# PGDCLT

**Post Graduate Diploma in Chemical Lab Technician**


Department of Chemistry
School of Basic and Applied Sciences
**Central University of Tamil Nadu**
Thiruvarur

**VISION**

- To develop enlightened citizenship of knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry and to be a global destination of higher education and research.

**MISSION**

- To serve a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India.
- The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

**OBJECTIVES AND GOALS**

I. To disseminate and advance knowledge by providing instructional and research facilities in such branches of learning as it may deem fit

II. To make special provisions for integrated courses in humanities, social sciences, science and technology in its educational programmes

III. To take appropriate measures for promoting innovations in teaching-learning process and inter-disciplinary studies and research

IV. To educate and train manpower for the development of the country

V. To establish linkages with industries for the promotion of science and technology

VI. To pay special attention to the improvement of the social and economic conditions and welfare of the people, their intellectual, academic and cultural development

**DEPARTMENT OF CHEMISTRY**

The Department of Chemistry started functioning from the year 2010 with five-year integrated M.Sc. Chemistry. The Department has the distinction of starting the first two-year PG program in Science at CUTN. Besides, the state-of-the-art PG and research laboratories were established. The Department is committed to excellence in chemistry by establishing research programs for meeting scientific and technological challenges faced by the ever changing, science centered world of the 21$^{st}$ century.

The department is presently offering M.Sc., Integrated M.Sc., M.Phil., Post Graduate Diploma in Chemical Lab Technician (PGDCLT) and Ph.D. programmes. The Department provides ample opportunity for the students to accumulate a thorough fundamental

knowledge of all fields of Chemistry. Meticulous lecture courses in the general areas of inorganic, organic and physical chemistry are conducted regularly in addition to the state-of-the-art laboratory courses which provides hands-on experience to the students at all levels.

The main focus of the department is to instill the necessary spark and provide the scientific impetus so that the students can virtually experience the jiggling and wiggling of atoms and molecules. To enable students to have a glimpse of contemporary research, both in terms of academia and industry, the final year students in Chemistry will be completely engaged in project works. Our aim is to produce highly sought after and knowledgeable graduates for pursuing careers with academia, industry and government.

## VISION AND MISSION OF THE DEPARTMENT

### VISION

The Department envisions establishing itself as a place of excellence for chemistry education and research programmes globally.

### MISSION

**M1**: To bridge the gap between academia and industry by regularly updating the curriculum on par with recent developments in science and encourage doing in house projects

**M2**: To educate and invoke the students to deliver their maximum outputs in competitive examinations and meet industrial competences

**M3**: To develop chemists with excellent analytical and synthetic skills through the curriculum with more laboratory components and industrial visits/internships

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Post Graduate Diploma in Chemical and Lab Technician (PGDCLT) programme will enable the student to

**PEO1**: Apply knowledge of chemistry and scientific laboratory procedures and techniques to perform operations of chemistry in laboratories and industries.

**PEO2**: Acquire knowledge about preparation of samples, storage of chemicals, maintenance of equipments and facilities, safe use of equipments and chemicals and storekeeping functions

**PEO3**: Have societal, health, safety, and cultural issues relevant to the science practices and provide a strong foundation for acquiring chemical lab safety and management

**PEO4**: Perform clerical work related to laboratory activities such as word processing, record keeping, filing, maintaining material safety data sheets for all chemicals and products

**PEO5**: enhance skills for employability through activities such as hands-on-training on analytical instrument, workshop and submission of research project dissertation about innovative lab practices and protocols

| Mission | PEO1 | PEO2 | PEO3 | PEO4 | PEO5 |
|---|---|---|---|---|---|
| **M1** | 3 | 3 | 3 | 3 | 3 |
| **M2** | 3 | 2 | 2 | 2 | 3 |
| **M3** | 2 | 2 | 2 | 2 | 3 |

**GRADUATE ATTRIBUTES**

- **Disciplinary Knowledge**: Content and pedagogical knowledge synchronised with the curriculum frameworks and policies
- **Communication Skills**: Possess clarity in conveying the ideas
- **Critical Thinking**: Capacity to apply analytical thought in the teaching and learning process
- **Problem Solving**: Participate in the educational problem solving and applying the knowledge in the day-to-day professional endeavours.
- **Cooperation**: Appreciate collaboration and cooperation among stakeholders of education.
- **ICT Skills**: Selecting and integrating appropriate ICT skills for professional development.
- **Ethics**: Doing what is right to society
- **Self-Directed Learning**: Developing autonomy and self-regulation in teaching learning and professional development.
- **Reasoning**: Ability to interpret and draw the conclusion from qualitative/quantitative data with open-mindedness
- **Creativity**: Ability to produce new ideas
- **Societal and Environmental Concern**: Performing an act or solving a problem with respect to societal and environmental concern
- **Lifelong Learning**: Understands the need for learning and practices it throughout life

**PROGRAMME OUTCOMES (POs)**

On successful completion of PGDCLT programme, the student will be able to

**PO1**: Assembles supplies, constructing apparatus, preparation of lab solutions related to experiment and demonstration

**PO2**: Operate, maintain and fix repairs on laboratory or analytical equipments such as electroanalytical instruments, analytical balance, spectrophotometers etc.

**PO3**: Design methodologies, analyse, and evaluate innovative ideas towards chemical and lab safety problems.

**PO4**: Become an lab technician/ employee / entrepreneur

**PO5**: Work independently as well as in a team.

| POs | PEO1 | PEO2 | PEO3 | PEO4 | PEO5 |
|---|---|---|---|---|---|
| **PO1** | 3 | 3 | 2 | 3 | 3 |
| **PO2** | 3 | 3 | 2 | 3 | 2 |
| **PO3** | 3 | 3 | 3 | 2 | 2 |
| **PO4** | 3 | 3 | 2 | 3 | 3 |
| **PO5** | 3 | 3 | 2 | 3 | 2 |

**PROGRAMME SPECIFIC OUTCOMES (PSOs)**

On successful completion of PGDCLT programme, the student will be able to

**PSO1**: Acquire the knowledge of fundamental concepts of analytical chemistry and spectrophotometer instruments in scientific field

**PSO2**: Understand the importance of chemical lab safety and management

**PSO3**: Develop technical skill about maintenance of analytical instruments and laboratory equipments

**PSO4**: Apply technical skill in a sophisticated laboratory environment and secure challenging position in industry and academics.

**PSO5**: Enhance employability through chemical lab technician and lab clerical work activities.

# ***P. G. Diploma in Chemical Lab Technician (PGDCLT)***

*Total No. of Credits: 32 (Two Semester)*

## *Department of Chemistry, CUTN*

**Course Preamble:**

The Department of Chemistry at CUTN offers the PGDCLT programme to strengthen the technical skills of the chemists and aspiring technicians to meet the dynamic challenges faced by academic, industrial and research laboratories. The PGDCLT programme can empower the students to secure positions in leading academic, research institutions or in industries as technical assistants, quality control analysts and lab assistants.

The PGDCLT is a two semester programme having a requirement of 32 credits which comprises of 35% theory and 65% practical component. The evaluation for the programme is based on continuous assessment and a final project report submission.

| | |
|---|---|
| **Course** | PGDCLT |
| **Duration** | One Year |
| **Intake** | 9 |
| **Eligibility** | Bachelor's degree in Chemistry (Main) or with Chemistry as one of the major subjects. Candidates should have secured a minimum of 60% marksor 6.5 CGPA (on a 10 point scale) in the qualifying degree examination for General category, 55% marks or 6.0 CGPA (on a 10 point scale) for OBC & EWS and 50% aggregate marks or 5.5 CGPA (on a 10 point scale) for SC/ST/PWD candidates. |

**Curriculum & Credit Distribution**

| **Semester - I** | | | | **(Total Credits : 16)** |
|---|---|---|---|---|
| **S.No.** | **Course Code** | **Title** | **T/L** | **Credits** |
| **1** | **CHE5011** | **Analytical Chemistry** | **T** | **4** |
| **2** | **CHE5012** | **Chemical Lab Safety and Management** | **T** | **4** |
| **3** | **CHE5013** | **Basic Laboratory Techniques – I** | **L** | **4** |
| **4** | **CHE5014** | **Basic Laboratory Techniques – II** | **L** | **4** |
| | | | | |
| **Semester - II** | | | | **(Total Credits : 16)** |
| **S.No.** | **Course Code** | **Title** | **T/L** | **Credits** |
| **5** | **CHE5021** | **Physical Methods in Chemistry** | **T** | **4** |
| **6** | **CHE5022** | **Advanced Instrumental Methods - I** | **L** | **4** |
| **7** | **CHE5023** | **Advanced Instrumental Methods - II** | **L** | **4** |
| **8** | **CHE5024** | **Project on Innovative Lab Practices and Protocols** | **L** | **4** |
| | | | | |
| **Semester I + Semester II** | | | | **Total No. of Credits: 32** |

**Semester I** **Course Type: Theory** **Course Code: CHE5011**
**Credit: 4** **Course Title: Analytical Chemistry**

| Course Outcomes | | Level |
|---|---|---|
| CO-1 | Analyze the accuracy and precision of statistical data. | Apply |
| CO-2 | Understand the importance of gravimetric analysis | Understand |
| CO-3 | Introduce various thermal and electroanalytical methods. | Knowledge |
| CO-4 | Understand the methodologies of analytical spectroscopy & separation techniques | Understand |
| CO-5 | Elucidate the analytical applicability of chromatography & spectroscopy in real samples (water quality, waste water treatment, etc.) | Skill |

## Unit-I Error Analysis

Errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals, Correlation & regression, correlation coefficient and linear regression.

## Unit –II Gravimetric & Electroanalytical Methods

Gravimetric Analysis: Principles, methods, requirements. Precipitation and theories of precipitation. Types of precipitation – co precipitation, post precipitation and precipitation from homogeneous solution – digestion, filtration and washing, drying and ignition. Inorganic and organic precipitating agents.

Electroanalytical Methods**:** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

## Unit –III Spectrophotometry

Optical methods of analysis: Origin of EMR spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instruments. Applications: Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Woodward–Fieser Rules (enones only), Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles & sampling techniques. Factors influencing vibrational frequencies. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

**Unit –IV Flame & Thermal Analysis**

Flame Atomic Absorption and Emission Spectrometry: Basic principles, choice of flame and burner designs, techniques of atomization and sample introduction, method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.
Thermal methods of analysis: Theory of thermogravimetry (TG), Differential Thermal Analysis (DTA), Differential Scanning Calorimeter (DSC) – Basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

**Unit –V Separation Techniques**

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by 8solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.
**Chromatography**: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition &ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

**Reference Books**


1. G. H. Jeffery, J. Bassett, J. Mendham, & R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5$^{th}$Ed., John Wiley & Sons, **1989.**
2. H. H. Willard, L.L. Merritt, J. Dean, & F. A. Settoe, Instrumental Methods of Analysis, 7$^{th}$ Edn. Wadsworth Publishing Company Ltd., Belmont, California, USA, **1988.**
3. G. D. Christian, P. K. Dasgupta, K. A. Schug, Analytical Chemistry, 7$^{th}$ Ed., John Wiley& Sons, New York, **2004.**
4. D. C. Harris, Exploring Chemical Analysis, Ed. New York, W.H. Freeman, **2004.**
5. S. M. Khopkar, Basic Concepts of Analytical Chemistry,3$^{rd}$ Edn., New Age, International Publisher, **2017.**
6. D. A. Skoog, F. J. Holler & T. A. Nieman, Principles of Instrumental Analysis, 6$^{th}$Edn, Cengage Learning India Ed.**1998**.
7. O. Mikes, Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, **1979.**
8. R.V. Ditts, Analytical Chemistry; Methods of Separation, New York van Nostrand, **1974**


| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 2 | 3 | 1 | 2 | 1 |
| **2** | 1 | 3 | 2 | 2 | 2 |
| **3** | 2 | 3 | 1 | 2 | 1 |
| **4** | 1 | 3 | 2 | 2 | 2 |
| **5** | 2 | 3 | 2 | 2 | 2 |

**Semester I** **Course Type: Theory** **Course Code: CHE5012**
**Credit: 4** **Course Title: Chemical Lab Safety and Management**

| Course Outcomes | | Level |
|---|---|---|
| CO-1 | Introduce good laboratory practices and lab safety | Knowledge |
| CO-2 | Introduce the storage of gas and cylinders | Knowledge |
| CO-3 | Know the various waste disposal methods | Understand |
| CO-4 | Avail knowledge towards various instrument maintenance | Knowledge |
| CO-5 | Execute the practice in handling of software and tools effectively | Apply |

**Unit-I Introduction to Basic laboratory safety**

About the laboratory laws – Case studies – Current norms and rules –Theories of accidents: Heinrich triangle, Swiss cheese model – Chemical safety Norms: Academic / Industrial – Accountability. Culture of lab safety: GLP, GMP, *etc*–Emergencies & Preparedness– Fire safety: Classification, Flash point, Elements of fire (Fire triangle, Fire tetrahedron), Fire extinguisher uses and safety measures.

**Unit-II Instrumental Safety and Maintenance**

Compressed gas cylinders – maintenance – Gas cylinders (high/ low pressure/ toxic/ flammable)–Cryogenic cylinders Lab facilities and management (Different types of labs) – Glove box – Vacuum pumps – High pressure reactors/equipment – Electrical and electronic equipment– Glassware– High energy/radiation sources (Laser, NMR, XRD etc.) 5G line in NMR.

**Unit-III Laboratory Chemicals Safety**

Handling of chemicals (solids/ liquids/ gases)–Storage of chemicals/ solvents, First Aid. Chemical spills and emergencies – Chemical wastes and disposal methods – Laboratory protocols: CHP – Equipment – Designs – Laws and controlling bodies: Local/ State/ National policies. Good Laboratory practices (GLP).

**Unit-IV Hazard Identification and Risk Assessment**

The process of risk management, hazard identification, Evaluation (Risk Assessment and Risk matrix) Risk control implementation, Action and recommendation. Hazard Evaluation Techniques, Quantitative and Qualitative Safety reviews.

**Unit-V Laboratory Management - Tools and Applications**

MS office and related data handling software – Chemdraw software, Origin and mercury software. Chemoffice – Laboratory Information and Management Systems (LIMS)

Electronic Note Books (ELN) Research tools: Scifinder, Beilstein, Endnote, Mendeley and Scopus.

## Reference Books


1. Robert H.Hill, Jr. David, C.Finster, Laboratory safety for chemistry students, 2nded., 2016.
2. Laboratory Waste Management: A Guidebook by ACS Task Force on Laboratory Waste Management, ACS Miscellaneous, 1994.
3. Margaret-Ann Armour, Hazardous Laboratory Chemicals Disposal Guide, 2nd Edition, 1996.
4. Svehla, G: Vogel's qualitative inorganic analysis, 7th Edition, Prentice Hall, 1996.
5. Vogel , A.I., Tatchell, A.R., Furnis , B.S., Hannaford , A.J., Smith, P.W.G., Vogel'sPractical Organic Chemistry, 5th edition, Pearson education Ltd, 1996.
6. Lisa Moran, Tina Masciangioli, Chemical Laboratory Safety and Security-A Guide to Prudent Chemical Management, The National Academies Press,Washington, DC,2010.
7. Guidelines for Chemical Laboratory Safety in Academic Institutions, American Chemical Society, Washington, DC,2016.
8. Chemical Safety Manual, Indian Institute of Technology-Bombay.
9. Laboratory Safety Handbook, Fens Laboratory Safety Team, Sabanci University, 1sted.2016.
10. Laboratory Manual Chemistry Laboratory Techniques, Prepared by Katherine J. Franz and Kevin M.Shea, Department of Chemistry, Massachusetts Institute of Technology.
11. Hazard in chemical laboratory - G. D Muir.
12. Handbook of Laboratory Safety Norman.V. Steere.


| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 3 | 1 | 1 | 3 | 1 |
| **2** | 3 | 2 | 2 | 2 | 2 |
| **3** | 3 | 3 | 1 | 3 | 1 |
| **4** | 3 | 2 | 2 | 2 | 2 |
| **5** | 3 | 3 | 2 | 2 | 2 |

**Semester I** **Course Type: Practical** **Course Code: CHE5013**
**Credit: 4** **Course Title: Basic Laboratory Techniques – I**

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | **Prepare solutions and sample** | **Skill** |
| **CO-2** | **Select the appropriate methods based on analysis** | **Knowledge** |
| **CO-3** | **Analyse the samples by various procedures** | **Skill** |
| **CO-4** | **Maintain laboratory glassware** | **Knowledge** |
| **CO-5** | **Prepare solution by applying stoichiometric calculations** | **Apply** |

Introduction of non instrumental basic laboratory techniques such as sample preparation, stoichiometric calculations, solution preparation, method selections, gravimetric, volumetric techniques, standardization methods and analysis of samples by various procedures and the use of glassware.

## Reference Books


1. Svehla, G: Vogel's qualitative inorganic analysis, 7th Edition, Prentice Hall, 1996
2. Gordon, A. J; Ford, R. A. The Chemist's Companion: A Handbook of Practical Data, Techniques, and References, Wiley-interscience, 1972.
3. Hein, M; Peisen, J.P, Miner, R. L, Foundations of College Chemistry in the Laboratory, John Wiley and Sons, 2011
4. Vogel, A. I, Elementary Practical Organic Chemistry: Small Scale Preparations Part 1, 2nd edition, 2010


| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 1 | 3 | 2 | 2 | 3 |
| **2** | 1 | 3 | 2 | 2 | 3 |
| **3** | 2 | 3 | 2 | 2 | 3 |
| **4** | 2 | 3 | 2 | 2 | 3 |
| **5** | 1 | 3 | 2 | 2 | 3 |

**Semester I** **Course Type: Practical** **Course Code: CHE5014**
**Credit: 4** **Course Title: Basic Laboratory Techniques – II**

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | **Usage of analytical balance** | **Apply** |
| **CO-2** | **Maintain instruments and other laboratory equipments** | **Knowledge** |
| **CO-3** | **Calibrate the potentiometer, pH and conductivity meters** | **Knowledge** |
| **CO-4** | **Maintain electro-analytical instruments** | **Skill** |
| **CO-5** | **Execute the practice in handling of laboratory equipments** | **Skill** |

Introduction of instrumental basic laboratory techniques such as the use and maintenance of analytical balance, potentiometers, pH meters, conductivity meters, mechanical shakers, melting point apparatus, water heaters, water deionisers, magnetic stirrers and hot plates etc.

## Reference Books


1. Holler, F. J; Crouch, S. R; West, D. M; Skoog, D. A; Fundamentals of Analytical Chemistry, Cengage, 9th edition, 2014
2. Bard, A. J.; Faulkner, L. R.; Electrochemical Methods: Fundamentals and Applications, Wiley, 2nd edition, 2000.
3. Findlay, A; Practical Physical Chemistry, Nadu Press, 2012
4. Halpern, A. M.; Mc Bane, G. C. Experimental Physical Chemistry: A Laboratory edition, 2006.


| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 1 | 3 | 2 | 2 | 3 |
| **2** | 1 | 3 | 2 | 2 | 3 |
| **3** | 2 | 3 | 2 | 2 | 3 |
| **4** | 2 | 3 | 2 | 2 | 3 |
| **5** | 1 | 3 | 2 | 2 | 3 |

**Semester II** **Course Type: Theory** **Course Code: CHE5021**
**Credit: 4** **Course Title: Physical Methods in Chemistry**

| Course Outcomes | | Level |
|---|---|---|
| CO-1 | Demonstrate the utility of UV-visible and IR spectroscopy in structural characterization | Knowledge |
| CO-2 | Provide basic knowledge about the use of NMR spectroscopy towards structure determination | Knowledge |
| CO-3 | Elucidate the structure of organic compounds based on $^{1}H$ and $^{13}C$ NMR spectroscopy | Apply |
| CO-4 | Identify the fragmentation patterns of compounds and solve the structure of compounds using mass spectrometry | Understand |
| CO-5 | Characterize unknown compounds using Thermal and EPR techniques | Apply |

## Unit 1 UV-Visible and Infra-Red Spectroscopy

Basics of UV Spectroscopy, factors governing absorption maximum and intensity. Woodward Fieser and Fieser-Kuhn's rules - calculation of λmax for simple organic molecules. Instrumentation of UV-Visible and applications of UV spectroscopy.Principle, instrumentation and sampling technique- Hook's law, vibrational frequency, modes of vibrations, and selection rules. Factors influencing vibrational frequency. Fingerprint and functional group region. Interpretation of the IR spectra of alkane, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenol, carbonyl compounds, amines and heterocyclics– related problems.

## Unit-II NMR Spectroscopy

$^{1}H$ NMR, Spectral parameters – intensity, chemical shift, multiplicity, coupling constant, factors affecting chemical shift. Analysis of first order and second – order spectra – shift reagents - structure determination of organic compounds by $^{1}H$ NMR spectra. Chemical shifts and coupling constants (spin-spin coupling) involving different nuclei ($^{1}H$, $^{13}C$) interpretation and applications to inorganic compounds. Examples for different spin systems.$^{13}C$ NMR: Proton coupled; off–resonance decoupled; proton noise decoupled $^{13}C$ NMR spectra. Assignment of chemical shifts, additively effect, characteristic chemical shifts of common organic compounds and functional groups.

## Unit-III Mass spectrometry and Mossbauer spectroscopy

Instrumentation – methods of ionisation - EI, CI, APCI, ESI. Mass analyser – magnetic and electrostatic sector, Molecular ion, base peak, multicharged ion, metastable ions and isotope ratio. Fragmentation patterns of saturated, unsaturated and aromatic hydrocarbons, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, amines, nitro, nitrile and halides. McLafferty rearrangement. Mossbauer spectroscopy- basic principle-isomer shift, quadrupole splitting, magnetic fieldeffect. Applications.

**Unit-IV ESR spectroscopy and magnetic measurements**

Its principle, hyperfine structure, ESR of simple radicals. Electron spin resonance spectroscopy-basic principles, hyperfine splitting, zero field splitting and Kramer's degeneracy, factors affecting 'g' value. Introduction, Experimental determination of magnetic measurements Gouy balance and NMR method, Curie and Curie-Weiss law, magnetic moment calculations, Neel and Curie temperature, Applications.

**Unit V Thermal methods and Circular dichroism**

Principle, instrumentation and applications of TG, TGA and DTA. Thermogram of calcium oxalate monohydrate, copper sulphate pentahydrate and polymer. Thermometric titrations, Principle and applications of DSC. Introduction, Cotton effect, ORD and CD, Axial halo ketone and Octant rule. Applications of ORD and CD in biomolecules (DNA and Protein only).

**Reference Books**


1. R. M. Silverstein and F. X. Webster, Spectrometric identification of organic compounds, John Wiley and Sons. Inc., 6th edition, 1997.
2. W. Kemp, Organic Spectroscopy, 3rd edition, MacMillan, 1994.
3. Jag Mohan, Organic Spectroscopy: Principles & Applications, Narosa Publishers, 2012.
4. R. S. Drago, Physical Methods for Chemistry, 2nd Edition, Saunders College Publishing, 1992.
5. Pavia, Lampman and Kriz, Introduction to Spectroscopy, Brooks/Cole Pubs Co, 5th edition, 2015.
6. D. H. Williams and Ian Fleming, Spectroscopic methods in organic chemistry, Tata McGraw Hill, 1998.
7. William Kemp, NMR in chemistry: A multinuclear introduction, MacMillan, 1988.


| **CO** | **Program Outcomes** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 2 | 1 | 3 | 3 | 1 |
| **2** | 2 | 1 | 3 | 3 | 2 |
| **3** | 2 | 1 | 3 | 3 | 1 |
| **4** | 2 | 1 | 3 | 3 | 1 |
| **5** | 2 | 1 | 3 | 3 | 1 |

**Semester II** **Course Type: Practical** **Course Code: CHE5022**
**Credit: 4** **Course Title: Advanced Instrumental Methods - I**

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | **Introduce instrumental equipments** | **Knowledge** |
| **CO-2** | **Avail hands on experience of rotary evaporator and immersion coolers** | **Apply** |
| **CO-3** | **Prepare samples for UV-Vis and IR techniques for analysis** | **Skill** |
| **CO-4** | **Demonstrate the handling of TGA-DTA instruments** | **Evaluate** |
| **CO-5** | **Prepare samples for chromatographic techniques** | **Skill** |

Introduction of instrumental techniques and hands on experience rotary evaporator, immersion coolers, spectroscopic instruments such as UV-Vis, IR and Fluorescence, thermal instruments such as TGA-DTA, DSC etc, flash chromatograph, Gel-Doc.

## Reference Books


1. F. James Holler, Stanley R Crouch, Donald M. West, Douglas A. Skoog, Fundamentals of Analytical Chemistry, Cengage, 9th edition, 2014
2. Vogel , A.I., Tatchell, A.R., Furnis , B.S., Hannaford , A.J., Smith, P.W.G., Vogel's Practical Organic Chemistry, 5th edition, Pearson education Ltd, 1996.
3. Rouessac, F; Rouessac, A; Chemical Analysis: Modern Instrumental Methods andTechniques, Wiley-Blackwell, 2000
4. Pavia, Lampman and Kriz, Introduction to Spectroscopy, Brooks/Cole Pubs Co, 5th edition, 2015.


| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 2 | 1 | 3 | 3 | 2 |
| **2** | 3 | 3 | 1 | 3 | 3 |
| **3** | 2 | 3 | 3 | 3 | 3 |
| **4** | 2 | 2 | 3 | 3 | 3 |
| **5** | 2 | 3 | 2 | 1 | 2 |

**Semester II** **Course Type: Practical** **Course Code: CHE5023**
**Credit: 4** **Course Title: Advanced Instrumental Methods - II**

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | **Introduce highly sensitive instruments** | **Knowledge** |
| **CO-2** | **Provide knowledge about the importance of log register and preparation of manuals** | **Knowledge** |
| **CO-3** | **Avail hands on experience of X-ray crystallographic instruments** | **Skill** |
| **CO-4** | **Demonstrate the protocols to handle instruments** | **Skill** |
| **CO-5** | **Maintain highly sensitive instruments by providing hands-on experience** | **Skill** |

Introduction and maintenance of highly sensitive instrumentation labs including log registers, preparing manuals and protocols for handling instruments like X-Ray Crystallography, SEM, GC-MS, LC-MS and NMR.

## Reference Books


1. Holler, F. J; Crouch, S. R; West, D. M; Skoog, D. A; Fundamentals of Analytical Chemistry, Cengage, 9th edition, 2014
2. Pavia, L, Introduction to Spectroscopy, Brooks, Cole Pubs Co, 5th edition, 2015
3. Rouessac, F; Rouessac, A; Chemical Analysis: Modern Instrumental Methods and Techniques, Wiley-Blackwell, 2000
4. Silverstein, R. M., and Webster, F. X., Spectrometric identification of organic compounds,John Wiley and Sons. Inc., 6th edition, 1997


| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 2 | 2 | 3 | 3 | 2 |
| **2** | 2 | 3 | 3 | 3 | 1 |
| **3** | 1 | 3 | 3 | 3 | 2 |
| **4** | 2 | 2 | 3 | 3 | 3 |
| **5** | 1 | 1 | 3 | 1 | 2 |

**Semester II** **Course Type: Practical** **Course Code: CHE5024**
**Credit: 4** **Course Title: Project on Innovative Lab Practices and Protocols**

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | **Develop a project based on lab practices and safety methods** | **Create** |
| **CO-2** | **Design a research-oriented project independently in a particular context.** | **Create** |
| **CO-3** | **Acquire the skill to write a dissertation, communication skills in a presentation** | **Evaluate** |
| **CO-4** | **Demonstrate the utility of various software** | **Apply** |
| **CO-5** | **Prepare a dissertation report with complete follow up of research methodology and to develop the skill of communication in presentation** | **Create** |

Individual project report for developing innovative lab practices and safety methods, critical studies based on environmental, governmental acts and regulations.

| CO | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **1** | 2 | 2 | 2 | 3 | 3 |
| **2** | 2 | 3 | 2 | 3 | 3 |
| **3** | 1 | 3 | 3 | 3 | 3 |
| **4** | 2 | 2 | 1 | 3 | 3 |
| **5** | 1 | 2 | 1 | 3 | 2 |