Centurion
UNIVERSITY
Shaping Lives...
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M.Sc.

Applied Chemistry Syllabus

(Two Years Programme)

School of Applied Sciences

Centurion University of Technology & Management

2022

DEPARTMENT OF CHEMISTRY

Sl No	Course Code	Course Name	Credit	Type [T+Pr+Pj]
1	CUTM1402	Advanced Characterization Techniques	4	3+0+1
2	CUTM1405	Synthesis and Application of Nano Composites	4	3+1+0
3	CUTM1408	Synthesis Routes of Nanomaterials	4	3+1+0
4	CUTM1409	Computational Materials Science	4	2+2+0
5	CUTM1415	Industrial Chemicals	4	3+0+1
6	CUTM2379	Phytochemistry and Toxicology	4	3+1+0
7	CUTM1417	Polymer Chemistry	4	3+1+0
8	CUTM1418	Packaging	4	3+1+0
9	CUTM1419	Industrial Pollution and its Management	4	3+1+0
10	CUTM1421	Biopolymer and Hydrogel	4	3+1+0
11	CUTM1422	Nano-Pharmaceuticals and Biomedical Science	4	3+1+0
12	CUTM1423	Synthetic Organic Chemistry	4	3+1+0
13	CUTM1424	Energy Storage System	4	3+0+1
14	CUTM1425	Sustainable Chemistry	4	3+1+0
15	CUTM1426	Analytical techniques	4	3+1+0
16	CUTM2378	Research Methodology and IPR	4	2+0+2

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1402	Advanced Characterizations Techniques	3-1-0	

Objective

- The objective of the subject is that the student acquires knowledge of the different existing experimental techniques for the microstructural and physicochemical characterizations of materials.
- Students gain knowledge about the principles of various techniques.

Course Outcome

Upon successful completion of this course, students will be able to address following points:

- Depending on the problem or needs of each case, the student must have sufficient criteria to select the most appropriate technique, as well as the interpretation of their results.
- The knowledge gained from this subject definitely help students to optimize material research.

Course content

Module-I

Compositional and Structural Characterization

X-ray diffraction (XRD), Small-angle XRD, Powder diffraction, Lattice parameters, Structure analysis, Strain analysis, Phase identification, Particle size analysis using - Scherer's formula, X-ray photoelectron spectroscopy (XPS), X-ray fluorescence (XRF), Energy dispersive X-ray analysis (EDAX).

Practice-1

Crystal structure and phase identification determination by XRD (Biovia MS and phase identification by using relevant software)

Practice-2

Study on molecular spectroscopy by fluorescence instrument

Module-II

Advanced Microscopy Techniques for Nanomaterials

Field emission scanning electron microscope (FESEM), Atomic force microscopy (AFM), Scanning tunneling microscopy (STM), Transmission electron microscopy (TEM), High-resolution transmission electron microscopy (HRTEM).

Module-III

Spectroscopic Techniques

Ultraviolet-visible spectroscopy, Photo-luminescence spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy, Nuclear magnetic resonance (NMR).

Practice-3

Familiarization with the ultraviolet-visible absorption spectroscopy

Practice-4

Band gap calculation from photo-luminescence spectra

Module-IV

Nanomaterials Electrical and Magnetic Characterization Techniques

Measurement of resistivity by 4-probe method, Hall measurement, Measurement of magnetic of properties of nanomaterial (Magnetic hysteresis and dielectric properties by LCR meter),Vibrating sample magnetometer.

Module-V

Mechanical Characterization Techniques

Elastic and plastic deformation-mechanical properties of materials, models for interpretation of nanoindentation load-displacement curves, Nanoindentation data analysis methods-Hardness testing of thin films and coatings, Mechanical properties evaluation by universal testing machine (UTM), Dynamic mechanical analysis.

Practice-5

Evaluation of mechanical properties of material by nanoindentation technique

Practice-6

Measurement of tensile strength of material by UTM

Module-VI

Physical and Optical Characterizations of Nanostructured Materials

Introduction to particle size characterization, Zeta potential measurement – Particle size analysis, specific surface area by BET analysis, Photoconductivity.

Module-VII

Thermal and Electrochemical Characterization

Differential scanning calorimeter (DSC), Differential thermal analyzer (DTA), Thermogravimetric analysis (TGA), Electrochemical analysis (Charging-discharging cyclic voltammetry).

Reference Books:

1. ASM Handbook: Materials Characterization, ASM International, 2008.
2. Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd., 2008.
3. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994.
4. Nanotechnology-Basic Science and Emerging Technologies, Mick Wilson, Kamali Kannangra Geoff Smith, Michelle Simons and Burkhard Raguse, Overseas Press.

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1405	Synthesis and Application of Nanocomposites	3-1-0	

Objective

To provide knowledge of the advantages of using different types of nanocomposites
• To make the students familiar with the mechanism of nanocomposites
• To make them aware the manufacturing and testing methods of nanocomposites

Course Outcome

Students will understand and appreciate the significance of the nanocomposites as an important class of materials
• Students will be well equipped to design and develop nanocomposites for specialized applications
• They will be able to predict the appropriate synthesis and application for different classes of nanocomposites.

Course content

Module-I

Introduction to Nanocomposite Materials

Definition of nanocomposites, Classification based on matrix and topology, Constituent of nanocomposites, General characteristics of particle reinforced composites- classification, Terminology used in fiber reinforced composites, Core-Shell nanocomposites

Module II

Basic Constituents materials in Nanocomposites

Role and Selection of reinforcement materials, Glass fibers, Carbon fibers, Boron Fibers, Natural fibers, Multiphase fibers

Module III

Fabrication of various types Nanocomposites

Ceramic/Metal nanocomposite Systems, Nanocomposites based on polymer matrix, Carbon-carbon, Carbon-metal nanocomposites, Bio-inspired nanocomposites

Module IV

Nanocomposite Processing Methods

Nanocomposite processing: In-situ polymerization technique, Solution casting, Electro spinning, melt mixing, Filament Winding, Injection and compression molding, Pultrusion Process

Practice 1 :

Synthesis of polymer nanocomposite using solution casting techniques

Practice 2:

Preparation of different polymer blends using BIOVIA materials studio

Practice 3:

Fabrication of nanocomposite fibers using electrospinning technique

Module V

Mechanical Properties -Stiffness and Strength

Geometrical aspects – volume and weight fraction, Unidirectional continuous fiber, Determination of stiffness and strengths of unidirectional composites, tension, compression, flexure and shear

Module VI

Application of Nanocomposites I

Application of Nanocomposites in Aerospace, Coating, Mechanical, Electrical & Electronics, Fuel cell

Practice 4:

Determination of tensile properties of nanocomposite

Practice 5:

Determination of Dielectric constant for a given nanocomposite material

Module VII

Applications of Nanocomposites II

Hybrid Nanocomposite materials for food packaging, graphene-carbon nanotube nanocomposite for energy storage applications, Nanocomposites for solar cells, Nano composite materials for Lithium ion battery.

Practice 6:

Synthesis of Graphene Oxide by Modified Hummer's Technique

Practice 7:

Studies on Dye Sensitized Solar Cell

Recommended Text Books:

- Composite Polymeric Materials – Sheldon
- Lubin - Handbook of composites – (Van Nostrand, 1982)
- Carbon Nanotube and Graphene Device Physics, by H.-S. Philip Wong (Author), Deji Akinwande (Author)
- K. Chawla, Composite Materials – Science & Engg., Springer- Veslag, New York, 1988.
- Mohr - SPIE Handbook of Technology and Engineering of Reinforced Plastics/Composites – (Van Nostrand, 1998)

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1408	Synthesis Routes of Nanomaterials	3-1-0	

Objective

- To equip the students with the concepts of synthesis routes in nanoscience that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background to pursue research in Nanotechnology as a career.
- This course is intended to cover the two groups of synthesis of nanostructures namely top-down and bottom-up approach various synthesis methods, including biological methods, advantages and disadvantages etc

Course Outcome

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- The students will be exposed to various structure specific synthesis methods, their advantages etc.
- To know about Top-down to Bottom up approach techniques.
- To optimize the methods for specific material applications.

Course content

Module-I:

Introduction

Introduction to synthesis of nanostructure materials, Bottom-up approach and Top-down approach with examples-Trapped particles-Quantum dots and artificial atoms-Quantum wires and Quantum wells. Conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state.

Module-II:

Physical Methods

Inert gas condensation, RF-plasma, MW plasma, Ion sputtering, laser ablation, laser pyrolysis, ball milling, molecular beam epitaxy, electro-deposition.

Practice-1

Ball-miling method of synthesis of nanomaterials.

Module -III: Chemical Methods (I)

Chemical precipitation and co-precipitation, Sol-Gel synthesis; Microemulsions synthesis, Hydrothermal, Solvothermal synthesis methods.

Module - IV: **Chemical Methods (II)**

Microwave assisted synthesis Core-Shell nanostructure, Quantum dot (QDs) synthesis, Sonochemical, Ultraviolet, Sonication

Module-V: Thermolysis Route

Flame spray pyrolysis, Flame spray Hydrolysis, solvated metal atom dispersion, hydrothermal routes, solution combustion synthesis, reaction types, boundaries and flow, PVD, CVD.

Module VI: **Different Lithography Route**

M based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, X-ray based lithography.

Practice :2

Electron beam lithography

Module VII: Preparation of Some Special Nanomaterials:

Preparation of metal nano particles like gold, silver, Iron and Copper, different types of nanooxides, TiO_2, ZnO etc.

Practice-3

Synthesis of TiO2 nanotubes by hydrothermal method.

Practice-4

Synthesis of copper nanoparticles.

Practice-5

Synthesis of gold nano particles.

Practice-6

Synthesis of ZnO nano particles by sol-gel route.

Text Books:

1. Inorganic Materials Synthesis and Fabrication by J.N. Lalena, D.A. Cleary, E.E. Carpenter, N.F. Dean, John Wiley & Sons Inc.
2. Introduction to Nano Technology by Charles P. Poole Jr and Frank J. Owens. Wiley India PvtLtd.
3. The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I by C.N.R. Rao, A. Muller and A.K. Cheetham.
4. Fabrication of fine pitch gratings by holography, electron beam lithography and nano-imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim;Frank Shepherd.

Reference Books:

1. Encyclopedia of Nanotechnology by M.Balakrishna Rao and K.Krishna Reddy, Vol I to X,
2. Encyclopedia of Nanotechnology by H.S. Nalwa
3. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology – by T.Pradeep; Tata Mc.Graw Hill
4. Handbook of chemical Vapor deposition (cvd), Principles, technology, and applications, By Hugh o. Pierson, Second edition, Noyes publications, William Andrew Publishing, LLC.

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1409	Computational Material Science	2-2-0	

Objective

- Expose the students to the challenges in the analyses of materials and how to address those challenges
- Impart practice of developing Toy Models of Molecular Dynamics, Hartree Fock and Density Functional Theory in Python for small scale systems using various Pseudo-Potentials
- Hands-on training on open source tools in Molecular Dynamics (LAMMPS) and Hartree-Fock and Density Functional Theory (Quantum Espresso); Data Visualization Tools like OVITO and VMD

Course Outcome

A student who completes this course should be able to:

- Get an idea of the issues and challenges involved in calculations of atomic, molecular and bulk properties of materials and how to approach their resolution using open source classical and quantum mechanical tools.
- Code and execute concepts of Molecular Dynamics, Monte Carlo Methods in Molecular Dynamics and derive thermodynamic properties of materials ensuing from Classical Statistical Mechanics
- Code and execute concepts of Hartree Fock Theory and Density Functional Theory using Python and derive various molecular and bulk material properties ensuing from electronic structure calculations involving Quantum Mechanics and Quantum Statistics
- Use open source software like LAMMPS, Quantum Espresso, OVITO and VMD for analysis and visualization of various types of materials and their properties

Course content

Module-I

Models of Molecular Interactions:

Model Van der Waals interaction potentials between neutral atoms and molecules: The

Lennard-Jones potential, Other Van der Waals Interactions: the Buckingham Potential, the

Stockmayer Potential

Practice (1 hour sessions):

1. Understanding the Lennard-Jones (LJ) Potential and its Parameters
2. Python simulation of Equation of State of Ideal Gases using LJ Interaction
3. Python simulations of Equation of State of Ideal Gases with Buckingham and Stockmayer Potentials

Module-2

Molecular Dynamics

Molecular Dynamics theory and numerical implementation, Statistical Ensembles and Molecular Dynamics, Diffusion and Osmosis.

Practice (1 hour sessions):

4. Thermodynamics of a Real Gas using LJ potential using Python
5. Introduction to Molecular Dynamics in LAMMPS; Visualization using OVITO & VMD
6. Simulation of Diffusion in LAMMPS
7. Simulation of Osmosis using LAMMPS

Module-3

Monte Carlo Methods

Monte Carlo Simulations, Metropolis algorithm, 2D Ising Model and its simulation, Phase Transitions, Monte Carlo Grand Canonical (MCGC) simulation of Lennard Jones (LJ) Fluid Flow and Heat Transfer

Practice (1 hour sessions):

8. Introduction to Monte-Carlo-Metropolis Algorithm: Python Implementation
9. Simulation of 2D-Ising Model using Monte-Carlo-Metropolis algorithm
10. Simulation 0f Phase Transitions Using LAMMPS
11. Simulation of Lennard-Jones (LJ) Fluid Flow Using LAMMPS
12. Thermal Conductivity and Viscosity simulation using LAMMPS

Module-4

Hartree Fock Methods:

The Variational Principle, The Hartree Approximation, The Hartree-Fock Approximation, Electron Density Distribution in Many-Electron atoms and simple Di-atomic molecules, Beyond HF Theory: Coupled Cluster Approximation

Practice: (1 hour)

13. Introduction to Hartree Fock Implementation in Python
14. Creation of data files and running the HF code
15. Electron Density Distribution in H, He, Li atoms
16. Electron Density Distribution in simple diatomic molecules: H_2, N_2, O_2, CO

Module-5

Density Functional Theory-I

Introduction to Density Functional Theory, The Hohenberg-Kohn Theorems, The Kohn-Sham Theory, Numerical Implementation

Module-6

Extensions of Density Functional Theory

The Local Density Approximation (LDA), The Generalized Gradient Approxiamtion (GGA) , Meta GGA, Adiabatic Connctions-Hybrid Orbitals, Perdew–Burke-Ernzerhof (PBE) Approximation, the Born-Oppenheimer Molecular Dynamics (BOMD), the Car-Parrinello Molecular Dynamics (CPMD)

Module-7

Designing Materials with Quantum Espresso

Introduction to Quantum Espresso: Modules and Possibilities

Practice (1 hour sessions)

17. Introduction to Quantum Espresso software: Implementation of DFT
18. Loading Data Files and Execution of Quantum Espresso; Interpretation of Output
19. Ground State Electron Density Distributions in C, N, O using LDA
20. Ground State Electron Density Distribution in C, N, O, Si using GGA, Meta GGA, PBE
21. Ground State Properties of Simple Molecules like N_2, O_2, H_2O, CO_2
22. Material Property Simulations in DFT with LDA/GGA/Meta GGA/PBE and their various combinations
23. Liquid-Gas Phase Transition Simulations in Born-Oppenheimer Molecular Dynamics
24. Liquid-Gas Phase Transition Simulations in Car-Parrinello Molecular Dynamics

Text Books:

1. Introduction to Computational Materials Science, Richard LeSar, (Cambridge University Press, 2016).
2. Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory. Attila Szabo, Neil S Ostlund. (Dover Publications Inc. 1996)

Reference Books and Online Materials:

1. Computational Materials Science: An Introduction. June Gunn Lee, (CRC Press, 2011)
2. For detailed calculation of van der Waals's forces/ Lennard-Jones Potential: https://www.youtube.com/watch?v=SntXBOUj5AE
3. Modeling materials using density functional theory. John R Kitchin. http://kitchingroup.cheme.cmu.edu/dft-book/dft.html
4. Practical Introduction to Hartree-Fock Algorithm using Python. Laksh, https://medium.com/analytics-vidhya/practical-introduction-to-hartree-fock-448fc64c107b
5. LAMMPS Tutorial. (A set of 13 Videos Distributed by Wanying Pang). https://www.youtube.com/watch?v=GXA2PyqKYdY&list=PLhjeNfGGtHcNRKdDn6iVxWGSVa4iqtW_Q
6. Tutorial on Diffusion, Calculation of Diffusivity..: https://www.youtube.com/watch?v=k-vzqUBYF8k
7. Tutorial on Monte Carlo Simulation: https://www.youtube.com/watch?v=GMCFVEfupDA
8. Molecular Dynamics simulation of Carbon Nanotubes in water: https://www.youtube.com/watch?v=9GbjlSqY4Vk
9. Ab-initio Green-Kubo Simulation of Thermal Transport in Liquids and Glasses. https://www.youtube.com/watch?v=9OkBHoZLBYg
10. Introduction to Density Functional Theory. Nicola Marzari.https://www.youtube.com/watch?v=kYxOWYWxYcQ

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1415	Industrial Chemicals	3-0-1	

Objective

To make the students well-grounded in the detail of chemicals and thorough knowledge of scientific techniques and the application of chemicals in market oriented and product oriented industry

Course Outcome

- Students will able to acquire a meaningful picture of Chemical industries and prepare for professional participation in Chemical industries so as to adapt themselves to jobs which are problem solving. After learning the subject, Students will be result-oriented and product oriented in the chemical, petrochemical, biochemical and allied technological fields.

Course content

Module –I (7 Hours)

Plastic Additive

Plasticizers, flame retardants, antioxidants, acid scavengers, light and heat stabilizers, lubricants, pigments, antistatic agents, slip compounds and thermal stabilizers, plastic resins and application

Project

- *Preparation biopolymer plastic and study the self life of vegetable, fruits and meat.*
- *Study of the physical, chemical, mechanical and biological properties of the prepared plastic additive.*

Module-II (6Hours)

Specialty Chemicals

Industrial Catalysts, paints, dye stuffs and pigments, personal care ingredients, uses and its effect in health, , food additives, fragrance and flavors ,preservatives,

Project

- *Synthesis and characterization of photocatalyst and its application towards organic dye degradation*
- *Synthesis of materials and its application towards UV protective textile material.*

Module-III(6Hours)

Market Directed Specialty and Fine Chemicals

Construction chemicals (Admixtures, Waterproofing, Flooring chemicals), electronic chemicals (Semiconductors and IC process chemicals – Printed circuit board chemicals and semiconductor packaging materials), application towards semiconductor and electronic device fabrication

Project

Synthesis of Silver/PMMA/Chitosan/ZnO nanocomposite film preparation for packaging application and preservatives.

Module-IV(6 Hours)

Extraction and isolation of Fine Chemicals

Extraction(Solid/Liquid, Liquid/Solid, Acid/Base), isolation, purification, recrystallisation , fermentation, membrane filtration, molecular distillation, gas and supercritical fluid chromatography for the separation of chemicals ,

Projects

- *Study on cosmetic formulation materials by using biovia and application on the area of UV –VIS blocking properties.*
- *Extraction and phytochemicals analysis of plant product and study its biological activity.*

Module-V(6 Hours)

Selected Industrial process

Raschig Process for production of hydroxylamine (nylon,textile). electrolysis, chloralkali Process for chlorine production, polymerization Processes, trans-esterification for organic chemical synthesis, crystal growth techniques for semiconductor material like Bridgeman techniques, Czochralski Process), additive manufacturing.

Project

- *Trans-esterification of vegetable oil and alcohol to produce ethyl acetate (Biodiesel) and calculate the efficiency*
- *Polythene from ethylene and polypropylene by simulation tool and its application*

Module-VI (6 Hours)

Management and treatments of Waste chemicals

Minimization of VOC emission, segregation of waste water stream, azodye catalytic degradation. Re-use and recycling of solvents and by-products

Project

Analysis of supplied waste water by chemical catalytic degradation and biological process.

Module-VII (6Hours)

Sustainable chemicals market and chemical safety

Global commodity chemicals market, sustainability in chemicals and chemical industry, future of bio-based chemicals, chemical safety; risk and concerns,

Book Suggested:

1. *Industrial Chemicals: Their Characteristics and Development by G.Agam ,2003*
2. *Industrial Chemistry – B.K. Sharma (Goel Publishing House, Meerut)*
3. *Analytical Chemistry (Sixth Edition) by Gary D. Christian, University of Washington ,John Wiley and Sons Inc. in 2004.*
4. *Analysis and Purification Methods in Combinatorial Chemistry is edited by Bing Yan and published by Wiley Intersciences in 2004*

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1417	Polymer Chemistry	3-1-0	

Objective

- To understand the importance of the chemical approach to polymers and the subject provides an introduction to polymer science with respect to synthesis, polymerization kinetics and network formation/gelation of macromolecules formed by step-growth and chain-growth polymerization.
- To Study the, methods of measuring the molecular weight, polymerization kinetics and Copolymerization and polymer processing technologies.
- To understand about radical and ionic polymerization and techniques of polymer analysis.
- To study mechanical properties and applications of polymers.

Course Outcome

- Students will understand about the basics of polymer and the differences between crystalline melting temperature and glass transition temperature, as well as the effect of kinetics on both.
- Students will develop specific skills, competencies, and thought processes sufficient to support further study or work in this field of Polymer Chemistry.
- Students will be able to evaluate the effect of factors such as polymer structure, molecular weight, branching and diluents on crystallinity.
- Students will also able to about the mechanical properties and applications of polymers

Course content

Module I: Fundamental (7 hrs)

Introduction of polymers; Degree of polymerization; Concept of molecular mass, polydispersity; Glass transition temperature (T_g) and melting point T_m; Factors affecting T_g and T_m, Importance of T_g.

Practice 1

Determination of molecular weight of polymer by Viscosity

Module II: Copolymerization (7 hrs)

Introduction of copolymerization; Types of copolymers; Copolymer composition; Methods of determination of reactivity ratios and copolymerization behavior; Kinetics of copolymerization.

Practice 2

Synthesis of Nylon

Module III: Radical Polymerization (7 hrs)

Introduction to Radical Polymerization; Kinetics of Radical Polymerization; Ziegler-Natta Catalysis: Stereochemistry of Polymers.

Practice 3

Free Radical Polymerization of Styrene

Practice 4

Preparation of Polyvinyl Chloride

Module IV: Ionic Polymerization (5 hrs)

Comparison of Radical and Ionic Polymerizations; Cationic Polymerization; Anionic Polymerization; Ring Opening Polymerization; End Group Functionalization.

Module V: Conducting Polymers (6 hrs)

Structural characteristics - Charge carriers and conducting mechanism; Classification of conducting polymers: Intrinsic and extrinsic conducting polymers; Chemical and Electrochemical methods of the sysnthesis of conducting polymers; Applications of conducting polymers.

Practice 5

Synthesis of polyurethane foam

Module VI: Analysis of Polymers (4 hrs)

Introduction and instrumentation; Applications of Differential thermal analysis (DTA); Thermogravimetric analysis (TGA); Differential scanning calorimetry (DSC) and Dynamic Mechanical Analysis (DMA); Determination of Mechanical Properties.

Module VII: Application of Polymers (6 hrs)

Processing of Polymer; Application of polymer in Elctronics; Application of polymer in cosmetics; Application of polymer in Medicine.

Practice 6

Synthesis of Polymer Nanoparticles

Text Books:

1. Principles of Polymerization, Fourth Edition – George Odian
2. Gedde Ulf. W. Polymer Physics, Chapman & Hall London (1995)
3. Rodriguez, Ferdinand, Principles of Polymer Systems Mc. Craw – Hill, International Book Co. International Student Edn. 1985.

Reference Books:

1. Cowie; JMG Polymers: Chemistry & Physics of Modern Materials, Nelson Thornes ltd.Chelterham, 2001
2. Hiemenz; Paul C. Polymer Chemistry- The Basic Concepts; Marcell&Deckker, Inc. New York (1984)
3. Polymer Science by V.R.Gowarikar, N.V.viswanathan and J.Sreedhar, New Age International.
4. Text book of Polymer science: F.M.Billmeyer, John wiley and sons.

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Course Outline

Code	Course Title	T-P-P (Credit)	Prerequisite
CUTM 1419	Industrial Pollution and its Management	3-1-0	

Objective

- *To create the knowledge among students with respect to the subject and it's possible applicability.*
- *To encourage understanding of basic and advanced concepts in Industrial pollution aspects and waste water treatment technologies.*
- *To expose the students for different processes used in industries and in research field.*
- *To grow skills required in various industries, research labs and in the field of human health.*
- *To develop the students to accept the challenges in industrial sectors.*

Course Outcome

- *To gain an understanding of scheme, legal requirements and appropriate mitigation and treatment technologies for industrial pollution control.*
- *To learn the process design of selected treatment technologies.*
- *To promote the solution of open-ended, multi-disciplinary problems typically found in industrial settings.*
- *To explain principles of physical/chemical/biological treatment processes*

Course content

Module-1: Fundamentals of pollution (7 hr.)

Hazardous Waste Regulations and Hazardous Materials, Climate change, Composting, Conservation, Air pollution, water pollution, thermal pollution, soil pollution, water pollution control, Noise pollution, Ecosystem ecology

Module 2 Water quality standard (4 hr.)

Drinking Water quality standard, Introduction to Irrigation Water Treatments, Stream standard and effluent standard, Characterization of Municipal waste water.

Practice 1: Water analysis-Determination of Chemical parameters

Practice 2: Water analysis-Determination of Physical parameters

Practice 3: Turbidity Measurement

Module 3 Methods of treatment of waste water (3 hr.)

Water treatment sewage plant, process with primary treatment aeration settling tank to chlorination and filtration, Learn the basics of water filtration, softening, desalination and disinfection for small to medium sized water supplies. Secondary treatment, Tertiary treatment methods for waste water treatment

Practice 4: Determination of Dissolved oxygen in water sample

Practice 5: Determining the chloride content in given water sample using mohr's method

Practice 6: Analyzing water samples for total phosphorous

Module 4 Air pollution and its Permissible limit (3 hr.)

National Ambient Air Quality Standards for Ozone, Air Pollution Control Devices, Measuring Particulate Matter in Air.

Module 5 Solid waste disposal and Management (4 hr.)

Industrial Solid waste disposal, Municipal Solid waste disposal and Management, Introduction to waste disposal, Soil Pollution: Fertilizers and Pesticides, Understanding Water and Waste Management

Module 6 Industrial Waste Water Treatment (5 hr.)

Water and Wastewater Treatment Engineering, Water Quality Control, Desalination and Water Purification, Cellular Garbage Disposal, Biological Treatment of Wastewater: Activated Sludge Process, Anaerobic treatment processes, Bio filters for biological odor control

Module7 Industrial water and air pollution (4 hr.)

Pulp & Paper Industry, Sugar Industry, Iron and steel Industry, Textile Industry, Coal-based Thermal Power Plants, Aluminium smelter, Cement industry, Batteries industry.

Reference Books:

1. Industrial Pollution and Management, **Arvind Kumar**, Aph Publishing Corporation.

2. Environmental Pollution by Chemicals - Walker, Hulchiason.

3. Biochemistry and Microbiology of Pollution - Higgins and Burns.

4. Environmental Pollution - Laurent Hodge, Holt.

5. Waste Water Treatment - Datta and Rao (Oxford and IBH).

6. Sewage and waste treatment – Hammer

7. Environment and Metal Pollution - Khan (ABD Pub. Jaipur).

8. Environment Pollution - Timmy Katyal (Satke Anmol Pub. New Delhi).

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1421	**Biopolymer and Hydrogel**	(3-1-0)	

Objective:

- To introduce students to various classes of biomaterials
- To develop understanding regarding the characteristics of the materials to be used as biomaterials
- To develop the understanding regarding the various applications of biomaterials.

Course Outcome*:*

- Students will get introduced to different classes of biomaterials and their applications
- The vast applications of biomaterials will encourage students to explore them in detail and to design and engineer synthetic and natural materials for biomedical applications
- The course would also enable the students to appreciate the role of tissue engineering as a tool to enhance the quality of life

Course content

Module-I (Fundamentals of biopolymers) (7 hrs)

Definition of biopolymers and types of biopolymers, Definition of bioplastics and types of bioplastics, Description of certain biopolymers like starch, cellulose, chitosan, gelatin, alginate, keratin, fatty acids, lipids, aliphatic polyesters (PLA, PHB), Cellulose derivatives and cellulose regenerating processes, Bio based composites from Soybean oil and Chicken feathers

Practice: Preparation of cellulose nanocrystals from raw cellulose

Module-II (Polymer biodegradation and biocomposites) (5 hrs)

Natural biodegradable polymer, synthetic biodegradable polymer and modified naturally biodegradable polymer, Testing methods of biodegradability [polymer-Enzyme assays, Plate test, Respiratory test, Gas evolution test (CO_2 & CH_4)], Use of biopolymers in composite and bioplastic formation and their application in packaging and medical industries

Practice: Investigation of rate of biodegradation of any sample (biopolymer) through anerobic condition

Module-III (Basics of biomaterials) (6 hrs)

Concept of biocompatibility and responsiveness, Technically important form of polymers (Hydrogel, bioceramics, bioelastomers and membranes), Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness and wear resistance) of biomaterials, Polymers used as biomaterials (Silicon rubber, Dacron, poly(methyl methacrylate, polyurethane and cellulose) and their application

Practice: Preparation of peptide hydrogel

Module-IV (Surface modification and characterization of biomaterials) (4 hrs)

Surface modification by the use of Corona discharge and plasma processes, Surface modification with polymer coatings, Bulk analysis methods applied to the study of Biomaterials (XRD, FTIR, DSC, TGA etc), Surface analysis methods applied to the study of biomaterials (SEM, AFM, etc.)

Module-V (Synthesis and Characterization of hydrogels) (6 hrs)

Introduction to hydrogel and brief historical overview, Classification of hydrogels based on origin, type of interaction, and ionic/non-ionic characteristics, Different types of gel forming techniques (Physically and chemically cross-linked hydrogels), Characterization of hydrogel by SEM, FTIR, 13-C NMR and BET/mercury porosimetry

Practice: Preparation of thermo-reversible agarose hydrogel for gel electrophoresis technique

Module-VI (Properties of Hydrogels) (7 hrs)

Evaluation of swelling behaviors of hydrogels (Swelling capacity and water retention capacity) and kinetic analysis, Effect of pH, ionic strength and temperature on swelling properties of hydrogels, Relationship between morphology and swelling properties, Mechanical and rheological properties of hydrogel, Mechanical properties of interpenetrating (IPN) and multi-networking hydrogel

Practice: Shear rheometric test on polyacrylamide hydrogel

Module-VII (Applications of Hydrogels) (7 hrs)

Introduction to hydrogel drug delivery systems, Targeted drug delivery and controlled delivery systems (pH responsive and glucose responsive delivery), Kinetics of Drug Diffusion through hydrogels, Hydrogels for bone replacement, artificial organs, dental applications, Hydrogel in agricultural application (controlled delivery of water and micronutrients)

Practice: Drug delivery via hydrogel beads

Text Books:

1. *B. Ratner, A. Hoffman, F. Schoen, J Lemons, Biomaterials Science: An introduction to materials in Medicine. 2nd edition, Academic Press, 2004.*
2. *S. Dumitriu, 2nd edition, Polymeric Biomaterials. Marcel Dekker, 2002*
3. *C. T. Laurencin, L. S. Nair, Nanotechnology and Tissue Engineering, The Scaffol, CRC Press, 2008*

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1422	**Nano-Pharmaceuticals and Bio-Medical Science**	3-0-1	

Objective

- To obtain a hands-on experience in converting a small novel idea / technique into a working model / prototype involving multi-disciplinary skills and / or knowledge and working in at team.

Course Outcome

- *To conceptualize a novel idea / technique into a product or paper*
- *To think in terms of multi-disciplinary environment*
- *To understand the management techniques of implementing a project*
- *To take on the challenges of teamwork, prepare a presentation in a professional manner, and document all aspects of design work*
- *To bridge the gap between industry and academia and they can pursue their dream in either directions.*

Course content

Module I: Nanotechnology in Food and pharmaceutical industry (6h)

Nanotechnology in Food and pharmaceutical industry: Nano particle-based drug delivery systems, Regenerative medicine, nano-immuno conjugates, Bio-availability and delivery of nutraceuticals and functional foods using nanotechnology, Polymer-based nano-composites for food packaging, nano-composites for food packaging, Toxicity and environmental risks of nano-materials

Assignment 1: Nano-composites for food packaging, Toxicity and environmental risks of nano-materials

Module II: Nanotechnology in Biomedical and Pharmaceutical Industry (6h)

Nanotechnology in Biomedical and Pharmaceutical Industry: Tissue engineering/regenerative medicine, Nano-robotics in surgery, Nano-tools for early detection diseases, Nano-medicine for cancer treatment

Assignment 2: Tissue engineering/regenerative medicine

Module III: Nanotechnology in Agriculture (6h)

Nanotechnology in Agriculture: Introduction of Nanotechnology in agriculture, Potential of nano-fertilizers, Precision farming, smart delivery system, Insecticides using nanotechnology

Assignment 3: Smart delivery system

Module IV: Molecular Cell Biology (6h)

Molecular Cell Biology: Cell- Structure & Function of Cell Membrane, Different cell types and their Functions, Sub-cellular Organelles and their Functions, Nucleotide- Structure and Functions of DNA & RNA. Biologically important nucleotide, protein synthesis, unnatural amino acid, Mechanistic understanding of various diseases and target identification for early detection

Assignment 4: Cell culture techniques and Visualizing cell organelles using fluorescent probes

Module V: Optical and non-optical probes (6h)

Optical and non-optical probes: Introduction to Fluorescence, Designing of Organic and in-organic Fluorophores and study of photo-physical properties, Synthesis of Nano and bio-probe, study of sensing properties, Chemistry of Non-optical probe: PET and MRI probe

Assignment 5: Understand the concept of fluorescence using laser light and Synthesis of Fluorescein dye

Module VI: Protein Labelling and bio-medical applications (6h)

Protein Labelling and bio-medical applications: Affinity based protein labelling, Labelling of protein through unnatural amino acid, Diagnostic Probe for early detection of diseases and bio-analytes

Assignment 6: Fluorescent Labelling of proteins for Live Cell Imaging

Module VII: Target Identification and Drug designing (8 h)

Target Identification and Drug designing: High-Throughput Screenings, Affinity matrix approaches: On-bead affinity matrix, Biotin tags in affinity matrix, Fluorescent tags in affinity matrix, Photo-affinity tags in affinity matrix, Drug western approaches, Three-hybrid system approaches, Three-hybrid system approaches: Yeast three-hybrid systems, Mammalian three-hybrid systems, Phage display approaches, mRNA display approaches, Protein micro-array approaches, Drug affinity responsive target stability (DARTS)

Assignment 7: A practical approach to antibody labelling

Reference Books:

1. Berg, J.M., Tymoczko, J. L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
2. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
3. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1423	Synthetic Organic Chemistry	3-1-0	

Objective

- To understand various reagents and rearrangements and their mechanism involved in various reactions.
- To understand and explain the stereochemical aspects of organic compounds and stereoselective reactions
- To understand how to design complex molecules by retrosynthetic methods

Course Outcome

After finishing the course the student will gain:

- Expertize in rearrangements reactions and the mechanism involved.
- Expertize in writing conformational structures.
- Expertise in designing and planning synthesis of complex molecules

Course content

Module I

Fundamentals **(4Hrs)**

Delocalized chemical bonding, Conjugation, Cross conjugation, Resonance, Hyperconjugation, Bonding in fullerenes, Tautomerism

Frost circle, Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule, energy levels of pi-molecular orbitals of simple systems.

Generation, structure, stability and reactivity ofcarbocations, carbanions

Generation, structure, stability and reactivity of Free radicals, carbenes and nitrenes.

Module II

Organic Reagents **4Hrs)**

Oxidising agents

Reducing agents

Organometallic reagents

Transition metal reagents

Practice (1 Hr)

1. Preparation of dibenzalacetone by Aldol Reaction

Module III

Molecular Rearrangement **(5Hrs)**

Rearranments: Rearrangement to electron deficient carbon: Pinacol-pinacolone, Wagner-Meerwein, Benzillic acid and Demjanov rearrangement

Rearrangements electron deficient nitrogen: Hofman, Curtius, Schimdt, Lossen and Beckmann rearrangement

Rearrangement electron deficient oxygen: Baeyer Villiger rearrangement
Rearrangements to electron rich carbon: Fovorskii, Wittig, Neber, Steven's and Sommelet Houser rearrangement
Aromatic rearrangements: Fries, Clasisen and Benzidine rearrangement and Free radical rearrangements

Practice **(4 Hrs)**
2. Preparation of Benzopinacolone from Benzopinacol
3. Benzil to benzilic acid preparation solvent free green synthesis

Module IV **(4Hrs)**
Stereochemistry
Coformational Isomers of cyclohexane
Cofigurational Isomerism
Absolute and relative stereochemistry
Atropisomerism
Practice **(4 Hrs)**
4. Cis-trans isomerism of alkene
5. Resolution of racemic phenylsuccinic acid

Module V **(5Hrs)**
Photochemistry
Electronic transitions
Photochemical reactions
Photochemical reductions
Photochemical rearrangement
Asymmetric Synthesis

Module VI **(4Hrs)**
Pericyclic Reaction
Woodward Hoffman rule, FMO theory
Electrocyclic reactions
Cycloaddition reactions
Sigmatropic and group transfer reactions

Module VII
Retrosynthesis **(4Hrs)**
Retrosynthetic Terminology
Retrosynthetic Guidelines for aromatic compounds
One group and two group disconnection methods
Examples of synthetic planning using retrosynthetic strategy
Practice **(2 Hrs)**
6. Synthesis of Aspirin

References:
March's Advanced Organic Chemistry: Reactions, mechanisms, and structure; Michael B. Smith and Jerry March; 6th edition; *Wiley-Interscience A John Wiley & Sons, Inc., Publication*
Organic Chemistry; Jonathan Clayden, Nick Greeves& Stuart Warren; 2nd Edition; *Oxford University Press*

Pericyclic Reactions: A Mechanistic and Problem-Solving Approach; Sunil KumarVinod Kumar P. Singh; 1st Edition
Pericyclic Reactions and Organic Photochemistry; Vinay P. Sharma, Rakesh Kumar; 1st Edition; *PragatiPrakashan*

Note: 1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester

Code	Course Title	T-P-P (Credit)	Prerequisite
CUTM1424	Energy Storage System	3-0-1	UG level Chemistry and Physics

Objective

- To provide a foundation for understanding the general principles and fundamentals of Li-Ion battery technology design and operation.
- To understand the expectancy of the hydrogen as a fuel and energy vector in the context of the renewable energy without CO_2.
- To learn basic electrochemical principles of the hydrogen fuel cells, basic fuel cell design concepts, fuel cell systems concepts.

Course Outcome

After successful completion of this course, students will be able to:

- State the various parts of the battery and their functions.
- Describe discharging and charging process of a lithium ion battery.
- Describe the components of a fuel cell and explain the purpose of each one.
- Explain and analyse dynamic fuel cell behaviour.
- Understand - how fuel cells are used for every day purposes: road, water and air transport vehicles, portable and stationary use.

Course content

MODULE-I (2Hr.)

Battery technology Overview: Battery definitions, terms and terminology, Battery types and their properties.

MODULE-II (4Hr.)

Introduction to lithium ion battery, Components, functions, advantages and disadvantages of lithium-ion batteries, Growth & development of Li-Ion batteries, charging procedures, Safety of lithium-ion batteries, Lifetime.

Project-1: Basic Structure and fabrication of Lithium-ion Battery. **(Assignment)**

Project-2: Working principle of Lithium-ion Battery. **(Assignment)**

MODULE-III (6Hr.)

Types of lithium ion battery: Lithium Cobalt Oxide (LCO), Lithium Iron Phosphate Battery (LFP), Lithium Manganese Oxide (LMO), Lithium Nickel Cobalt Aluminium Oxide (LNCA), Lithium Nickel Manganese Cobalt Oxide (LNMC), Lithium Polymer Battery, Lithium Polymer Battery technology, Difference between the lithium ion and lithium polymer.

MODULE-IV (6 Hr.)

Applications of Li-ion battery: i. Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements. ii. Automotive Applications- Drive Cycles, SLI (starting, lighting and ignition) batteries, Start-Stop (Micro) Hybrids, Power Assist Hybrids, Plug-In Hybrids, BEVs.

Project-3: Improvements in battery technology offer a valuable storage solution for renewable energy/ Benefits of Li-Ion battery. **(Assignment)**

MODULE-V (4Hr.)

Fuel Cells: Introduction to fuel cells, components of fuel cells, Types of fuel cells: Alkaline fuel cells, proton exchange membrane fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell.

Project-4: Energy generation technology in fuel cell. **(Assignment)**

Project-5: Hydrogen powered fuel cell technology. **(Assignment)**

MODULE-VI (3 Hr.)

Solid oxide fuel cell, Types of solid oxide fuel cells: High temperature, intermediate temperature Single chamber solid oxide fuel cells.

Project-6: Modelling of solid-oxide fuel cell. **(Assignment)**

MODULE-VII (5Hr.)

Working Principle and Application of fuel cells: working principle of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, description of some commercially available fuel cell stacks, fuel cell cars and buses, overview on research activities.

Text Books:

1. Lithium-Ion Batteries Basics and Applications by Reiner Korthauer, Springer.
2. Lithium-Ion Batteries Science and Technologies by Ralph J. Brodd (auth.), Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa (eds.), Springer.
3. Lithium-ion Batteries Fundamentals and Applications. by Wu, Yuping, CRC Press, Taylor and Francis.

4. O'hayre, S.W. Cha, W.G. Colella, F.B. Prinz, Fuel Cell Fundamentals, 3rd edition, Wiley publisher.
5. High-temperature Solid Oxide Fuel Cells for the 21st Century, Second Edition Fundamentals, Design and Applications by Kendall, Kevin Kendall, Michaela.
6. Fuel cells from fundamentals to applications by Supramaniam Srinivasan, Springer.

Recommended Books:

1. Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.
2. Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
3. Lithium ion rechargeable batteries by edited by Kazunori Ozawa, Wiley.
4. E. Lipman, A. Z. Weber, Fuel Cells and Hydrogen Production, A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, Springer reference.
5. Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and design by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, CRC press

Code	Course Title	T-P-P	Prerequisite
CUTM1425	Sustainable Chemistry	3-1-0	

Course Objectives

- To learn the fundamental philosophy and the latest developments in sustainable chemistry.
- To understand why solvent replacements are being sought.
- To familiarize with different green reaction alternatives of conventional reaction procedures with real world applications.
- To understand how waste biomass can be converted to wealth.
- To understand importance of recycling and its application in circular economy

Course Outcome

After completion of the course:

- Will be able to understand the necessity of sustainable chemistry.
- Could synthesize green solvents for sustainable development.
- Can plan a synthesis with less hazardous chemicals and processes
- ***should have knowledge and understanding of how value-addition could be done to waste biomass and other waste products.***

Course Content

Module I **(4 Hrs.)**

Fundamental:

Basic Concepts of Sustainable Chemistry; Sustainability assessment; Essentials of sustainable chemistry; Role of chemistry in sustainability.

Module II **(4 Hrs.)**

Green Chemistry:

Principles of green chemistry; Designing safer chemicals, predict the properties and environmental aspects before synthesis; Use of catalysts, to reduce time and energy demands, minimize waste; Design for energy efficiency, least energy intensive route for synthesis.

Module III **(4 Hrs.)**

Green Solvents:

Atom economy, metathesis; Ionic liquids, classification, synthesis & applications; Deep eutectic solvents, classification, synthesis & applications; Supercritical fluids, preparation and various applications.

Practice 1: Ionic liquid synthesis

Practice 2: Deep eutectic solvents preparation

Practice 3: Supercritical fluids

Module IV **(5 Hrs.)**

Green Synthetic Methods:

Safer Chemical Design; Green Chemistry Molecular design pyramid, Example of failed chemical design (thalidomide), Safer Chemical Design examples. Green alternative of conventional synthetic methods; Green catalysis (Phase Transfer Catalysts, Chitosan, enzymes), solvent free reactions, Microwave assisted reactions, Examples of Green Synthesis-Ibuprofen. Industrial Green Improvements of Consumer Products; Vitamin C Synthesis using enzymes (Hoffman La Roche), Zoloft -Presidential Chemistry Award Winning Innovation (Pfizer), Methyl Methacrylate syngas process (Eastman Chemicals). Real world applications of green chemistry: Award winning discoveries

Practice 4: Green synthesis of nanoparticles (Au/Ag/Cu) using leaf extracts.

Practice 5: Green synthesis of Nylon precursor adipic acid

Practice 6: Solvent-Free Wittig Reaction

Module V **(5 Hrs.)**

Value addition to Waste Biomass:

Renewable Feed stocks; Types of biomass derived fuels & energy, biogas, bioethanol, biodiesel; Thermochemical conversion, gasification pathway, pyrolysis pathway; Biochemical Conversion, anaerobic digestion, fermentation.

Module VI **(4 Hrs.)**

Sustainable materials:

Application of Renewable Raw Materials in organic synthesis: Historical developments-Alizarine, Indigo and Coniine synthesis. Application of Renewable Raw Materials in synthesis: Synthesis of (±)-Usnic acid from lignin, tetracyclin antibiotics from Chitin derived L-Rednose, (−)-Bissetone and (−)-palythazine from cellulose derived glucose. Biodegradable polymers (PEF, PLA, PBS and PHA) and their applications. Synthesis of biodegradable polymers.

Module VII **(4 Hrs.)**

Recycling and circular economy:

Plastic recycling in circular economy. Sustainable packaging. Life Cycle Analysis (LCA), Cradle to grave and Cradle to Cradle design. Circular economy: Examples and success stories.

Text Books:

1. ***New trends in Green chemistry: V. K. Ahluwalia, M. Kidwai Anamaya Publishers***
2. ***Introduction to Green Chemistry: Albert S. Matlack, 2nd edition, CRC Press***
3. ***Waste to Wealth-The circular economy advantage: Peter Lacy and JakobRutqvist, Ma Editions***
4. ***Green Solvents-Ionic Liquids: Paul T. Anastas (Series Editor), Peter Wasserscheid, Annegret Stark, Wiley-VCH***
5. ***Sustainable chemistry: G. Reniers and C.A Brebbia, WIT Press***
6. ***Valorization of biomass to value added commodities: Daramola, Michael, Ayeni, and Augustine (Eds), Springer***

Note: 1 credit theory= 10 hours; 1 credit practice/project= 12.5 hours

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1426	Analytical Techniques	3-1-0	Nil

Objective

- To reinforce chemical principles central to analytical chemistry.
- To introduce instrumental techniques for chemical measurement.
- To develop critical thinking for interpreting analytical data.
- To select instrumentation appropriate to the measurement need.
- To gain an insight into the key methodologies used

Course Outcome

- Students who complete this class will understand that analytical instruments are not black boxes, but rather complex tools whose utility depends in detail on how analysts both configure and apply them.
- Students will learn facts about major classes of instruments commonly used in chemical analysis. Their knowledge will be captured by the ability to block diagram these complex pieces of equipment, and tailor the specifications to the measurement needs.
- Analysts will develop the ability to apply calibration curves, internal standards and the method of standard addition as needed for various measurement problems.
- Can Use sample data obtained from spectrochemical techniques to calculate unknown concentrations or obtain structural information where applicable.
- Able to describe the various chromatographies described within this course and analyze a given chromatogram

Course content

Module-1 **5hrs**

Basic Tools of Analytical Methods: Chemical Measurements and Analytical tools,Experimental Error,Statistics and Quality Assurance,Chemical Equilibrium,Sample Preparation

Practise-1: Gravimetric Analysis of SULFATE as Barium Sulfate

Practise-2:Determination of the Concentration of Acetic Acid in its Commercial Solution (Vinegar)

Practise-3: Determination of the Concentration of Citric Acid in Commercial Soda

Practise-4: Determination of Number of Particles of Water Crystallization in Borax

Module-2 **6 hrs**

Chemical Equilibria for Quantitative Analysis-I: Gravimetric Analysis, Systematic Treatment, Monoprotic Acid-Base Equilibria, Polyprotic Acid-Base Equilibria, Acid-Base Titrations, Complexometric Titrations

Module-3 **4 hrs**

Electrochemical Analysis: Effects of Electrolytes, Fundamentals of Electro chemistry , Potentiometry and Conductometry, Redox Titrations

Module-4 **3 hrs**

Spectrophotometry: Fundamentals of Spectrophotometry, Applications of Spectro photometry ,Spectrophotometers

Module-5 **3 hrs**

Molecular analysis by Spectroscopy: Analysis by uv vis spectroscopy, Infrared Spectroscopy Analysis, NMR Spectroscopy analysis

Practise-5: Study of kinetics of a reaction by using spectrophotometric method

Module 6 **4 hrs**

Spectrochemical Analysis: Atomic absorption Spectroscopy, Mass Spectrometry, Vibrational spectroscopies, Electronic and optical sensors

Module-7 **5 hrs**

Analytical Separations: Introduction to Analytical Separations, Gas Chromatography, Liquid chromatography, High-Performance Liquid Chromatography, Electrophoresis Analyses

Practise-6: Separation of Amino Acids by Thin Layer Chromatography

Text Books

1. Instrumental Methods of analysis- Willard, Merrit, Dean and Settle.
2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler
3. Spectroscopic methods in organic chemistry- D.H. Williams and I. Fleming
4. Absorption spectroscopy of organic molecules- V.M. Parikh
5. Applications of spectroscopic techniques in Organic chemistry- P.S. Kalsi
6. A Text book of Qualitative Inorganic Analysis- A. I. Vogel
7. Physical Methods in Inorganic Chemistry (DWAP)- R. Drago
8. Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West (Holt Rinehart and Winston Inc

Source of reference; EdX, Coursera, Udemy, MIT open course

Note: *1 credit theory=10 hrs lecture, 1 credit practice/project=12.5 hrs lab/workshop/field work in a semester*

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM2379	Phytochemistry & Toxicology	3-1-0	

To know the techniques of isolation, purification and identification of phytomolecules.

To evaluate the toxicity of a substance

Objective

Course Outcome

After completion of this course a student will be able

- to do the extraction of phytomolecules.

-to identify the phytomolevcules

-to purify the phytomolecules

-to asses the toxicity level in a substance

Module-I

Basics of Phytochemistry, isolation, purification and identification techniques of phytomolecules.

Module-II

Modern methods of extraction, application of latest techniques like

Spectroscopy, chromatography and electrophoresis in the

Module III

Isolation, Identification and Analysis of Phytoconstituents

a) Terpenoids: Menthol, Citral, Artemisin

b) Glycosides: Glycyrhetinic acid & Rutin

Module IV

Isolation, Identification and Analysis of Phytoconstituents

c) Alkaloids: Atropine,Quinine,Reserpine,Caffeine

d) Resins: Podophyllotoxin, Curcumin

Module V

Industrial production, estimation and utilization of the following phytoconstituents: Curcumin, Atropine, Podophyllotoxin, Caffeine,Taxol, Vincristine and Vinblastine

Module- VI: Introduction to toxicology, Background of Toxicology, Subdisciplines of toxicology, Acute, Sub acute and chronic toxicology,

Module-VII: Toxicity Pathways, Mechanism of toxicology, Adverse Outcome Pathways, Dose response relationship

Course Outline

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1418	Packaging	3-1-0	

Course Objective

They came to know about the labelling requirements and packaging guidelines for Drugs and Cosmetics.

Course Outcome

The student will be able to identify suitable packaging material for the given formulation. Also will be able to determine the testing required for packaging evaluation.

Course content

Module I **(5h+4h)**

Fundamentals of packaging - Definition, functions of packaging, types and selection of package, Packaging hazards, interaction of package and contents, materials and machine

interface, Environmental and recycling considerations – life cycle assessment Package Design – Fundamentals, factors influencing design, stages in package development. **Packaging materials -** Major Plastic packaging materials viz. Polyolefins, Polystyrene, Polyvinylchloride, Polyesters, Polyamides (Nylons), Polycarbonate and newer materials such as High Nitrile Polymers, Polyethylene Napthalate (PEN), Nanomaterials, biodegradable materials – properties and
applications, recycling; Wood, Paper, Textile, Glass, Metals – Tin, Steel, aluminum, Labelling materials, Cushioning Materials – properties and areas of application.

Project:

1. Collect and describe about 2 different types of packaging materials.

Module II **(5h+3h)**

Conversion technology - Extrusion – Blown film, cast film, sheet, multilayer film & sheet, Lamination, Injection molding, Blow molding, Thermoforming; Cartoning Machinery, Bottling, Can former, Form Fill and Seal machines, Corrugated box manufacturing machineries, Drums – types of drums, molded pulp containers, Closures, Application of Robotics in packaging. Surface treatment for printing, Printing processes – offset, flexo, gravure and pad printing.

Project:

1. Write a 2-page review on recent developments on robotic packaging.
2.

Module III **(5h+3h)**

Specialty packaging - Aerosol packaging, Shrink and Stretch wrapping, Blister packaging, Anti-static packaging, Aseptic packaging, Active packaging, Modified Atmospheric Packaging, Openable package; Cosmetic packaging, Hardware packaging, Textile packaging, Food packaging; Child resistant and Health care packaging, Export packaging, Lidding, RFID in packaging.

Project:

1. Collect any two types of specialty packaging material and elaborate about them.

Module IV **(5h+3h)**

Testing - Package Testing – Drop test, Impact test, Vibration Test, Stacking and Compression test, Packaging Materials Testing: Mechanical – Tensile, tear burst, impact, compression test, Elongation, barrier properties – WVTR test, Adhesion test, Optical – Gloss, haze and clarity; Chemical Resistance test – solvents and chemicals, solubility test, burning test, solvent retention; Hardness and corrosion test for metals; Clarity and brittleness test for glass.

Project:

1. List the standard values for packaging testing provided in 3 different pharmacopoeia.

Suggested Readings

1. Dean, D. A., Evans, E. R., & Hall, I. H. (Eds.). (2005). *Pharmaceutical packaging technology*. CRC Press.
2. Paine, F. A. (1990). *Fundamentals of packaging*. London: Blackie.
3. Athayle, A.S. (1992). *Plastics in Flexible Packaging*. Multi-tech Publishing Co.
4. Kirwar, M.J. (2005). *Paper and Paperboard Packaging Technology*. Blackwell Publishing.

Subject Name	Code	Type of course	T-P-Pr (Credit)
Research Methodology and IPR	CUTM 2378	Theory+Project	**(2-0-2)**(04)

Objective

- To develop an appropriate framework for research studies
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research.
- To Demonstrate enhanced Scientific writing skills
- warn the common mistakes in the field of research methodology.
- To make expertise in academic writing, patenting

- **Course Outcome**
-

- Search, select and critically analyse research articles and papers
- Formulate and evaluate research questions
- Develop the ability to apply the methods while working on a research project work
- Describe the appropriate statistical methods required for a particular research design
- Choose the appropriate research design and develop appropriate research hypothesis for a research project

Module 1: Elementary Research Methodology

Research Concept, Objective, characteristics, Steps and Significance of Research, Arbitrary and Scientific Research, Research approaches. Types of research: Historical, Descriptive, Analytical, Case Study, Quantitative vs. qualitative, Conceptual, Empirical Action Research, Research Methods vs Methodology. Research Problems: Selection and definition of the research problems, formulating a research problem, identifying variables and Constructing hypothesis; Choosing a mentor, lab and research question; maintaining a lab notebook; Selection of problems - stages in the execution of research

Module II: Academic Writing and Presentation

Technical writing skills - types of reports; layout of a formal report; standard of Journal (Impact Factor, Citation Index), Scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Module III: Scientific communication skills

Concept of effective communication- setting clear goals for communication; determining outcomes and results; barriers to effective communication; non-verbal communication-importance of body language, power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

Module IV: Introduction to IPR

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications. IP as a factor in R&D; IPs of relevance to biochemistry and few case studies; plant variety protection.

Module V: Types of Patents

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of different regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

PROJECTS

1. Write a review article and submit to a journal
2. Write a book chapter/ book for publishing
3. Write an original article for a journal

Books:

1. **Geoffrey Marczyk, David DeMatteo, David Festinger (2005)** *Essentials of Research Design and Methodology***, John Wiley & Sons, Inc.**
2. Carol Ellison (2010) ***McGraw-Hill's ConcisevGuide to WritingvResearch Papers***, McGraw-Hill
3. Kothari CR (2016) ***Research Methodology: Methods and Techniques***, New Age Pvt Ltd
4. Ganbawale RM, (2017) ***Bioststistics and Research Methodology***, New Central Book Agency
5. Sinha, S.C. and Dhiman, A.K., (2002). ***Research Methodology***, Ess Ess Publications. 2 volumes.
6. Trochim, W.M.K., (2005). ***Research Methods: the concise knowledge base***, Atomic Dog Publishing. 270p.
7. Wadehra, B.L. (2000). ***Law relating to patents, trademarks, copyright designs and geographical indications***. Universal Law Publishing.
8. Neuman, W.L. (2008). ***Social research methods: Qualitative and quantitative approaches,*** Pearson Education