Experiments** | | |
|---|---|---|
| 1. | Isolation and estimation of chromium from waste water by spectrophotometry | 6 hours |
| 2. | Analysis of oils and fats - Saponification and acid value | 6 hours |
| 3. | Determination of nitrate in different soil and water samples by spectrophotometry | 6 hours |
| 4. | Extraction and estimation of benzoic acid in fruit juices | 6 hours |
| 5. | Heavy metal analysis in textiles and textile dyes by AAS | 6 hours |
| 6. | Study of degradation of organic dyes by hydrogen peroxide catalyzed by copperand iron nanoparticles | 6 hours |
| 7. | Determination of caffeine in soft drinks by HPLC | 6 hours |
| 8. | Extraction of copper by diethyl dithiocarbomate and its spectrophotometric determination | 6 hours |
| 9. | Analysis of water quality through COD, DO, BOD measurements | 6 hours |
| 10. | Assay of Riboflavin and Iron in tablet formulations by spectrophotometry | 6 hours |
| | | |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000. |

**Reference Books**

| | |
|---|---|
| 1. | Analytical Chemistry, International Adaptation, Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, 7th Edition, Wiley, 2020. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY614L | Advanced Inorganic Chemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding structure, bonding and reactivity of transition metals, rare earth metals, and organometallics.
2. Making the students realize the importance of bio-inorganic and inorganic photochemistry
3. Explaining chemistry and applications of advanced materials

**Course Outcomes**

1. Recall electronic structure, bonding, and reactivity of coordination complexes.
2. Outline synthesis and stability of transition metal organometallic complexes.
3. Develop catalytic pathways leading to desired products.
4. Apply the principles of transition metal coordination complexes in understanding functions of biological systems.
5. Propose materials for energy generation, energy storage and magnetic applications.
6. Interpret photochemical and electronic properties of coordination complexes.

| Module:1 | Descriptive chemistry of transition metals and rare earths | 6 hours |
|---|---|---|

Periodic trends – comparison of periodic properties by electronic configuration. Oxidation states –chemistry of various oxidation states, stabilization of unusual oxidation states. Heavier transition elements. Chemistry of uranium-compounds of uranium and their chemical properties.

| Module:2 | Inorganic –Clusters and polyacids | 5 hours |
|---|---|---|

Isopoly and heteropoly acids. Clusters - Polynuclear carbonyls- synthesis, reactivity, molecularStructure, stereochemical non-rigidity and Polyhedral Skeletal Electron-Pair Theory (PSPET).

| Module:3 | Organometallic Catalysis | 6 hours |
|---|---|---|

Catalytic cycles-oxidative addition and reductive elimination. Hydrogenation of olefins - hydroformylation of olefins - Fischer - Tropsch process - polymerisation of alkenes - Ziegler–Natta Catalyst - mechanistic Studies - Single-Site Catalysts - Metallocenes - Nonmetallocene Catalysts -olefin metathesis

| Module:4 | Bioinorganic systems | 7 hours |
|---|---|---|

Porphyrin systems: Dioxygen Transport - Hemoglobin, Hemerythrin and Hemocyanin. Cooperativity in $O_2$ binding, $O_2$ and CO discrimination. Inorganic model compounds. Oxygen Metabolism - Oxygen atom transfer by cytochromes-P450 - Nitrogenases - Carbonic anhydrase - Carboxypeptidase - Alcohol dehydrogenase – Photosystem.

| Module:5 | Medicinal applications of bioinorganic compounds | 5 hours |
|---|---|---|

Metal complexes in medicine- Cisplatin and its mode of action. Gold and Lithium compounds as drugs - Metal complexes as probes of nucleic acid, metal ions in

| | | |
|---|---|---|
| genetic regulations, metal DNAand RNA interaction – Potential binding sites. | | |
| **Module:6** | **Advanced materials** | **8 hours** |
| 2D Layered advanced Materials - Graphene, Graphene Oxide, MXenes, $MoS_2$, BN, BCN – synthesis, structural features, characterization, selected applications – electronic devices, watersplitting - photocatalysis - energy storage.<br>Perovskite – Structure - Oxide to Halide Perovskites – Types of inorganic – organic perovskite solar cells – Stability; Manganese-doped cadmium selenide / cadmium sulphide quantum dots/nanocrystals - Photomagnetic effects. | | |
| **Module:7** | **Inorganic Photochemistry** | **6 hours** |
| Photochemistry of Ru(II) and Cr(III) complexes – Porphyrin-based photosensitizers for photodynamic therapy - Photoactivation of small molecules like $CO_2$ and $H_2O$ by transition metalcomplexes | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | **Total Lecture hours:** | **45 hours** |
| | **Total Tutorial hours:** | **15 hours** |

| **Text Book(s)** | |
|---|---|
| 1. | Inorganic Chemistry, D. F. Shriver and P.W. Atkins, Oxford University Press, 5th Ed., 2010. |
| 2. | Concise Inorganic Chemistry, J. D. Lee, Oxford University Press, 5th Edition, 2014. |
| 3. | Bioinorganic Chemistry: An Introduction, Dieter Rehder, Oxford University Press, 1st Ed., 2014. |
| 4. | Homogeneous Catalysis - Mechanisms and Industrial Applications, S. Bhaduri, D. Mukesh, 2nd Edition, Wiley,2014. |
| 5. | Spectral Methods in Transition Metal Complexes, K. Sridharan, 1st Edition, Elsevier, 2016. |
| 6. | X-ray photoelectron spectroscopy: An Introduction to Principles and Practices, Paul van der Heide, Wiley-Blackwell, 1st Edition, 2012. |

| **Reference Books** | |
|---|---|
| 1. | Principles of structure and reactivity, Inorganic Chemistry, J.E. Huheey, E. A. Kelter and R.L. Kelter, Harper Collins College Publishers, 4th Edition, 2011. |
| 2. | C.N.R. Rao, Muller and A. K. Cheetham, Chemistry of Nanomaterials, Vol. I & II, C.N.R. Rao, Muller and A. K. Cheetham, WileyVCH Verlag GmbH KGaA, 2014. |
| 3. | Bioinorganic chemistry, D. Rehder, E. Nordlander, Oxford University Press India, 2014. |
| 4. | Inorganic Photochemistry, Van Eldik, Grazyna Stochel, Academic Press, 2011. |
| 5. | 2D Inorganic materials beyond Graphene, Editors: C. N. R. Rao & U.V. Waghmare, WorldScientific Publishing Company, 2017. |
| 6. | 2D Metal Carbides and Nitrides (MXenes) Structure, Properties and Applications, Editors:Babak Anasori & Yury Gogotsi, Springer, Cham, 2019. |
| 7. | Light-Induced Spontaneous Magnetization in Doped Colloidal Quantum Dots, R. Beaulac, L. Schneider, P. I. Archer, G. Bacher, D. R. Gamelin, Science, 2009, |

| | | | | |
|---|---|---|---|---|
| | 325, 973-976. | | | |
| 8. | Review of recent progress in chemical stability of perovskite solar cells, G. Niu, X. Guo, L. Wang, J. Mater. Chem. A, 2015, 3, 8970-8980 | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY615L | Materials Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the basic aspects of structure types of solids, polymers, composite materials and materials synthesis.
2. Correlating the structure and property of materials for transport, optical and dielectric properties.

**Course Outcomes**

1. Categorize and recognize structure types of solids.
2. Compare the different methods of materials synthesis.
3. Apply composite materials for achieving required properties for different applications.
4. Interpret the reason for functioning of a given material.
5. Identify appropriate material for a given application in conducting, magnetic, optical, and dielectric applications.
6. Build a device using suitable material for practical application

| Module:1 | Symmetry and structural aspects of solids | 9 hours |
|---|---|---|

Symmetry elements - point groups, space groups. Fundamentals and applications of X-ray diffraction, indexing of cubic system. $AB_2$ -pyrite, cuprite - $A_2B_3$ - $Al_2O_3$ (Corundum type) and rare- earth oxides, $AB_3$ - $ReO_3$, pervoskites, $K_2NiF_4$, $A_2B_2O_7$ (pyrochlores), $AB_2O_4$ (Spinels), Zeolites. Alloys-Cu-Ni, Cu-Zn, amorphous and glass materials.

| Module:2 | Preparative Strategies Basics | 6 hours |
|---|---|---|

Chemistry behind solid state synthesis – thermodynamic and kinetic aspects, phase transitions in solids. Techniques high temperature solid state synthesis- Co-precipitation, precursor, sol-gel, combustion, intercalation, chimie douce, ion-exchange, microwave, electrochemical, sonochemical, hydrothermal - High temperature and high-pressure synthesis.

| Module:3 | Polymers and Composite Materials | 6 hours |
|---|---|---|

Polymer structure – chain structure – micro structure – crystal structure crystallinity – determination of crystallinity, size and orientation of crystallites using X-Rays-conformation and configuration. Composite materials - metal matrix, ceramic -matrix, polymers matrix – properties and applications.

| Module:4 | Transport Properties | 8 hours |
|---|---|---|

Non-stoichiometry: Preliminary aspects, Defects in solids: Stoichiometric and non-stoichiometric defects – point defects – Schottky and Frenkel defects and properties-color centers. Electronic conductors – metals, semiconductors, superconductors – Ionic conductors – fast ion conductors, solid electrolytes, mixed conductors-measurements – two and four probe measurements, impedance measurements.

| Module:5 | Magnetic Properties | 4 hours |
|---|---|---|

Magnetic properties- Dia, para, ferro, anti-ferro and ferri magnetism-spinels and garnets-measurements-magnetic moment and magnetic susceptibility.

| | | |
|---|---|---|
| **Module:6** | **Optical and Dielectric Properties** | **6 hours** |
| Optical properties- Optical absorption and band gaps – luminescence- lasers: principle, characteristics and materials, Dielectric properties- ferro, anti-ferro, piezo and pyro electric properties- relationship and applications. | | |
| **Module:7** | **Thermoelectric and Battery materials** | **4 hours** |
| Thermoelectric materials- intermetallics and oxides. Lithium battery materials – electrode and electrolyte materials. Solid Oxide Fuel Cells- material aspects. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Anthony R. West, Solid State Chemistry and its Applications, 2nd Ed., John Wiley & Sons, 2014. |
| 2. | Bradley D. Fahlman, Materials Chemistry, 2nd Ed., Springer, 2011. |
| | |
| **Reference Books** | |
| 1. | Lesley E. Smart and Elaine A. Moore, Solid State Chemistry-An Introduction, 4th Ed., CRC Press,Taylor and Francis Group, 2012. |
| 2. | Richard J. D. Tilley, Understanding Solids: The Science of Materials, 2nd Ed., Wiley, 2013. |
| 3. | Chawla K Krishnan, Composite Materials –Science and Engineering, Springer, 2012. |
| 4. | Robert J. Young and Peter A. Lovell, Introduction to Polymers, 3rd Ed., CRC Press, 2011. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY616L | Nanomaterials and Characterization Techniques | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding different types of nanomaterials, their syntheses and characterization
2. Applying nanomaterials for technological applications

**Course Outcomes**

1. Define different types of nanomaterials based on dimensionality and structure.
2. Propose preparation methods for different nanomaterials.
3. Analyse nanomaterials using characterization techniques.
4. Explain the structural and chemical properties of carbon-based nanomaterials.
5. Propose nanomaterials for specific optical, electronic and energy storage applications.
6. Relate structure of nanomaterials with their properties.

| Module:1 | Zero-Dimensional Nanostructures | 6 hours |
|---|---|---|

Quantum dots and hollow spheres: uniform and heterogeneous particle arrays, core-shell quantum dots and hollow spheres - synthesis and characteristics. LED, solar cell and laser applications.

| Module:2 | One-Dimensional Nanostructures | 6 hours |
|---|---|---|

Carbon nanotubes (CNTs), nanowires and nanofibers: synthesis and characteristics, functionalization of CNTs, role of 1D nanostructure as inter-connects in electronics.

| Module:3 | Two-Dimensional Nanostructures | 6 hours |
|---|---|---|

Thin films, nanosheets and nanodisks: preparation and characteristics, Role of a spin coater innanoscale film formation, 2D nanostructures as templates.

| Module:4 | Three-Dimensional Nanostructures | 6 hours |
|---|---|---|

Dendrites, nanopillers, nanoflowers and core-shell materials: preparation methods and characteristics, applications as catalysts and electrode material in batteries.

| Module:5 | Energy Conversion and Storage Materials | 6 hours |
|---|---|---|

Fuel cells: Hydrogen storage cells, Piezoelectric materials: principle and working mechanism. Fabrication of a piezoelectric sensor using electrospun nanofiber web.

| Module:6 | Nanomaterials Characterization – 1 | 6 hours |
|---|---|---|

Powder X-Ray diffraction- peak broadening and particle size analysis, $N_2$ adsorption - surface area,pore size analysis, thermal analysis using TGA and DTA.

| Module:7 | Nanomaterials Characterization – 2 | 7 hours |
|---|---|---|

UV-Vis spectroscopy- surface plasmon resonance, morphology and particle size analysis - SEM, AFM and HR-TEM, Raman spectroscopy – application for carbon nanomaterials.

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

Industry Expert Lecture

| | Total Lecture hours: | 45 hours |
|---|---|---|

| | | | | |
|---|---|---|---|---|
| **Text Book(s)** | | | | |
| 1. | Nanomaterials: An Introduction to Synthesis, Properties and Applications, D. Vollath (Ed), 2nd edition, Wiley VCH, 2013. | | | |
| 2. | Nanomaterials, Nanotechnologies and Design, Michael F. Ashby, Paulo J. Ferreira and Daniel L. Schodek, Butterworth-Heinemann, 2009. | | | |
| 3. | Textbook of Nanoscience and Nanotechnology, B.S. Murty , P. Shankar , Baldev Raj , B B Rath , James Murday, Universities Press (India) Pvt. Limited, 2013. | | | |
| **Reference Books** | | | | |
| 1. | Essentials in Nanoscience and Nanotechnology, Narendra Kumar, Sunita Kumbhat, John Wiley & Sons, Inc., 2016. | | | |
| 2. | Materials Chemistry, Bradley D. Fahlman, 3rd edition, Springer Nature B.V. 2018 | | | |
| 3. | Piezoelectric polymer and piezocapacitive nanoweb based sensors for monitoring vital signals and energy expenditure in smart textiles, J. Fiber Bioeng. Inform. 6, 369, 2013. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY617L | Inorganic Photochemistry | 4 | 0 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Applying the principles of photochemistry in photosynthesis, solar energy conversion medical photochemistry.
2. Developing the devices based on photochemistry for solar energy conversion and medicalapplications.

**Course Outcomes**

1. Explain the mechanism of photochemical and photophysical processes.
2. Apply photophysical processes for versatile applications.
3. Analyze and interpret photoredox reactions.
4. Examine and classify photochemical reactions in coordination complexes.
5. Construct solar energy conversion devices.
6. Develope therapeutic techniques based on photochemical principles.

| Module:1 | Photochemistry | 5 hours |
|---|---|---|

Photochemical *Vs* Thermal reactions, Laws of photochemistry, Photophysical mechanism of excited states, Electronic Structure - Types of Excited States and Electronic Transitions - Absorption and Emission Bands - Jablonski Diagram, fluorescence, phosphorescence and delayed fluorescence, photosensitizers, chemiluminecence, bioluminescence internal conversion, intersystem crossing, Typesof transitions in inorganic complexes.

| Module:2 | Binuclear Photophysical Process | 9 hours |
|---|---|---|

Quantum yields and experimental determination, numerical problems on quantum efficiency, Quenching of excited states, fluorescence life time, Stern–Volmer Equation, mechanism of quenching - heavy atom quenching, excimer and exciplex.

| Module:3 | Applications of Photophysical and Photochemical Process | 7 hours |
|---|---|---|

Characteristics and inorganic practical applications of fluorescence and phosphorescence, Photochemical Reactivity - Electrochemical Behavior - Polynuclear Metal Complexes, Explanation of incidents - Photosynthesis in plants, Photochemical smog, atmospheric ozone layer, vision by rhodopsin, formation of vitamin D in sunlight, photodegradation of plastics and organic pollutants.

| Module:4 | Inorganic Photochemistry | 8 hours |
|---|---|---|

Photoredox reactions of Cobalt(III), models of photoredox systems–radical pair model, photoredox reactions of Iron(III) complexes, photochemistry of metal-carbonyl complexes.

| Module:5 | Ligand Field Photochemistry | 9 hours |
|---|---|---|

Photosubstitution – photoisomerisation, photoracemization, photoaquation, rearrangement reactions Photochemistry of Chromium – photolysis rules – stereochemistry photoisomerisation photoracemization, Photonation, Photoactive excited states, Cobalt(III) complex in photosensitization.

| Module:6 | Solar Energy Conversion | 10 hours |
|---|---|---|

| | | | | |
|---|---|---|---|---|
| Solar energy conversion – Introduction to three generations of solar cells - photovoltaic p-n junctionsolar cell - importance of silicon - single crystal, polycrystal and amorphous - Si wafer preparation; Heterojunction – photoelectrochemical-liquid junction solar cell, multiple junction solar cell, dye- sensitized solar cell; Perovskite solar cells. | | | | |
| **Module:7** | **Medical Photochemistry** | | | **10 hours** |
| Introduction, Cells, Tissues and Light, Historical aspects, importance and applications of Photosensitization, photophysics and photochemistry of PDT, Type I and Type II Mechanism, Singlet oxygen, Generations of PDT, Cancer photodetection, Porphyrin photosensitizers for PDT. | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| Industry Expert Lecture | | | | |
| | | | | |
| | **Total Lecture hours:** | | | **60 hours** |
| **Text Book(s)** | | | | |
| 1. | Inorganic photochemistry, Julia A Wienstein, Springer, 2013. | | | |
| 2. | Photochemistry of Transition Metal Complexes, Torn Bitterley, Elsevier, 2011. | | | |
| **Reference Books** | | | | |
| 1. | Applied photochemistry, Rachel C Evans, Peter Douglas, Hugh D Buren, Springer, 2013. | | | |
| 2. | Photochemistry of Inorganic and Organometallic complexes, B.J. Palmer, Elsevier, 2012. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY618P | Inorganic Chemistry Specialization Lab II | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Training the students in synthesis of inorganic complexes and materials.
2. Acquainting chemical and instrumental methods of analysis of inorganic complexes and materials

**Course Outcomes**

1. Make use of synthesis methodologies to make inorganic complexes.
2. Apply the different methods of material synthesis to prepare oxides.
3. Relate the principle of redox chemistry in intercalation reactions.
4. Analyze the prepared materials using chemical and instrumental analytical techniques.

| | **Indicative Experiments** | |
|---|---|---|
| 1. | **I. Preparation and Analysis of Complexes (UV-Visible and FTIR) Metal Analysis:**<br>1.Chloropentaamminecobalt (III) chloride, $[Co(NH_3)_5Cl]Cl_2$<br>2.Tristhioureazinc(II)sulphate, $Zn(SC(NH_3)_2)_3OSO_3$<br>3.Potassium bisoxalatocuprate(II)dihydrate, $K_2[Cu(C_2O_4)_2]. 2H_2O$<br>4. Molar conductance of $[Co(NH_3)_6]Cl_3$ and $[Co(NH_3)_5Cl]Cl_2$ | 24 hours |
| 2. | **II. Synthesis of Oxides (Phase purity check by powder XRD):**<br>1. $CaMnO_3$ by ceramic method<br>2. $BaTiO_3$ by sol-gel method<br>3. $SnO_2$ by precipitation method<br>4. Ruby by combustion method | 24 hours |
| 3. | **III. Simple Redox Reactions**<br>1. Hydrogen intercalation in tungsten trioxide | 8 hours |
| | | |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas, John Wiley & Sons, Inc., 2015. |
| 2. | Practical Inorganic Chemistry – Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer, 2013. |

**Reference Books**

| | |
|---|---|
| 1. | Handbook on Synthesis Strategies for Advanced Materials, Volume-I: Techniques and Fundamentals, A. K. Tyagi, Raghumani, S. Ningthoujam, Springer Nature Singapore Pte. Ltd., 2022. |

Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY619P | Inorganic Chemistry Specialization Lab III | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Training in synthesis of inorganic material, characterization and chemical analysis
2. Understanding the importance of different instrumental methods in chemical analysis of materials.

**Course Outcomes**

1. Understand the principle of powder X-ray diffraction technique.
2. Illustrate the basic concepts of various physical properties.
3. Apply powder X-ray diffraction technique for materials analysis.
4. Evaluate structure property relationship of materials.

| | **Indicative Experiments** | |
|---|---|---|
| I. | **I. Applications of powder X-ray diffraction**<br>1. Analysis of XRD data of inorganic material<br>i) Phase identification<br>ii) Latitce parameters calculation and indexing<br>iii) Theoretical Density calculation from XRD | 16 hours |
| | 2. Vegard's law verification and crystallite size calculation<br>i) Verification of Vegard's law<br>a. $Ba_{1-x}Sr_xTiO_3$<br>b. $Ca_{1-x}Sr_xTiO_3$<br>ii) Crystallite size calculation using Scherrer formula | 16 hours |
| II. | **II. Physical property measurements**<br>1. Resistivity measurement – Four probe method – Si band gap<br>2. Determination of magnetic parameters using Hysteresis Loop<br>3. Photocatalysis (dye degradation)<br>4. Measurement of dielectric constant<br>5. Oxide Semiconductor band gap – DRS – Tauc's plot | 28 hours |
| | | |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | X-Ray Diffraction - A Practical Approach, C. Suryanarayana, M. Grant Norton, Springer NY, 2013. |

**Reference Books**

| | |
|---|---|
| 1. | Practical Inorganic Chemistry – Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer, 2013. |

Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY620L | Process Chemistry in Pharmaceutical Industry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Gaining the knowledge of process chemistry in pharmaceutical industry
2. Understanding scale up of process in pharmaceutical industry.
3. Developing the skills to improve the existing methods into cost effective green methods

**Course Outcomes**

1. Recall the importance of process chemistry.
2. Explain the role of solvents and importance of solvent free reactions in process industry.
3. Assess the reaction conditions in laboratory and its scale up in process industry
4. Outline safety in process industry, including catalyst selection and impurity minimization.
5. Appraise and validate of scale up process and finished products.
6. Propose process scale up process for reactions and tools for purification of finished product.

| Module:1 | Introductory level of Process Chemistry | 6 hours |
|---|---|---|

Introduction to process chemistry approaches to process development, Principle of process development, Route Selection, expedient and cost-effective routes, Reagent selection, solvent selection, alternatives to solvents, Water as as a solvent. Various examples of reactions regularlyperformed in process chemistry lab.

| Module:2 | Selection of Solvents and solvent free reactions | 6 hours |
|---|---|---|

Running the reaction, assessing operating conditions for the laboratory, reaction scale selection, selection of reaction conditions, Example of various name reaction and their selection is processchemistry lab.

| Module:3 | Selection of Reactions | 6 hours |
|---|---|---|

Running the reaction, assessing operating conditions for the laboratory, reaction scale selection,selection of reaction conditions.

| Module:4 | Industrial Safety Studies | 6 hours |
|---|---|---|

Purification of products; tools and techniques - crystallization and reslurrying, final product form, polymorphs. Validation of finished products, Various purification techniques – Solvent washing, HPLC (use of chiral column), Column Chromatography, Plate layer Column chromatography.

| Module:5 | In Process Control (IPC) | 6 hours |
|---|---|---|

In process control (IPC) - importance, selection of IPC, Reproducible IPC, optimization by minimizing impurities, optimization of catalytic reaction, work up of reaction.

| Module:6 | Purification Tools and Identification Techniques | 6 hours |
|---|---|---|

Purification of products; tools and techniques – crystallization, chromatographic separation, reslurrying, final product form, polymorphs, Identification of Finished

| | | | | |
|---|---|---|---|---|
| product by instrumental techniques. | | | | |
| **Module:7** | **Scale Up Process and validation of Finished products** | | | **7 hours** |
| Batch reactions, Continuous and Semi-continuous reactions, Continuous reactors to scale up of the process- Static mixers, plug floe reactors, microwave reactors, Sonochemical reactors. Validation as per ICH, EMEA and FDA guidelines | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| Industry Expert Lecture | | | | |
| | | | | |
| | **Total Lecture hours:** | | | **45 hours** |
| | **Total Tutorial hours:** | | | **15 hours** |
| **Text Book(s)** | | | | |
| 1. | Practical Process research and Development, Neal G. Anderson 2nd Edition, AcademicPress, 2012. | | | |
| 2. | Fundamentals of Analytical Chemistry, Douglas A Skoog, Donald M West, F James Holler, Stanley R.Crouch, 9th Edition, Wadsworth Publishing Co Inc., 2012. | | | |
| **Reference Books** | | | | |
| 1. | The Art of Drug Synthesis, Douglas S. Johnson, Jie Jack Li, John Wiley and Sons, 2013. | | | |
| 2. | Green Chemistry in the Pharmaceutical Industry, Peter J. Dunn, Andrew Wells, Michael T. Williams, John Wiley & Sons, 2010. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY621L | Pharmacognosy and Phytochemistry | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Acquainting biological functions and pharmacological uses of natural products.
2. Recognizing primary and secondary metabolites and their sources
3. Understanding the concepts of isolation methods and separation of bioactive compounds.
4. Learning pharmacognostical analysis of the bioactive compounds

**Course Outcomes**

1. Recall the sources of natural medicines and analysis of crude drugs.
2. Define methods of evaluation of natural products based on various parameters.
3. Analyze the isolated drugs as per ICH guidelines.
4. Apply techniques to discover new alternative medicines.
5. Evaluate the isolated drugs for various pharmacological activities.
6. Propose methods to synthesize new drugs based on natural/isolated drugs.

| Module:1 | Pharmacognosy | 6 hours |
|---|---|---|

Introduction, definition, history, scope, development and classification; Source of Drugs: Biological, marine, mineral and plant tissue cultures as source of drug. Scheme of pharmacognostic studies of a crude drug. Biosynthesis: Shikimic acid pathway and acetate pathway. Systematic analysis of Crudedrugs.

| Module:2 | Standardization of herbal drugs | 6 hours |
|---|---|---|

WHO guidelines, Sampling of crude drug, Methods of drug evaluation. Determination of foreign matter, moisture, LOD, Ash value. Extractable values, Determination of swelling index, foaming index and their significance. Phytochemical investigations: General chemical tests.

| Module:3 | Extraction techniques | 6 hours |
|---|---|---|

General methods of extraction, types – maceration, Decoction, percolation, Immersion and 70oxhlet extraction. Advanced techniques- counter current, steam distillation, supercritical gases, sonication, microwaves assisted extraction. Factors affecting the choice of extraction process

| Module:4 | Drugs containing terpenoids and volatile oils | 6 hours |
|---|---|---|

Terpenoids: Classification, Isoprene rule, Isolation and separation techniques, General properties Camphor, Menthol, Eucalyptol. Volatile Oils or Essential Oils: Method of Preparations, Classifications of Volatile oils, Camphor oil, Geranium oil, Citral- Structure, uses. Pentacyclic triterpenoids: amyrines; taraxasterol: Structure and pharmacological applications.

| Module:5 | Drugs containing alkaloids | 5 hours |
|---|---|---|

Occurrence, function of alkaloids in plants, pharmaceutical applications. Isolation Qualitative tests and general properties. General methods of structural elucidation. Morphine, Reserpine, Papaverine-structure, chemical properties and uses.

| Module:6 | Plant glycosides | 9 hours |
|---|---|---|

Glycosides: Basic ring system, classification, isolation, properties, qualitative

| | | | | |
|---|---|---|---|---|
| analysis. Pharmacological activity of Senna glycosides, Cardiac glycosides-Digoxin, digitoxin, strophanthidin, Steroidal saponins glycosides- Diosgenin, hecogenin. Plant pigments: Occurrence, nomenclature, and general methods of structure determination, isolation and synthesis of quercetin and cyanidin. | | | | |
| **Module:7** | **Marine drugs** | | | **5 hours** |
| Selected Drug Molecules: Cardiovascular active substances, Cytotoxic compounds, antimicrobial compounds, Antibiotic compounds, Anti-inflammatory agents. Marine toxins. | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| Industry Expert Lecture | | | | |
| | | | | |
| | **Total Lecture hours:** | | | **45 hours** |
| | **Total Tutorial hours:** | | | **15 hours** |
| **Text Book(s)** | | | | |
| 1. | Gurdeep R Chatwal (2016), Organic chemistry of Natural products, Volume I&II, 5th edition,Himalaya publishing House. | | | |
| 2. | S.V.Bhat, B.A. Nagasampagi, M.Sivakumar (2014), Chemistry of Natural Products, Revisededition, Narosa Publishers. | | | |
| **Reference Books** | | | | |
| 1. | Jeffrey B. Harborne (2012), Phytochemical methods: A Guide to Modern Techniques of PlantAnalysis, 4th edition, Indian reprint, Springer. | | | |
| 2. | Ashutoshkar (2007), Pharmacognosy and Pharmacobiotechnology, 2nd edition, New ageinternational (P) limited, New Delhi. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY621P | Pharmacognosy and Phytochemistry Lab | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Learning the chemistry behind development and activity of pharmaceuticals.
2. Gaining the knowledge of mechanism of action and adverse effects of drugs.
3. Understanding the need of judicial usage of antibiotics.

**Course Outcomes**

1. Analyze composition and importance of phytoconstituents.
2. Apply the skill of extraction and isolation of phytoconstituents.
3. Assess the purity of the extracted or isolated phytoconstituents.
4. Estimate various parameters of isolated drugs and check the standards as per ICH guidelines.

| Indicative Experiments | | |
|---|---|---|
| 1. | Extraction, Isolation and Characterization (UV/IR/NMR/MS) of the following the phytoconstituents from the Natural products | 6 hours |
| 2. | Starch from Potatoes | 6 hours |
| 3. | Caffeine from Tea Leaves/Tea Dust Powder | 6 hours |
| 4. | Lycopene from Tomato | 6 hours |
| 5. | Lawsone from Henna Powder/Leaves | 6 hours |
| 6. | Curcumin from Turmeric Powder | 6 hours |
| 7. | Extraction and detection of volatile oils by Clevenger's Method (Hydro-distillation method). | 4 hours |
| 8. | Determination of Extractive Values of some crude Drugs. | 4 hours |
| 9. | Determination of Extractive Values of some crude Drugs. | 4 hours |
| 10. | Estimation of Caffeine from Tea by Spectrophotometric/HPTLC Method | 4 hours |
| 11. | Determination of Saponification and Acid value of the Fat and Oils bytaking any real sample | 4 hours |
| 12. | Estimation of Ascorbic acid from Citrus Fruits (Vitamin C) | 4 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Practical Pharmacognosy and Phytochemistry, Sushilkumar A. Shinde, N. M. Bhopale, 1st Edition, Vallabh Prakashan Publisher, 2023. |
| 2. | Practical Pharmacognosy, Techniques and Experiment, Khandelwal K. R, Nirali Prakashan, 2006. |
| | |

**Reference Books**

| | |
|---|---|
| 1. | Phytochemical Methods: A Guide to Modern techniques of Plant Analysis, Jeffreey B. Harborne, 4th Edition, Indian Reprint, Springer, 2012. |

| | | | | |
|---|---|---|---|---|
| 2. | Natural Products: A Laboratory Guide, Raphael and Ikan, 2nd Edition, Academic Press, 2013. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY622L | Pharmaceutical Quality Control and Quality Assurance | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Ascertaining the quality of the finished pharmaceutical product and its validation to facilitate its market launch.
2. Gaining the knowledge about ICH guidelines, i.e., the organization that sets and governs thelaws and rules for all the quality tests.
3. Controlling the quality of the formulation and assuring the compliance of standards.

**Course Outcomes**

1. Recall the importance and methods of quality assurance in the pharmaceutical industry.
2. Outline auditing, quality of auditing, and personal responsibilities involved in quality control of an organization.
3. Analyze the documentations associated with manufacturing, master formula, distribution,returned goods and recovered materials.
4. Apply validation process at different levels, including personal, equipment, and regulatory aspects.
5. Evaluate the quality process and factors influencing the stability of products, andquality of packaging materials.
6. Propose quality assurance and control measures for documentation based on regulations in pharmaceutical industry.

| Module:1 | Concept and Philosophy | 7 hours |
|---|---|---|

Total Quality Management (TQM), Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP).

| Module:2 | Quality Audit | 6 hours |
|---|---|---|

Quality audit, Standard Operating Procedure (SOP), International Conference Harmonization (ICH), ISO-9000, ISO14000, WHO specifications, USFDA guidelines and ICMR.

| Module:3 | Organization and personnel responsibilities | 6 hours |
|---|---|---|

Training, Hygiene, Premises: Location, Design, Plant layout, Construction, Maintenance and Sanitations. Environmental control, Sterile areas, control of contamination.

| Module:4 | Documentation & Handling | 5 hours |
|---|---|---|

Manufacturing documents, Master Formula, batch formula Record, Distribution of records,Handling of returned goods, Recovered materials and Reprocessing.

| Module:5 | Regulatory aspects of Pharmaceuticals | 7 hours |
|---|---|---|

Validation of Personnel, Equipment and Cleaning methods, Regulatory aspects of pharmaceutics New Drug Approval Process: Investigational New Drug (IND), New Drug Applications (NDA) andits approval, Drugs and Cosmetic Act, Patent Regime.

| Module:6 | Quality process | 7 hours |
|---|---|---|

In-process quality control on various dosage forms, Sterile and non- sterile

| | | |
|---|---|---|
| operations. Factors affecting stability of formulations and shelf – life prediction, techniques to determine and improve shelf life. | | |
| **Module:7** | **Quality control of packaging materials** | **5 hours** |
| Types of plastics, primary and secondary packaging materials (glass, closures, cartons, blister andtheir control). | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Quality Assurance of Aseptic Preparation Services: Standards Part A, 5th edition, Alison M Beaney, Royal Pharmaceutical Society and the NHS Pharmaceutical Quality Assurance Committee, 2016. |
| 2. | Managing for quality and performance excellence ninth edition James R.Every, WilliamM.Lindsay South-western Cengage learning, 2014. |
| | |
| **Reference Books** | |
| 1. | Sed mtiazhaider. (2011), Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA |
| 2. | Ira R. Berry, Robert A Nash (2013), Pharmaceutical process validation, 3rd Rev Edition, Marcel Dekker. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY623L | Medicinal Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the chemistry behind the development and activity of pharmaceutical materials.
2. Imparting the knowledge of mechanism of action and adverse effects of drugs.
3. Acquainting the mechanism of action of antibiotics and their adverse effects upon erratic usage.

**Course Outcomes**

1. Relate drug's properties with its structure.
2. Explain the factors affecting absorption, distribution, metabolism, and excretion of drugs and hence the considerations to be made in drug design.
3. Outline the relationship between drug's chemical structure and therapeutic properties.
4. Apply the knowledge of different theories of drug actions at molecular level to identifydifferent targets for the development of new drugs

| Module:1 | Introduction to receptors | 6 hours |
|---|---|---|

Introduction, targets, Agonist, antagonist, partial agonist.Receptors, Receptor types, Theories of Drug –receptor interaction, Drug synergism, Drug resistance, physicochemical factors influencingdrug action. Isosterism and bioisosterism

| Module:2 | Antibiotics | 9 hours |
|---|---|---|

Introduction, Targets of antibiotics action, classification of antibiotics, enzyme-based mechanism of action, SAR of penicllins and tetracyclins, clinical application of penicillins, cephalosporin, Beta lactamase inhibitors, tetracyclines, Current trends in antibiotic therapy.

| Module:3 | Antihypertensive agents and diuretics | 6 hours |
|---|---|---|

Classification of cardiovascular agents, introduction to hypertension, etiology, types, classification of antihypertensive agents, classification and mechanism of action of diuretics, Furosemide,Hydrochlorothiazide, Amiloride.

| Module:4 | Drugs for Tuberculosis | 5 hours |
|---|---|---|

Classification, mechanism of action of drugs employed for the treatment of Tuberculosis Currenttreatment strategy for tuberculosis.

| Module:5 | Analgesics, Antipyretics and Anti-inflammatory Drugs | 6 hours |
|---|---|---|

Introduction, Mechanism of inflammation, classification and mechanism of action of NSAIDs and SAR of paracetamol, Ibuprofen, Diclofenac, naproxen, indomethacin, phenylbutazone andmeperidine

| Module:6 | Medicinal Chemistry of Antidiabetic Agents | 6 hours |
|---|---|---|

Introduction, Types of diabetics, Drugs used for the treatment, chemical classification, SAR, Mechanism of action, Study the treatment strategy of diabetic mellitus. Chemistry of insulin, sulfonyl ureas

| Module:7 | Drugs for malaria | 5 hours |
|---|---|---|

Classification, mechanism of action of drugs employed for the treatment of

| | | | | |
|---|---|---|---|---|
| malaria. Current treatment strategy for malaria. | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| Industry Expert Lecture | | | | |
| | | | | |
| | **Total Lecture hours:** | | | **45 hours** |
| **Text Book(s)** | | | | |
| 1. | Wilson and Gisvold's textbook of organic medicinal and pharmaceutical chemistry, Wilson, Charles Owens,;Beale, John Marlowe ;Block, John H, Lipincott William, 12th edition, 2011. | | | |
| 2. | An Introduction to Medicinal Chemistry - Graham L. Patrick, 5th edition, Oxford UniversityPress, 2013. | | | |
| **Reference Books** | | | | |
| 1. | Foye's Princles of Medicinal Chemistry, Lipincott Williams, Seventh Edition, 2012 | | | |
| 2. | Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P.Rotella, Alfred Burger, Academic press, 2010. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY623P | Medicinal Chemistry Lab | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

Acquiring hands on training in synthesis of some drug molecules and estimation of parameters related to drug designing.

**Course Outcomes**

1. Understand the practical aspects of drug synthesis.
2. Learn the skill to synthesize and purify the drug molecules.
3. Assess the quality of the commercial product as per standard procedures like ICH guidelines.
4. Learn the analytical techniques to estimate various parameters related to drug designing

| **Indicative Experiments** | | |
|---|---|---|
| 1. | Synthesis of medicinally active compounds (Any two) from the following given compounds- Phenytoin, Benzocaine, Barbituric acid and Phenothiazine. | 6 hours |
| 2. | Synthesis of medicinally active compound; Phenytoin from benzoin- Step One: Benzoin to Benzil | 6 hours |
| 3. | Synthesis of medicinally active compound: Phenytoin spectroscopic methods | 6 hours |
| 4. | Synthesis of medicinally active compounds – Benzocaine Step One: p-nitrobenzoic acid to p-amino benzoic acid | 6 hours |
| 5. | Synthesis of medicinally active compounds – Benzocaine Step Two: p-amino benzoic acid to Benzocaine Purification by column, crystallization,<br>Characterization by spectroscopic methods | 6 hours |
| 6. | Quantification of active substance in commercial products: Assay of Isoniazid Tablets IP | 6 hours |
| 7. | Quantification of active substance in commercial products: Assay of Paracetamol Tablets IP | 4 hours |
| 8. | Quantification of active substance in commercial products: Assay of Aspirin Tablets IP | 4 hours |
| 9. | Quantification of active substance in commercial products- Assay of Sulphanilamide Tablets IP | 4 hours |
| 10. | Quantification of active substance in commercial products- Assay of Chloramphenichol Capsules IP | 4 hours |
| 11. | Substituent effects of groups in medicinally active molecules | 4 hours |
| 12. | In vitro antioxidant studies by hydrogen peroxide method | 4 hours |
| | | |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Vogel text book of practical organic chemistry, Brian S. Furniss, Antony J. |

| | | | | |
|---|---|---|---|---|
| | Hannaford, Peter W. G. Smith, Austin R. Tatchell, 5th Edition, Longman Scientific & Technical Publishers Ltd., 2011. | | | |
| 2. | Indian Pharmacopoeia 1996, The Controller of Publications, Civil Lines, Delhi – 110054. | | | |
| **Reference Books** | | | | |
| 1. | Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic press, 2010. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY624L | Advanced Physical Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding thermodynamics of chemical equilibrium, kinetics of fast reactions and electrode kinetics.
2. Enriching knowledge about photoinduced electron transfer and photocatalytic reactions.
3. Understanding the principles and applications statistical thermodynamics.
4. Getting insight into electric properties of molecules and their interactions.

**Course Outcomes**

1. Evaluate the thermodynamics of equilibrium and relationship between equilibrium with temperature and pressure.
2. Analyze the kinetics of fast reactions using instrumentation techniques.
3. Apply theories in electrochemistry to analyze electrode kinetics through Butler-Volmer andTafel equations.
4. Explain photoinduced electron transfer and analyze photocatalytic reactions includinghydrogen generation reactions.
5. Analyze most probable distributions of a system among the energy levels using the principles of statistical thermodynamics.
6. Summarize Boltzmann, Bose-Einstein and Fermi-Dirac statistics and evaluate different partitionfunctions for diatomic molecules.
7. Analyze the electric properties of molecules and their interactions.

| Module:1 | Chemical Equilibrium | 7 hours |
|---|---|---|

Spontaneous chemical reactions: The Gibb's energy minimum – a) reaction Gibbs energy, b) Exergonic and endergonic reactions; Description of equilibrium – a) Perfect gas equilibria, b) The general case of a reaction, c) calculation of equilibrium constant, d) The relation between equilibrium constants, e) Molecular interpretation of the equilibrium constant, f) Equilibria in biological systems;
Response of equilibria to conditions: Change in equilibria with changes in pressure, temperature; Value of equilibrium constant at different temperatures.

| Module:2 | Chemical Kinetics-II | 5 hours |
|---|---|---|

Study of kinetics of fast reactions-stopped flow technique, relaxation method, processinstrumentation, methodologies and applications.

| Module:3 | Electrochemistry-II | 5 hours |
|---|---|---|

Electrical Double layer: Theories of Double-Layer structure, diffuse-double-layer theory of Gouyand Chapman, the Stern Model; electrode kinetics-derivation of the fundamental equation of electrode kinetics. Butler-Volmer equation-low field and high field approximations-Tafelequation.

| Module:4 | Photophysical Chemistry II | 7 hours |
|---|---|---|

Photoinduced electron transfer: Reaction rates, free energy dependence of electron transfer on rate, Photoinduced energy transfer - FRET, rate and efficiency

| | | |
|---|---|---|
| calculation of FRET - Absorption of light and nature of electronic spectra. Semiconductor as photo catalysts in photolysis reactions: Generation of hydrogen by photo catalysts - photo catalytic break down of water and harnessing solar energy - photocatalytic degradation of dyes - environmental applications. | | |
| **Module:5** | **Statistical Thermodynamics I** | **6 hours** |
| Concepts of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical and microcanonical ensembles. | | |
| **Module:6** | **Statistical Thermodynamics II** | **6 hours** |
| Thermodynamics and entropy, Maxwell – Boltzmann, Bose – Einstein and Fermi – Dirac statistics, partition function - rotational, translational, vibrational and electronic partitionfunctions for diatomic molecules. Heat capacity of solids. | | |
| **Module:7** | **Molecular Interactions** | **7 hours** |
| Electric Properties of molecules - Electric dipole moments, Polarizabilities, Polarization, Relative permittivities; Interactions between molecules: Interactions between dipoles – a) Potential energy interaction,b) Dipole-dipole interaction, c) Dipole–induced-dipole interactions, d) Induced-dipole–induced-dipole interactions, e)hydrogen bonding, f) hydrophobic interaction g) Repulsive and totalinteractions. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, 2018, International 11th Edition,Oxford University Press, United Kingdom. |
| 2. | B. R. Puri, L. R. Sharma, M. S. Pathania, principles of physical chemistry, 47th Edition, VishalPublishing Co., 2017. |
| 3. | Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, John Wiley and Sons Inc. 2001. |
| | |
| **Reference Books** | |
| 1. | N. Levine, Physical Chemistry, 6th Edition, McGraw Hill, New York, 2011. |
| 2. | K. J. Laidler, Chemical Kinetics, 3rd Edition, Harper & Row, New York, 2013. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY625P | General Organic and Inorganic Chemistry Lab | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Imparting skills in synthesis of organic molecules and inorganic complexes & materials.
2. Analyzing the synthesized materials using instrumental methods of chemical analysis.

**Course Outcomes**

1. Estimate the given organic compounds using quantitative analysis.
2. Make use of synthesis methodologies for drug molecules and inorganic complexes.
3. Demonstrate extraction of natural products.
4. Apply preparation methods for getting the given inorganic oxides of importance.
5. Evaluate the products obtained using characterization techniques.

| | **Indicative Experiments** | |
|---|---|---|
| 1. | Estimation of the following:<br>a) Estimation of Glucose<br>b) Estimation of Methyl Ketone | 12 hours |
| 2. | Synthesis of the following drug molecules:<br>a) Synthesis of phenytoin<br>b) Synthesis of 2,3-diphenyl quinoxaline<br>c) Synthesis of 2-phenylindole | 12 hours |
| 3. | Extraction of natural products:<br>a) Caffeine from Tea leaves<br>b) Piperine from Black pepper | 12 hours |
| 4. | Coordination Complexes:<br>a) Preparation of Chloropentaammine cobalt(III) chloride, $[Co(NH_3)_5Cl]Cl_2$<br>b) Preparation of Potassium bisoxalatocuprate(II)dihydrate, $K_2[Cu(C_2O_4)_2].2H_2O$ | 12 hours |
| 5. | Synthesis of oxides:<br>a) $YBa_2Cu_3O_7$ by ceramic method<br>b) $SnO_2$ by precipitation method<br>c) Ruby by combustion method | 12 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000. |
| 2. | Practical Inorganic Chemistry – Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer, 2013. |

| | | | | |
|---|---|---|---|---|
| 3. | Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas, John Wiley & Sons, Inc., 2015. | | | |
| **Reference Books** | | | | |
| 1. | Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000. | | | |
| | | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY626P | Analytical Chemistry Lab I | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

The courses is aimed at Imparting the training in operating different instruments used in the analysis of various chemical constituents.

**Course Outcomes**

1. Design chromatographic and titrimetric methods for identification of species.
2. Analyse different constituents through instrumental methods of analysis
3. Evaluate different contaminants in materials using turbidimetry and conductivity measurements

| Indicative Experiments | | |
|---|---|---|
| 1. | Determination of chloride by precipitation titration using conductometry. | 10 hours |
| 2. | Estimation of phosphate in waste water using colorimetry. | 10 hours |
| 3. | Extraction and iodometric estimation of copper in different alloys. | 10 hours |
| 4. | Estimation of Fe(II) by 1,10 phenonthroline using spectrophotometry. | 10 hours |
| 5. | Determination of Sulphate Ion by Turbidimetry | 10 hours |
| 6. | Decomposition of Diacetone alcohol - Dilatometry method. | 10 hours |
| 7. | Determination of specific rotation by polarimetry- Kinetics of inversion of sucrose in normal sugar and refined sugar samples. | 10 hours |
| 8. | Determination of solubility product by potentiometry – concentration cell | 10 hours |
| 9. | Gas chromatography assay of flavour chemicals. | 10 hours |
| 10. | Characterization of Functional Groups using IR Spectroscopy. | 10 hours |
| | **Total Laboratory Hours** | **60 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Advanced Physical Chemistry Practical Guide, Charu Arora, Sumantra Bhattacharya, Bentham Science Publishers, 2022. |
| 2. | Kissinger, Laboratory Techniques in Electroanalytical Chemistry, Second edition, CRC Press, 2016. |

**Reference Books**

| | |
|---|---|
| 1. | R. Holze, Experimental Electrochemistry: A Laboratory Textbook, Second edition, Wiley-VCH, 2019. |

Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

# Open Elective

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY627L | Drug Design | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Familiarizing principles and applications of drug design and development.
2. Acquainting computational skills for understanding mechanism, interaction forces in drug actions and quantitative measurement of biological responses.

**Course Outcomes**

1. Demonstrate the steps involved in the drug discovery and design process.
2. Summarize the screening methods in the design of drugs.
3. Predict the functional groups involved in drug action and modifications required for a betterbiological response.
4. Choose ideal targets in drug design.
5. Outline pharmacophore and perform conformational searching.
6. Evaluate and formulate various QSAR models.

| Module:1 | Fundamentals of drug design | 7 hours |
|---|---|---|

Introduction, Drugs, agonist, antagonist, inhibitors-different types, lead molecule, lead discovery, random screening, non-random screening, Drug metabolism studies, clinical observations, drug targeting without lead, natural products as lead molecules, existing drugs as lead. Drug-Likeness and other compound filter mechanism

| Module:2 | Lead Modification | 6 hours |
|---|---|---|

Identification of the active site, pharmacophore, functional group modification, SAR, Scaffolds, Drug like molecules, Modifications- Homologation, chain elongation/branching, ring chain transformation, bioisosterims, Fragmentation of structures, Stereochemistry and Drug Action

| Module:3 | Targets in drug Design | 6 hours |
|---|---|---|

Targets in drug design: various targets in drug action, Species-specific genes as drug targets, membrane drug targets, RNA, DNA, Proteins validation of the targets, evaluating a structure forstructure based drug design.

| Module:4 | Pharmacophore and pharmacophore mapping | 6 hours |
|---|---|---|

Pharmacophore, 2D pharmacophore, 3D pharmacophore, Data bases (Cambridge, PDB) searching, conformational search, random conformational search, methods to derive pharmacophore, Pharmacophore Mapping.

| Module:5 | Molecular interaction | 6 hours |
|---|---|---|

Concept of Virtual screening, Structure-Based Virtual Screening (*in silico*), Protein–Ligand Docking, Scoring Functions for Protein–Ligand Docking, Practical Aspects of Structure-BasedVirtual Screening, The Prediction of ADMET, Properties, Toxicity Prediction.

| Module:6 | Molecular descriptors | 6 hours |
|---|---|---|

Lipophilicity parameters, Measurement of partition coefficient and related parameters, Calculation of partition coefficient, electronic parameters, Steric parameters, Polarizability, parameters, Indicator variables, Other parameters

| | | |
|---|---|---|
| involved topological features | | |
| **Module:7** | **Basics of Quantitative Models in QSAR Approaches** | **6 hours** |
| Hansch Analysis, Free Wilson analysis, The Relationships between Hansch and Free Wilson Analysis, Nonlinear relationship, Dissociation and Ionization of Acids and Bases, Other QSAR Approaches, Applications of Hansch analysis, Free Wilson analysis. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industrial invited lectures on Molecular modelling, Tools involved in molecular modelling and bioinformatics. Methods involved in drug Design. | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Textbook of Drug Design and Discovery, Kristian Stromgaard, Povl Krogsgaard-Larsen, 4th Edition, CRC Press, 2010. |
| 2. | The organic chemistry of drug design and drug action, Richard B Silverman, 3rd edition, Elsevier Publishers, 2014. |
| 3. | QSAR: Hansch Analysis and Related Approaches, Vol.1, Hugo Kubinyi, VCH Publishers, 2006. |
| **Reference Books** | |
| 1. | Drug Design: Structure- and Ligand- Based Approaches, Kenneth M. Merz, Jr, Dagmar Ringe, Charles H. Reynolds, Cambridge University Press, 2010. |
| 2. | Textbook of Drug Design and Discovery, Tommy Liljefors, Povl Krogsgaard-Larsen, Ulf Madsen, 3rd edition, CRC Press, 2006. |
| 3. | Recent Advances in QSAR Studies: Methods and Applications, Tomasz Puzyn, Jerzy Leszczynski, Mark T. Cronin, Springer, 2010. |
| 4. | Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic press, 2010 |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY628L | Polymer Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the basic concepts about polymers/macromolecules and polymerization techniques
2. Knowing structure of polymers, tacticity and reactivity ratios.
3. Make use of instrumental techniques for characterizing polymers

**Course Outcomes**

1. Recall the importance of macromolecules/polymers in day-to-day life and sustainable development.
2. Apply instrumental techniques for polymer characterization.
3. Develop macromolecules for specific applications and requirements in industry.

| Module:1 | Concept of Polymer | 7 hours |
|---|---|---|

Definition, nomenclature, Molecular weight (Mn, Mw), PDI. DP, Tg, Tm. Polymerization Techniques: Bulk, Suspension, Emulsion Polymerization and Interfacial Polycondensation

| Module:2 | Chain Polymerization | 8 hours |
|---|---|---|

Radical, cationic, anionic and coordination polymerization (Initiation – propagation – transfer- termination- processing kinetics – termination - living / controlled), Metathesis polymerization, metallocene and Non-metallocene Step Polymerization: Functionality monomers (monomers of type (XX + YY), XY type monomers, monomers of type (XX + YYY), examples)

| Module:3 | Characterization | 6 hours |
|---|---|---|

Methods for the characterization of Polymers: Molecular weight (Mn, Mw) and Polydispersity index (PDI) By size exclusion chromatography (GPC), Chain end analysis, Thermal analysis of polymers by DSC, TGA, TGDTA. Determination of branching

| Module:4 | Stereoselectivity in polymers | 5 hours |
|---|---|---|

Stereospecific polymerization: Stereoselective polymerization using single-site catalysts.

| Module:5 | Evolution in polymer chemistry | 5 hours |
|---|---|---|

From multisite to single site polymerization. Metathesis polymerization, ROP (ring opening polymerization).

| Module:6 | Controlled/Living polymerization | 7 hours |
|---|---|---|

Polymerization techniques such as NMP (nitroxy mediated polymerization), GTP (group transfer polymerization), ATRP (atom transfer radical polymerization), RAFT (reversible addition fragmentation and chain transfer polymerization), metallocene and non-metallocene polymerization techniques

| Module:7 | Copolymers | 5 hours |
|---|---|---|

Block copolymers, alternative and random block copolymers. Reactivity ratios. Synthesis-Applications

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

| | | | |
|---|---|---|---|
| Industry Expert Lecture | | | |
| | | | |
| | **Total Lecture hours:** | | **45 hours** |
| **Text Book(s)** | | | |
| 1. | Principles of Polymerization, George Odian, 4th Edition, Wiley, 2004. | | |
| 2. | Polymer Science and Technology, Joel R. Fried, 3rd Edition, Prentice Hall, 2014. | | |
| **Reference Books** | | | |
| 1. | High Performance Polymers, Johannes Karl Fink, 2nd Edition, Elsevier, 2014. | | |
| 2. | Handbook of Polymer Synthesis, Characterization, and Processing, Enrique Saldivar-Guerra and Eduardo Vivaldo-Lima, Wiley-Blackwell, 2013. | | |
| 3. | Applications of Ionic Liquids in Polymer Science and Technology, David Mecerreyes, Springer, 2015. | | |
| 4. | Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, Manas Chanda, 2nd Edition, CRC Press, 2013. | | |
| 5. | Chemical and physical chemistry of polymers, M. Fontanille and Y. Gnanou, Wiely, 2008. | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY629L | Biophysical Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the fundamental principles and underlying interplay between physical phenomena and the physical properties of biomolecules.
2. Imparting knowledge on application of biophysical techniques and macromolecular analysis.
3. Performing biochemical assays using various biophysical methods.

**Course Outcomes**

1. Recall characteristics and classifications of amino acids.
2. Outline the methods of quantitative and qualitative analysis of biological molecules.
3. Explain protein-protein and protein-nucleic acid interactions.

| Module:1 | Intermolecular interactions | 7 hours |
|---|---|---|

Hydrogen bonding, hydrophobic interactions and water as universal solvent in biological systems; Disruption of hydrophobic interactions by urea and other denaturants; Ionic interactions, hydrophobic versus ionic interactions; Disulfide bond, formation of specific disulfide link.

| Module:2 | Structure of biomolecules | 8 hours |
|---|---|---|

Conformational properties of amino acids and peptides; Primary, secondary, tertiary and quaternary structures; Structural features and prediction of protein structures; Structural features of nucleic acids- Ramachandran plot, Central Dogma (DNA → RNA → Protein).

| Module:3 | Thermodynamics of biomolecules | 5 hours |
|---|---|---|

Two state model of protein stability, chemical denaturation and stabilization, surface denaturation; Principles of ionization equilibrium ionization of side chain, equilibria in proteins.

| Module:4 | Properties of Amino Acids | 7 hours |
|---|---|---|

Predicting properties from amino acid composition, unusual amino acids; Primary structure, Secondary structure, Tertiary structure, Quaternary structure; Homologies in proteins.

| Module:5 | Biophysical Analysis: Optical and Spectroscopic techniques | 5 hours |
|---|---|---|

Optical and Spectroscopic techniques for nucleic acid and protein quantification, protein secondary structure determination, biomolecular modifications, etc, by UV-Visible spectroscopy, Fluorescence spectroscopy, IR, NMR and Mass spectroscopy, MALDI, ORD and CD.

| Module:6 | Biophysical Analysis: Microscopic Techniques | 6 hours |
|---|---|---|

Macromolecular size determination, Microscopic techniques, Protein aggregation, Self-assembly, Surface morphology, etc, by Light microscopy; Fluorescence microscopy, Atomic force microscope, Electron microscope, Scanning electron microscopy, Transmission electron microscope.

| | | |
|---|---|---|
| **Module:7** | **Biophysical Analysis: Chromatographic Techniques & Ultracentrifugation** | **5 hours** |
| Protein purification by size exclusion, GPC and ion exchange chromatographic techniques. Ultracentrifugation - Sedimentation velocity and equilibrium- determination of molecular weights. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Alan Cooper, Biophysical Chemistry, 2nd Edition, RSC Publishing, UK, 2011. |
| **Reference Books** | |
| 1. | Cantor and Schimmel, Biophysical Chemistry, Vols. I - III, W. H. Freeman & Co., USA, 2008. |
| 2. | J. L. Gurth and A. Gurth, Biophysical Chemistry, 9th Edition, Pragati Prakashan, Meerut,India, 2015. |
| 3. | P Narayanan, Essentials of Biophysics, 2nd Edition, New Age International, New Delhi, India, 2016. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY630L | Computational Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Providing essential theoretical background of computational chemistry and practical and programming skills to perform scientific computations to solve chemical problems.
2. Exposing the students to a variety of computational tools in chemical science.

**Course Outcomes**

1. Assess applicability of computational methods to specific problems in chemistry.
2. Apply appropriate computational techniques to study molecules.
3. Make use of computational chemistry software and high-performance computer hardware for solving molecular structural problems.

| Module:1 | Introduction to Computational Chemistry | 4 hours |
|---|---|---|

The promise of computational chemistry, Potential Energy Surfaces, Computational Strategies- Coordinate systems, Geometry optimization, Local and Global minima, Conformational Analysis, Transition State Optimization, saddle point, vibrational frequencies, and normal mode analysis, Intrinsic Reaction Coordinate (IRC) analysis.

| Module:2 | Computational Chemistry Methods-I | 6 hours |
|---|---|---|

Molecular Mechanics-Force field methods, Semi-empirical methods, Variational method, Roothaan- Hall equations, self-consistent field approach, electron spin and Pauli principle, antisymmetric wave functions and Slater determinants.

| Module:3 | Computational Chemistry Methods-II | 6 hours |
|---|---|---|

*Ab initio* methods- Basis sets, Slater and Gaussian functions, polarization and diffuse functions, split-valence sets, correlation-consistent sets, Born-Oppenheimer approximation, Hartree-Fock theory, electron correlation problem, Perturbation theory, Koopmans theorem. Density Functional Theory (DFT) and methods.

| Module:4 | Molecular Dynamics Simulations | 5 hours |
|---|---|---|

Basic principles-Equations of motion, force calculations, integration schemes, boundary conditions, phase space and distribution functions, time step and time scale considerations, stability, Practical aspects of simulations, *ab initio* molecular dynamics. Structural and dielectric properties of a polar medium, SCF reaction field (SCRF), implicit and explicit solvation, solvent Models.

| Module:5 | Hybrid Methods and Relativistic Methods | 5 hours |
|---|---|---|

Combined methods, like the combination of quantum chemical methods and molecular mechanics (QM/MM) or ONIOM for the description of biochemical problems, for example the interaction of a drug and a receptor, relativistic quantum chemistry, relativistic effective core potential (RECP).

| | | |
|---|---|---|
| **Module:6** | **Introduction to Scientific Computing with FORTRAN** | **8 hours** |
| Basic elements of Modern FORTRAN programming and its applications in solving computational problems. Writing program for involving simple formulae in organic, inorganic and physical chemistry, developing the algorithm for numerical computation of chemical problems of interest. | | |
| **Module:7** | **Computational Chemistry Concepts** | **9 hours** |
| Geometrical Parameters, understanding of electrostatic, van der Waals and hydrophobic interactions, Hydrogen bonding, Ground state, Excited States, Transition States - Exploring the energy landscape and its minima, charge density and electron density; Frontier Molecular orbital Analysis, Binding energy, stability constant, Wave function analysis. Structure-Activity Relationships, Descriptors of chemical reactivity and selectivity, DFT reactivity descriptors. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | F. Jensen, Introduction to Computational Chemistry, 3rd Edition, John Wiley & Sons Ltd, UK, 2017. |
| 2. | Norman S. Clerman and Walter Spector, Modern Fortran: Style and Usage, Cambridge University Press, New York, USA, 2012. |
| **Reference Books** | |
| 1. | A. Szabo and N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced ElectronicStructure Theory, Dover Publications, New York, 2012. |
| 2. | Errol G. Lewars, Computational Chemistry: Introduction to the Theory and Applications ofMolecular and Quantum Mechanics, 2nd Edition, Springer, 2011. |
| 3. | Stephen Wilson, Chemistry by Computer: An Overview of the Applications of Computers inChemistry, Springer, 2011. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY631L | NMR, EPR and Mass Spectrometry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding the basic principles, theory and instrumentation of $^{1}H$ NMR, $^{13}C$ NMR, 2DNMR, solid state NMR, EPR and Mass spectrometry.
2. Imparting knowledge in applications of these spectroscopic techniques

**Course Outcomes**

1. Interpret NMR, EPR and Mass spectra of organic molecules
2. Apply spectroscopic techniques to understand structure and stereochemistry of organic molecules

| Module:1 | Proton NMR | 6 hours |
|---|---|---|

Introduction, Instrumentation: Continuous wave method, Frequency sweep method, pulse technique- Rotating frame of reference-FT NMR-Chemically equivalent and non-equivalent protons- variable temperature spectra-first order spectra, second order spectra-simplification of complex spectra- NOE effects-shift reagents. chemical shift-relaxation processes-spin-spin coupling-coupling constant-the effect of proton exchange reactions- variable temperature spectra-first order spectra, second order spectra-simplification of complex spectra- NOE effects-shift reagents.

| Module:2 | $^{13}C$ NMR | 5 hours |
|---|---|---|

History-and Problem areas-theory and experiment-sensitivity-Instrumentation – FT-NMR- Pulsetechnique-Behavior of magnetization subjected to RF pulse.

| Module:3 | $^{13}C$ NMR applications | 9 hours |
|---|---|---|

Relaxations: spin-lattice and dipole-dipole relaxation and other relaxations - coupling constants- theoretical aspects of nuclear shielding such as local diamagnetic shielding, neighbour anisotropy shielding, local paramagnetic shielding, the factors affecting the Chemical shift-Coupling constants: $^{1}H$ &$^{13}C$, $^{13}C$ &$^{13}C$ and coupling with other nuclei-$^{1}H$ decoupling and decoupling methods-empirical relationships and empirical additivity rules- chemical shift reagents, solvent effect-chemical shift and structure elucidations. DEPT methods.

| Module:4 | Applications of two dimensional NMR | 6 hours |
|---|---|---|

Introduction and applications of 2D NMR techniques such as H, H-COSY, C, H-COSY, DQF- COSY, MQF-COSY, TOCSY, NOESY, ROESY, HSQC to small molecules.

| Module:5 | Solid state NMR | 5 hours |
|---|---|---|

Introduction-Origin-Basic principles and methods of high-resolution NMR of solids-Magic angle spinning- Interactions in the solid state-MAS-CP method and its advantages.

| Module:6 | Mass spectrometry | 8 hours |
|---|---|---|

Introduction- Instrumentation-Advanced Ionization techniques such as, ESI, FAB, MALDI, Field desorption-mass analyzers such as Quadrupole Analyzer, ion trap, Time-of -flight Analyzer- Applications of mass spectra to elucidate molecular formula and structure.

| | | |
|---|---|---|
| **Module:7** | **ESR Basic Principles and Applications** | **4 hours** |
| Electronic zeeman effect – ESR spectrum of hydrogen atom (first order treatment) - g factors – Hyperfine constants – interactions affecting the energies of unpaired electrons in the transition metal ion complexes – zero field splitting – Kramer's degeneracy – anisotropy in the hyperfine coupling constant – nuclear quadrupole interactions - ESR of organic radicals in solution –McConnell's relation – ESR instrumentation. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Understanding NMR Spectroscopy, James Keeler, Wiley India Pvt Ltd; Second edition, 2013. |
| 2. | Organic Spectroscopy through Solved Problems, Kali Shankar Mukherjee BodhisattwaMukhopadhyay, First Edition, 2013. |
| 3. | Organic Spectroscopy Principles, Problems and Their Solutions, Jaggdamba Singh and JayaSingh, A Pragadhi Edition, 2016. |
| 4. | Elementary Organic Spectroscopy, Principles and Chemical Applications, S.Chand andCompany, Fifth Revised Edition, 2013. |
| 5. | Introduction to Magnetic Resonance Spectroscopy Esr, NMR, Nqr, D. N. Sathyanarayana, I K International Publishing House Pvt. Ltd; 2nd edition, 2013. |
| **Reference Books** | |
| 1. | Spectroscopy of Organic Compounds by P. S. Kalsi, New Age international Publishers,17$^{th}$edition, 2016. |
| 2. | Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X.Webster, David J. Kiemle, David L. Bryce, Wiley, 8$^{th}$ Edition, 2015. |
| 3. | Principles of NMR Spectroscopy, David Goldenberg, University Science Books; 4 th Edition, 2016. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY632L | Bioorganic Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding classifications of enzymes and their functions
2. Creating knowledge on synthesis and structure of nucleic acids, proteins and enzymes
3. Familiarizing the basic concepts of bioorganic chemistry and biochemical models and their applications in organic synthesis and industry.

**Course Outcomes**

1. Classify enzymes and explain their properties.
2. Outline the role of biocatalysts in organic synthesis.
3. Choose biocatalysts for specific organic transformations.
4. Make use of the concepts of bioorganic chemistry for drug design and to explain drug action.

| Module:1 | Biocatalysts in organic synthesis | 6 hours |
|---|---|---|

Enzyme, Properties and Nomenclature, Classification of enzymes, pros and cons of biocatalyst, Mechanistic Aspects, Coenzymes, Enzyme Sources, Immobilized enzymes, comparisons between the homo and heterogeneous biocatalysts

| Module:2 | Organic transformations using biocatalysts-I | 6 hours |
|---|---|---|

Organic transformations using biocatalysts: Hydrolysis of esters, amides, phosphates epoxides,nitriles-Oxidations of alcohols, aldehydes, Sulfoxidation, Baeyer-Villiger oxidation, Dihydroxylation of Aromatic Compounds

| Module:3 | Organic transformations using biocatalysts-II | 6 hours |
|---|---|---|

Reduction of C=C, aldehydes, ketones- Formation of C-C bond (eg. Aldol, Acyloin, Benzoin, Machael)-Addition and Elimination Reactions by biocatalysts: Cyanohydrin Formation, Addition of Water and Ammonia - Group Transfer Reactions (eg. glycosyl and amino transfer) – Halogenation and De-halogenation reactions,

| Module:4 | Enzymes in organic synthesis | 5 hours |
|---|---|---|

Synthesis of esters, Lactones, amides, peptides, peracid, medium engineering

| Module:5 | Basics of concepts in bioorganic chemistry | 5 hours |
|---|---|---|

Basic considerations, proximity effects in organic chemistry, molecular adaptation-Bio-isosterism,molecular recognition at the supra molecular level.

| Module:6 | Developments in crown ether chemistry - I | 8 hours |
|---|---|---|

Developments in crown ether chemistry- Aza crown ethers-Lariat , Lariat pivot, Bi cyclic, tri cyclic (monoaza, bi-aza, tri-aza), pH regulation and ion-selectivity. Host-Guest complexation chemistry, membrane chemistry-micelles. Bis and Photo responsive crown ethers. Regulation of membrane transport phenomenon.

| Module:7 | Developments in crown ether chemistry-II | 7 hours |
|---|---|---|

Cyclodextrines, enzyme design using steroid template, Remote functionalization, biomemetic polyene cyclisation. Chemical mutations and site directed mutagenesis. Chemical mutations and semi synthetic enzymes- Molecular recognition and drug design.

| | | |
|---|---|---|
| **Module:8** | **Contemporary Issues** | **2 hours** |
| Industry Expert Lecture | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Bio-transformations in Organic Chemistry, Kurt Faber, 7th edition, Springer, 2011. |
| 2. | An Introduction to Medicinal Chemistry, Graham L Patrick, 5th edition, OUP Oxford, 2013. |
| 3. | Burger's Medicinal Chemistry & Drug Discovery, Donald J. Abraham, 15th edition, 2014. |
| 4. | Bioorganic, Bioinorganic and Supramolecular Chemistry, P. S. Kasi and J. P. Kalsi, New Age Publications, 3rd edition, 2017. |
| **Reference Books** | |
| 1. | The Organic Chemistry of Biological Pathways, John E. McMurry and Tadhg P. Begley, 2nd edition, 2015. |
| 2. | Bio-organic Chemistry, Harish Kumar and Parmjit S. Panesar, Narosa Publishing House Pvt. Ltd., New Delhi, 2012. |
| 3. | Foye's Principles of Medicinal Chemistry, Thomas L. Lemke, David A. Williams, 7th Edition, 2012. |
| 4. | Biocatalysts: An Industrial Perspective, Gonzalo de Gonzalo; Pablo Domínguez de María, RSC Publishers, 2017. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | |
| Recommended by Board of Studies | 26-02-2024 | | |
| Approved by Academic Council | No. 73 | Date | 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY633L | Nanomaterials | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understanding synthesis, characterization, properties and applications of nanomaterials.
2. Applying nanomaterials for technological applications.

**Course Outcomes**

1. Propose synthetic techniques for nanomaterials preparation.
2. Apply characterization techniques to understand the structure and properties of nanomaterials
3. Explain the chemistry and structure of carbon nanomaterials.
4. Propose appropriate nanocomposite materials for different applications.
5. Assess thermal, magnetic, optical, and mechanical properties of nanomaterials.
6. Fabricate nanodevices for various applications.

| Module:1 | Synthesis of nanomaterials | 6 hours |
|---|---|---|

Synthesis: Top-down processes: physical processes- milling, lithographic processes, machining, vapour phase condensation, plasma assisted deposition; Bottom– up processes; micro emulsion technique.

| Module:2 | Characterization of nanomaterials | 6 hours |
|---|---|---|

UV – Visible spectroscopy- particle size calculation, particle size analyzer – basic principles - application to selected nanomaterials; Powder XRD – peak broadening, Scherer's equation.

| Module:3 | Carbon materials | 6 hours |
|---|---|---|

Graphene, Fullerene, SWNT, MWNT, Functionalised CNT – preparation, properties andapplications.

| Module:4 | Nanocomposites | 6 hours |
|---|---|---|

Nanocomposites – Metal Matrix nanocomposites, Ceramics matrix nanocomposites, Polymer matrix nanocomposites, metal chalcogenides – Preparation, Properties and applications.

| Module:5 | Properties of Nanomaterials | 6 hours |
|---|---|---|

Band diagrams. Electrical transport properties, Thermal transport properties, Magnetic Properties,Optical Properties, Mechanical properties.

| Module:6 | Nanodevice fabrication | 7 hours |
|---|---|---|

Nanodevices - introduction- template fabrication, polycarbonate etched track templates, fabrication of anodized alumina membrane - Fabrication of nanostructures in the templates; electrodeposition,sol-gel, CVD methods.

| Module:7 | Applications of Nanomaterials | 6 hours |
|---|---|---|

Electronic, magnetic, thermal and biological – application with and an example for each category.

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

Industry Expert Lecture

| | | |
|---|---|---|
| | **Total Lecture hours:** | **45 hours** |
| **Text Book(s)** | | |
| 1. | Nanomaterials: An Introduction to Synthesis, Properties and Applications, D. Vollath (Ed), 2nd edition, Wiley VCH, 2013. | |
| 2. | Nanomaterials, Nanotechnologies and Design, Michael F. Ashby, Paulo J. Ferreira and Daniel L. Schodek, Butterworth-Heinemann, 2009. | |
| 3. | Textbook of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, Baldev Raj, B B Rath , James Murday, Universities Press (India) Pvt. Limited, 2013. | |
| **Reference Books** | | |
| 1. | Essentials in Nanoscience and Nanotechnology, Narendra Kumar, Sunita Kumbhat, John Wiley & Sons, Inc., 2016. | |
| 2. | Materials Chemistry, Bradley D. Fahlman, 3rd edition, Springer Nature B.V. 2018 | |
| 3. | NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep (Ed.), McGraw Hill Education, 2017. | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | |
| Recommended by Board of Studies | 26-02-2024 | |
| Approved by Academic Council | No. 73 | Date 14-03-2024 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PCHY634L | Green Chemistry | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Providing ecofriendly methodologies for organic synthesis.
2. Knowing solvent-less and aqueous phase reactions and ultrasound and microwave methodologies.
3. Understanding the application of biocatalysts in organic synthesis
4. Design green processes that reduce or eliminate the use and generation of hazardous substances.

**Course Outcomes**

1. Define green chemistry principles.
2. Make use of green synthetic methods to reduce waste and hazardous materials.
3. Apply phase transfer catalysts, solid phase synthesis and green extraction methods.

| Module:1 | Green Chemistry Principles | 5 hours |
|---|---|---|

Evaluating the effects of chemistry. Definition, tools and principles of green chemistry. Wasteminimization, solvent-free and aqueous phase reactions

| Module:2 | Green Chemical Approach in Conventional Synthesis | 6 hours |
|---|---|---|

Introduction-Diels alder-Aldol condensation-Heck, oxidation and reduction-photochemical reactions. Alternative solvents- designing a green synthesis. Industrial applications- synthesis of Ibuprofen, Sertraline and Adipic acid.

| Module:3 | Green Chemical Approach Under sonication | 5 hours |
|---|---|---|

Sonochemistry - Introduction, types of sonochemical reactions, a few synthetic applications - substitution, addition, elimination, hydrolysis, esterification, oxidation, reduction.

| Module:4 | Phase Transfer Catalysts | 3 hours |
|---|---|---|

Definition, mechanisms, reaction, preparation, advantages and types of PTC.

| Module:5 | Green Chemical Approach in Conventional Synthesis with PTC | 7 hours |
|---|---|---|

Synthesis of nitriles, alkyl halides, elimination reactions, C-alkylation, N-alkylation, oxidation usinghydrogen peroxide, dihalocarbenes, heterocyclic synthesis, β-lactams synthesis, crown ethers.

| Module:6 | Green Approach in Solid Phase | 11 hours |
|---|---|---|

Introduction– solid phase organic synthesis without using any solvent- halogenation, Micheal addition, aldol condensation, Grignard reagent, Reformatsky reaction, Witting reaction, aromatic substitution reactions-nuclear bromination and nitration by Green synthetic methods. Biochemical oxidations-biochemical reduction-enzyme catalyzed reactions in organic synthesis

| Module:7 | Green Approach in Extraction Process | 6 hours |
|---|---|---|

Extraction and separation of phyto-constituents: hydro extraction, wet steam and dry extraction, head space extraction, super critical fluid extraction, pressurized liquid extraction, Microwave assisted methods, Ultrasonication assisted extraction and

| | | | | |
|---|---|---|---|---|
| simulated moving bed technology. | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| Industry Expert Lecture | | | | |
| | | | | |
| | **Total Lecture hours:** | | | **45 hours** |
| **Text Book(s)** | | | | |
| 1. | New Trends in Green Chemistry, V. K. Ahluwalia and M. Kidwai, Anamaya Publishers, NewDelhi, 2012. | | | |
| 2. | Green Chemistry: An Introductory Text, Mike Lancaster, 3rd edition, The Royal Society of Chemistry, 2017. | | | |
| 3. | Introduction to Green Chemistry, Albert S. Matlack, CRC press, 2010. | | | |
| **Reference Books** | | | | |
| 1. | Alternative Energy Sources, Michaelides, Efstathios E. (Stathis), Springer, Germany, 2012. | | | |
| 2. | Alternative Solvents for Natural Products Extraction, Farid Chemat, Maryline Abert Vian, Springer Berlin, 2014. | | | |
| 3. | Green Chemistry in 21st Century and Beyond, Sunita Dhingra & VK Ahluwalia, Manakin Press,2017. | | | |
| Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar | | | | |
| Recommended by Board of Studies | | 26-02-2024 | | |
| Approved by Academic Council | | No. 73 | Date | 14-03-2024 |

# Skill Enhancement

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PENG501P | Technical Report Writing | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To develop writing skills for preparing technical reports
2. To analyze and evaluate general and complex technical information
3. To enable proficiency in drafting and presenting reports

**Course Outcomes**

At the end of the course, the student will be able to

1. Construct error free sentences using appropriate grammar, vocabulary and style
2. Apply the advanced rules of grammar for proofreading reports
3. Interpret information and concepts in preparing reports
4. Demonstrate the structure and function of technical reports
5. Improve the ability of presenting technical reports

| Indicative Experiments | |
|---|---|
| 1. | **Basics of Technical Communication**<br>General and Technical communication,<br>Process of communication, Levels of communication |
| 2. | **Vocabulary& Editing**<br>Word usage: confusing words, Phrasal verbs<br>Punctuation and Proof reading |
| 3. | **Advanced Grammar**<br>Shifts: Voice, Tense, Person, Number<br>Clarity: Pronoun reference, Misplace and unclear modifiers |
| 4. | **Elements of Technical writing**<br>Developing paragraphs, Eliminating unnecessary words, Avoiding clichés and slang<br>Sentence clarity and combining |
| 5. | **The Art of condensation**<br>Steps to effective precis writing,<br>Paraphrasing and summarizing |
| 6. | **Technical Reports:** Meaning, Objectives, Characteristics and Categories |
| 7. | **Formats of reports and Prewriting**: purpose, audience, sources of information, organizing the material |
| 8. | **Data Visualization**<br>Interpreting Data Graphs - Tables – Charts - Imagery - Info graphics |
| 9. | **Systematization of Information:** Preparing Questionnaire<br>Techniques to Converge Objective-Oriented data in Diverse Technical Reports |
| 10. | **Research and Analyses:**<br>Reference styles,<br>Synchronize Technical Details from Magazines, Articles and e-content |
| 11.. | **Structure of Reports** |

| | | | | |
|---|---|---|---|---|
| | Title – Preface – Acknowledgement - Abstract/Summary – Introduction - Materials and Methods – Results – Discussion - Conclusion - Suggestions/Recommendations | | | |
| 12. | **Writing the Report:** First draft, Revising,<br>Thesis statement, Developing unity and coherence | | | |
| 13. | **Writing scientific abstracts:** Parts of the abstract, Revising the abstract<br>Avoiding Plagiarism, Best practices for writers | | | |
| 14. | **Supplementary Texts**<br>Appendix – Index – Glossary – References – Bibliography - Notes | | | |
| 15 | **Presentation**<br>Presenting Technical Reports<br>Planning, creating and digital presentation of reports | | | |
| | | **Total Laboratory hours :** | | **60 hours** |
| **Text Book(s)** | | | | |
| 1. | Raman, Meenakshi and Sangeeta Sharma, (2015).Technical Communication: Principles and Practice, Third edition, Oxford University Press, New Delhi. | | | |
| **Reference Books** | | | | |
| 1. | Aruna, Koneru, (2020). English Language Skills for Engineers. McGraw Hill Education, Noida. | | | |
| 2. | Rizvi,M. Ashraf (2018)Effective Technical Communication Second Edition. McGraw Hill Education, Chennai. | | | |
| 3. | Kumar, Sanjay and Pushpalatha, (2018). English Language and Communication Skills for Engineers, Oxford University Press. | | | |
| 4. | Elizabeth Tebeaux and Sam Dragga, (2020).The Essentials of Technical Communication, Fifth Edition, Oxford University Press. | | | |
| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | | 19-05-2022 | | |
| Approved by Academic Council | | No. 70 | Date | 24-06-2023 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PSTS501P | Qualitative Skills Practice | 0 | 0 | 3 | 1.5 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To develop the quantitative ability for solving basic level problems.
2. To improve the verbal and professional communication skills.

**Course Outcomes:**

At the end of the course, the student will be able to

1. Execute appropriate analytical skills
2. Solve problems pertaining to quantitative and reasoning ability
3. Learn better vocabulary for workplace communication
4. Demonstrate appropriate behavior in an organized environment

| Module:1 | Business Etiquette: Social and Cultural Etiquette; Writing Company Blogs; Internal Communications and Planning: Writing press release and meeting notes | 9 hours |
|---|---|---|

Value, Manners- Netiquette, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body– Make it relevant to your audience.

| Module: 2 | Time Management Skills | 3 hours |
|---|---|---|

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

| Module:3 | Presentation skills – Preparing presentation; Organizing materials; Maintaining and preparing visual aids; Dealing with questions | 7 hours |
|---|---|---|

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

| Module:4 | QuantitativeAbility-L1–Number properties; Averages; Progressions; Percentages; Ratios | 11 hours |
|---|---|---|

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions

| Module: 5 | Reasoning Ability – L1 – Analytical Reasoning | 8 hours |
|---|---|---|

| | | |
|---|---|---|
| Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations, Ordering / ranking / grouping, Puzzle test, Selection Decision table | | |
| **Module: 6** | **Verbal Ability – L1 – Vocabulary Building** | **7 hours** |
| Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

**Reference Books**

| | |
|---|---|
| 1 | Kerry Patterson, Joseph Grenny, Ron Mcmillan and Al Switzler, (2017), 2nd Edition, Crucial conversatins: Tools for Talking when stakesare High McGraw-Hill contemporary, Bangalore. |
| 2. | Dale Carnegie,(2016).How to Win Friends and Influence People. Gallery Books, New York. |
| 3. | Scott Peck. M, (2003). Road Less Travelled. Bantam Press, New York City. |
| 4. | SMART, (2018). Place Mentor, 1st edition. Oxford University Press, Chennai. |
| 5. | FACE, (2016). Aptipedia Aptitude Encyclopedia. Wiley publications, Delhi. |
| 6. | ETHNUS, (2013). Aptimithra. McGraw – Hill Education Pvt .Ltd, Bangalore. |

**Websites:**

| | |
|---|---|
| 1. | **www.chalkstreet.com** |
| 2. | **www.skillsyouneed.com** |
| 3. | **www.mindtools.com** |
| 4. | **www.thebalance.com** |
| 5. | **www.eguru.ooo** |

| | | | |
|---|---|---|---|
| Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | |
| Recommended by Board of Studies | 19-05-2022 | | |
| Approved by Academic Council | No.70 | Date | 24-06-2023 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PSTS502P | Quantitative Skill Practice | 0 | 0 | 3 | 1.5 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To develop the students' advanced problem solving skills
2. To enhance critical thinking and innovative skills

**Course Outcomes:**

At the end of the course, the student will be able to

1. Create positive impression during official conversations and interviews
2. Demonstrate comprehending skills of various texts
3. Improve advanced level thinking ability in general aptitude
4. Develop emotional stability to tackle difficult circumstances

| | | |
|---|---|---|
| **Module:1** | **Resume skills – Resume Template; Use of power verbs; Types of resume; Customizing resume** | **2 hours** |

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write-up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout-Understanding different company's requirement, Digitizing career portfolio

| | | |
|---|---|---|
| **Module: 2** | **Interview skills – Types of Interview; Use of power verbs; Types of resume; Customizing resume** | **3 hours** |

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview¸ Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

| | | |
|---|---|---|
| **Module:3** | **Emotional Intelligence - L1 – Transactional Analysis; Brain storming; Psychometric Analysis; SWOT analysis** | **12 hours** |

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure ,Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways, SWOT analysis

| | | |
|---|---|---|
| **Module:4** | **Quantitative Ability - L3–Permutation - Combinations; Probability; Geometry and menstruation; Trigonometry; Logarithms; Functions; Quadratic Equations; Set Theory** | **14 hours** |

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

| Module:5 | Reasoning ability - L3 – Logical reasoning; Data Analysis and Interpretation | 7 hours |
|---|---|---|
| Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats | | |
| | | |
| **Module:6** | **Verbal Ability - L3 – Comprehension and Critical reasoning** | **7 hours** |
| Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion,( b) Assumption & Inference, (c) Strengthening & Weakening an Argument | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

**Reference Books**


| | |
|---|---|
| 1. | Michael Farra and JIST Editors,(2011).Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Jist Works, Saint Paul, Minnesota. |
| 2. | Flage Daniel E, (2003).The Art of Questioning: An Introduction to Critical Thinking. Pearson, London. |
| 3. | David Allen, (2015).Getting Things done: The Art of Stress-Free productivity. Penguin Books, New York City. |
| 4. | SMART, (2018). Place Mentor 1st edition. Oxford University Press, Chennai. |
| 5. | FACE, (2016).Aptipedia Aptitude Encyclopedia. Wileypublications, Delhi. |
| 6. | ETHNUS, (2013).Aptimithra. McGraw-Hill Education Pvt Ltd, Bangalore. |


**Websites:**

| | |
|---|---|
| 1. | www.chalkstreet.com |
| 2. | www.skillsyouneed.com |
| 3. | www.mindtools.com |
| 4. | www.thebalance.com |
| 5. | www.eguru.ooo |

Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 19-05-2022 | | |
| Approved by Academic Council | No.70 | Date | 24-06-2023 |