CURRICULUM & SYLLABI

Integrated MSc Chemistry

Effective from AY: 2024-25



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department
CHEMISTRY

VISION

To be among the best mathematics departments in the country, to build an international reputation as a center of excellence in mathematics and computational research, training, and education, and to inculcate Mathematical thinking to meet the challenges and growth of science and technology as well as the needs of industry and society, with moral and ethical responsibility.

MISSION

- To attract motivated and talented students by providing a learning environment where they can learn and develop the mathematical and computational skills needed to formulate and solve real-world problems.
- To foster an environment conducive to quality research and to train principled and highly skilled researchers with clear thinking and determination to meet the dynamic challenges of science and engineering.
- To keep up with the rapid advancements of technology while improving academic standards through innovative teaching and learning processes.
- To satisfy the country's human resource and scientific manpower requirements in mathematics through learner-centered contemporary education and research.

Integrated M.SC., Chemistry

Program Educational Objectives

PEO-1	Impart proficiency in the fundamentals and applications of all disciplines of Science
PEO-2	Facilitate as a deep learner and progressive careers in teaching, academia, research organizations, national/international laboratories and industry
PEO-3	Inculcate critical thinking and analytical reasoning in the development of chemicals, materials and processes for sustainable domestic and industrial applications.
PEO-4	Provide solutions to chemistry related societal and industrial challenges with suitable research methodologies.
PEO-5	Formulate procedures and regulations with environmental and ecological dimensions for safe handling and endurable benefits of chemicals.

Program Articulation Matrix

PEO Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
To attract motivated and talented students by providing a learning environment where they can learn and understand the basic chemical science skills needed to formulate and solve real-world problems.	2	3	2	3	2
To foster an environment conducive to quality research and to train principled and highly skilled researchers with clear thinking and determination capable of meeting the dynamic challenges of science and engineering.	3	3	3	2	2
To keep up with the rapid advancements of technology while improving academic standards through innovative teaching and learning processes	2	3	2	2	2
To satisfy the country's human resource and scientific manpower requirements in mathematics through learner-centered contemporary education and research.	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: Integrated M.Sc Chemistry

Program Outcomes

At the end of the program, the student will be able to:

PO-1	**Scientific knowledge:** Gain and apply the knowledge of Science. Mathematics, Physics and Chemistry fundamentals to understand Nature and apply it to develop new theories and models.
PO-2	**Problem analysis**: Identify, formulate, research literature and analyze the complex scientific problems/phenomena reaching substantiated conclusions using principles of Mathematics, Physics, Chemistry, Engineering, Humanities and Management
PO-3	**Design/Development of solutions**: Design solutions for complex science problems and find out solutions that meet the specified needs.
PO-4	**Conduct investigations of complex problems**:Use of research-based knowledge and research methods including devise materials for societal needs in pharmaceutical, agricultural, environmental, materials fields
PO-5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern IT tools including prediction and modeling to complex real-life/scientific problems with an understanding of the limitations.
PO-6	**The science and society**: Function effectively as an individual, and as a member or leader in diverse teams to manage projects and in multidisciplinary environments
PO-7	**Environment and sustainability**: Demonstrate the knowledge of green methodologies in synthesis, energy storage and sustainable devices for various scientific applications
PO-8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Career:** Prepare students to qualify for various national and international competitive examinations. Join the pharma, textile, paints and chemical industries with sound knowledge.in chemical sciences
PO-10	**Project management and Finance**: Demonstrate knowledge and understanding of the Mathematical principles and apply these to one's work as a member and leader in a team to manage projects and in multidisciplinary environments.
PO-11	**Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological changes for up to-date research and teaching methods.
PO-12	**Individual and team work:** Function effectively as an individual, member, or leader in diverse teams and multidisciplinary settings.

Program Specific Outcomes

PSO-1	Understand the basic concepts of all disciplines of Chemistry
PSO-2	Apply the chemistry knowledge to provide solutions to the contemporary societal problems in fields of materials science, environmental science, and pharmaceutical chemistry
PSO-3	Able to Interpret the properties of various chemicals using the analytical techniques learned and relate the chemical characteristics to functioning and performance of various functional materials
PSO-4	Able to design synthetic schemes for the biologically active molecules

CURRICULUM
Integrated M.Sc., Chemistry

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2101	Differential and Integral Calculus	**3-0-0**	**3**
2	PH2101	Mechanics, Waves and Oscillations	**3-0-0**	**3**
3	CY2101	General Chemistry	**3-0-0**	**3**
4	HS2161	Functional English-I	**2-0-2**	**3**
5	PH2103	Mechanics, Waves and Oscillations Laboratory	**0-1-2**	**2**
6	CY2103	General Chemistry Laboratory-I	**0-1-2**	**2**
7	IC1101	EAA-I (Games & Sports / Yoga & Wellness)	**0-0-0**	**0**
Total Credits				**16**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2102	Elementary Ordinary Differential Equations	**3-0-0**	**3**
2	PH2102	Heat and Thermodynamics	**3-0-0**	**3**
3	CY2102	Organic Chemistry – I	**3-0-0**	**3**
4	HS2162	Functional English-II	**0-1-2**	**2**
5	PH2104	Heat and Thermodynamics Laboratory	**0-1-2**	**2**
6	CY2104	General Chemistry Lab – II	**0-0-2**	**2**
7	HS2164	Foundation Course in German	**2-0-2**	**3**
8	IC1102	EAA-II (Games & Sports / Yoga & Wellness)	**0-0-0**	**0**
Total Credits				**18**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2201	Modern Algebra	**3-1-0**	**4**
2	MA2203	Computer Programming in C	**3-0-2**	**4**
3	PH2201	Optics	**3-0-0**	**3**
4	CY2201	Inorganic Chemistry-1	**3-0-0**	**3**
5	CY2203	Physical Chemistry-1	**3-0-0**	**3**
6	PH2203	Optics Laboratory	**0-1-2**	**2**
7	CY2205	Inorganic Chemistry Laboratory	**0-1-2**	**2**
			Total Credits	**21**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2202	Vector Calculus	**3-1-0**	**4**
2	MA2204	Linear Algebra	**3-0-2**	**4**
3	PH2202	Electricity and Magnetism	**3-0-0**	**3**
4	PH2204	Modern Physics	**3-0-0**	**3**
5	CY2202	Organic Chemistry-2	**3-0-0**	**3**
6	PH2206	Electricity and Magnetism Laboratory	**0-1-2**	**2**
7	CY2204	Organic Chemistry Laboratory	**0-1-2**	**2**
			Total Credits	**21**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2301	Mathematical Analysis	**3-1-0**	**4**
2	PH2301	Basic Electronics	**3-0-0**	**3**
3	PH2303	Fundamentals of Nanomaterials and Applications	**3-0-0**	**3**
4	CY2301	Inorganic Chemistry-2	**3-0-0**	**3**
5	CY2303	Physical Chemistry-2	**3-0-0**	**3**
6	PH2305	Basic Electronics Laboratory	**0-1-2**	**2**
7	CY2305	Physical Chemistry Laboratory	**0-1-2**	**2**
			Total Credits	**20**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2302	Introductory Methods of Numerical Analysis	**3-1-0**	**4**
2	MA23xx	Professional Elective – 1	3-1-**0**	**4**
3	PH23xx	Professional Elective – 2	**3-0-0**	**3**
4	CY23xx	Professional Elective – 3	**3-0-0**	**3**
5	MA2390	Seminar & Technical Writing-I	**0-1-0**	**1**
6	MA2396	Minor Project	**0-0-4**	**2**
			Total Credits	**17**

After completing 6 semesters of Integrated M.Sc., the students will join in MSc. Chemistry course.
The structure of 7, 8, 9 and 10 semesters are same as the structure of M.Sc. Chemistry course

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CY16001	Main Group and Transition Metal Chemistry	4-0-0	4
2	CY16003	Chemical Kinetics and Electrochemistry	4-0-0	4
3	CY16005	Chemical and Statistical Thermodynamics	3-0-0	3
4	CY16007	Organic Reactions and Mechanism	3-0-0	3
5	CY160XX	Professional Elective-4	3-0-0	3
6	CY16009	Inorganic Chemistry Laboratory-I	0-1-2	2
7	CY16011	Organic Chemistry Laboratory-I	0-1-2	2
			Total Credits	**21**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CY16002	Photochemistry and Pericyclic reactions	4-0-0	4
2	CY16004	Group Theory and Spectroscopy	4-0-0	4
3	CY16006	Quantum Chemistry	3-0-0	3
4	CY160XX	Professional Elective-5	3-0-0	3
5	CY160XX	Professional Elective-6	3-0-0	3
6	CY16008	Inorganic Chemistry Laboratory-II	0-1-2	2
7	CY16010	Physical Chemistry Laboratory-I	0-1-2	2
			Total Credits	**21**

9th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CY17001	Organic Synthesis	4-0-0	4
2	CY17003	Organometallic Chemistry	3-0-0	3
3	CY170XX	Professional Elective-7	3-0-0	3
4	CY170XX	Professional Elective-8	3-0-0	3
5	CY17005	Organic Chemistry Laboratory-II	0-1-2	2
6	CY17007	Physical Chemistry Laboratory-II	0-1-2	2
7	CY17089	Seminar & Technical Writing-II	0-2-0	2
			Total Credits	**21**

10th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CY170XX	Professional Elective-9	3-0-0	3
2	CY170XX	Professional Elective-10	3-0-0	3
3	CY17094	Comprehensive Viva-Voce	0-2-0	2
4	CY17098	Dissertation	0-2-10	8
			Total Credits	**16**

Professional Elective Courses

Professional Elective-1		
S.No.	**Code**	**Course Title**
1	MA2322	Analytical Solid Geometry
2	MA2324	Theory of Equations
3	MA2326	Elementary Number Theory

Professional Elective-2		
S.No.	**Code**	**Course Title**
1	PH2322	Renewable energy sources
2	PH2324	Basic Photovoltaic Devices and Applications
3	PH2326	Physics of semiconductors

Professional Elective-3		
S.No.	**Code**	**Course Title**
1	CY2322	Instrumental analysis for industrial applications
2	CY2324	Applied organic chemistry
3	CY2326	Environmental chemistry

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	CY16021	Bio-inorganic Chemistry
2	CY16023	Heterocyclic Chemistry
3	CY16025	Solid State Chemistry
Professional Elective-II		
S.No.	**Code**	**Course Title**
1	CY16022	Chemistry of Natural Products
2	CY16024	Bio-organic Chemistry

Professional Elective-III		
S.No.	**Code**	**Course Title**
1	CY16030	Nuclear and Radiochemistry
2	CY16032	Advanced Inorganic Materials

Professional Elective-IV		
S.No.	**Code**	**Course Title**
1	CY17021	Spectroscopy for Structural Elucidation
2	CY17023	Chemical Education

Professional Elective-V		
S.No.	**Code**	**Course Title**
1	CY17031	Applied Analytical Methods
2	CY17033	Electroanalytical Methods

Professional Elective-VI		
S.No.	**Code**	**Course Title**
1	CY17022	Medicinal Chemistry
2	CY17024	Stereoselective Synthesis
3	CY17026	Advanced Organic Spectroscopy
4	CY17028	Emerging Topics in Organic Synthesis
5	CY17030	Advances in Total Synthesis of Natural Products
6	CY17032	Advances in Industrial Catalysis
7	CY17034	Microscopic and Diffraction Methods
8	CY17036	Supramolecular Chemistry

Professional Elective-VII		
S.No.	**Code**	**Course Title**
1	CY17044	Green Chemistry
2	CY17046	Polymer Chemistry

3	CY17048	Chemistry of Nanomaterials
4	CY17050	Industrial Applications of Organic Chemistry
5	CY17052	Statistical Treatment of Data and Quality Control
6	CY17054	Surface Analytical Techniques
7	CY17056	Chemical and Electrochemical Energy Systems

The Overall Credit Structure

Course Category	**Credits (UG)**	**Credits (MSc)**	**Total Credits**
Basic Science / program core	91	42	133
Humanities and Social Sciences	9	0	9
Professional Elective	10	21	31
Seminar and Technical Writing	1	2	3

Minor project	2	0	2
Short Term Industrial / Research Experience	0	2	2
Comprehensive Viva-Voce	0	2	2
Dissertation	0	8	8
Total Graded Credit Requirement	**113**	**77**	**190**

SYLLABI

Integrated M.Sc. Chemistry

1st Semester

MA2101 **3-0-0 (3)**

Differential and Integral Calculus

Pre-Requisites: None

Course Outcomes:

CO-1	To find the Taylor series expansion of a function.
CO-2	To find the maxima and minima of functions of several variables.
CO-3	To identify the convergence of an improper integral.
CO-4	To evaluate the surface area and volume of a solid of revolution.
CO-5	To compute the surface area and volume of regions using multiple integrations.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Differential Calculus: Taylor's theorem with remainders, Taylor's and Maclaurin's expansions, Curvature and Evolutes, Asymptotes, and Curve tracing.

Functions of several variables - partial differentiation, total differentiation, Euler's theorem and generalization, Change of variables – Jacobians, maxima, and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Integral Calculus: Evaluation of lengths of plane curves, plane areas, volume, and surface area of a solid of revolution

Convergence of Improper integrals, Beta and Gamma integrals, Elementary properties of Beta and Gamma integrals, Differentiation under integral sign.

Double and triple integrals, computation of surface areas and volumes using multiple integrations, change of variables in double and triple integrals.

Learning Resources:

Text Books:

1. Shanti Narayanan, Differential Calculus, S. Chand, and Co., 2021
2. Shanti Narayanan, Integral Calculus, S. Chand, and Co., 2021

Reference Books:

1. George Thomas, J., Ross L. Finney, Calculus, Ninth Edition Pearson, 2018.
2. Sudhir R. Ghorpade, B. V. Limaye, A Course in Calculus and Real Analysis, Springer, 2018.
3. Sudhir R. Ghorpade, B.V.Limaye, A Course in Multivariable Calculus and Analysis, Springer, 2012.

PH2101 **3-0-0 (3)**

Mechanics, Waves and Oscillations

Pre-Requisite: **None**

Course Outcomes:

CO-1	Understand integration of vectors and Stokes greens and gauss theorems
CO-2	Identify and apply the laws of mechanics along with the necessary mathematics for solving numerical.
CO-3	Understand physical characteristics of SHM and obtaining solution of the oscillator using differential equations.
CO-4	Use Lissajous figures to understand simple harmonic vibrations of same frequency and different frequencies
CO-5	Solve wave equation of a longitudinal and transverse vibrations.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Scalar and Vector Fields: Scalar and vector fields, gradient of a scalar field and its physical significance. Divergence and curl of a vector field and related problems, vector integration: line, surface and volume integrals. Stokes, Gauss and Greens theorems, Laws of motion, motion of variable mass system, motion of a rocket, multi-stage rocket, conservation of energy and momentum, definition of rigid body, rotational kinematic relations, and equation of motion for a rotating body, angular momentum and inertial tensor.

Central Forces: Central forces – definition and examples, conservative nature of central forces, conservative force as a negative gradient of potential energy, equation of motion under a central force, gravitational potential and gravitational field, derivation of Kepler's laws. Galilean relativity, absolute frames, Michelson-Morley experiment, Postulates of special theory of relativity. Lorentz transformation, time dilation, length contraction, addition of velocities, mass-energy relation.

Simple Harmonic Oscillator: Simple harmonic oscillator and its solution, physical characteristics of SHM, torsion pendulum, - measurements of rigidity modulus, compound pendulum, measurement of ‗g', Lissajous figures, damped harmonic oscillator and its solution, comparison with undamped harmonic oscillator, logarithmic decrement, relaxation time, quality factor, differential equation of forced oscillator and its solution, amplitude resonance, velocity resonance, coupled oscillators.

Transverse wave propagation: Transverse wave propagation along a stretched string, general solution of wave equation and its significance, modes of vibration of stretched string clamped at ends, overtones, energy transport, transverse, longitudinal vibrations in bars- wave equation and its general solution, Boundary conditions, clamped free bar, free-free bar, bar supported at both ends.

Learning Resources:

Text books:

1. Halliday, Resnick, Walker, Fundamentals of Physics, Wiley India, 2013, Tenth Edition.

2. C. Kittel, W. Knight, M.A. Ruderman, Mechanics, Berkeley Physics Course. Vol.1, McGraw Hill, 2008, Fourth Edition.

Reference books:

1. Hugh D. Young, Roger A. University Physics, Freedman Pearson Education, 2017, Fourteenth Edition.
2. Daniel Kleppner, Robert Kolenkow, An introduction to Mechanics, McGraw Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/115/106/115106119/.
2. https://onlinecourses.nptel.ac.in/noc20_ph22/preview.

PH2103 **0-1-2 (2)**

Mechanics, Waves and Oscillations Laboratory

Pre-Requisite: **None**

Course Outcomes:

CO-1	Measure different physical constants by simple and compound pendulum.
CO-2	Measure the different modulus of the materials.
CO-3	Study the different oscillations such as simple harmonic damped oscillations.
CO-4	Measure moment of inertia of different objects.
CO-5	Measure surface tension of different liquids.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. Determination of gll by simple and compound pendulum.
2. Moment of Inertia of a fly wheel.
3. Determine surface tension of a liquid through capillary rise method.
4. Determination of rigidity moduli by torsion Pendulum.
5. Study of Oscillations under bifilar suspension
6. Observation of Lissajous figures from CRO.
7. Velocity of transverse wave along a stretched string.
8. Study of damping of a bar pendulum.
9. Study of coupled oscillator.
10. Maxwell wheel for the verification of conservation of energy.
11. Determination of the shear modulus of steel, copper, aluminum and brass.
12. Determination of the centrifugal force as a function of the mass.

Learning Resources:

Text Books:

1. Physics Department Manual, NIT Warangal, 2021
2. S.P. Singh, Advanced Practical Physics by Pragati Prakashan, Anu books, Meerut, 2019.

Reference books:

1. R.K Shukla, Anchal Srivastava, Practical Physics, New Age International Private Limited, 2008.

2. C. Kittel, W. Knight, M.A. Ruderman, Berkeley Physics Course, Vol.1, Mechanics, McGraw Hill, 2008, Fifth Edition.

Online Resources:

1. https://www.phywe.com/physics/thermodynamics/
2. https://vlab.amrita.edu/index.php?sub=1&brch=74

CY2101 **3-0-0 (3)**

General Chemistry

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the behaviour of electrons in the atom and molecule and relate the basic concepts of atomic/molecular chemistry to the behaviour of molecules in real world
CO-2	Interpret the characteristics of bonds and the properties of elements
CO-3	Identify the crystal structure of solids based on their miller indices
CO-4	Understand concepts of hybridization, bonding and physical properties of organic compounds
CO-5	Identify the type of intermediates formed in the sequence of organic reactions and their stability

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Atomic Structure and elementary quantum mechanics: Emergence of quantum mechanics, Probability Distribution of Electrons, Radial and Angular Probability Distribution, Orbitals and quantum numbers.

Chemical Bonding: Ionic solids, packing of ions in crystals, lattice energy, Madelung constant, polarity and polarizability of ions, Bonding theories, Covalent and ionic character, non-covalent interactions.

Solid state: Laws of crystallography, Bravais lattices and crystal systems, miller indices, band theory, X-ray diffraction by crystals, Bragg's equation.

Bonding and physical properties of organic molecules: Nomenclature and Physical properties, hybridization, resonance, Inductive effect, Hückel's rules, Concept of acids and bases, structural and solvent effect.

Basic reaction mechanism and intermediates: reactive intermediates and classification of reaction mechanism

Learning Resources:

Text Books:

1. O.P. Agarwal, Unified Chemistry paper I and II, Jai Prakash Nath Publications, 2019, Third Edition,

2. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2015, Fifth Edition.
3. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, Pearson Education, 2010, Seventh Edition.

Reference Books:

1. Samuel H. Maron, Carl F. Prutton, Principles of physical chemistry, Oxford & IBH Publishing, 2017, Fourth Edition.
2. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan Publisher India Limited, 2020 Volume 3, Fifth Edition.
3. T. W. Graham Solomons, C. B. Fryhle, Organic Chemistry, Wiley, Tenth Edition.
4. I. L. Finar, Organic Chemistry, Vol-1, Pearson Education, Sixth Edition.

CY2103 **0-1-2 (2)**

General Chemistry Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Know the basic knowledge of qualitative analysis
CO-2	Acquire hands on experience in the semi micro analysis of mixture of cations and anions
CO-3	Interpret the chemistry involved in the separation of ions in a mixture
CO-4	Identify individual cations and anions in a mixture
CO-5	Analyze the influence of interfering ions on identification of ions

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Qualitative inorganic analysis:

1. Dry test for cations and anions
2. Wet test for anions
3. Semi-micro analysis and Group separation:

   Anions: Nitrate (NO_3^-), Sulfate (SO_4^{2-}), Nitrite (NO_2^-), Chloride (Cl-), Bromide (Br−), Iodide (I-Acetate (CH_3COO^-), Carbonate (CO_3^{2-}), Sulphide (S^{2-}), Bromate (BrO_3^-), Iodate (IO_3^-), Phosphate (PO_4^{3-}).

   Cation: Silver (Ag^+), Potassium (K^+), Sodium (Na^+), Lead (Pb^{2+}), Copper (Cu^{2+}), Cadmium (Cd^{2+}), Tin (Sn^{2+}), Iron (Fe^{3+}), Chromium (Cr^{3+}), Cobalt (Co^{3+}), Nickel (Ni^{2+}), Manganese (Mn^{2+}), Zinc (Zn^{2+}), Barium (Ba^{2+}), Strontium (Sr^{2+}), Calcium (Ca^{2+}), Ammonium (NH_4^+).

4. Qualitative analysis of mixture of inorganic substances containing six radicals (interfering acid radicals: phosphate, fluoride and mixture of acid radicals: carbonate, sulfite, sulfide, nitrate, chloride, bromide, phosphate, arsenate, nitrate, iodate and sulfate)

Learning Resources:

Text Books:

1. G. Sevhla, Vogel's Textbook of Macro and Semi micro Qualitative Inorganic Analysis, Longman Inc., 1979, Fifth Edition.

HS2161 **2-0-2 (3)**

Functional English-I

Pre-Requisites: English proficiency above B1 level as per the CEFR (Common European Framework of Reference) for languages.

Course Outcomes:

CO-1	Infer explicit and implicit meaning of a given text.
CO-2	Build grammatically correct sentences using a variety of sentence structures and appropriate vocabulary.
CO-3	Demonstrate use of English speech sounds, stress and intonation in day-to-day situations/conversations/interactions.
CO-4	Develop active listening skills and strategies
CO-5	Compose cohesive and coherent paragraphs, emails, and letters.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO1	PSO2	PSO3	PSO4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Course Overview:

The course is designed to train students in receptive (listening and reading) as well as productive and interactive (speaking and writing) skills by incorporating a comprehensive, coherent and integrated approach that improves the learners' ability to effectively use English language in academic/ workplace contexts. The shift is from learning about the language to using the language. On successful completion of the course learners would be confident of appearing for international language qualification/proficiency tests such as IELTS, TOEFL, or BEC, besides being able to express themselves clearly in speech and competently handle the writing tasks and verbal ability component of campus placement tests. Activity based teaching-learning methods would be adopted to ensure that learners would engage in actual use of language both in the classroom and laboratory sessions.

Syllabus:

Listening (Lab): Types of listening- attentive, selective, pleasure; barriers to listening; effective listening strategies- Listening to motivational speeches.

Speaking (Lab): Ice-Breaking Activity, Introducing self and others

Reading: Intensive Reading Vs Extensive Reading, short stories, skimming and scanning

Writing: Structure of a paragraph and types of paragraphs- descriptive, argumentative, narrative, expository, persuasive- writing self- profiles, writing prompts

Grammar &Vocabulary: Phrasal verbs, Verbs, Tenses (Present, Past & Future)

Phonetics-Pronunciation: Introduction to speech sounds -Vowels and Consonants (Lab)

Listening (Lab): Short structured talks on specific topics. Task based listening activities.

Speaking: JAM Session- Hypothetical Situations, features of good conversation, situational dialogues, greetings, taking leave, making requests and seeking permissions, role play, discussion in pairs/ small groups on specific topics

Reading: Reading for global comprehension, summarizing, paraphrasing- skimming- scanning

Writing: Interpreting visual information, predicting, advanced features of good writing – use of cohesive devices and connectives, use of discourse markers.

Grammar & Vocabulary: Nouns, Pre- fixes and suffixes, vocabulary building.

Phonetics-pronunciation (Lab): Intonation- errors in pronunciation, influence of Mother Tongue (MTI), common Indian variants in pronunciation- differences in British and American pronunciation

Listening: Listening to motivational videos (Steve Jobs, Mark Zukerberg, renowned scientists- Einstein, C V Raman, Marie Curie, Grigori Perelman, Jennifer A. Doudna etc, Ted Talks) Listening for specific details. Listening Comprehension Tests. (Task based group activity)

Speaking: Telephone Etiquette, non-verbal communication, how to make effective formal presentations.
Reading: Identifying sequence of ideas; recognizing verbal techniques.

Writing: Official letter writing, e- mail etiquette, cover letter & resume writing- types- drafting e- resumes Grammar & Vocabulary: Idioms and Phrasal Verbs, Synonyms & Antonyms, technical vocabulary

Phonetics-Pronunciation (Lab): Structure of syllables, word stress and rhythm, weak forms and strong forms in context, basic rules of word accent, stress shift**Learning Resources:**

Text Books:

1. Bailey, Stephen. Academic writing: A handbook for international students. Routledge, 2014.
2. M. Rizvi, Ashraf. Effective Technical Communication. 2nd ed., McGraw hill, 2017.

Reference Books:

1. Raymond Murphy, Murphy's English Grammar, Cambridge University Press 2004
2. Meenakshi Raman, Sangeeta Sharma, Technical Communication: English Skills for Engineers, Oxford University Press, 2009
3. Michael Swan, Practical English Usage, Oxford University Press, 1996
4. Chase, Becky Tarver. Pathways: Listening, Speaking and Critical Thinking. Heinley ELT; 2nd Edition, 2018.
5. Louis Rogers, Skillful Level 2 Reading & Writing Student's Book Pack (B1) Macmillan Educational, 2013.
6. Hewings, Martin. Cambridge Academic English (B2). CUP, 2012.

Online Resources:

1. https://www.bbc.co.uk/learningenglish/
2. https://www.talkenglish.com/speaking/basics/speaking_basics_ii.aspx
3. https://www.englishclub.com/speaking/
4. https://www.esolcourses.com/content/topicsmenu/listening.html
5. https://www.cambridgeenglish.org/learning-english/free-resources/writeand-improve/

2nd Semester

MA2102 **3-0-0 (3)**

Elementary Ordinary Differential Equations

Pre-Requisites: None

Course Outcomes:

CO-1	Test the plausibility of a solution to a differential equation that models a physical situation.
CO-2	Understand situations involving exponential growth or decay and second-order physical systems.
CO-3	Understand the existence and uniqueness of solutions.
CO-4	Solve homogeneous and non-homogeneous linear differential equations with constant coefficients.
CO-5	Solve second-order linear differential equations with variable coefficients.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Differential Equations of the first order: Linear Vs. Nonlinear Equations: Homogeneous Differential Equations, Differential Equations Reducible to Homogeneous Form - Exact differential equations, Integrating Factors - Linear equation, Reducible to Linear Form: Bernoulli's equations, Total Differential Equations. Existence and uniqueness of solutions (statement only); equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type; Applications: Newton's law of cooling, Law of natural growth and decay, orthogonal trajectories.

Differential Equations of Higher Order: Solution of homogeneous linear differential equations with constant coefficients, Solution of Non-homogeneous linear differential equations with constant coefficients, Legendre's equation, Cauchy-Euler equation;

Second-order linear differential equations with variable coefficients by the following methods: (i) complementary function is given, (ii) reducing to normal form, (iii) change of independent variable, (iv) variation of parameters.

Learning Resources:

Text Books:

1. Bronson Richard, Dr. Varsha Gejji, Differential Equations, Schaum Series, 2017, Third Edition.
2. George F. Simmons, Differential Equations with Applications and Historical Notes, McGraw-Hill, 2017, Second Edition.
3. William E. Boyce, Richard C. Diprima, Douglas B. Meade, Elementary differential equations and boundary value problems, Wiley, 2021.

Reference Books:

1. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Co., 2020.

2. Earl A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications Inc.1989.

PH2102 **3-0-0 (3)**

Heat and Thermodynamics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Gain knowledge in Kinetic theory of gases.
CO-2	Understand the nature of thermodynamic properties of matter like internal energy, enthalpy, entropy, temperature, pressure and specific volume.
CO-3	Understand the significance of first law and second of thermodynamics and their applications.
CO-4	Understand the process of thermal conductivity, viscosity and diffusion in gases.
CO-5	Understand the interrelationship between thermodynamic functions and ability to use such relationships to solve practical problems.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to thermodynamic system, Zeroth law of thermodynamics, isothermal and adiabatic processes, indicator diagram–reversible and irreversible processes, Carnot‘s engine, Carnot‘s theorem, Second law of thermodynamics, Entropy, entropy measurement, entropy and disorder, entropy of universe, temperature entropy diagram.

Thermodynamic potentials – Maxwell‘s relations– Gibb‘s Helmholtz equation– importance Clausius Clapeyron equation, Stefan Boltzmann‘s law, ratio of specific heats, difference of two specific heats for a perfect gas, Joule Kelvin effect and its expression, Joule Kelvin effect for perfect gas and van der wall‘s gas. First order and second order phase transitions, Different methods of liquification‘s of gases, liquefaction of air by Linde‘s and Claude‘s methods, production of low temperatures, adiabatic demagnetization, refrigeration, working of vapor compression machine and vapor absorption machine.

Black body radiation, Stefan‘s law, distribution of energy in black body spectrum, statement of Wein‘s and Rayleigh-Jean‘s Law. Plank‘s quantum theory of radiation, derivation of Plank‘s Law. Wien‘s and Rayleigh-Jean‘s Law from Plank‘s radiation law.

Maxwell Boltzmann distribution law, Application to an ideal gas, MB distribution law of molecular speeds, mean speed, rms speed and most probable speed of a molecule, relation between them, quantum statistics, Bose Einstein distribution law, energy distribution of photon gas, Fermi Dirac distribution law, Fermi energy of electron gas.

Learning Resources:

Text Books:

1. Brij Lal, N. Subrahmanyam, P.S. Hemne, Heat and Thermodynamics, S Chand &co, 2001, Fourth Edition.
2. Mark W. Zemansky, Heat and Thermodynamics, Mc Graw Hill, 2017, Fifth Edition.

Reference Books:

1. Claus Borgnakke, Fundamentals of Thermodynamics, Wiley publisher, 2020.
2. Jean-philippe ansermet, Sylvain d. Brechet, Principles of Thermodynamics, Cambridge University Press, 2019
3. Robert F. Sekerka, Thermal Physics, Elsevier, 2015.

Online resources

1. https://onlinecourses.nptel.ac.in/noc20_ce27/preview
2. https://onlinecourses.nptel.ac.in/noc21_me35/preview

PH2104 **0-1-2 (2)**

Heat and Thermodynamics Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Understands different heat transfer mechanisms.
CO-2	Learn to measure the thermal conductivity metals, glasses.
CO-3	Learn to measure the molar heat capacities of air.
CO-4	Understands to black body radiation
CO-5	Understand Seebeck, Joule-Thomson and Peltier effects.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. Study of Thermal conduction of solid bodies (metals and glasses).
2. Determination of Thermal conductivity of metals (Wiedmann-Franz law).
3. Study of phase changes of materials.
4. Determination of adiabatic coefficient of various gases.
5. Determination of specific heat of water.
6. Determine the molar heat capacities of air at constant volume C_v and at constant pressure C_p.
7. Determination of the Joule-Thomson coefficient of N_2 and CO_2.
8. Study of Peltier effect (a) cooling engine, (b) heat pump
9. Black Body Radiation: Determination of Stefan's Constant.
10. Verification of Newton's Law of Cooling.
11. Coefficient of thermal conductivity of a bad conductor using Lee's disc apparatus.
12. Study of Stirling engine working.

Learning Resources:

Text Books:

1. Heat and Thermodynamics Lab Manual, Department of Physics, NITW, 2021
2. S.P. Singh, Advanced Practical Physics, Pragati Prakashan, Anu books, Meerut, 2019.

Reference Books:

1. R.K Shukla, Anchal Srivastava, Practical Physics, New Age International Private Limited, 2008.
2.

Online Resources:

1. https://www.phywe.com/physics/thermodynamics/
2. https://vlab.amrita.edu/index.php?sub=1&brch=194

CY2102 **3-0-0 (3)**

Organic Chemistry – I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Utilize the concept of physical organic chemistry in organic reactions
CO-2	understand the synthesis and reactivity of various functional groups
CO-3	Understand the biological importance of heterocyclic compounds
CO-4	Analyse the functional group interconversion
CO-5	Know properties of hetero cyclic compounds

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemistry of organic functional groups: Alkanes, olefins, alkynes, halides, alcohols, phenols, ketones, aldehydes, carboxylic acids, ethers, derivatives of carboxylic acids, amines, nitro, azo and cyano compounds; synthesis and basic reactivity with mechanisms.

Functional group interconversion (oxidations and reductions) and Heterocyclic Compounds: Systematic nomenclature of heterocyclic compounds (Hantzsch Widman, replacement and fusion methods), biological importance of heterocyclic compounds. Preparation & Properties of Pyrrole, Furan, Thiophene, Preparation & Properties of Pyridine, quinoline, isouinoline, indole

Learning Resources:

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, Pearson Education, 2010, Seventh Edition.
2. I. L. Finar, Organic Chemistry, Vol-1, Pearson Education, Sixth Edition.

Reference Books:

1. T. W. Graham Solomonsm C. B. Fryhle, Organic Chemistry, Wiley, Tenth Edition.
2. E. L. Eliel, S. H. Wilen, Stereochemistry of Organic Compounds, Wiley.

CY2104 **0-1-2 (2)**

General Chemistry Lab– II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire hands on experience in experimental measurement of various physical quantities and understand the effect of impurity on Critical Solution Temperature of a system
CO-2	Understand the redox concept in titrations and photochemistry involved in blue printing
CO-3	Apply the concept of Nernst distribution law to understand the distribution of a solute in two immiscible liquids
CO-4	Apply various purification methods in the separation of organic mixtures
CO-5	Apply various chromatographic methods in the separation if organic compounds

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Standardization of potassium permanganate
2. Determination of relative surface tension of a liquid with respect to water.
3. Determination of relative viscosity of a given liquid with respect to water at room temperature.
4. To study the effect of impurities (sodium chloride and succinic acid) on the critical solution temperature of organic solvent-water system
5. Determination of the distribution coefficient of acetic acid between water and cyclohexane
6. Blue printing of an object by photochemical reaction
7. Determination of acid strength in citrus fruit.
8. Determination of melting point, mixed melting point
9. Purification of organic compounds by recrystallization, sublimation, distillation
10. Separation of compounds by TLC and Column Chromatography
11. Determining Partition Coefficients of Sulfonamides by Reversed-Phase Chromatography
12. Single-stage preparation of Aspirin and Paracetamol

Learning Resources:

Text Books:

1. Practical Organic Chemistry-G. Mann & B.C Saunders, ELBS Edition and Longman Group Limited, 2002
2. Physical Chemistry Laboratory Manual by Department of Chemistry, NITW.

3. Amritha Anand, Ramesh Kumari, Physical Chemistry Laboratory Manual, Wiley distributors, Dreamtech Press, 2019

Reference Books:

1. Shoemaker D.P., Garland C.W., Nibler J.W., Experiments in Physical Chemistry, McGraw Hill, 2008, Eighth Edition.
2. J.B. Yadav, Advanced Practical Physical Chemistry, Krishna's Educational Publishers, 2019, Thirty Eighth Edition.
3. Text Book of Practical Organic Chemistry, Vogel A.I., ELBS, 2004, Fifth Edition.

HS2162 **2-0-2 (3)**

Functional English – II

Pre-Requisites: English proficiency above B1 level as per the CEFR (Common European Framework of Reference) for languages.

Course Outcomes:

CO-1	Select appropriate listening and reading strategies to meet the academic and professional needs.
CO-2	Acquire proficiency in oral and written communication
CO-3	Apply various techniques for effective oral presentations and group discussions.
CO-4	Demonstrate neutral accent while speaking, avoiding vernacular influence.
CO-5	Draft well-structured reports, SOPs, reviews, and conference abstracts

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Course Overview:

The course is designed to train students in receptive (listening and reading) as well as productive and interactive (speaking and writing) skills by incorporating a comprehensive, coherent and integrated approach that improves the learners' ability to effectively use English language in academic/ workplace contexts. The shift is from *learning about the language* to *using the language*. On successful completion of the course learners would be confident of appearing for international language qualification/proficiency tests such as IELTS, TOEFL, or BEC, besides being able to express themselves clearly in speech and competently handle the writing tasks and verbal ability component of campus placement tests. Activity based teaching-learning methods would be adopted to ensure that learners would engage in actual use of language both in the classroom and laboratory sessions

Syllabus:

Listening (Lab): Listening for global comprehension and summarizing.

Speaking (Lab): Discussing specific topics in pairs (or) small groups and reporting the discussion, complaining, apologizing.

Reading: Reading between the lines, Critical reading for evaluation.

Writing: SWOT Description and Analysis, Writing SOP, Letters for Internship/Fellowship.

Grammar & Vocabulary: Concord: Subject-Verb Agreement, Correction of sentence

Listening (Lab): Making predictions while listening to conversations (or) transactional dialogues.

Speaking (Lab): Role plays for practice of conversational English in academic contexts (formal and informal).

Reading: Intensive reading Vs extensive reading, reading biographies, magazines, books – fiction, non-fiction; skimming, scanning.

Writing: Writing reviews (books, biographies, short stories etc, writing technical reports- structure- feature-types- format and style

Grammar & Vocabulary: Gender inclusive language (gendered noun, gender- neutral noun), quantifying expressions, adjectives, adverbs, degrees of comparison, advanced vocabulary, scientific vocabulary.

Listening (Lab): Identifying key terms, understanding concepts, interpreting the concepts

Speaking (Lab): Formal oral presentations on topics from academic contexts- prerequisites of a group discussion.

Reading: Reading comprehension, The RAP strategy for in depth reading, intensive reading and extensive reading

Writing: Writing conference abstracts, image description, poster presentation

Grammar & Vocabulary: Reported speech, reporting verbs for academic purposes, correction of sentences, vocabulary and scientific vocabulary

Learning Resources:

Text Books:

1. Bailey, Stephen. Academic writing: A handbook for international students. Routledge, 2014.

Reference Books:

1. Raymond Murphy, Murphy's English Grammar, Cambridge University Press 2004
2. Meenakshi Raman, Sangeeta Sharma, Technical Communication: English Skills for Engineers, Oxford University Press, 2009
3. Michael Swan, Practical English Usage, Oxford University Press, 1996
4. Chase, Becky Tarver. Pathways: Listening, Speaking and Critical Thinking. Heinley ELT; 2nd Edition, 2018.
5. Louis Rogers, Skillful Level 2 Reading & Writing Student's Book Pack (B1) Macmillan Educational, 2013.
6. Hewings, Martin. Cambridge Academic English (B2). CUP, 2012.

Other Suggested Readings:

1. https://www.bbc.co.uk/learningenglish/
2. https://www.talkenglish.com/speaking/basics/speaking_basics_ii.aspx
3. https://www.englishclub.com/speaking/
4. https://www.esolcourses.com/content/topicsmenu/listening.html
5. https://www.cambridgeenglish.org/learning-english/free-resources/writeand-improve/

HS2164 **3-0-0 (3)**

Foundation Course in German

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basics of German Language, its pronunciation, its basic grammatical rules etc.
CO-2	Identify the features pertaining to the syntax and its usage.
CO-3	Analyse the sentences heard or read in its basic features without much delay or translation.
CO-4	Apply the rules of grammar and syntax while speaking, writing, reading or listening.
CO-5	Demonstrate their linguistic ability in the four faculties mentioned in CO4.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Alphabet (Alphabet) Buchstabieren (Spelling) Begrüssen / Grüssen Und Sich Verabschieden (Greetings and Saying 'Bye') Sich Selbst Und Andere Vorsellen (Introducing Oneself and others)

GRAMMAR: Personal pronomen: Ich, Du, Er, Sie, Es, Wir, Ihr, Sie, Sie) (Personal pronouns: I, You, He, She, It, We, You All, They, You) Verb Und Konjugation: Präsens (Verb And Conjugation: Present Tense)) Verben ,Haben8 Und ,Sein8 (Verbs: To Have And To Be) Zahlen (Null – Eine Milliarde (Numbers Zero – One Billion) Rechnen Auf Deutsch: +, - X, ÷ (Calculating In German) Telefonnummer Angeben (Giving The Phone Number) Deutsche Namen (German Names) Ja/Nein Fragen (Yes/No Questions)

GRAMMAR: Satzstruktur (Sentence Structure) Nominativ (Nominative – Subject Case) W- Fragen: Was, Wer, Wann, Woher, Wo, Wie Viele (W-Questions: What, Who, When, Where From, Where, How Many) Bestimmter Artikel: Der, Die, Das (Definite Articles; Der, Die, Das) Namen Der Deutschen Städte (Names of German Cities) Namen Der Länder (Names of Countries) Familienmitglieder (Members of The Family) Wer/Was Ist Das? / Wer/Was Sind Das? (Who Is This/What Is This? Who are They/What are They?)

GRAMMAR: Unbestimmter Artikel: Ein, Eine (Indefenite Articles; A, An) Plural Der Substantive (Plural Forms Of Nouns) Internationale Wörter (International Words) Aussagesatz (Statement) Fragesatz (Interrogative Sentence –Questions) Negation: Nicht, Kein/Keine (Negation: Not, No/None) Wochentage (Days of The Week) Monate (Months) Jahreszeiten (Seasons) Berufe (Professions) Uhrzeit (Telling The Time) Wichtige Feste (Important Festivals)

GRAMMAR: Ja/Nein/Doch (Yes/No/Of Course) Demonstrativpronomen: Dieser, Diese, Dieses, Diesen (Demonstrativpronomen: This, That) Imperativformen: Du/Ihr/Sie (Imperative Forms: You, You All) Possessivpronomen (Possessive Pronoun) Man (One) Essen/Getränke (Fo0d/Drinks)) Farben (Colors)

Kleidungsstücke (Dresses) Körperteile (Parts of The Body) Schulsachen (Things for The School) Fächer (Subjects)

GRAMMAR: Akkusativ (Akkusative – The Object Case) Akkusativverben (Verbs in Accusative) Die Ordnungszahlen (Ordinal Numbers) Dativ (Dative -The Object Case) Genitiv (Genetive Case) Tageszeiten (Times of the Day) Sportarten (Different Kinds of Sports) Freizeitbeschäftigung (Hobbys) Lesetexte (Texts for Reading Comprehension) German Songs - Let Us Sing in German!

GRAMMAR: Modalverben: Können, Müssen, Wollen, Möchten, Sollen, Dürfen (Modal Verbs: Can, Must, Want, Like, Should, May) Perfekt (The Present Perfect Tense) Präteritum (Simple Past Tense) Futur I (Future Tense)

Learning Resources:

Text Books:

1. Rosi McNab, Get Started in German Absolute Beginner Course, Orion Publishing Group, 2012, First Edition (Hachette UK).
2. Maria Hamby, Beginning with German: Strategies to Maximize Your Understanding in German (A2 Level), Independently Published, 2021, First Edition (ThriftBooks) (Powell's Books).
3. Emil Otto, Introductory German Lessons, Publisher and year of publication not specified, Edition not specified.
4. Ben Denne, Easy German, Publisher and year of publication not specified, Edition not specified

3rd Semester

MA2201 **3-1-0 (4)**

Modern Algebra

Pre-Requisites: None

Course Outcomes:

CO-1	Discover the binary operations as basic entities which give specific mathematical structures to a set
CO-2	Understand the group structure and possible subgroups
CO-3	Analyze the structure of rings and subrings
CO-4	Classify the groups and rings using isomorphisms between the respective mathematical structures
CO-5	Adapt with mathematical abstractness

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Groups: Binary operation, Definition and examples of Groups, preliminary lemmas; dihedral groups, symmetric groups, the quaternion group as special examples; Subgroups - Abelian and non-Abelian groups, Cyclic groups; permutation groups; Cosets, Lagrange's Theorem and its consequences on finite groups; a counting principle; Normal Subgroups and Quotient Groups; Centralizers, Normalizers, Centre of a group;

Mappings between Groups: Homomorphism between groups, the kernel of a group, fibers of Homomorphisms, isomorphism, Fundamental theorem of isomorphism on groups; Automorphisms; Cayley's Theorem; Permutation groups;

Rings: Definition of rings and various examples; units & zero divisors of a ring; special classes of rings (viz., division ring, integral domain, field), characteristic of an integral domain; homomorphisms on rings; Ideals and Quotient rings;

Learning Resources:

Text Books:

1. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 1975, Second Edition.
2. David S. Dummit, Richard M. Foote, Abstract Algebra, Wiley, 2004, Third Edition.

Reference Books:

1. Vijay K. Khanna, S. K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, 2013, Fourth Edition.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning, 2013, Eighth Edition.
3. John B. Fraleigh, A First Course in Abstract Algebra, Pearson, 2013, Seventh Edition.

MA2203 **3-0-2 (4)**

Computer Programming in C

Pre-Requisite: **None**

Course Outcomes:

CO-1	Implement programs using classes and objects.
CO-2	Able to understand the overloading concept.
CO-3	Specify the forms of inheritance and use them in programs.
CO-4	Analyze polymorphic behavior of objects and polymorphism.
CO-5	Understand virtual functions.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements.

Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf.

Flow of Control: Statement and blocks, if - else, switch, loops - while, for, do while, break and continue, go to and labels.

Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments.

Arrays and Pointers: One dimensional, two dimensional arrays, pointers and functions, multi-dimensional arrays.

Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.

Learning Resources:

Text Books:

1. B. S. Gottfried, "Programming with C", McGraw Hill Education, Fourth edition (2018).

2. B. W. Kernighan, D. Ritchie, "The C Programming Language", Pearson Education India, Second edition (2015).

Reference Books:

1. E Balagurusamy, "Computing Fundamentals and C Programming", McGraw Hill Education; Second edition (2017).
2. Y. Kanetkar, "Let Us C", BPB Publications, Sixteenth edition (2017).
3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education India Private Limited, Seventh edition (2017).

Lab experiments

Programs on

1. Expression evaluation.
2. Conditional branching, iterations, pattern matching.
3. Function, recursion.
4. Arrays, pointers, parameter passing.

5 string using array and pointers.

6. Structures, union.

PH2201 **3-0-0 (3)**

Optics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the concepts of geometrical optics, its construction and importance in optical instruments.
CO-2	Understand and minimize the aberrations in lenses and its applications
CO-3	Explain the physics of image formation based on the fundamental principles of optics
CO-4	Analyze the intensity variation of light due to polarization, interference and diffraction.
CO-5	Analyze the optical applications using the concepts of interference, diffraction and polarization.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Geometric Optics: Optical path, Fermat's principle of Extreme path, applications, Law of reflection, refraction, cardinal points of an optical system, Image formation, Magnification, Cardinal points of a thick lens, focal length of a thick lens, Bi-convex lens, power of a thick lens, Telescopes types, advantages. Translation matrix, refraction matrix, system matrix for thick and thin lens, system matrix for two thin lenses. Dispersion by a prism, dispersive power, angular and chromatic dispersions.

Aberrations in lenses: Aberrations in lenses, Chromatic Aberration, Achromatic Combination of lenses, Monochromatic defects, Spherical aberration, Astigmatism, Coma, Curvature and Distortion, Minimizing aberration.

Interference: Huygens's wave theory of light-Laws of reflection and refraction.- Division of amplitude and wave front; Phase change on reflection: Stokes' treatment; Interference in Thin Films: parallel and wedge-shaped films; Fringes of equal inclination (Hai dinger Fringes); Fringes of equal thickness (Fizeau Fringes); Michelson Interferometer Application; Fabry- Perot interferometer.

Diffraction: Fresnel and Fraunhofer classes of diffraction, Fraunhofer diffraction at single, double ,multiple slits and circular aperture. Diffraction grating- Determination of wavelength of light using diffraction grating (Normal incidence and Minimum deviation); Resolving power; Rayleigh's criterion –limits of resolution for telescopes and microscope, Zone plate- construction and its comparison with convex lens.

Polarization: Polarization of light; Malus law; polarization by reflection; Brewster's law; Analysis of linearly and circularly polarized light; Polarization by double refraction and Huygen's theory; Nicol prism, Half wave and Quarter wave plates; Optical activity and Fresnel's theory, laurents half shade polarimeter; Biquartz polarimeter.- Photo Elasticity- Polariscope.

Learning Resources:

Text Books:

1. Ajoy Ghatak, Optics, McGraw Hill, 2015, Third Edition.
2. Francis Arthur Jenkins, Harvey Elliott White, Fundamentals of Optics, McGraw-Hill, 2018, Fifth Edition.

Reference Books:

1. Optics-Hecht, Zajak; Addison-Wesley, 2015, Third Edition.
2. V. Rajendran, Engineering Physics, Tata McGraw-Hill Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/122/107/122107035/
2. https://isaacphysics.org/concepts/cp_diffraction
3. https://www.rp-photonics.com/

PH2203 **0-1-2 (2)**

Optics Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand phenomenon based on light and related theories
CO-2	Get skills to identify and apply formulas of optics and wave physics
CO-3	Understand the applications of diffraction and polarization
CO-4	Understand the applications of interference in design and working of interferometers.
CO-5	Understand the resolving power of different optical instruments.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. To determine the refractive index of a prism by using a spectrometer.
2. To find the wavelength of white light by a plane transmission diffraction grating.
3. To find the specific rotation of sugar solution by using a polarimeter.
4. To find the wavelength of Sodium light by Newton‘s ring.
5. To verify the expression for the resolving power of a Telescope.
6. To find refractive index of the given liquid samples and find Molar refraction and specific refraction
7. Polarization of Light & Verification of Malus Law
8. Determination the wavelength of He-Ne laser using diffraction grating.
9. Spectrometer- Determination of Cauchy's constants
10. Dispersive power of a prism
11. Determination of numerical aperture and acceptance angle of the optical fiber using laser
12. Determination of thickness of thin wire–Air Wedge
13. Brewster‘s Angle determination

Learning Resources:

Text Books:

1. Optics Lab Manual by Department of Physics, NITW, 2021.
2. S. K. Gupta, Engineering Physics Practical, Ninth Edition, Krishna Prakashan Media publishers, 2010

Reference Books:

1. Indu Prakash, Ramakrishna, A Text Book of Practical Physics, Kitab Mahal, New Delhi, 2011, Eleventh Edition.

2. Jr. W.D. Callister, Materials Science and Engineering: An Introduction, Wiley, New York, 2007, Seventh Edition.

Online Resources:

1. http://www-math.mit.edu/~gs/
2. https://nptel.ac.in/courses/111/106/111106051/

CY2201 **3-0-0 (3)**

Inorganic Chemistry-1

Pre-Requisites: None

Course Outcomes:

CO-1	Compare the periodic properties of elements in s & p block elements
CO-2	Understand the various theories of acids and bases
CO-3	Learn the concepts of electrode potentials, emf and factors influencing emf
CO-4	Apply various acid-base theories to understand strengths of acid bases
CO-5	Apply the knowledge of redox potentials in understanding the corrosion process

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Periodicity of Elements: s & p-block elements: Effective nuclear charge, screening effect, Slater rules, Atomic and ionic radii, Ionization enthalpy, Electron gain enthalpy, Electronegativity, Diagonal relationship, Inert pair effect.

Acids and bases: Arrhenius theory, Bronsted theory, Lewis theory, Lux theory, Strength of acid and bases, Hard and soft acids and bases, Superacids

Redox chemistry: Redox reaction and EMF, Electrodes and Electrochemical cells, Effect of pH, precipitation, complex formation on emf, Redox potential diagrams, Redox titrations, Practical applications, Corrosion,

Learning Resources:

Text Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2015, Fifth Edition.
2. Catherine E. Housecroft, A. G. Sharpe, Inorganic chemistry, Pearson, 2018, Fifth edition.

Reference Books:

1. Huheey, J. H., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principle of structure and reactivity, Pearson Education India, 2006, Fourth Edition.
2. D. F. Shriver, P. W. Atkins, Inorganic Chemistry, Oxford University Press, 2006, Fourth Edition.

CY2203 **3-0-0 (3)**

Physical Chemistry-1

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the differences among the colligative properties of solutions.
CO-2	Identify the physical states of matter based on their properties
CO-3	Interpret the distribution of solute between two immiscible solvents
CO-4	Apply phase rule to different systems for isolating the components
CO-5	Apply the concepts of colloids and adsorption in commercially viable technologies

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Liquid state and gaseous state: Liquid state: Vacancy theory of liquids, Physical properties of liquids: Vapor pressure, surface tension, Viscosity Gaseous State: Deviation of real gases from ideal behavior, van der Waals equation -Critical phenomenon, Andrew isotherms of CO_2 -The law of corresponding states-liquefaction of gases.

Solutions: Liquid-liquid mixtures: Raoult's law, Henry's law, Ideal and Non-ideal solutions, Partially miscible liquids, completely immiscible liquid mixtures- Nernst's distribution law and its Applications.

Phase rule: Components, Degree of freedom, Gibbs Phase rule, Phase equilibria of one component system and two component system**.**

Colloids and Surface Chemistry: Colloids: Preparation of sols, emulsions, gels, Micelles and reverse micelles, critical micelle concentration; Adsorption and its types, Langmuir theory of unilayer adsorption isotherm, BET isotherm and surface area analysis.

Dilute solutions and colligative properties: Colligative Properties: Lowering of Vapour Pressure, Osmotic Pressure, Elevation in Boiling Point, Depression in freezing point, applications of colligative properties. Abnormal behavior of solutions.

Learning Resources:

Text Books:

1. O. P. Agarwal, Unified Course in Chemistry-3, Jai Prakash Nath Publication, 2018.
2. G.M. Barrow Physical Chemistry, McGraw-Hill Education, 2008, Sixth Edition.
3. S. H. Maron, C. F. Prutton, Principles of Physical Chemistry, Macmillan, 1965, Fourth Edition.

Reference Books:

1. P. Atkins, J. de Paula, W. H. Freeman, Physical Chemistry, 2006, Eighth Edition.
2. S. K. Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer, Netherlands, 2006.
3. A.J. Bard, L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, Wiley, 2000, Second Edition.
4. K. J. Laidler, J. H. Meiser, Physical Chemistry, Houghton Mifflin Company, Boston, 1999, Third Edition.

CY2205 **0-1-2 (2)**

Inorganic Chemistry Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Gain hands on experience in the volumetric analysis
CO-2	Acquire the knowledge in estimation of metal content in ores
CO-3	Understand principles of volumetric titrations
CO-4	Understand the analysis of cations and anions by spectrophotometric method
CO-5	Analyze water samples for their hardness

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Determination of Mn^{2+} in pyrolusite by permanganometric method.
2. Determination of Fe^{2+} in hematite by dichrometric method.
3. Determination of total hardness of water by complexometric method.
4. Determination of Al^{3+} by back titration method.
5. Determination of Zn^{2+} by precipitation titration method.
6. Determination of sulphate by spectrometric method.
7. Determination of fluoride by ion-selective method.
8. Determination of Cu^{2+} by conductometric titration method.
9. Determination of Ni^{2+} by colorimetry
10. Analysis of kidney stones by permanganometric titration.
11. Determination of calcium in milk powder by EDTA complexometry.

Learning Resources:

Text Books:

1. G H Jeffery, J Bassett, J Mendham and R C Denney, Vogel's Textbook of Quantitative Chemical Analysis, Longman Inc., 1989, Fifth Edition.
2. J. D. Woolins, Inorganic Experiments, John Wiley & Sons, 2010, Third Edition.

Reference Books:

1. Elias, A. J., A Collection of Interesting General Chemistry Experiments, Universities Press (India) Pvt. Ltd., 2002
2. Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods, Springer, 1979, Second Edition.
3. Z. Szafran, R. M. Pike, M. M. Singh, Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience, Wiley, 1991, First Edition.

4th Semester

MA2202 **3-1-0 (4)**

Vector Calculus

Pre-Requisites: MAI101

Course Outcomes:

CO-1	Find the derivative along a curve and directional derivatives.
CO-2	Evaluate and interpret gradient, divergence, curl and their related vector Identities
CO-3	Familiar with line, surface and volume integrals along with its applications
CO-4	Use theorems of Gauss, Green and Stokes to compute integrals.
CO-5	Addresses some of the problems of physics and engineering

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Vector differentiation: Introduction - Scalar and vector valued point functions, Derivatives, Curves, Tangents and length, Velocity and acceleration, Curvature and torsion of a curve, Level surfaces. Gradient of a scalar field and its geometrical interpretation, Directional derivative, Divergence of a vector field and its applications, Curl of a vector field and its applications, Vector identities.

Vector integration: Line integrals, Line integral independent of path, Work done by force, Circulation, Double Integrals, Green's theorem in the plane, Surfaces and surface integrals, Triple integrals, Divergence theorem of Gauss, Stoke's theorem, Proofs and problems based on these theorems.

Curvilinear Coordinates: Orthogonal curvilinear coordinates, Conditions for orthogonally fundamental triad of mutually orthogonal unit vectors. Gradient, Divergence, Curl and Laplacian operators in terms of orthogonal curvilinear coordinates, cylindrical polar coordinates and Spherical polar coordinates.

Learning Resources:

Text Books:

1. Shanti Narayan, P.K. Mittal, A Textbook of Vector Calculus, S Chand & Co Ltd, 2005.
2. Harry F. Davis, Arthur David Snider, Introduction to vector analysis, Allyn and Bacon Inc, Boston, 1975, Third Edition.

Reference Books:

1. Joseph George Coffin, Vector Analysis: An Introduction to Vector-Methods and Their Various Applications to Physics and Mathematics, John Wiley & Sons, Inc., 1911, Second Edition.
2. P.C.Matthews, Vector Calculus, Springer Undergraduate Mathematics Series, Springer-Verlag London, 1998, First Edition.
3. Murray Spiegel, Seymour Lipschutz and Dennis Spellman, Vector Analysis, Schaum's Outlines Series, 2017, Second Edition.

MA2204 **3-1-0 (4)**

Linear Algebra

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the knowledge of vector space and subspaces.
CO-2	Find rank and nullity of a linear transformation and the corresponding matrix.
CO-3	Test the consistency of system of linear algebraic equations.
CO-4	Solve eigenvalue problems.
CO-5	Illustrate the concept of inner products and orthogonalization.

Course Articulation Matrix:

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

Syllabus:

System of Linear Equations: Elementary row operations, Row echelon form, Row reduced echelon form, Determinant, Rank of a matrix, Inverse of a matrix by elementary operations. Solutions of Homogeneous and Non-homogeneous linear system of equations.

Diagonalization of Matrices: Characteristic equation, Eigenvalues and eigenvectors of a matrix, Cayley-Hamilton Theorem and its use in finding inverse of a matrix and in finding higher powers of a matrix, Similar matrices, Diagonalization of square matrices.

Vector Spaces and Linear Transformations: Vector spaces, Subspaces, Linear dependence and independence, Span of a set, Basis and dimension, Direct sum, Quotient space. Linear transformations, Range and null space, Rank and nullity, Change of basis.

Orthogonality: Inner Product, Length, and Orthogonality-Orthogonal Sets.

Learning Resources:

Text Books:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, Pearson Education, 2022, Fifth Edition.
2. Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 2009, Fourth Edition.

Reference Books:

1. K. Hoffman, R. Kunze, Linear Algebra, Pearson Education, 2005, Second Edition.
2. S. Lang, Linear Algebra, Undergraduate Texts in Mathematics, Springer-Verlag, 2004.
3. M. Thamban Nair, Arindama Singh, Linear Algebra, Springer, 2018.

Online Resources:

1. http://www-math.mit.edu/~gs/
2. https://nptel.ac.in/courses/111/106/111106051/

PH2202 **3-0-0 (3)**

Electricity and Magnetism

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the application of Coulomb‘s law for the electric field.
CO-2	Understand the relation between electric field and potential.
CO-3	Calculate the magnetic forces that act on moving charges and the magnetic fields
CO-4	Apply Gauss‘s law of electrostatics to solve a variety of problems.
CO-5	Understand the concepts of induction and self-induction.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Electrostatics : Electric Field and Electric Potential- Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry; Electrostatics- Coulomb‘s law and applications, Laplace's and Poisson equations, The Uniqueness Theorem, Potential and Electric Field due to an arbitrary charged wire, sphere, disc, electric dipole, Force and Torque on a dipole, Energy stored in an electric field; Electrostatic energy of system of charges- Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor, Capacitance of a system of charged conductors, Parallel-plate capacitor.

Magnetism : *Magnetic Field*- Lorentz force, Biot-Savart's Law, Magnetic force between current elements, Ampere's Circuital Law, Maxwell's corrections in Ampere's law; Curl and Divergence of B, vector potential, magnetic flux, Calculation of B for circular and solenoid currents, Magnetic Force on (i) point charge (ii) current carrying wire (iii) between current elements. Torque on a current loop in a uniform Magnetic Field; Intensity of magnetization, Relation between B, H and M.

AC & DC currents: *Steady currents*-Electric current and drift velocity, current density, equation of continuity, electric resistivity and conductivity, Wiedemann-Frenz Law; *Alternating Current*- Mean and r.m.s value of current, emf with sinusoidal wave form, Reactance, Impedance, Phase angle, power dissipation in AC circuit, Power factor, vector diagram, Faraday's Law, Lenz's Law, Self Inductance and Mutual Inductance, LR, CR and LCR, Resonance, Q-factor -Transformer and motors.

Electromagnetic Waves: Maxwell‘s Equations, Displacement current term, Plane Electromagnetic Waves, Energy Carried by Electromagnetic Waves, Momentum and Radiation Pressure, The Electromagnetic

Spectrum.

Learning Resources:

Text Books:

1. Edward M. Purcell, Electricity and Magnetism, Cambridge Press, 2013, Third Edition.
2. D.J. Griffiths, Introduction to Electrodynamics, Cambridge Press, 2017, Fourth Edition.

Reference Books:

1. S.Mahajanand Choudhury, Electricity, Magnetism & Electromagnetic Theory, Tata McGraw Hill, 2012.
2. J.H.Fewkes, Yearwood, Electricity and Magnetism, Vol.I, Oxford Univ. Press, 2005.
3. Ajoy Ghatak, K Thyagarajan, Ravi Varshney, Problems and Solutions in Electromagnetics, Viva Books Private Limited, 2015.

Online Resources:

1. https://ocw.mit.edu/courses/physics/8-022-physics-ii-electricity-and-magnetism-fall-2004/lecture-notes/
2. https://examupdates.in/electricity-and-magnetism-notes/

PH2204 **3-0-0 (3)**

Modern Physics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics.
CO-2	Describe the main features of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
CO-3	Apply the basic properties of nuclei like density, size, binding energy, nuclear
CO-4	Forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
CO-5	Estimate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Failures of classical mechanics- Quantum theory of Light, Planck‘s quantum, Planck‘s constant and light as a collection of photons, Photo-electric effect and Compton scattering, Problems with Rutherford model-instability of atoms and observation of discrete atomic spectra.

Wave Particle Duality, matter waves and De Broglie wavelength; Davisson-Germer experiment. wave packets. Superposition of two waves, Group and Phase velocities. Heisenberg Uncertainty Principle, Illustration of the Principle through Experiments. Two slit interference experiment with photons, atoms & particles, eigen values and eigen functions, normalization; Schrodinger equation-particle in a box, Particle in finite potential well-Quantum mechanical tunneling.

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph,semi-empirical mass formula and binding energy.

Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Classification of Elementary Particles.

Learning Resources:

Text Books:

1. Arthur Beiser, Concepts of Modern Physics, McGraw-Hill, 2015, Fifth Edition.
2. E.H. Wichman, Quantum Physics, Berkeley Physics, Vol.4, 2008, Tata McGraw-Hill Co.
3. R.A. Serway, C.J. Moses, C.A.Moyer, Modern Physics, Cengage Learning, 2005.

Reference Books:

1. Fishbane and Gasiorowicz, Modern Physics – Bernstein, Pearson Education, 2015, Fourth Edition.
2. J.R. Taylor, C.D. Zafiratos, M.A. Dubson, Modern Physics, PHI Learning, 2012, Third Edition.
3. R. Gautreau, W. Savin, Theory and Problems of Modern Physics, Schaum`s outline, TMH, 2011, Second Edition.

Online Resources:

1. http://web.sbu.edu/physics/courses/physics-203p.pdf
2. https://drive.google.com/file/d/1OPregBXJ2ldBYeoWh1v9KCxQwzvzlYqY/view
3. http://higgs.physics.ucdavis.edu/9D_part1.pdf

PH2206 **0-1-2 (2)**

Electricity and Magnetism Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Demonstrate the construction, functioning and uses of different electrical bridge circuits, and electrical devices.
CO-2	Analyse the experimental data, sources of error and their estimation in detail
CO-3	Understand the characteristics of RC and LRC circuit.
CO-4	Understand the concepts of self-induction and mutual induction via standard methods.
CO-5	Understand Faraday's laws

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

Measurements with a multimeter.

1. Study characteristics of a series RC circuit.
2. Measurement of response curve of a Series LCR circuit and determine the (a) Resonantfrequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
3. Measurement of response curve of a parallel LCR circuit and determine the (a) Anti-resonant frequency and (b) Quality factor Q.
4. Measurement of low resistance using Carey foster bridge.
5. Measurement of field strength B and its variation in a solenoid
6. **D**etermine self-inductance of a coil by Anderson's bridge.
7. Verification of superposition and maximum power transfer theorems.
8. Determine self-inductance of a coil by Rayleigh's method.
9. Determine the mutual inductance of two coils by Absolute method.
10. Determination of the resistance of a galvanometer by Kelvin's method using P. O box.
11. Study of rise and decay of current in LR circuit with a source of constant EMF.
12. Determination of velocity of sound in air.
13. Study of electromagnetic induction and verification of Faraday's law.

Learning Resources:

Text Books:

1. Electricity and Magnestism Lab Manual, Department of Physics, NITW, 2021
2. Indu Prakash, Ramakrishna, A Text Book of Practical Physics, Kitab Mahal, New Delhi, 2011, Eleventh Edition.

CY2202 **3-0-0 (3)**

Organic Chemistry-2

Pre-Requisites: **None**

Course Outcomes:

CO-1	Learn the chemistry of biomolecules, carbohydrates, Terpenoids and alkaloids
CO-2	Interpret the change in the biological or materials property of a molecule based on the stereochemistry of molecules
CO-3	Understand the principle of spectroscopy
CO-4	Apply the concept of stereochemistry in preparation and separation of stereo chemicals at industrial scale
CO-5	Apply the concepts of electronic, vibrational and NMR spectroscopy for structural elucidation of organic compounds

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic Stereochemistry: Chiral molecules, optical isomerism, specific rotation, Enantiomer & Diastereomers, Meso compound, Racemic mixture, classifications of chiral molecules based on symmetry Relative and Absolute configuration, Racemization and Resolution methods, Erythro, Threo-nomenclature, Geometrical isomerism

Spectroscopy: Electromagnetic spectrum, Franck-Condon principle, Born-Oppenheimer approximation.

Electronic spectroscopy: Beer-Lambert law, electronic transitions, wavelength and absorption shifts, Woodward-Fieser rules of dienes.

Vibrational spectroscopy: Hooke's law, selection rules, characteristic infrared absorptions of various functional groups, structural elucidation.

NMR spectroscopy: Principle, Processional frequency, orientation of protons in the magnetic field, number of signals, chemical shift, spin-spin coupling, coupling constant (J), applications.

Chemistry of biomolecules: Amino acids, Proteins, Peptides, Coenzymes, Lipids & Fatty acids.

Carbohydrates: Classification, Structures and conformational studies and Reactions of monosaccharides, Oligosaccharides, Polysaccharides, and unnatural sugars.

Terpenoids and Alkaloids: Classification, Structure and synthesis.

Learning Resources:

Text Books:

1. S.M. Mukherjee, S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan India Limited, 2009.
2. W. Carruthers, Some Modern Methods of Organic Synthesis, Cambridge University Press, Cambridge. 2007, Fourth Edition.

Reference Books:

1. P. S. Kalsi, Stereochemistry of Organic Compounds
2. Silvestin, Bacceler, Applications of Spectroscopy to Organic Compounds, Pergaman Press, 2003.
3. Michael B. Smith, Organic Synthesis, Mc Graw-Hill, 2004, Second Edition.
4. William Kemp, Macmillan, Organic Spectroscopy, 2009, Third Edition.

Online Resources:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
   (A virtual Textbook of Organic Chemistry)

CY2204 **0-1-2 (2)**

Organic Chemistry Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the physical properties and solubility of the organic molecules.
CO-2	Identify the organic compounds using chemical tests.
CO-3	Understand the reactivity of functional groups present in the molecules.
CO-4	Use the derivatization techniques to confirm the compound present in given mixture.
CO-5	Apply the experimental organic chemistry for the preparation of value added product.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Qualitative and quantitative analysis of organic compounds: Identification of each of the component (organic compounds) by using: Preliminary examination, separation and identification organic compounds (extra elements).

Green chemistry experiments: Extraction of natural products: Extraction and Identification of DNA from from Green peas.

Extraction

1. Isolation of (+)-Limonene from Orange Oil
2. Isolation of Plant Pigments from Green and Red Leaves
3. Caffeine Extraction from Tea and Coffee
4. Isolation of Essential Oils by Preparative Gas Chromatography
5. Analysis of Racemic and (*S*)-Ibuprofen

Organic reactions

1. A S_N1 Reaction: Synthesis of *tert*-Butyl Chloride
2. Kinetics of a S_N1 Reaction
3. Counterion Effects in the Nucleophilic Substitution Reaction of the Acetate Ion with Alkyl Bromides in the Synthesis of Esters
4. Conversion of Alcohols into Alkyl Chlorides Using Cyanuric Chloride
5. Gabriel Synthesis of *n*-Octylamine Under Phase-Transfer Catalysis: The First Step
6. Green Esterification: The Synthesis of Aromas in the Presence of an Acid Resin

7. Synthesis and Characterization of Biodiesel Propyl Esters to Determine the Fatty Acid Content of Unknown Plant Oils
8. Synthesis of Dimedone

Learning Resources:

Text Books:

1. G. Mann, B.C Saunders, Practical Organic Chemistry, ELBS Edition and Longman Group Limited, 2002.
2. Text Book of Practical Organic Chemistry, Vogel A. I., Fifth Edition, ELBS, 2000

5th Semester

MA2301 **3-1-0 (4)**

Mathematical Analysis

Pre-Requisites: MAI101

Course Outcomes:

CO-1	Know the fundamental principles of real numbers that underpin the formal development of real analysis
CO-2	Apply the understanding of the theory of sequences and series
CO-3	Understand the concepts related to metric spaces such as continuity.
CO-4	Apply the mean value theorems and the fundamental theorem of calculus.
CO-5	Adapt with the skills in constructing mathematical arguments

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Sequence and Series of Real Numbers: Equivalence and countability of sets, real numbers, least upper bounds and greatest lower bounds; Sequences of real numbers – convergence and divergence of sequences, bounded and monotone sequences, operations on sequences, limit superior and limit inferior, Cauchy sequences; Series of real numbers – convergence and divergence, series with non-negative terms, alternating series, conditional and absolute convergence of series, rearrangement of series, Tests of absolute convergence – comparison test, ratio test, root test; powers series and radius of convergence; series whose terms form a non-increasing sequence; summation by parts.

Metric Spaces and Continuous Functions: Limit of a function on the real line; metric spaces; point set topology on metric spaces; open sets; closed sets; limits in metric spaces; continuous functions on metric spaces.

Calculus: Definition of Riemann integral; existence; properties of Riemann integral; derivatives; mean value theorems; fundamental theorem of calculus.

Learning Resources:

Text Books:

1. Richard R. Goldberg, Methods of Real Analysis, John Wiley & Sons, Reprint by Oxford and IBH Publishing, 2020, Second Edition.

Reference Books:

1. Robert G. Bartle, Donald R. Sherbert, Introduction to Real Analysis, Wiley India, 2014, Fourth Edition.

2. Ajit Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2016, Special Indian Edition.
3. Tom M. Apostol, Mathematical Analysis, Addison-Wesley, 1974, Second Edition.

PH2301 **3-0-0 (3)**

Basic Electronics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand operating principles of electronic components like diode, Zener diode, BJT and FET
CO-2	Comprehend the functioning and biasing of transistors and study their characteristics
CO-3	Comprehend the I-V characteristics of BJT, FET and J-FET devices
CO-4	Understand functioning of amplifiers and oscillators and be able to design related circuits as well
CO-5	Understand and appreciate number systems and the functioning of basic logic gates

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

PN Junction Diode: Basics, ideal diode, PN junction diode, V-I characteristics, Zener diode, Half, full wave (center tapped and Bridge) rectifiers, RC and LC filters, Design of un-regulated DC power supply, Clipping and Clamping circuits, voltage multiplier circuits.

BJT: Construction and Operation, CE, CB and CC characteristics, DC load line and bias point, fixed, emitter feedback, collector feedback, and voltage divider biasing circuits, Thermal stability, switching circuits, Constant Current sourcs, transistor power dissipation, switching.

Field effect transistors (FET): JFET, Construction, Working, and characteristics, Biasing in ohmic and active regions, Trans-conductance, amplification and switching, MOSFET, CMOS introduction.

Amplifiers and Oscillators: Classification, RC-coupled CE amplifier – frequency response. Feedback circuits, noise, input and output impedances. Emitter follower and Darlington pair. RC oscillators- RC phase shift and Wien‘s bridge oscillators, LC oscillators- Hartley and Colpitt oscillators.

Digital Electronics: Binary, octal, decimal and hexadecimal number systems, Booleon algebra, -Basic and Universal Gates, Half adder, Full adder and parallel adder logic circuits. Logic families and their characteristics.

Learning Resources:

Text Books:

1. David A. Bell, Electronic Devices and Circuits, Oxford University Press, 2008, Fifth Edition
2. Albert Malvino, David, Electronic Principles, McGraw-Hill, 2016, Fifth Edition.

Reference Books:

1. Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson education, 2013, Fifth Edition.
2. Jacob Millman, Chrisots C. Halkias, Satyabrata Jit Millman, Electronic Devices and Circuits, McGraw Hill, 2007, Second Edition.

Online Resources:

1. https://nptel.ac.in/courses/117/103/117103063/
2. https://nptel.ac.in/courses/117/107/117107095/

PH2303 **3-0-0 (3)**

Fundamentals of Nanomaterials and Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Understand why nanomaterials exhibit varying properties compared to their bulk
CO-2	Distinguish various nanostructured materials based on size, shape, properties and functionalities
CO-3	Comprehend and choose appropriate method for synthesis of nano-structured materials
CO-4	Understand characterization techniques and estimate grain size and bandgap using formulations
CO-5	Understand and appreciate applications of various nanomaterials in a variety of fields

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to miniaturization: Historical background, Development of nanomaterials, units, Scaling laws, organization of matter- atoms, molecules, clusters and supramolecules.- Structure and Bonding, Hierarchical, molecular and crystalline structures - Bulk to surface transition, Quantum size effects, density of states, band gap and dimensionality, surface reconstruction, self-assembly.

Classification of Nanomaterials: Nomenclature of nanomaterials, 2D materials, Carbon based materials, self-assembled nanomaterials, core-shell particles, Nano metals, Nano- composites, contemporary nano-structured / nano-dimensional thin films

Physical and chemical methods for synthesis of Nanomaterials: Top down and bottom up approaches - Mechanical milling, evaporation, IGCT, vapour transport, molecular beam epitaxy, laser deposition, Colloidal and sol-gel techniques, size distribution, properties variation and yield of nanomaterials, Bio-inspired and template methods.

Nanomaterial characterization techniques: X-Ray Diffraction, Grain Size estimation, UV- Vis spectroscopy, Effect of grain size - Scanning and Transmission electron microscopy, Particle size analyzer, scanning probe/tunneling and Atomic force microscopy and surface techniques.

Applications of Nanomaterials: Mechanical, magnetic, electrical, optical, biocompatibility, toxicity, chemical, gas and bio-sensing, battery and energy harvesting applications, textiles, cosmetics, drug delivery, Magnetic hyperthermia, defense, and other contemporary applications.

Learning Resources:

Text Books:

1. Sulabha K. KulkarnI, Nanotechnology: principles and practices Springer publications, 2019, Third Edition.
2. T. Pradeep, NANO, The Essentials, Tata McGraw-Hill, 2008

Reference Books:

1. Edward L. Wolf, Nanophysics and Nanotechnology, Wiley-VCH, 2015, Third Edition.
2. Robert Vajtai, Springer Handbook of Nanomaterials, 2013.
3. B. Rogers, J Adams, S. Pennathur, Nanotechnology the Whole Story, CRC Press, 2013.

Online Resources:

1. https://www.classcentral.com/subject/nanotechnology

PH2305 **0-1-2 (2)**

Basic Electronics Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the operating principles of electronic components like resistor, diode, LED etc.
CO-2	Design circuits for studying the characteristics of rectifier diode, LED and photo-diodes
CO-3	Analyse output wave forms and also measure voltage and current of half and full wave rectifiers
CO-4	Verify the characteristics of NPN (CE, CB and CC configurations) transistor and FET
CO-5	Verify truth tables of basic digital logic gates and troubleshoot related circuits in general

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Experiments:

1. Obtain I-V characteristics of semiconductor rectifier diode, LED, and Photo-diode
2. To observe waveform at the output of half wave rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
3. To observe waveform at the output of full wave rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
4. To observe waveform at the output of bridge rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
5. To construct clamper circuits on breadboard and to observe waveforms at the output of clamper circuits
6. To construct clipper circuits on breadboard and to observe waveforms at the output of clipper circuits
7. To obtain common emitter, common base and common collector characteristics of NPN transistor
8. To design and construct common emitter amplifier circuit on breadboard and to measure gain at different frequencies and to plot the frequency response
9. To understand the working of transistor as a switch. To draw DC load line for given circuit.
10. To observe input-output waveforms of common collector (CC) amplifier and to measure gain of amplifier at different frequencies and to plot the frequency response
11. To obtain characteristics of field effect transistor (FET) and to measure gain of FET common source (CS) amplifier.
12. To construct and verify truth table of basic digital logic gates OR, AND, NOT, NAND, NOR, EX-OR, EX-NO

Learning Resources:

Text Books:

1. Electronics Lab Manual, Department of Physics, NITW,2021
2. Albert Paul Malvino, Patrick Hoppe, David J. Bates, Experiments Manual for Use with Electronic Principles, MCG Hill, 2015

Reference Books:

1. Albert Malvino, David J Bates, Problems and Solutions in Basic Electronics, McGraw Hill Education, 2011, Special Indian Edition.
2. Jacob Millman, Chrisots C. Halkias, Satyabrata Jit, Electronic Devices and Circuits with simulation, McGraw Hill, 2009.

Online Resources:

1. http://vlabs.iitkgp.ac.in/be/

CY2301 **3-0-0 (3)**

Inorganic Chemistry-2

Pre-Requisites: None

Course Outcomes:

CO-1	understand the general chemistry of d and f block elements
CO-2	Understanding the general chemistry of main group elements
CO-3	Learn bonding theories in coordination compounds
CO-4	Interpret the biological importance of organometallic compounds
CO-5	Apply theories of bonding in the interpretation of colour and magnetic properties of coordination compounds

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Transition Metal Chemistry: d-block elements: oxidation state, complex formation, color and magnetic properties, organometallic compounds and their biological importance

Inner Transition Metal Chemistry: Lanthanides and actinides: Oxidation state, separation, physical properties, super heavy elements, Nuclear fuels

Main group Chemistry: Polyhedral boranes and carboranes: structure, bonding and electron count, Isolobal analogy, boron heterocycles, P-N compounds, S-N heterocycles

Coordination Chemistry: Theories of metal-ligand bonding- Valence bond theory and crystal field theory, Limitations, applications

Learning Resources:

Text Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2015, Fifth Edition.
2. Catherine E. Housecroft, A. G. Sharpe, Inorganic chemistry, Pearson, 2018, Fifth Edition.

Reference Books:

1. William F. Trench, Introduction to Real Analysis, Library of Congress Cataloging-in- Publication Data, 2010, Second Edition.
2. Tom M. Apostol, Mathematical Analysis, Addison Wesley, 1974, Second Edition.

CY2303 **3-0-0 (3)**

Physical Chemistry-2

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the unique vocabulary of thermodynamics for explaining the basic concepts associated with it.
CO-2	Apply the laws of thermodynamics to closed and open systems undergoing different thermodynamic processes and evaluate the feasibility of a thermodynamic cycle.
CO-3	Apply the knowledge of electrochemistry in understanding electrochemical energy systems
CO-4	Analyze the types of reactions and theories of reaction rates.
CO-5	Perceive the theories of ionization and electrochemistry for analysing electrochemical processes.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Thermodynamics: First Law of Thermodynamics: Enthalpy, Heat Capacity, Joule-Thomson Effect, Isothermal Expansion of an Ideal Gas, Thermochemistry, Second Law of Thermodynamics**:** Spontaneous, Irreversible Process, The Carnot Cycle, Entropy, Helmholtz Free Energy, Gibbs-Helmholtz Equations, Clausius-Clapeyron equation, Van't Hoff Isotherm and Isochore.

Electrochemistry: Kohlrausch Law, Transport Numbers, Arrhenius theory of electrolyte dissociation, ostwald's dilution law, Debye-Huckel Theory of Strong Electrolytes- Debye-Huckel-Onsagar Equation, Activity and Activity coefficients, Ionic strength, Electrochemical Cells and EMF: Nernst equation, Reference Electrodes, Concentration cells, liquid junction potential and its determination, applications of emf measurements, Rechargeable Batteries, Fuel Cells

Chemical Kinetics: Order of a reaction**,** Effect of Temperature on Reaction Rates. Theories of Reaction Rates**:** collision theory (mathematical treatment). Collision theory of bimolecular gaseous reactions (overview).

Learning Resources:

Text Books:

1. O. P. Agarwal, Unified Course in Chemistry-3, Jai Prakash Nath Publication, 2018.
2. G.M. Barrow, Physical Chemistry, Tata McGraw-Hill Education, 2008, Sixth Edition.
3. S. H. Maron and C. F. Prutton, Principles of Physical Chemistry, Macmillan, 1965, Fourth Edition.

Reference Books:

1. P. Atkins, J. de Paula, W. H. Freeman, Physical Chemistry, 2006, Eighth Edition.
2. S. K. Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer, Netherlands, 2006.
3. A.J. Bard, L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, Wiley, 2000, Second Edition.
4. K. J. Laidler, J. H. Meiser, Physical Chemistry, Houghton Mifflin Company, Boston, 1999, Third Edition.

CY2305 **0-1-2 (2)**

Physical Chemistry Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Relate qualitative and quantitative concepts of physical chemistry for solving problems in physical chemistry with appropriate methodologies
CO-2	Demonstrate procedures and methods applied in analytical and practical tasks of physical chemistry
CO-3	Identify the appropriate instrumental technique to measure the physical property of interest
CO-4	Apply the scientific process in the design, conduct, evaluation and reporting of experimental investigations
CO-5	Assess and mitigate risks when working with chemicals and hazardous substances

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Determination of dissociation constant of a weak acid and verification of Ostwald's dilution law
2. Determination of concentrations of strong acid/weak acid using conductometry
3. Determination of concentrations of strong acid/weak acid by potentiometry
4. Evaluation of E^o values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measurement of emf by constructing the Daniel cell.
5. Determination of the concentration of strong/weak acid by pH metry
6. Measurement of pH of given samples of milk, juice, soap, detergent and shampoo.
7. To study the kinetics of acid hydrolysis of methyl acetate
8. To study the kinetics of acid-catalysed iodination of acetone
9. Iodine Clock reaction
10. Determination of decomposition of hydrogen peroxide in the presence of ferric chloride.
11. Verification of Beer-Lambert's and determination of the concentration of given $KMnO_4$ solution using spectrophotometer
12. Determination of specific rate constant of oxidation of alcohol by potassium dichromate
13. Spectrophotometric Determination of Critical Micelle Concentration.
14. Verification of Freundlich's Adsorption isotherm for the adsorption of acetic acid on charcoal

Learning Resources:

Text Books:

1. Shoemaker D.P., Garland C.W. and Nibler J.W. Experiments in Physical Chemistry, McGraw Hill, 2008, Eighth Edition.
2. S.W. Rajbhoj and T.K. Chondheka, Systematic Experimental Physical Chemistry, Anjali Publication, 2013, Third Edition.

Reference Books:

1. A. J. Elias, A Collection of Interesting General Chemistry Experiments, Universities Press, 2007, Revised Edition.
2. Alexander Findley, Practical Physical Chemistry, Wiley, 1972, Ninth Edition.
3. R.C. Das, B. Behera, Experiments in Physical Chemistry, McGraw-Hill, 1984.

6th Semester

MA2302 **3-1-0 (4)**

Introductory Methods of Numerical Analysis

Pre-Requisites:

Course Outcomes:

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

CO1	find the roots of nonlinear equations numerically
CO2	interpolate the given data by different interpolating polynomials
CO3	find the value of the derivative at a tabulated point
CO4	evaluate the definite integrals using Newton quadrature formula

Course Articulation Matrix:

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

1 – Slightly; 2 – Moderately; 3 – Substantially

Syllabus:

Solutions of Algebraic and Transcendental equations: The Bisection Method- Method of False position, Newton Method and Its Extensions- Error Analysis for Iterative Methods- Accelerating Convergence

Solution of linear algebraic system of equations: Gauss-Seidel iteration methods, Solution of tridiagonal system, Ill conditioned equations.

Interpolation: Unequally spaced data – Lagrange's and Newton's divided difference formulae, Equally spaced data –finite differences, finite difference (Forward, Backward, and central) operators and their properties, Newton forward and Backward difference interpolation formula, Central difference interpolation formula

Numerical differentiation: Differentiation: Finite difference approximations for first and second order derivatives.

Numerical Integration- Newton Cotes formula, Composite Trapezoidal, Simpson 1/3, and 3/8 rules.

Numerical solution of ordinary differential equations: Taylor's, Euler method, Modfied Euler method, Runge-Kutta 4th order method

Learning Resources:

Text Books:

1. Numerical Analysis: Mathematics of Scientific Computing, D. Kincaid and W. Cheney, 3rd Edition., American Mathematical Society, 2009.
2. Numerical Methods for Engineers and Scientists, M.K. Jain, SRK Iyengar and R.K Jain, New Age International, 2008.

3. Computer Oriented Numerical Methods, V. Rajaraman, Third Edition, Prentice Hall of India, 2006.

Reference Books:

1. Introduction to Numerical Analysis, F.B.Hildebrand, Dover Publications Inc, 2003
2. Introductory Methods of Numerical Analysis, S.S.Sastry, Prentice Hall of India, 2012
3. Elementary Numerical Analysis: An Algorithmic Approach, S.D. Conte and C. de Boor, Mc-GrawHill, 1981.

0-1-0 (1)

MA2390

Seminar and Technical Writing - I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2		2			3
CO-2	2		2			3
CO-3	2		2			3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X

V			X

7th Semester

CY16001 **4-0-0 (4)**

Main Group and Transition Metal Chemistry

Pre-Requisites: **Basic inorganic chemistry**

Course Outcomes:

CO-1	Understand the structure, bonding and properties of metal carbonyls, metallocenes and main group compounds
CO-2	Apply the concepts of bonding for interpreting structural properties of coordination compounds
CO-3	Correlate the kinetics and mechanisms involved in inorganic reactions
CO-4	Analyze electronic spectra and magnetic properties of coordination compounds
CO-5	Interpret the role of various metal ions in biology and medicine

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	–	1	1	1	2
CO-2	2	1	1	2	–	3
CO-3	2	–	2	1	1	1
CO-4	2	2	1	–	–	1
CO-5	3	–	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Main group Chemistry: Structure and bonding in polyhedral boranes and carboranes, styx notation, Wade's rule electron count in polyhedral boranes; synthesis of polyhedral boranes, Isolobal analogy, boron heterocycles, borazine, P-N compounds, structural features and reactivity of S-N heterocycles, Isopoly & heteropoly acids.

Bonding in coordination compounds: Review of Crystal field theory (CFT) and its applications. Jahn-Teller effect. Molecular orbital theory of octahedral, tetrahedral and square planar complexes. Pi bonding in metal complexes.

Thermodynamic and Kinetic aspects of metal complexes: Stepwise and overall formation constants and their interaction, trends in stepwise constants. Factors affecting stability of metal complexes with reference to the nature of metal ion and ligand chelate effect. Methods for the determination of stability constants.

Reaction mechanism of transition metal complexes: Energy profile of a reaction, reactivity of metal complex, inert and labile complexes, kinetics of octahedral substitution, acid & base hydrolysis, conjugate base mechanism, anation reactions, substitution Reactions in octahedral complexes-A, D and I Mechanisms, Substitution reactions in square planer complexes, Trans Effect-theories and applications, Electron Transfer Reactions-Outer Sphere and Inner Sphere.

Electronic and magnetic properties of transition metal complexes: Types of electronic transition, selection rules for d-d transitions. Spectroscopic ground states, Orgel and Tanabe-Sugano diagrams for transition metal complexes. Calculation of Racah parameters, Charge transfer spectra. Different types of magnetic behaviour. Factors affecting observed magnetic moments. Origin of magnetic moment, spin contribution, spin only formulas, orbital contribution, spin-spin coupling. Methods for magnetic susceptibility measurement, Ferro- and antiferromagnetism, mechanism of antiferromagnetic interaction, spin cross over and anomalous magnetic moments.

Coordination chemistry in biology: Metal ions in Biological Systems, Metal Binding Biomolecules, Metal Containing Units in Biology, Metal ion containing oxygen transport and electron transport proteins.

Learning Resources:

Text Books:

1. J.D. Lee, Concise Inorganic chemistry, Wiley India, 2015, 5th Edition.
2. C.E. Housecroft, A. G. Sharpe, Inorganic chemistry, Pearson, 2018, 5th Edition.

Reference Books:

1. J.H. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi, Inorganic chemistry: principle of structure and reactivity, Pearson Education India, 2006, 4th Edition.
2. D.F. Shriver, P.W. Atkins, Inorganic chemistry, Oxford University Press, 2006, 4th Edition.

CY16003 **4-0-0 (4)**

Chemical Kinetics and Electrochemistry

Pre-Requisites: Basic physical chemistry at undergraduate level

Course Outcomes:

CO-1	Understand the theories of reaction rates
CO-2	Interpret the mechanism and kinetics of complex and enzymatic reaction
CO-3	Analyze the effect of various factors on reaction rates
CO-4	Interpret the electrochemical characteristics of electrolyte
CO-5	Apply the concepts of electro kinetic phenomenon for various physical insights

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	1	1	1
CO-2	1	2	1	1	2	1
CO-3	2	1	-	-	1	1
CO-4	2	1	1	-	-	1
CO-5	1	1	1	-	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Chemical Dynamics: Basic concepts of kinetics, Effect of temperature on reaction rates, Mechanism and kinetics of Complex reactions: Equilibrium approximation and Steady state approximation, theories of reaction rates, kinetics of fast reactions, reactions in solutions, photochemical reactions and polymerization

Catalysis: Acid-Base Catalysis, Enzyme Catalysis, Inhibition of Enzymatic Reactions, Langmuir-Hinshelwood mechanism for surface reactions, Autocatalysis and oscillatory chemical reactions

Electrolytic Conduction: DHO Theory of strong electrolytes, validity and deviations of DHO equation, Debye Hukel theory of activity coefficients-Debye Huckel Limiting law, validity, Debye-Huckel-Bjerrum equation, applications of conductance measurements

Electrodics and Interfacial Electrochemistry: Theories of Electrical DoubleLayer, Electrokinetic phenomena, Butler-Volmer Equation, Tafel Equation

Learning Resources:

Text Books:

1. K.J. Laidler, Chemical Kinetics, Pearson Education, 2003, 3rd Edition
2. Samuel Glasstone, An Introduction to Electrochemistry, East-West Publisher, 2006

Reference Books:

1. P. Atkins and J. de Paula, W. H. Freeman, Physical Chemistry, Oxford University press, 2006, 8th Edition
2. S. H. Maron, C. F. Prutton, Principles of Physical Chemistry, Macmillan, 1965, 4th Edition

CY16005 **3-0-0 (3)**

Chemical and Statistical Thermodynamics

Pre-Requisites: Basic physical chemistry at graduation level

Course Outcomes:

CO-1	Understand the relationship of thermodynamic variables
CO-2	Understand the Phase rule and Phase diagrams
CO-3	Apply the laws of thermodynamics to real systems to understand the stabilities
CO-4	Evaluate the thermodynamic parameters using partition function
CO-5	Analyze the microscopic parameters from macroscopic behavior of system

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2	2	1	3	1	3
CO-2	2	3	1	2	1	2
CO-3	2	2	2	2	3	3
CO-4	2	2	1	2	3	3
CO-5	2	3	1	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Classical Thermodynamics: Thermodynamic Variables, Laws of Thermodynamics, Thermodynamic Relationships and Applications, Partial Molar Quantities, Phase equilibria and Phase Rule, Fugacity, Activity and Activity Coefficient.

Statistical Thermodynamics: Statistical Treatment of Entropy; Maxwell Boltzmann Functions, Partition Functions and Their Relation to Thermodynamic Variables, Bose-Einstein and Fermi-Dirac Statistics.

Learning Resources:

Text Books:

1. Thermodynamics for Chemists, S. Glasstone, East-West Publishers, 2008.
2. Physical Chemistry: A Molecular Approach (Viva student edition), Donald A Mcquarrie, John D Simon, Viva Books-2015

Reference books:

1. Molecular Thermodynamics, Donald A. Macquarrie, John D. Simon, Viva Books-2018, Viva student edition
2. Physical Chemistry, P. Atkins and Julia de Paula, Oxford, 2011 and 9th Edition

CY16007 **3-0-0 (3)**

Organic Reactions and Mechanism

Pre-Requisites: Basic Organic Chemistry, Functional group interconversion

Course Outcomes:

CO-1	Understand kinetic and thermodynamic aspects of the chemical reactions
CO-2	Classify chiral molecules using symmetry elements
CO-3	Identify various types of organic reactions with mechanisms
CO-4	Apply stereochemistry principles in interpreting molecular conformations
CO-5	Predict the stereochemistry of the products

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	–	–	–	–	–
CO-2	–	–	–	–	–	–
CO-3	–	1	3	–	3	3
CO-4	–	2	3	3	3	3
CO-5	–	–	2	–	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Study of reaction intermediates: Generation and reactions of Carbocations, Carbanions, free radicals, carbenes, nitrenes, arynes, ylides

Types of organic reactions: Addition, substitution, elimination reactions in aliphatic and Aromatic systems

Stereochemical aspects of organic reactions: Isomerism, Basic concepts of stereochemistry, CIP rules, nomenclature, racemization and resolution methods, specific rotation, enantiomeric and diastereomeric excess, types of stereo chemical reactions (examples).

Experimental methods for studying reaction mechanisms: Theoretical and physical aspects of organic reactions

Oxidation reactions: Oxidation of hydrocarbons, alcohols, amines, nitro compounds, sulfides, reagents for the oxidation of specific functional groups

Reduction reactions: Reduction of unsaturated hydrocarbons, reductive dehalogenation, reaction of carbonyl compounds, nitro and nitriles, sulfones, sulfoxides

Learning Resources:

Text Books:

1. M.B. Smith and J. March, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Wiley Interscience, 2016, 7th Edition.

2. E. L. Eliel, S. H. Wiley, Stereochemistry of Organic Compounds, Wiley Interscience, 2008, 1st Edition.

Reference Books

1. Stereochemistry of Organic Compounds: Principles and Applications, Fourth Edition, D. Nasipuri, New Age International Publishers, 2020.

2. Organic Chemistry, Francis A. Carey, Tata McGraw Hill publishing company Limited, New Delhi 2010, 8th Edition.

CY16009 **0-1-2 (2)**

Inorganic Chemistry Laboratory - I

Pre-Requisites: Basic inorganic chemistry experiments at undergraduate level

Course Outcomes:

CO-1	Gain hands on experience in the volumetric analysis, gravimetric and spectrophotometric analysis
CO-2	Acquire the knowledge in estimation of anions and cations
CO-3	Understand the principle involved in various types of volumetric titrations
CO-4	Estimate the metal ion contents by gravimetric analysis
CO-5	Analyze water samples for their alkalinity and quality parameters

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	3	–	1	–	–
CO-2	2	2	–	1	–	–
CO-3	1	1	–	1	–	–
CO-4	2	2	–	–	–	–
CO-5	2	1	–	1	2	–

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Determination of total alkalinity, and water quality analysis
Determination of cations and anions in environmental samples (e.g. Zn by complexometry, Cu by iodometry, sulphate by semi-gravimetry, Al by oxine method, Ni by DMG method)
Estimation of salt by ion-exchange method
Separation and estimation of Cu^{2+}- Ni^{2+} mixtures by volumetric and gravimetric methods
Separation of Mn and Fe using isoamyl alcohol and estimation of Mn
Estimation of sulfate by spectrophotometry
Determination of Iron by colorimetry
Determination of Cu^{2+} by electrogravimetry

Learning Resources:

Text Books:

1. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's textbook of quantitative chemical analysis, Longman Inc., 1989, 5th Edition.
2. J. D. Woolins, Inorganic experiments, John Wiley & Sons, 2010, 3rd Edition.

Reference Books:

1. A.J. Elias, A Collection of interesting general chemistry experiments, Universities Press (India) Pvt. Ltd., 2002.
2. G. Pass, H. Sutfille, Practical inorganic chemistry: preparations, reactions and instrumental methods, Springer, 1979, 2nd Edition.
3. Z. Szafran, R. M. Pike, M.M. Singh, Microscale inorganic chemistry: A comprehensive laboratory experience, Wiley, 1991, 1st Edition.

CY16011 **0-1-2 (2)**

Organic Chemistry Laboratory - I

Pre-Requisites: Basic organic chemistry experiments at undergraduate level

Course Outcomes:

CO-1	Understand the principle involved in separation and purification techniques
CO-2	Obtain hands-on experience of chromatography techniques
CO-3	Analyze the functional groups in organic molecules
CO-4	Choose an appropriate technique for the purification of synthesized compound
CO-5	Understand the principle involved in separation of binary mixtures
CO-6	Obtain practical experience in the separation and identification of individual compounds in the binary mixtures

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	1	1	1	2
CO-2	1	2	2	2	1	2
CO-3	3	2	3	1	3	2
CO-4	2	-	2	-	2	1
CO-5	2	2	2	-	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Purification Techniques:

Crystallization, fractional crystallization, Sublimation,

Simple distillation, Fractional distillation, Vacuum distillation and Steam distillation.

Isolation and purification of products by chromatographic techniques:

TLC and column Chromatography.

Separation and Analysis of Single functional group and Binary Mixture:

Solubility tests for organic compounds, identification of single functional group in the organic compounds.

Separation of Binary mixture

Detection of elements N, Cl, Br, I, S and functional groups alcoholic/phenolic OH, carboxylic, aldehyde, ketone, ester, nitro, amino, amide, N-substituted amino, imido groups, unsaturation (C=C), aromatic hydrocarbons, and halogenated derivatives present in the organic molecules.

Synthesis of simple organic compounds:

Aspirin, Hippuric acid, *m*-Nitroaniline, Oxidative coupling reaction: BINOL.

Learning Resources:

Text Books:

1. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International Private Limited, 2009, 5th Edition.
2. N. K. Vishnai, Advanced Practical Organic Chemistry, Vikas Publishing House Pvt Ltd, 2009, 3rd Edition.

Reference Books:

1. D.L. Pavia, G.M. Lampman, G.A. Kriz, R.G. Engel, Introduction to Organic Laboratory Techniques, Brooks/Cole 2010, 3rd Edition.

8th Semester

CY16002 **4-0-0 (4)**

Photochemistry and Pericyclic Reactions

Pre-Requisites: **Basic reactions and stereochemistry**

Course Outcomes:

CO-1	Understand the photochemical and thermal reactions
CO-2	Classify the various types of pericyclic and photochemical reactions
CO-3	Apply the orbital correlation and frontier molecular orbital methods for pericyclic reactions
CO-4	Evaluate various types of organic photochemical and pericyclic reactions mechanisms with stereochemical outcome
CO-5	understand the aromaticity of various organic compounds

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	1	3	1	3	3
CO-2	3	1	3	1	3	3
CO3	3	1	2	1	3	3
CO4	2	1	3	1	3	3
CO5	3	1	3	1	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Organic Photochemistry: Photochemical energy, Frank Condon Principle, Jablonski diagram, Singlet and Triplet states, Dissipation of photochemical energy, Photosensitization, Quantum efficiency, Experimental methods of photochemistry.

Photochemical Reactions: Classification of photochemical reactions, Norrish type I and II cleavages, Patterno-Buchi reaction. Photoreduction, Photochemistry of enones, Rearrangement of, α,β-unsaturated ketones and cyclohexadienes, Photo-fragmentation reactions (Barton, Hofmann-Loffler-Freytag).

Pericyclic Reactions: Introduction, Molecular orbitals and their symmetry properties, MO's of ethylene, 1,3 Butadiene, 1,3,5- Hexatriene, Allyl system, Classification of pericyclic reactions, selection rules [Woodward-Hoffman correlation diagram, FMO and Perturbation of molecular (PMO)]

Electrocyclic Reactions: Conrotatory and disrotatory motions in (4n) and (4n+2), allyl systems and secondary effects; Antarafacial and suprafacial additions, Notation of cycloaddition of (4n) and (4n+2) systems, Secondary effects of substitutes on the rates of cycloaddition reaction, 1,3-dipolarcycloadditions; **Chelotropic reactions**, Sigmatropic Reactions, Suprafacial and antarafacial shifts, retention and inversion of configurations, Claisen and Cope rearrangements, Ene-reactions, fluxional molecules.

Aromaticity: Localized and delocalised covalent bond, Concept of resonance and aromaticity, Huckel's rule for aromaticity in benzenoid and non-benzenoid compounds, Anti-aromaticity and homo-aromaticity, Aromaticity of various rings like annulenes, heteroannulenes, sydnones and Fullerenes (C60), Synthesis and properties of annulenes and Azulene, Craig's rule.

Learning Resources:

Text Books:

1. L. N. Ferguson, The modern structural theory in Organic Chemistry, Prentice Hall, 2008.
2. Charles Dupey, O. Chapman, Molecular reactions and photochemistry, Prentice Hall, 2006.
3. S.M. Mukherjee, Pericyclic reactions, Macmillan India Limited, 2009.

Reference Books:

1. Jerry March, Advanced Organic Chemistry Reactions, Mechanism & Structure, Wiley, 2006, 4th Edition.
2. Jack Hine, Physical Organic Chemistry, Mc. Graw Hill, 2007.

CY 16004 **4-0-0 (4)**

Group Theory and Spectroscopy

Pre-Requisites: Fundamentals of inorganic chemistry and physical chemistry at undergraduate level

Course Outcomes:

CO-1	Understand molecular symmetry, structure and motions with rotational, vibrational and electronic quantum levels and spectral properties
CO-2	Interpret molecular symmetry, symmetry operations and molecular point groups
CO-3	Analyze molecular structure and geometry with magnetic resonance spectral characteristics
CO-4	Justify molecular functionality and structure comprehensively
CO-5	Propose a relevant spectroscopic method for structural elucidation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	3	2	1
CO2	-	2	1	2	3	2
CO3	1	2	2	1	3	-
CO4	3	-	2	1	2	3
CO5	1	2	1	2	-	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Symmetry elements, Point Groups and Group Theory: Symmetry Elements, Symmetry Operations; Point groups, Assignment of point groups to molecules; Stereographic projections; Group generating elements, Group multiplication tables, Isomorphic groups, sub-groups, classes.

Matrix Representation and Applications of Group Theory: Matrix representation of symmetry elements and point groups; Character tables, Reducible and Irreducible Representations; Construction of character Tables, Mulliken Symbolism, The Standard Reduction Formula, The Direct Product. Symmetry of Normal Modes of Molecules, Infrared and Raman Activity, Criteria for Optical Activity; Symmetry Restrictions on Dipole Moment.

Microwave, Infrared and Raman Spectroscopy: Rotation of Molecules, Rigid and Non-rigid Rotors, Selection Rules of Transitions; Diatomic and Polyatomic Molecules, Applications; Selection Rules of Vibrational Transitions; Vibrational Rotational Spectra, Applications; Raman Effect; Quantum Mechanical Description; Rotational and Vibrational Raman Spectra; Mutual Exclusion and Complementarity

Magnetic Resonance Spectroscopy: Magnetic Nuclei and Nuclear Spin, ^{1}H NMR Spectroscopy: Chemical Shift; Spin-Spin Coupling; Pascal's triangle, Coupling constant, Relaxation Mechanism; spin-lattice and spin-spin relaxations, inversion recovery method, spin-echos methods; Nuclear Overhauser Effect, INDOR and NOE Methods; Nuclear quadrupole resonance spectroscopy; ^{13}C NMR Spectroscopy: Fourier Transform NMR; Off-Resonance and Spin-Decoupled ^{13}C NMR Spectroscopy; Applications; NMR

Spectroscopy of ^{19}F, ^{15}N and ^{31}P nuclides.^{19}F NMR heteronuclear coupling. Electron Spin and Its Magnetism; 'g'-Factor; ESR Spectral Phenomenon; Hyperfine structure, Line width and anisotropy; Zero-field splitting, Kramer's degeneracy, ENDOR and EEDOR methods, Applications.

Learning Resources:

Text Books:

1. K. Veera Reddy, Symmetry and spectroscopy of molecules, New Age International, 2020, 2nd Edition.
2. C. N. Banwell and E. M. McCash, Fundamentals of molecular spectroscopy, Tata McGraw Hill Education, 2017, 4th Edition.

Reference Books:

1. F. A. Cotton, Chemical Applications of Group Theory, Wiley Publishers, 2000, 3rd Edition.
2. D.C. Harris, M.D. Bertolucci, Symmetry and spectroscopy: an introduction to vibrational and electronic spectroscopy, Dover Publications 1989.

Other Suggested Readings:

1. A. Dutta, Symmetry and group theory https://onlinecourses.nptel.ac.in/noc22_cy40/preview .

CY16006 **3-0-0 (3)**

Quantum chemistry

Pre-Requisites: Basic physical chemistry and knowledge of atomic structure

Course Outcomes:

CO-1	Understand the behavior of electron
CO-2	Understand the first principles of calculation
CO-3	Apply first principles of calculation to real problems in chemistry
CO-4	Apply the concept of Molecular Orbital Theory to complex molecular systems
CO-5	Evaluate the electronic structure and properties of molecules

Course Articulation Matrix

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	1	1	2
CO-2	2	2	1	1	2	3
CO-3	3	2	1	2	3	3
CO-4	2	3	1	3	2	3
CO-5	2	3	1	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Emergence of quantum mechanics: Postulates of quantum mechanics, Time independent schrodinger equation and its application to Particle in a 3-D Box, Simple harmonic oscillator, Rigid rotor and H-Like atoms. quantum well and quantum tunneling.

Approximation methods: Variational and Perturbation theory, first and second order perturbation corrections.

Chemical bonding: Molecular orbital theory; Hartree-Fock self consistent field (SCF) method, Roothaan Hartree-Fock equation, Huckel MO theory; Spin-orbit coupling.

Learning Resources:

Text Books:

1. D.A. McQuarrie, Quantum Chemistry (Student viva edition), Viva Books-2016
2. R. K. Prasad, Quantum Chemistry, New age international Limited, 1997. 5th Edition

Reference books:

1. L. Pauling, E.B. Wilson, Introduction to Quantum Mechanics: With Applications to Chemistry, Dover Books on Physics, 1985.

2. T.A. Albright, J.K. Burdett, M. H. Whangbo, Orbital Interactions in Chemistry, Wiley-Interscience; 2013.

CY16008 **0-1-2 (2)**

Inorganic Chemistry Laboratory-II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Obtain hands-on experience in the spectrophotometry and electroanalytical methods
CO-2	Apply spectro- and electroanalytical methods for quantification of metal ions and other components in complex mixtures
CO-3	Predict characteristics of synthesized metal complexes
CO-4	Analyze metal ion content and other components
CO-5	Predict the order of metal ions in spectrochemical series

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	3	–	1	–	–
CO-2	2	3	–	1	–	–
CO-3	–	1	–	–	–	–
CO-4	2	1	–	1	–	–
CO-5	1	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Synthesis of Potassium bis(Oxalato)cuprate(II) dihydrate complex, Manganese(III) acetylacetonate, Mercury tetrathiocyanatocobaltate (II), Hexaamine cobalt (III) chloride

Characterization of the metal complexes by FT-IR/ESR/UV-Visible methods

Estimation of oxalate and copper in the potassium bis (oxalate) cuprate(II) dihydrate

Determination of Stoichiometry of a metal complex by mono variation and by continuous variation method

Simultaneous determination of two metal ions by spectrophotometric method

Determination of crystal field splitting of metal complexes and verification of spectrochemical series

Estimation of paracetamol in the given formulation using potentiometry

Estimation of Aspirin in the given formulation by pH-metry

Estimation of Ascorbic acid in the given formulation by potentiometry

Estimation of Ibuprofen in the given formulation by conductometry

Learning Resources:

Text Books:

1. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, Longman Inc., 1989, 5th Edition
2. J. D. Woolins, Inorganic Experiments, John Wiley & Sons, 2010, 3rd Edition.

Reference Books:

1. A.J. Elias, A Collection of Interesting General Chemistry Experiments, Universities Press (India) Pvt. Ltd., 2002.
2. G. Pass, H. Sutfille, Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods, Springer, 1979, 2nd Edition.

CY16010 **0-1-2 (2)**

Physical Chemistry Laboratory - I

Pre-Requisites: Fundamentals of physical chemistry, chemistry laboratory techniques and safety protocols

Course Outcomes:

CO-1	Understand standard procedures of potentiometric, conductometric and pH-metric techniques and kinetics experiments
CO-2	Explain the principles of potentiometric, conductometric and pH-metric techniques and kinetics experiments
CO-3	Determine dissociation constants and reaction kinetics by performing titrations.
CO-4	Interpret the experimental data to identify trends and calculate relevant chemical parameters.
CO-5	Assess the accuracy and reliability of experimental results compared to theoretical values.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	–	–	–	–	–
CO-2	2	1	–	–	–	1
CO-3	3	1	–	–	–	2
CO-4	3	2	–	–	1	2
CO-5	1	2	–	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Determination of concentration and dissociation constant of a weak acid/ weak base using potentiometer.

Determination of individual concentrations of mixture of acids with a strong base using potentiometer.

Determination of isoelectric point of an amino acid using potentiometer.

Determination of concentrations of reductant/oxidant using potentiometer.

Determination of concentrations of HCl and CH_3COOH in their mixture pH-metrically.

Determination of pk_a values of di and tribasic acids pH-metrically.

Determine the buffer capacity of various buffer solutions pH-metrically.

Determination of hydrolytic constant K_h of NH_4Cl solution using pH meter.

Effect of ionic strength on persulphate and iodide reaction.

Effect of temperature on rate of reaction and determination of activation energy.

Determination of catalytic constant of acid with respect to iodination of acetone.

Study the kinetics of interaction of Crystal Violet with NaOH colorimetrically.

Study the kinetics of base catalyzed hydrolysis of ester.

Determination of individual concentrations of weak acid, strong acid and salt mixture with a strong base using a conductometer.

Determination of solubility and solubility product constant (K_{sp}) of sparingly soluble salt conductometrically.

Learning Resources:

Text Books:

1. Amritha Anand, Ramesh Kumari, Physical Chemistry Laboratory Manual, Wiley, 2019
2. Physical Chemistry Laboratory Manual of NITW

Reference Books:

1. J.B. Yadav, Advanced Practical Physical Chemistry, 2019 and 38th Edition
2. D.P Shoemaker., C.W Garland and J.W.Nibler, Experiments in Physical chemistry, McGraw Hill, 2008, 8th Edition

9th Semester

CY17001 **4-0-0 (4)**

Organic Synthesis

Pre-Requisites: **Basic knowledge of organic chemistry**

Course Outcomes:

CO-1	Understand the concepts involved in C-C and C=C bond formation reactions
CO-2	Demonstrate the applications of reagents in organic reactions
CO-3	Apply the knowledge of protecting and deprotection of functional groups
CO-4	Plan synthetic strategies using disconnections approaches
CO-5	Design the synthetic scheme for small and large organic molecules

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	3	-	2	2
CO-2	1	-	3	-	2	2
CO-3	1	-	3	-	2	2
CO-4	1	-	3	-	2	2
CO-5	1	-	3	-	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Carbon-Carbon Single bond formation reactions: Importance of enolates, alkylation of active methylene groups, Gama alkylation of 1,3-dicarbonyl compounds; dianions in the synthesis, enamine related reactions, kinetics of C- and O-alkylations, alkylation of alpha-thio and selenocarbanions, umpolung, allylic alkylation of alkenes, organolithium, magnesium and cuprates, applications of carbenes, carbenoids, formation of C-C bonds by addition of free radicals to alkenes, cyclisation reactions (3 to 7 membered rings),

Carbon-Carbon double bond formation reactions: Wittig and Wittig version of reactions, Fragmentation reactions, Wharton olefin synthesis, alkenes from tosylhydrazone, sulfone, titanium and chromium reagents, alkene metathesis, Oxidative decarboxylation of acids, stereospecific synthesis from 1,2-diols, Reactions at inactivated C-H bonds

Protecting groups: Protection and deprotection of hydroxy, carboxyl, carbonyl, carboxy amino groups and carbon-carbon multiple bonds; chemo-and regioselective protection and deprotection, protecting group free organic synthesis.

Disconnection approach to organic synthesis: Target selection, functional group interconversion, disconnection, synthons, synthetic equivalent, retron, topological studies, one group two group disconnections, 1,2-, 1,3-, 1,4-, 1,5-, 1,6- difunctions, reversal polarity, convergent and divergent synthesis, building block approach, biomimetic approach,

Stereochemistry in organic synthesis: Topology, Chemo-, regeo-stereoselectivity, substrate, reagent and catalyst controlled stereoselective reactions. Crams's rule, Felkin-Ahn's model, chiral oxidation and reduction reactions, Chiral oxidation and reduction reactions, stereoselective cyclization reactions (Baldwin rules).

Learning Resources:

Text Books:

1. W. Carruthers, I. Coldham, Some modern methods of organic synthesis, Cambridge University Press, Cambridge, 2015, 4th Edition.
2. M.B. Smith, Organic synthesis, Academic Press, 2016, 4th Edition.

Reference Books:

1. S. Warren, Organic synthesis: the disconnection approach, John Wiley & Sons, 2007.
2. G. Zweifel, M. Nantz, W. H. Freeman, Modern Organic Synthesis, John Wiley & Sons, 2006.

CY17003 **3-0-0 (3)**

Organometallic Chemistry

Pre-Requisites: Basic knowledge of d- and f-block elements

Course Outcomes:

CO-1	Understand the structure and bonding aspects of organometallic compounds
CO-2	Establish the structure-reactivity/activity relationship in organometallic chemistry
CO-3	Predict the chemical behavior and reactivity of metal organometallic compounds
CO-4	Understand the operating mechanisms in the catalytic processes
CO-5	Develop materials for various industrial processes

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	–	–	–	–	–
CO-2	2	–	–	–	2	–
CO-3	2	–	–	–	–	–
CO-4	1	–	–	–	–	–
CO-5	3	–	–	–	3	–

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Overview of reactions in organometallic chemistry, metal sigma and pi complexes, Carbenes and Carbyne complexes and Metal clusters

Main Group Organometallics: Structure, Bonding and reactivity of main group organometallic compounds, Application of main group organometallic compounds.

Homogeneous Catalysis: Introduction to homogenous catalysis, Catalytic Cycles, Alkene Isomerization, Hydrogenation, Hydroformylation, Hydrocynation, Hydrosilyation and Hydroboration, Coupling Reactions, oxidation catalysis, cooperative catalysis.

Applications: Organic applications-carbon-carbon coupling, Metathesis, cyclopropanation, C-H insertion, Hydrogenation, Carbonylation, Oxidation, C-H activation, Click Chemistry. General Applications-Dimerization, Oligomerization and Polymerization of alkenes, Activation of CO and CO_2, Green Chemistry, Energy Chemistry, Nanoparticles, Organometallic Materials.

Learning Resources:

Text Books:

1. B.D. Gupta, A.J. Elias Basic organometallic chemistry- concepts, synthesis and applications, University Press Private Limited, India, 2011.

2. R. H. Crabtree, The organometallic chemistry of the transition metals, Wiley, 2014, 6th Edition.

Reference Books:

1. C. E. Housecroft, A. G. Sharpe, Inorganic chemistry, Pearson, 2018, 5th Edition.

2. D. F. Shriver, P. W. Atkins Inorganic chemistry, Oxford University Press, 2006, 4th Edition

CY17005 **0-1-2 (2)**

Organic Chemistry Laboratory – II

Pre-Requisites: **Organic Chemistry Laboratory-I**

Course Outcomes:

CO-1	Obtain hands-on experience in determining the purity of compound using volumetric and gravimetric methods.
CO-2	Estimate the acid, iodine and saponification values of oils.
CO-3	Apply the synthetic methodologies for the preparation of organic compounds
CO-4	Examine the greener methods of synthesis of organic compounds
CO-5	Develop the knowledge and skills in the synthetic organic chemistry useful for industrial applications

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	2	-	1	1
CO-2	1	2	2	-	2	2
CO-3	3	2	3	-	3	3
CO-4	3	1	3	-	3	2
CO-5	3	1	3	-	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Synthesis of organic compounds based on Oxidation: Benzyl chloride to benzoic acid, Reduction of nitrobenzene to aniline

Electrophilic aromatic substitution: Nitro benzene, sulphanilic acid, *p*-bromo acetanilide

Synthesis of optically active compounds: benzo pinacol

***O*-acylation & *N*-acylation**: *O*-Benzoylation: phenyl benzoate

Diazotization reaction: Azo-dye preparation

Preparation organic compounds by green chemistry methods: i) acetylation of Aniline, ii) base catalyzed aldol condensation, iii) Diels-Alder reaction, iv) Benzil-benzilic acid rearrangement.

Advanced reactions: L-Proline mediated asymmetric aldol reaction, Click reaction (in homogeneous and heterogeneous conditions), cross-coupling and acid-amine coupling reactions

Estimations: keto group of acetone, formaldehyde in formalin, sugars, acids in an oil, saponification value of an oil, acid and ester in a mixture, iodine value of an oil.

Learning Resources:

Text Books:

1. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International Private Limited, 5th Edition, 2009.
2. Text Book of Practical Organic Chemistry, Vogel A. I., 5th Edition, ELBS, 2004.

Reference Books:

1. V. K. Ahulwalia, Sunita Dhingra, Comprehensive Practical Organic Chemistry Qualitative Analysis, Universities Press, 2008.
2. F. Clark, Jr. Most, Experimental Organic Chemistry, John Wiley & Sons, 2002.

CY17007 **0-1-2 (2)**

Physical Chemistry Laboratory - II

Pre-Requisites: Fundamentals of physical chemistry and chemistry laboratory techniques.

Course Outcomes:

CO-1	Understand the principles and analytical applications of diverse instrumental techniques
CO-2	Identify suitable methodologies and instrumental techniques for the study of physical and chemical properties
CO-3	Select appropriate analytical methods for determining analytes of interest
CO-4	Understand the usage of computer
CO-5	Understand the applications of computational chemistry

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	–	1	1	1
CO-2	2	2	1	2	2	1
CO-3	1	2	2	–	2	1
CO-4	–	1	–	–	–	2
CO-5	–	1	1	–	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Instrumental Analyses: Determination of redox potentials using cyclic voltammetry, Determination of binding constant by using spectrophotometry, Determination of Stern-Volmer quenching constant using fluorimetry, Determination of surface area and pore structure of graphite by BET analysis, Determination of crystal structure and particle size by XRD analysis, Measuring carbon monoxide in automobile exhaust by gas chromatography, DNA composition by high-performance liquid chromatography, Analysis of analgesic tablets by high-performance liquid chromatography, Optical rotatory dispersion of chiral compounds,

Computational experiments: Molecule drawing and visualization, Computation of single point energies, Geometry optimization, Molecular frequency calculation, Electron densities and electrostatic potentials, Reaction in Gas-phase

Learning Resources:

Text Books:

1. G H Jeffery, J Bassett, J Mendham, R C Denney, Vogel's textbook of quantitative chemical analysis, Longman Inc., 2009, 7th Edition.
2. D. C. Harris, Quantitative Chemical Analysis, 2015, 9th Edition.

Reference Books:

1. J.B. Yadav, Advanced Practical Physical Chemistry, 2019, 38th Edition.
2. R. D. Baun, Introduction to Instrumental Analysis, McGraw-Hill, NY, 1987.

CY17089 **0-2-0 (2)**

Seminar and Technical Writing - II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2		2			3
CO-2	2		2			3
CO-3	2		2			3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

4th Semester

CY17094 **0-2-0 (2)**

Comprehensive viva-voce

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the knowledge gained in the course work
CO-2	Demonstrate the ability in problem solving
CO-3	Communicate effectively using engineering terminology

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

In Comprehensive viva-voce each student will be evaluated for their overall comprehension of the course work and laboratory training that they have undergone. The students will be expected to answer questions orally, write down simple equations, draw plots, schematics, write simple code etc. as questioned by the panel. Assessment will be done by the panel based on the student response.

CY17098 **0-2-10 (8)**

Dissertation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic
CO-2	Review literature to identify gaps and define objectives & scope of the work.
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives
CO-4	Analyze the results to draw valid conclusions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2			2	1
CO-2	2	2			1	2
CO-3	2	2	3	3	3	2
CO-4	2	2		3	3	

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The method of evaluation should be as per the guidelines stipulated for the B.Tech. Project evaluation. The template for preparation of the project report may be downloaded from (https://www.nitw.ac.in/path/?dept=/nitwForms) under UG Forms. The students are required to submit a report showing that plagiarism is within 30%. The B.Tech. Project work will be evaluated for 100 marks, with the following weightages:

Component	Weightage
Periodic evaluation by Guide	40 marks
Mid-term review	20 marks
End Semester viva-voce examination	40 marks
Total	100 marks

The midterm review and the end semester viva-voce examination will be conducted by a committee constituted by the Head of the Department. If the performance of a student is not satisfactory, he/ she can be awarded ‘F’ grade. Such a student will be given a maximum time of three months to improve his/her performance. If the performance of such a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Selection of Topic	
II	Literature Survey	
III	Objectives and Solution Methodology	
IV	Performance of the Task and clarity on the work	
V	Report Preparation	
VI	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III		X		
IV			X	
V				X
VI				X

Professional Elective - 1

MA2322 **3-1-0 (4)**

Analytical Solid Geometry

Pre-Requisites: NIL

Course Outcomes: At the end of the course, the student will be able to

CO1	To understand the fundamental concepts of 3D geometry
CO2	To describe some of the surfaces using 3D geometry
CO3	To explain the properties of planes, lines, spheres and cones.
CO4.	To interpret the problems geometrically and then to get the solution.

Course Articulation Matrix:

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

Syllabus:

The Plane: Equation of plane in terms of its intercepts on the axis, Equations of the plane through the given points, Length of the perpendicular from a given point to a given plane, Bisectors of angles between two planes, Combined equation of two planes, Orthogonal projection on a plane.

Sphere: Definition-The Sphere through four given points-Equations of a Circle - Intersection of a Sphere and a Line - Equation of a tangent Plane - Angle of Intersection of Two Spheres Radical Plane.

Cones: Definition-Condition that the General Equation of second degree Represents a Cone Cone and a Plane through its Vertex - Intersection of a Line with a Cone - The Right Circular Cone.

Cylinders: Definition of a cylinder. Equation to the cylinder whose generators intersect a given conic and are parallel to a given line, Enveloping cylinder of a sphere. The right circular cylinder. Equation of the right circular cylinder with a given axis and radius.

Learning Resources:

Text Books

1. Analytical Solid Geometry, Shanti Narayan and P K Mittal,S. Chand Limited, 2007 (7th edition).
2. Elementary Treatise on Coordinate Geometry of Three Dimensions, R. J. T. Bell, Macmillan India Ltd, 1994.

Reference Books:

1. A Text Book of Analytical Geometry of Three Dimensions, P.K. Jain and Khaleel Ahmed Wiley Eastern Ltd., 1999.

MA2324 **3-1-0 (4)**

Theory of Equations

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Able to solve some of the polynomial equations.
CO2	use the Descartes's rule of sign to find the nature of roots
CO3	Location of the roots of an equation.
CO4	understand Cardon's, Ferrari's and Descartes' method to find roots of cubic and biquadratic equations
CO5	Illuminating sequel to geometry, algebra and analytic geometry.

Course Articulation Matrix:

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

Syllabus:

Graphical representation of a polynomial – Maxima and minima values of polynomials Theorems relating to the real roots of equations - Existence of a root in the general equation - Imaginary roots – Theorem determining the number of roots of an equation – Equal roots – Imaginary roots occurring in pairs - Synthetic division - Diminishing the roots of equation by a given number.

Formation of equation whose roots are functions of the roots of a given equation - Descartes' rule of signs for positive roots - Descartes' rule of signs for negative roots - The fundamental theorem of algebra.

Relations between the roots and coefficients of equation and related theorems - Applications of the theorem - Depression of an equation when a relation exists between two of its roots – The cube roots of unity - Symmetric functions of the roots - Common roots and multiple roots .

Transformation and numerical solution of algebraic equations – Location of the roots of an equation – Binomial and reciprocal equations – Solutions of cubic equations (Cardon's method) - Ferrari's and Descartes' solution of biquadratic equations.

Learning Resources:

Text Books:

1. Theory of equations, H.W. Turnbull, Oliver and Boyd, Edinburgh and London, Interscience Publishers Inc, 1952, 4th Edition.
2. An introduction to the modern theory of equations, Florian Cajori, The Macmillan Company, New York, London, 1919

Reference Books:

1. Theory of Equations, C. C. Mac Duffee, John Wiley, New York; Chapman & Hall, London, 1954.
2. Higher Algebra, Hall and Knight, MacMillan and Co., 1989, 3rd Edition.

3. First Course in the Theory of Equations, Leonard Eugene Dickson, John Wiley & Sons, Inc. New York; Chapman & Hall, London, 1992.

MA2326 **3-1-0 (4)**

Elementary Number Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the knowledge of distribution of prime numbers.
CO-2	Utilize the Chinese remainder theorem to solve simultaneous linear congruences.
CO-3	Illustrate number theoretic functions and their properties.
CO-4	Solve equations involving quadratic residues.
CO-5	Solve certain types of Diophantine equations.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Divisibility: Division algorithm, Greatest common divisor, Euclidean algorithm, Least common multiple, Prime numbers and their properties, Fundamental theorem of arithmetic.

Congruences: Introduction to congruences, Linear congruences, The Chinese remainder theorem, Divisibility tests. Arithmetic functions and its properties, Mobius inversion formula, The Euler φ function and other multiplicative functions, Fermat's little theorem, Euler's theorem, and Wilson's theorem.

Quadratic Residues: Primitive roots, Quadratic residues, Legendre symbol, Law of quadratic reciprocity, The Jacobi symbol-properties.

Diophantine Equations: Diophantine equations, Pythagorean triples, Sums of squares.

Learning Resources:

Text Books:

1. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery, An Introduction to the Theory of Numbers, Wiley, 1991, Fifth Edition.
2. Kenneth H. Rosen, Elementary Number Theory and its Applications, Addison-Wesley, 2011, Sixth Edition.

Reference Books:

1. H. Davenport, James H. Davenport, The Higher Arithmetic: An Introduction to the Theory of Numbers, Cambridge University Press, 2008, Eighth Edition.
2. David M. Burton, Elementary Number Theory, Mc Graw Hill, 2011.

Online Resources:

1. https://ocw.mit.edu/courses/mathematics/18-781-theory-of-numbers-spring-2012/index.html
2. https://nptel.ac.in/courses/111/103/111103020/

Professional Elective - 2

PH2322 **3-0-0 (3)**

Renewable Energy Sources

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the Need, importance and scope of non-conventional and alternate energy resources
CO-2	Understand role significance of solar energy.
CO-3	Understand the role of ocean energy in the Energy Generation and importance of Wind Energy
CO-4	get the utilization of Biogas plants and geothermal energy
CO-5	Comprehend the concept of energy Conservation

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Solar Energy: Solar Radiation, Measurements of Solar Radiation, Flat Plate And Concentrating Collectors, Solar Direct Thermal Applications, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation, Solar PV Applications.

Wind Energy: Wind Energy Estimation, Types of Wind Energy Systems, Performance, Site Selection, Details of Wind Turbine Generator.

Ocean Energy: Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.

Bio-Mass: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gasdigesters, gas yield, combustion characteristics of bio-gas, utilization for cooking.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, scope in India.

Energy Conservation: Principles of energy conservation, the different energy conservation appliances, cooking stoves, Benefits of improved cooking stoves over the traditional cooking stoves.

Learning Resources:

Text Books:

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 2011, Third Edition.

2. B H Khan, Non-Conventional Energy Resources, McGraw Hill, 2009, Second Edition.

Reference Books:

1. Twidell, Wier, Renewable Energy Resources, CRC Press (Taylor & Francis) , 2008
2. D.O. Hall, R.P. Overeed, Biomass Renegerable Energy, John Wiley and Sons, 2008

Online Resources:

1. https://nptel.ac.in/courses/115/105/115105127/
2. https://nptel.ac.in/courses/103/103/103103206/

PH2324 **3-0-0 (3)**

Photovoltaic Devices and Applications

Pre-Requisites: **None**

Course Outcomes:

CO-1	Fundamentals of PV systems and its various applications.
CO-2	The principle of direct solar energy conversion to power using PV technology.
CO-3	The structure, materials and operation of solar cells, PV modules, and arrays.
CO-4	The socio-economic and environmental merits of photovoltaic systems for a variety of applications.
CO-5	The prospects of photovoltaic technology for sustainable power generation.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Semiconductors, PN junction, abrupt and graded junctions, junction in equilibrium, biasing, energy band diagram, hetero and Schottky junctions, built-in voltage, junction capacitance.

The Photovoltaic (PV) Effect: Need for Solar cells, Various generations of solar cells, photovoltaic effect - Principle, design and working of solar cells, energy level alignment, basic equations, characteristics, efficiencies.

Physical Aspects of Solar Cell Efficiency: Energy losses in solar cells, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, Effect of irradiation, temperature and relative humidity.

Design, Fabrication and Applications of PV cells: Design and various fabrication techniques for solar PV systems, Building-integrated photovoltaic unit, stand-alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Learning Resources:

Text Books:

1. Ashcroft, N., D. Mermin, Holt, Solid State Physics, Rinehart and Winston, 2021, Third Edition.
2. Bube R., Photovoltaic Material, Imperial college press,1998.

Reference Books:

1. Kittel, Charles, Introduction to Solid State Physics, Eighth Edition, John Wiley & Sons, 2004.
2. Angèle Reinders, Pierre Verlinden, Wilfried van Sark, Photovoltaic Solar Energy: From Fundamentals to Applications, Wiley publishers, 2017

Online Resources:

1. https://www.nrel.gov/docs/legosti/old/1448.pdf

PH2326 **3-0-0 (3)**

Physics of Semiconductor Devices

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basic properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier injection/excitation.
CO-2	Knowledge of semiconductor carrier properties and statistics.
CO-3	Analyze PN junctions in semiconductor devices under various conditions.
CO-4	Explain the working, design considerations and applications of various semiconducting devices including p-n junctions, BJTs and FETs.
CO-5	Understand BJT switching

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Semiconductors: Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, compensation, and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field.

Optical Excitation in Semiconductor: Optical absorption, carrier generation, Carrier lifetime, diffusion length and photo conductivity, Direct and indirect recombination and trapping, Photoconductive devices. Diffusion of carriers, Einstein relation, Continuity equation, Carrier injection, Diffusion length. Haynes-Shockley experiment.

Junctions: p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener, and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact.

Field Effect Transistors: JEFT amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics. MOSFET, Operation, MOS capacitor, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control, MOS C-V analysis and time dependent capacitance. Output and transfer characteristics of MOSFET.

Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle.

Learning Resources:

Text Books:

1. Sze, S.M., Physics of Semiconductor Devices, John Wiley, 2008, Third Edition.
2. Tyagi, M.S., Introduction to semiconductor materials and devices, John Wiley, 2008, First Edition.

Reference Books:

1. Mishra, Umesh K., Singh, Jaspreet, Semiconductor Device Physics and Design, Springer, 2008, First Edition.
2. Pierret, R.F., Semiconductor Device Fundamentals, Pearson, 2006, First Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/108/108108122/
2. https://www.coursera.org/specializations/semiconductor-devices#courses

Professional Elective - 3

CY2322 **3-0-0 (3)**

Instrumental Analysis for Industrial Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Explain the theoretical principles behind the instrumental techniques and their applications.
CO-2	Model concepts and techniques in instrumental analysis independently towards industrial applications.
CO-3	Analyze instrumental results for deriving conclusions with relevance to experimental evidences.
CO-4	Assess the appropriateness of an instrumental method for the analysis of samples in various formats and from complex matrices.
CO-5	Design experimental methodology for determining analytes of interest of domestic and industrial applications.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

UV-Visible Spectrophotometry and Fluorescence: Overview of bioorganic chemistry- historical connection between organic and biological chemistry; weak interactions in organic Beer-Lambert's law, Instrumentation of Absorption Spectrophotometer, Quantitative analysis, limitations, Enzyme linked immunosorbent analysis (ELISA), Molecular fluorescence, influencing factors, basic instrumentation, standardization, quantitative methods, Applications, Diagnostics of biomarkers.

Thermoanalytical methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications.

Chromatography methods: Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications, Capillary Electrophoresis: Principle and application.

Surface area and Particle size Analyses: BET- Principle, Pore width, particle size and surface area analysis, Dynamic light scattering – Principle, instrumentation and applications.

X-ray spectroscopic and diffraction methods: X-ray absorbance and fluorescence, Principle, instrumentation, quantitative analysis. X-ray diffraction, Principle, Crystal structure and size analyses. Medical diagnostics, Analysis of geological samples and ores.

Microscopic methods: SEM, Principle, Sample preparations, Surface morphology and particle size analysis, TEM, Principle, Sample preparation, Surface morphology, and Structural determination of nanoparticles. Metal and non-metal nanocomposites, industrial materials.

Atomic spectrometry and atomic absorption: Atomization, Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, and quantitative aspects. Analysis of geological samples and ores.

Electroanalytical methods: Ion selective electrodes, Electrochemical sensors, Ion selective and Potentiometric sensors, Amperometry, Principles, Applications.

Learning Resources:

Text Books:

1. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning India, 2020, 7th Edition.
2. Russel S. Drago, Physical Methods for Chemists, Saunders College Publishing, 2016, 2nd Edition.

Reference Books:

1. D. L. B. Wetzel, George Charalambous, Instrumental Methods in Food and Beverage Analysis (Developments in Food Science), Elsevier, 1998.
2. Michael D. Cole, The Analysis of Controlled Substances (Analytical Techniques in the Sciences (AnTs), Wiley, 2003.
3. Erno Pungor, G. Horvai, A Practical Guide to Instrumental Analysis, CRC Press, 2020.

CY2322 **3-0-0 (3)**

Applied Organic Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply the theoretical knowledge of organic chemistry for the synthesis of molecules with industrial importance
CO-2	Use the knowledge of organic chemistry in paint, agriculture, and cosmetic industry
CO-3	Understand the essentials of organic chemistry in drug synthesis
CO-4	Use the knowledge of organic chemistry for the development of sustainable synthetic processes
CO-5	Apply the knowledge of organic chemistry in food industry

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Paints, Varnishes and Soaps: **Paints & Varnishes:** Primary constituents of paints, Dispersion medium (solvent), binder Pigments, formulation of paints and varnishes. Requirements of a good paint.

Surface Coatings: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives. **Soaps:** manufacture of soaps by hot and cold process, classification of soaps, cleansing of soap and classification of detergents (anionic and cationic).

Fertilizers and Pesticides: **Fertilizers:** natural fertilizers, nitrogenous fertilizer (NH_4NO_3, urea), phosphatic fertilizer (superphosphate, TSP, polyphosphate), potash fertilizer (KCl, KNO_3, K_2SO_4), bio fertilizers.

Pesticides: classification, structure of some important pesticides (DDT, BHC, allethrin and pyrethrin).

Insecticides: Pesticides – classification of Insecticides, fungicides, herbicides as organic and inorganic – general methods of application and toxicity. Safety measures when using pesticides.

Insecticides: Plant products – Nicotine, pyrethrin – Inorganic pesticides – borates. Organic pesticides – D.D.T. and BHC. **Fungicides and Herbicides:** Fungicide: Sulphur compounds, Copper compounds, Bordeaux mixture. Herbicides: Acaricides – Rodenticides. Attractants – Repellents. Preservation of seeds.

Chemistry of Essential oils, Perfumes and Cosmetics: **Essential oil:** Definition–occurrences–Methods of production from plants–Steam distillation and expression method. **Perfumes:** Formulations–Requirements for a good perfume–Compositions of perfumes–classification of perfumery materials–animals-synthetic formulations–manufacturing and packaging process of perfumes. **Cosmetics:** Face cream–Sun screen lotion–shaving cream–composition and formulation–Uses and hazards, Sprayer–Hand lotion–nail lacquers–nail bleaches–hair oil–hair dyes–composition and formulations–Uses and hazards

Chemistry of Drugs: Classification of drugs based on structure and action: Antibacterial: sulfa drugs, synthesis of sulfathiazole, sulfapyridine, Antibiotics: β-Lactam antibiotics and synthesis of penicillin, chloramphenicol, Antiviral drugs: Azidothimidine, acyclovir; Antipyretics: Paracetamol, Analgesics: Analgine, Non-steroidal anti-inflammatory drugs: Ibuprofen, Antimalarial: Chloroquine, Antacids: Ranitidine

Engineering Materials: Energy materials, soft materials, smart materials, organic electronics, semiconductors, insulators, corrosion inhibitors

Introduction to Green Chemistry: Principles of green chemistry (12 principles), Green reagents (water and bio-based), solvents (green solvents eg. Water), and alternative reaction media (ionic liquids), multicomponent reactions, atom economy (examples: Diels-Alder reaction, Claisen rearrangement), sustainable organic chemistry

Food Chemistry: **Flavouring agents:** Definition of flavours–Classification–Chemical composition–common characteristics–Formulations–Uses and hazards, Preserving agents, antioxidants.

Sugar industry: Double sulphitation process. Refining and grading of sugar. Saccharin: synthesis and use as a sugar substitute – aspartame (structure and synthesis). Ethanol: manufacture from molasses by fermentation.

Learning Resources:

Text Books:

1. G. R. Chatwal, Gurudeep, Synthetic Organic Chemistry, Himalaya Publishers, 2009.
2. Ashutoshkar, Medicinal Chemistry, New Age Publications, 2010, Fifth Edition.
3. V. K. Ahluwalia, M. Kidwai, New Trends in Green Chemistry, New Age Publications, 2004
4. B. Srilakshmi , Food Science, New age International Pvt. Ltd. Publishers, III ed. 2003.

Reference Books:

1. John W. Nicholson, Chemistry and Physics of Modern Materials, Royal Society of Chemistry, 2012, Third Edition.
2. A. S. Khanna, High-Performance Organic Coatings, Elsevier, 2008
3. P.T. Anastas and J.C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, 2000.
4. H.D. Belitz, Werner Grosch, Peter Schieberle, Food Chemistry, Springer Science & Business Media, 2009, Fourth Edition.

CY2326 **3-0-0 (3)**

Environmental Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify relationship between chemical exposure and effects on physiological systems.
CO-2	Understand causes and effects of environmental pollution and mitigation strategies.
CO-3	Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil).
CO-4	Describe water purification and waste treatment processes and the practical chemistry involved.
CO-5	Discuss local and global environmental issues based on the knowledge gained throughout the course.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemistry of Atmosphere: Origin, composition and structure of atmosphere-particles, ions and radicals in the atmosphere, Greenhouse effect-Causes, consequences and abatement of Greenhouse effect-Ozone depletion- Causes, consequences and abatement of ozone depletion, Photochemical smog-Effects and control.

Air Pollution-Monitoring and Control: Air sampling techniques-Sources and effects, of oxides of sulphur, oxides of nitrogen, oxides of carbon, Monitoring of air pollutants by Instrumental methods, Monitoring and Control of particulate pollution- Monitoring of air pollutants by Instrumental methods, Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods.

Water Pollutants and waste water treatment: Water and Environment; Types of Pollutants, Pollution indicators, Waste water Constituents, water Quality requirements, various methods of waste water treatment.

Soil chemistry: Nature and composition of soil, Acid base and ion exchange reactions in soil, macronutrients in soil, Micronutrients in soil, Nitrogen, phosphorous and potassium in soil, Fertilizers, wastes and pollutants in soil, Soil loss and degradation, Agriculture and health.

Solid Waste Management and environmental impact assessment: Solid waste disposal and management: classification and origin, methods of solid waste disposal, Microbiology involved in solid waste disposal, Environmental Impact Assessment, Environmental Impact Assessment process in India-Environmental acts and rules.

Learning Resources:

Text Books:

1. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, Narosa publishing House, 2005, Second Edition.
2. M. N. Rao, A.K. Datta, Waste water treatment, Oxford Publications, 2013, Third Edition.

Reference Books:

1. J. Glynn Henry, Garry W. Heinke, Environmental Science and Engineering, Prentice-Hall, Inc., New Jersey, USA, 1996, Second Edition.

Professional Electives I-VII

CY16021 **3-0-0 (3)**

Bioinorganic Chemistry

Pre-Requisites:

Course Outcomes:

CO-1	Understand role of metal ions in biological processes
CO-2	Interpret toxicological mechanisms of metals and the biological defenses against the toxic effects
CO-3	Identify metal sites in enzymes involved in the activation of molecules
CO-4	Understand medicinal applications of inorganic compounds
CO-5	Evaluate coordination chemistry principles in modulating properties of metal centers in enzymes

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	**3**	**–**	**–**	**–**	**–**	**–**
CO-2	**2**	**–**	**1**	**1**	**1**	**–**
CO-3	**2**	**–**	**–**	**–**	**–**	**–**
CO-4	**3**	**–**	**2**	**–**	**–**	**–**
CO-5	**2**	**–**	**1**	**1**	**1**	**–**

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Fundamental concepts in biochemistry and biology: biosphere; living organisms; cells and cell compartments; biomolecules, distribution of elements in the earth's crust, seawater and organisms, inorganic elements in biological systems. Essential and trace metal ions in biology and their distribution, overview of metal ion function in metalloproteins and enzymes, metal ion transport and storage, function of special ligands - porphyrins, chlorin and corrin.

Principles of coordination chemistry and physical methods in Bioinorganic Chemistry: Overview of thermodynamics and kinetics aspects, electronic and geometrical aspects of metal ions, reactions of coordinated ligands, analysis of biomolecules by physical methods.

Functions of biomolecules: Sodium and potassium transport, dioxygen binding and activation by heme, non-heme and copper proteins, Iron transport and storage proteins in bacterial and mammalian systems, Electron transport–FAD, NAD, FMN, ubiquinone and blue copper proteins, Cytochromes, Iron- sulfur proteins – rubredoxin, ferredoxins, Photosynthesis.

Enzymes: Hydrolytic enzymes, enzymes deal with hydrogen peroxide and dioxygen, cobalt containing enzymes, Nitrogen-cycle enzymes.

Medicinal applications: metals in medicine, anti-cancer agents–cisplatin and other compounds, radiopharmaceuticals (Tc), diagnostic (Gd in MRI) and therapeutic agents Toxicity of Hg, Cd, Pb and As and chelation therapy.

Learning Resources:

Text Books:

1. S. J. Lippard, J. M. Berg, Principle of Bioinorganic chemistry, Univ. Science Books, 1994.
2. I. Bertini, H. B. Gray, E. I. Stiefel, J. S. Valentine, Biological Inorganic Chemistry: Structure & Reactivity, Univ. Science Books, 2007.

Reference Books:

1. G. N. Mukherjee, A. Das, Elements of Bioinorganic Chemistry, UN Dhur Pvt. Ltd, 1993, 4th Edition.
2. W. Kaim, B. Schwederski, A. Klein, Bioinorganic Chemistry -Inorganic Elements in the Chemistry of Life: An Introduction and Guide, Wiley, 2013, 2nd Edition.

CY16023 **3-0-0 (3)**

Heterocyclic Chemistry

Pre-Requisites: Basic knowledge of organic functional groups

Course Outcomes:

CO-1	Classify heterocyclic compounds and their nomenclature
CO-2	Understand the physical and chemical properties of simple and fused heterocyclic compounds
CO-3	Design the route to synthesize the heterocyclic compounds
CO-4	Apply the knowledge of heterocyclic chemistry to synthesize the natural products
CO-5	Apply the knowledge of heterocyclic chemistry to synthesize drug like molecules

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	-	2	-	1	1
CO-2	2	-	3	-	2	1
CO-3	3	-	3	-	3	1
CO-4	1	-	1	-	3	3
CO-5	1	-	1	-	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Non-Aromatic Heterocycles: Different types of strains, interactions and conformational aspects of non-aromatic heterocycles. Synthesis, reactivity and importance of following ring systems. Three and four membered heterocycles with O, N, S.

Aromatic Heterocyclic Compounds preparation properties and reactivities: Pyrrole, furan, thiophene and pyridine. Bicyclic ring systems derived from pyrrole, furan and Thiophene: Indoles, Isoindoles, carbazole, Benzofurans, Benzothiophene. Bicyclic ring systems derived from pyridine: Quinolines, Isoquinolines and Acridines. Five-membered heterocyclic compounds with two hetero atoms: Pyrazoles, Benzopyrazoles, Imidazoles, Bezimidazoles, Isoxazoles, Oxazoles, Benzoxazoles, Thiazoles. Six membered heterocyclics with two hetero atoms: Pyridazines, Pyrimidines, Quinazolines and Pyrazines. Synthesis of drug molecules based on the above heterocyclic rings.

Oxygen heterocyclic compounds: Coumarins, Chromones, Flavones and Isoflavones.

Mesoionic heterocycles: synthesis and aromaticity of sydnones, 1,3-dipolar addition reactions of mesoionic heterocycles.

Learning Resources:

Text Books:

1. J. A. Joule, K. Mills, Heterocyclic Chemistry, Wiley, 2010, 5th Edition.

2. V. K. Ahulwalia, Heterocyclic Chemistry, Narosa, 2012, 1st Edition.

Reference Books:

1. T. L., Gilchrist, Heterocyclic Chemistry, Pearson Education, 2008, 3rd Edition.
2. R. K. Bansal, Heterocyclic Chemistry, New Age International, 2017, 5th Edition.

CY16025 **3-0-0 (3)**

Solid State Chemistry

Pre-Requisites: **Basics of crystal structure**

Course Outcomes:

CO-1	Understand structures of crystal systems and imperfections in crystals
CO-2	Relate the knowledge of diffraction techniques for structure determination
CO-3	Selection of an appropriate technique for characterizing the new solid materials
CO-4	Impact of crystal structures on the solid materials
CO-5	Understand electrical, optical and dielectric properties of solids

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	1	-	-	-
CO-2	-	1	-	-	1	1
CO-3	1	-	1	-	-	-
CO-4	-	1	-	-	-	-
CO-5	1	2	-	1	1	2
CO-6	1	-	1	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Crystal structure: Lattice Energy, Miller Indices, Crystal defects, Types of crystals, Solid-Solutions, Phase diagram and their interpretations, Some Important Structure: Perovskite, Spinel, Pyrochlore.

Synthesis and Characterization of Crystals: Shake 'n Bake, Chimie Douce, Hydrothermal and Microwave Methods; X-ray diffraction: Single crystal and Powder Methods: The Debye Scherrer Method, Electron diffraction, Neutron diffraction.

Properties of solids: Superconductivity, Low- and High-temperature Superconductivity, BCS theory, Electrical Properties, Magnetic properties, and Optical & dielectric properties.

Learning Resources:

Text Books:

1. Lesley Smart, Elaine Moore, Solid State Chemistry, An Introduction, CRC press, 5th Edition 2020.
2. Anthony R. West, Solid State Chemistry and its Applications, Wiley publication, 2nd Edition 2022.

Reference Books:

1. V. Keer, Principles of the Solid State, New Age International 2nd Edition, 2017.
2. Weller, T. Overton, J. Rourke, and F. Armstrong, Inorganic Chemistry, Oxford University Press, 6th Edition, 2014. (South Asia Edition 2015)

CY16022 **3-0-0 (3)**

Chemistry of Natural Products

Pre-Requisites: **Basic knowledge of Organic Synthesis**

Course Outcomes:

CO-1	Understand the concept of structure elucidation of natural compounds
CO-2	Build the synthetic schemes of natural products and bioactive molecules
CO-3	Analyze the stereochemistry of drug molecules
CO-4	Apply the knowledge of biosynthesis in total synthesis of organic molecules.
CO-5	Design new synthetic methodologies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2		3		3	2
CO-2	2		3		3	2
CO-3	3	1	3	1	3	2
CO-4	3		3		3	2
CO-5	3	1	3	1	3	2
CO-6	3		3		3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Classification of Natural Products, isolation of natural products, general methods of structural elucidation and stereochemistry.

Terpenoids: Classification, Structure and synthesis of Mono, sesqui, di, tri terpenoids, biogenesis of terpenoids (Geraniol, Alpha- Terpineol, Alpha-pinene, Camphor, Cadenene, Abeitic acid)

Steroids: Classification, structure, stereochemistry and synthesis of steroids (Cholesterol).

Alkaloids: Structure and chemistry of papaverine, Quinine, Morphine, Lysergic acid and Resepine, nicotine, atropine.

Vitamins: Structure and synthesis of vitamins B1

Learning Resources:

Text Books:

1. I. L. Finar, Organic Chemistry, Vol. I & II, Pearson Education India, 2002, 5th Edition.
2. O.P. Agarwal, Organic Chemistry Natural Products -Vol. I, Krishna Prakashan Media (P) Ltd, 2015.

Reference Books:

1. R. Cooper, G. Nicola, Natural Products: Chemistry Sources, Separations, and Structures, CRC Press. 2015.
2. J.J. Li, E.J. Corey, Total Synthesis of Natural Products: At the Frontiers of Organic Chemistry, Springer, 2015

CY16024 **3-0-0 (3)**

Bio-organic Chemistry

Pre-Requisites: **Structure and properties of organic compounds**

Course Outcomes:

CO-1	Understand the importance of biomolecules
CO-2	Illustrate the structure and functions of bioorganic molecules
CO-3	Interpret the physiological role of RNA, DNA and enzymes
CO-4	Utilize the concepts of protein purification and synthesis in bio-pharma industry
CO-5	Apply the concepts of enzyme catalysis for industrial applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	1	3	3
CO-2	3		3		3	3
CO-3	3	1	3	2	3	3
CO-4	3		3		3	3
CO-5	3	1	3	2	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Amino acids: Amino acids: structure, acid-base chemistry, and chemical synthesis; Asymmetric Synthesis of Amino Acids.

Proteins and Peptides: Introduction, Quaternary Structure of Proteins, Protein Purification Methods, amino acid analysis and peptide sequencing; peptide bond formation and coupling reagents-carbodiimides and phosphonium reagents; orthogonal protecting groups; solid-phase peptide synthesis: (Fmoc/Boc strategies); native peptide ligation; cyclic peptides; Enzyme chemistry: Introduction, proteases and phosphatases; proteins as drug targets, Enzyme technology, Enzyme catalysis.

Coenzymes: Structure and biological function of coenzyme A, thiamine pyrophosphate (TPP), pyridoxal phosphate (PLP), oxidized and reduced forms of NAD^+, NADH, $NADP^+$, NADPH, ATP.

Nucleosides, nucleotides and nucleic acids: Introduction to nucleic acids: biological importance, discovery, structure; chemical synthesis of nucleosides and protecting groups for nucleobase, sugar and phosphates; solution and solid phase synthesis of oligonucleotides: PCR; enzymatic synthesis of nucleic acids; principle behind sequencing; nucleic acid as drug targets.

Lipids: Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins. Lipid metabolism -β-oxidation of fatty acids.

Learning Resources:

Text Books:

1. A.L. Lehninger, Principles of Biochemistry, Worth Publishers, 2017, 7th Edition.
2. H.B. Dugas, Bioorganic Chemistry, Springer, 1996, 3rd Edition.
3. L. Stryer, W.H.F. Freeman, Biochemistry, 2006, 6th Edition.

Reference Books:

1. O.P. Agarwal, Organic Chemistry Natural Products -Vol. I, Krishna Prakashan Media (P) Ltd, 2015.
2. D. Voet, J.G. Voet, C.W. Pratt, Biochemistry Wiley, 2018.

CY16032 **3-0-0 (3)**

Advanced Inorganic Materials

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the concepts involved in synthesizing advanced inorganic materials.
CO-2	Apply the concept to design new inorganic materials.
CO-3	Understand the structure-property correlation in these materials.
CO-4	Understand and identify societal issues and design new inorganic materials to solve them.
CO-5	Apply the concept to develop new devices for renewable energy applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	–	–	2	–	1
CO-2	3	1	–	1	–	2
CO-3	2	1	–	2	–	1
CO-4	3	–	–	1	–	1
CO-5	3	1	–	2	–	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to advanced inorganic materials. Definition and classes of materials. Molecular design of materials. From the molecule to the material. Basic experimental techniques for the characterization of materials: General aspects.

Methods of Synthesis: Chemical Method, High-Pressure Method, Arc Technique, and Skull Method.

Different methods for single crystal growth: Crystal Growth from Melt: Bridgman and Stockbargar, Czochralski and Vernuil methods; Crystal growth from liquid solution: Flux growth and temperature gradient methods; Crystal growth from vapor phase: Epitaxial growth methods.

Thin film preparation: Physical and Chemical methods.

Solid Solutions: Formation of Substitutional, Interstitial and Complex Solid Solutions; Mechanistic Approach; Study of Solid solutions by X-ray Powder Diffraction and Density Measurement.

Properties: Application of MXene. Gallium-nitride, Gallium-arsenide and their semiconducting properties in LED, Indium-tin-oxide (ITO) and its transparent conducting property, Allotropes of carbon (graphite, diamond, fullerene, graphene, carbon nanotube) and their properties. Thermoelectric materials, Superconducting property of Inorganic materials, Topological insulator materials and their properties, Inorganic materials for solar cell application, and Battery materials. Microporous, mesoporous, and macroporous materials. Zeolites and other porous materials. Applications.

Learning Resources:

Text Books:

1. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced inorganic chemistry, John Wiley and Sons, New York, 1996, 6th Edition.
2. E. Smart and E. A. Moore, Solid state chemistry –An introduction, CRC Press, 2012, 4th Edition.

Reference Books:

1. W. Henderson, Main group chemistry, Royal Society of Chemistry, Cambridge, 2000.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic chemistry-principles of structure and reactivity, Harper-Collins, NY, 1993, 4th Edition.

CY16030 **3-0-0 (3)**

Nuclear and Radiochemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the general concept of radioactivity
CO-2	Identify various methods and instrument used in measuring radioactivity
CO-3	Know the applications of radioactivity in various human endeavour
CO-4	Describe about various effects of radiation exposure
CO-5	Know about management of hazardous nuclear waste

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	–	–	1	–	1
CO-2	2	2	–	1	–	2
CO-3	2	–	–	2	–	2
CO-4	2	–	–	1	–	1
CO-5	3	–	–	2	–	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Radioactivity in nature, Radioelements, Isotopes, Radionuclides, Physical Properties of atomic nuclei and elementary particles, Radioactive decay and decay modes.

Nuclear Radiation and Measurement: General properties, Alpha, beta and gamma radiation, Neutrons, Short-lived elementary particles in atoms and molecules, Activity and counting rate, Detectors, Spectrometry, Determination of absolute disintegration rates, Neutron detection, Statistics and errors of counting.

Nuclear Reactions and Chemical effects of nuclear reactions: Mono and binuclear reactions, Energetics, projectiles, yields and mechanisms of nuclear reactions, low and High energy reactions, Heavy ion reactions, Nuclear fission, Nuclear fusion. Recoil effects, Excitation effects, Szilard Chalmers reactions, Recoil and self-labelling, Dependence of Half-lives and Radiation emission on chemical bonding.

Nuclear Energy: Energy production by nuclear fission, Nuclear Fuel and Fuel Cycles, Fuel elements, Nuclear reactors, Moderators and coolants, Reprocessing, Radioactive waste, Nuclear reactors, Controlled thermo nuclear reactors, Nuclear explosives.

Applications of Radio Chemistry: Dating by Nuclear Methods, Radiotracers in chemistry, Radionuclides in the life sciences, Industrial applications of Radionuclides and Nuclear radiation

Radiation Protection: Dosimetry, External and Internal radiation sources, Effects of radiation in humans, animals and plants, radiation exposure, safety recommendations and regulations.

Learning Resources:

Text Books:

1. K. H. Lieser, Nuclear and Radiochemistry: Fundamentals and applications, Wiley VCH, 2001, 2nd Edition.
2. G. Choppin, J.-O. Liljenzin, J. Rydberg, Radiochemistry and nuclear chemistry, Butterworth-Heinemann, Woburn, MA, 2002, 3rd Edition.

Reference Books:

1. G. F. Knoll, Radiation Detection and measurement, Wiley, New York, 2000, 3rd Edition.
2. W. D. Ehmann, D. E. Vance, Radiochemistry and nuclear methods of analysis, Wiley Interscience, New York, 1991.

CY17021 **3-0-0 (3)**

Spectroscopy for Structural Elucidation

Pre-Requisites: **Molecular Spectroscopy**

Course Outcomes:

CO-1	Summarize the basic principles of spectroscopy
CO-2	Identify the structure of organic compounds using spectroscopy
CO-3	Analyze the structural aspects and stereochemistry of organic compounds using spectroscopy
CO-4	Interpret molecular mass and fragmentation of organic compounds using mass spectrometry
CO-5	Solve the structure of unknown organic compounds by using spectral data

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	3	-	-	-	-
CO-2	1	3	-	-	1	-
CO-3	1	3	-	-	1	-
CO-4	1	3	-	-	1	-
CO-5	1	3	-	-	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Ultraviolet and Visible Spectroscopy: Factors influencing the position of UV bands. Woodward-Fieser rules for calculating absorption maxima of unsaturated compounds and related compounds. Applications of UV spectroscopy.

Infrared Spectroscopy: Interpretation of illustrative examples. Characteristic absorptions in common classes of compounds. Applications of IR spectroscopy.

NMR spectroscopy-I (^{1}H-NMR): Chemical shifts, Equivalent and non-equivalent protons, enantiotopic and diastereotopic protons, Spin-spin coupling: ^{1}H-NMR of organic molecules ethyl acetate, ethanol, anisole, paracetamol, *p*-Toluidine, ethylbenzoate, *N*-acetanilide and cinnamaldehyde. First order and non-first order spectra, lanthanide shift reagents and double resonance techniques. Nuclear Over Hauser enhancement (NOE). Applications of ^{1}H-NMR spectroscopy.

Introduction, Types of ^{13}C-NMR spectra: coupled, proton-decoupled and off-resonance decoupled (ORD) spectra. ^{13}C chemical shifts, factors affecting the chemical shifts.

Mass spectrometry: Principle of EI, CI, Electrospray (ESI) ionization, Fast Atom Bombardment (FAB). Principles of different ionization techniques (EI, CI, FAB etc.). Types of fragments: Nitrogen rule, isotopic peaks, metastable peaks. High resolution mass spectrometry. Determination of molecular formula.

Learning Resources:

Text Books:

1. W. Kemp, Macmillan, Organic Spectroscopy, 2009, 3rd Edition.
2. P. S. Kalsi, Spectroscopy of Organic Compounds, New Age International Publishers, 2020, 8th Edition.

Reference Books:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to Spectroscopy, Brooks/Cole,Thompson Learning, 2001, 3rd Edition.
2. R. M. Silverstein, F. X. Webster, D. J. Kiemle, D.L. Bryce, Spectrometric Identification of Organic Compounds, Wiley, 2014, 8th Edition.

CY17023 **3-0-0 (3)**

Chemical Education

Pre-Requisites:

Course Outcomes:

CO-1	Understand the importance of chemical education and ethical standards
CO-2	Identify promising modern research trends with their strength, growth and application
CO-3	Discover the strengths of chemical education in modern world and mankind in future
CO-4	Examine safety and ecological approaches in dealing hazardous compounds and effluents
CO-5	Recommend models and tools helping effective dissemination of trends in chemical education and research

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	-	-	-	-	1
CO-2	2	-	1	-	-	2
CO-3	2	1	-	1	-	1
CO-4	3	1	2	2	2	3
CO-5	3	2	-	-	1	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemistry as the Central Science: Uniqueness of Chemical Stoichiometry; Chemistry of Inanimate and Living Materials, Chemistry and Civilization; Chemistry in Product Industry; UN Slogan, 'Chemistry- Our Life and Our Future'; Amazements in Chemistry: Amusement in Chemistry Classroom; Chemistry and Magic.

Chemical Hazards and Disasters: Chemistry of Explosives, Poisons and Polluttants; GLPs; Models and Tools of Chemical Education: Models and Virtual Experiments

Thrust Areas of Chemical Research: Topic by Relevance to Health, Nutrition, Energy, Environment, Sanitation, Technology, Rural Employment, Harnessing Natural Resources; IPR and Patents in Chemical Research and Innovations: Intellectual Property Rights in Chemical Innovations and Products; Patent Paradigms

Learning Resources:

Text Books:

1. Chemical Education, S. Ladage and S.D. Samant, Narosa Publishing House, 2012

2. Affective Dimensions in Chemistry Education, M. Kahveci and M. Orgill, Springer (e-Book), 2015.

3-0-0 (3)

CY17031

Applied Analytical Methods

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basic concepts of analytical chemistry
CO-2	Identify the sources of errors in analytical results
CO-3	Identify the importance of separation methods for purifying the mixture of compounds
CO-4	Choose the appropriate analytical technique for qualitative and quantitative estimation of unknown samples
CO-5	Evaluate the pattern of experimental data using the analytical techniques studied.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	1	1	1	1
CO-2	2	1	1	1	1	1
CO-3	1	1	1	3	2	1
CO-4	1	1	1	3	3	2
CO-5	1	1	1	3	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Errors and Statistical Treatment of Data: Accuracy and Precision; Errors and Error Distributions; Standard Deviation; Confidence limits and intervals, Criteria for Rejection of Data – z- test, t-test, F-test, Q-test.

Separation Methods: Solvent extraction, Distribution Law; Extraction by Chelation, Extraction by Solvation, Extraction by Ion-Pair Formation, Batch and Continuous Extractions; Solid Phase Separation; Chromatographic Separations, Basic Principle, Stationary and Mobile Phases, void time, retention rime, and retention factor, separation factor, Electrophoresis.

Spectroanalytical Methods: Atomic Spectroscopy: Atomic Absorption, Atomic Emission, and Atomic Fluorescence; Molecular Spectroscopy: Beer's law, Deviations of Beer's Law, standard-addition method, steady-state fluorescence, life-time, fluorescence quenching, Phosphorescence, turbidimetry and nephelometry, refractometry; Mossbauer Spectroscopy: Recoilless Gamma Ray Absorption; Mossbauer Effect; Chemical Shift (Isomer Shit); Quadrupole Shift; Zeeman Effect; Applications; Polarimetry: Optical Rotatory Dispersion and circular dichroism in Qualitative and Quantitative Analysis of Chiral Compounds.

Thermoanalytical Methods: Thermogravimetric Analysis (TGA); Differential Thermal Analysis (DTA); Differential Scanning Calorimetry (DSC); Applications.

Radioanalytical Methods: Radioactive nuclides, Neutron activation analysis (NAA), isotope dilution analysis.

Learning Resources:

Text Books:

1. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, Saunders College Publishing, 2004, 8th Edition.
2. G. D. Christian, Analytical Chemistry, Wiley India, 2009, 6th Edition.

Reference Books:

1. D. Harvey, Modern Analytical Chemistry, McGraw Hill, 1999, 1st Edition.
2. R.A. Day Jr, A.L. Underwood, Quantitative Analysis, PHI, 2009, 6th Edition.

CY17033 **3-0-0 (3)**

Electroanalytical Methods

Pre-Requisites: Fundamentals in analytical and physical chemistry, and basic mathematics. Familiarity with electrochemistry concepts is recommended.

Course Outcomes:

CO-1	Understand the basic principles of stationary and dynamic electroanalytical methods
CO-2	Identify strengths of pulse methods for superior quantitative analysis
CO-3	Analyze the results of micro- and rotating disc electrodes for interpreting mechanisms of electrochemical reactions
CO-4	Evaluate the efficiency and capacity of electrochemical energy storage materials
CO-5	Choose a combination of electroanalytical methods for comprehensive analysis of electrochemical materials and devices

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	2	1	2	1	2
CO-2	1	2	2	2	-	2
CO-3	3	2	1	1	3	1
CO-4	1	-	2	-	2	3
CO-5	2	1	3	-	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Steady-state and potential step techniques: Open circuit potential, Stern layer thickness, Linear sweep voltammetry, Cyclic voltammetry, Reversibility and accompanied chemical and catalytic reactions, Principles and applications. Microelectrodes, Capacitance, Turnover number, Surface electrochemistry.

Pulse voltammetry and hydrodynamic analysis: Normal and differential pulse voltammetry, Square wave voltammetry: Anodic stripping and cathodic stripping voltammetry and applications. Hydrodynamic measurements, rotating disk and rotating ring disk electrodes, and flow-cell analysis, capillary systems and lab-on-chip analysis.

Chronomethods: Principles, instrumentation and applications in Electrocatalysis (Oxygen and hydrogen evolution reactions), electrochemical sensors, development of capacitors and electrochemical supercapacitors, cyclic charging discharging processes, C rate and electrochemical capacitance. Electrochemical supercapacitors: Ragone plot, comparison with batteries, energy and power densities of storage devices, Pseudocapacitance, Ruthenium and porous materials, applications.

Electrochemical impedance and polarization methods: Electrochemical impedance spectroscopic measurements, principles and applications, equivalent circuits, Nyquist and Bode plots, potentiodynamic polarization studies, Randles model, Tafel methods. Electrochemical quartz crystal microbalance, principle, Thin layer coatings, Adlayer formations, electrodeposition of metals, applications.

Hyphenated methods: Electrochemical scanning tunneling microscopy, principles, instrumentation, Potential-UV-VIS measurements, Potential-Infrared measurements, applications.

Learning Resources:

Text Books:

1. A.J Bard, L. R Faulkner, Electrochemical methods: Fundamentals and applications, John Wiley, 2022
2. F. Scholz, Electroanalytical methods: Guide to experiments and applications, Springer, 2014

Reference Books:

1. B. E. Conway, Electrochemical supercapacitors - Scientific fundamentals and technological applications, Springer, 2014.
2. P. M. S Monk, Fundamentals of Electroanalytical Chemistry, John Wiley, 2008
3. P. Ceroni, A. Credi, M. Venturi, Electrochemistry of Functional Supramolecular Systems, John Wiley, 2010.

CY17022 **3-0-0 (3)**

Medicinal Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand basic concepts of drug discovery
CO-2	Apply the concepts in lead discovery
CO-3	Identify the importance of Lipinski rule and bioisosterism
CO-4	Evaluate the concepts of SAR and QSAR
CO-5	Design and develop a molecule with drug like property

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	-	3	1	1	3
CO-2	3	-	3	1	3	2
CO-3	3	-	3	-	3	-
CO-4	3	-	3	-	-	-
CO-5	3	-	3	1	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basics of Drug Discovery: Origin, comparison with ayurveda and homeopathic medicines, drug efficacy, potency, assay development, IC_{50}, LD_{50}, ED_{50}, Therapeutic index, margin of safety, agonist, antagonist, IND, NDA, quantal dose and graded dose. pharmacophore identification, lead modification, Lipinski rule, drug-like properties, druggability, bioisosterism, ADME, Factors affecting on ADME, Toxicity (CYPs, Glucuronidation)

Drug targets: Macromolecules as targets (receptors, enzymes, nucleic acids, cell organelles).

Drug discovery stages and strategies: SAR and QSARS, tereo chemical and metabolic aspects of drugs, serendipitous drug discovery, drug discovery without lead, natural products, fragment and metabolites based drug discovery (examples), clinical observations, random screening and non-random screening.

Chemistry of Drugs: Pharmacological activity, uses and limitations of Antipyretics, Analgesics, Sedatives, Hypnotics, Barbiturates, Sulpha drugs, Anaesthetics, Antiseptics, Antibacterial, Diuretics, Anthelmintic, Anticoagulants, Anticonvulsants, Antihistamines, Psychotherapeutics, Anti TB Drugs, Diagnostic agents and Antimalarial drugs (selective examples)

Drug Delivery Systems: Introduction to the necessity of Drug Delivery Systems, Types of drug delivery systems, Micelles, Vesicles, Polymers, Dendrimers, Nano spheres, Nano tubes etc., Osmatic Oral Drug Delivery Systems, Transdermal Drug Delivery Systems, Implantable Drug Delivery Systems.

Combinatorial synthesis: Combinatorial and building block approaches for the drugs and role of biomarkers (examples).

Learning Resources:

Text Books:

1. A. Kar, Medicinal Chemistry, New Age Publications, 2007.
2. G. L. Patrick, An Introduction to Medicinal Chemistry, Oxford Press, 2009, 4th Edition.

Reference Books:

1. Burger, Medicinal Chemistry Vol-I & II, Wiely Int.Sci., 1999.
2. R. B. Silverman, M. W. Holladay, The organic chemistry of Drug Design and Drug Action Academic Press, 2014, 3rd Edition.

CY17024 **3-0-0 (3)**

Stereoselective Synthesis

Pre-Requisites: **None**

Course Outcomes:

CO-1	To understand the 3-dimentional behavior of the organic/organometallic compounds during the reaction
CO-2	To predict the possible product from the 3-dimentional orientation of the intermediate that participate in the reaction
CO-3	Apply the knowledge of stereoselective synthesis for the preparation of active pharmaceutical ingredients and drug like compounds
CO-4	Apply the knowledge of stereoselective synthesis for the preparation of materials in materials and agriculture industry
CO-5	To understand and apply the knowledge of separation techniques for small and large scale reactions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	3	1	3	3
CO-2	2	2	2	1	2	3
CO-3	2	2	3	2	3	3
CO-4	3	2	3	1	3	3
CO-5	1	1	1	1	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Strategies of asymmetric synthesis: Strategies of asymmetric synthesis, double stereo differentiating reactions, diastereoselective synthesis, Nucleophilic addition to cyclic carbonyl compounds, Aldol reactions based on achiral enolates, chiral enolates, small ring templates, chiral auxiliaries, achiral auxiliaries, intraanular and extraanular setreocontrol.

Stereo selective Reactions: Stereo selective reactions of C=C double bond, Asymmetric hydrogenation, Oganoboranes, organosilanes

Enantioselective Reactions. Enantioselective synthesis with chiral organometallic complexes, oxidation and reductions with chiral complexes, complex hydrides, Organocatalysis, asymmetric cross-coupling reactions, asymmetric metathesis reactions, directed asymmetric synthesis of natural and drug like molecules.

Learning Resources:

Text Books:

1. L. Ernest , Eliel ,H. Samuel H. Wilen Stereochemistry of Organic Compounds, , Wiely-India, 2008.
2. Stereochemistry: Conformation and Mechanism, P.S. Kalsi, New Age Publishers, 2019, 10th Edition.

Reference Books:

1. I. Ojima, Catalytic Asymmetric Synthesis, John Wiley & Sons, Hoboken, New Jersey, USA. 2012.

2. G. R. Stephenson. Chapman, Hall, Advanced asymmetric synthesis, Springer Science, 1996.

CY17026 **3-0-0 (3)**

Advanced Organic Spectroscopy

Pre-Requisites: Molecular spectroscopy, Spectroscopy for structural elucidation

Course Outcomes:

CO-1	Understand the concepts of spectroscopy
CO-2	Summarize the principles of PMR and CMR spectroscopies
CO-3	Analyze the concepts of ^{19}F spectroscopy in determining the structures of molecules
CO-4	Apply the principles of 2D NMR spectroscopy in resolving the structures of organic molecules
CO-5	Discuss the principle of ^{31}P and mass spectrometry and their applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	3	-	-	-	-
CO-2	1	3	-	-	1	-
CO-3	1	3	-	-	1	-
CO-4	1	3	-	-	1	-
CO-5	1	3	-	-	1	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Spectroscopy II (^{1}H-NMR): Applications of ^{1}H-NMR spectroscopy: Reaction mechanisms E,Z isomers, study of conformational changes through NMR of cyclohexane and decalins, study of dynamic processes using NMR spectroscopy. Chiral lanthanide shift reagents and Mosher's acid.

^{13}C NMR spectroscopy: Calculation of chemical shifts of alkanes, alkenes and alkynes. Homonuclear (^{13}C, ^{13}C J) and heteronuclear (^{13}C, ^{1}H J and ^{13}C, 2H J) coupling. ^{13}C-NMR spectral editing techniques: principle and applications of APT, INEPT and DEPT methods.

2D-NMR spectroscopy: Principles of 2D NMR, Classification of 2D-experiments. Homonuclear and Heteronuclear 2D-J-resolved spectroscopy, ROESY, NOESY and 2D- INADEQUATE experiments and their applications.

^{19}F NMR spectroscopy: Introduction, ^{19}F chemical shifts, spin-spin coupling, coupling constants. Homonuclear couplings, Applications of ^{19}F NMR involving coupling with ^{19}F, ^{1}H and ^{31}P: 1, 2 dichloro-1, 1 difluoro ethane, BrF_5, SF_4, PF_5, ClF_3, IF_5, CF_3CH_2OH.

^{31}P NMR spectroscopy: ^{31}P chemical shifts, coupling constants. Applications of ^{31}P NMR involving coupling with ^{31}P, ^{19}F, ^{1}H and ^{13}C: Simple molecules ^{31}P, P_4S_3, H_3PO_4, H_3PO_3, H_3PO_2 and HPF_2.

Advanced Mass spectrometry: Mass Analyzers: Quadruple, Ion traps, Time of flight (TOF) mass analyzers Mass Spectrometry / Mass Spectrometry: Tandem Mass Spectrometry, Instrumentation, Applications. Hyphenated Techniques: GC-MS Principle, instrumentation, LC-MS, ICP – MS - Principle Instrumentation, and Applications, Desorption ionization methods, Spectroscopic Solutions

of Structural Problems.

Learning Resources:

Text Books:

3. D. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Cengage Learning, 2015, 5th Edition.

4. P. S. Kalsi, Spectroscopy of Organic Compounds, New Age International Publishers, 2020, 8th, Edition.

Reference Books:

1. W. Kemp, Organic Spectroscopy, Palgrave Publishers, 2007, 3rd Edition.

2. R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, Spectrometric Identification of Organic Compounds, Wiley, 2014, 8th Edition.

CY17028 **3-0-0 (3)**

Emerging Topics in Organic Synthesis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the concepts of multicomponent reactions and their mechanisms
CO-2	Understand the tandem reactions in organic synthesis
CO-3	Apply the principles of click chemistry in drug discovery, biology and materials chemistry
CO-4	Utilize the soft metal catalyst in organic synthesis
CO-5	Discuss the flow chemistry, micro reactors, separation techniques and process chemistry in organic synthesis

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	–	3	–	3	3
CO-2	2	–	3	–	3	3
CO-3	2	–	3	–	3	3
CO-4	–	–	3	–	3	3
CO-5	3	–	3	–	3	3
CO-6	3	–	3	–	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Recent developments in the multicomponent reactions (MCRs): General Approaches of MCRs, Synthesis of different heterocyclic compounds using 3, 4 and 5 component reactions, MCRs using homogeneous and heterogeneous catalysts.

Importance of click chemistry, applications of click chemistry in drug discovery, biology and materials chemistry. alternative solvent systems in organic synthesis, recent developments in ionic liquids, deep eutectic solvents.

Tandem (cascade/domino) reactions in organic synthesis, metal carbenes in organic synthesis, *n*-heterocyclic carbenes in organic synthesis, hypervalent iodine reagents in organic synthesis.

Soft metals in organic synthesis: silver in organic synthesis, indium in organic synthesis, gold in organic synthesis. nanomaterials in catalysis and organic synthesis, photocatalysis.

Recent advances in flow chemistry and micro reactors, separation techniques, process chemistry, trouble shooting in organic synthesis.

Learning Resources:

Text Books:

1. R. P. Herrera, E. Marqués-López, Multicomponent Reactions: Concepts and Applications for Design and Synthesis, John Wiley & Sons. 2015, 1st Edition.

2. L. F. Tietze, G. Brasche, K. Gericke, Domino Reactions in Organic Synthesis, John Wiley & Sons, 2006.

Reference Books:

1. T. Wirth, Microreactors in Organic Synthesis and Catalysis, John Wiley & Sons, 2008.
2. K H Dtz, Metal Carbenes in Organic Synthesis, Springer Science & Business Media, 2004.

CY17030 **3-0-0 (3)**

Advances in Total Synthesis of Natural Products

Pre-Requisites: **Organic synthesis**

Course Outcomes:

CO-1	Understand the concepts and tactics used in total synthesis of natural products
CO-2	Illustrate the multistep organic synthesis using different reagents
CO-3	Develop the retrosynthetic analysis for complex natural products
CO-4	Analyze the different concepts and strategies in total synthesis
CO-5	Choose the synthon approach in total synthesis of natural products

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	3	-	2	2
CO-2	1	-	3	-	2	2
CO-3	1	-	3	-	2	3
CO-4	1	-	3	-	2	3
CO-5	1	-	3	-	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Concepts and tactics in organic synthesis, linear synthesis, Convergent, Divergent and Building block approaches.

Practical difficulties in large scale synthesis, Symmetry driven total synthesis of Resolvin E2.

Dearomatization strategies in natural product synthesis, protecting group free synthesis, Solid-phase chemistry in the total synthesis of non-peptidic natural products.

Structure, absolute configuration and total synthesis of natural products: Taxol.

Learning Resources:

Text Books:

1. E. M. Carreira, L. Kvaerno, Classics in Stereoselective Synthesis, Wiley-VCH, 2008.
2. E. J. Corey, X.-M. Cheng, The Logic of Chemical Synthesis, John Wiley & Sons Inc. 1995.

Reference Books:

1. K. C. Nicolaou, E. J. Sorensen, Classics in total synthesis-I: Targets Strategies, Methods, Wiley-VCH, 2000.

2. K. C. Nicolaou, Scott A. Snyder, Classics in total synthesis-II: More Targets Strategies, Methods, Wiley-VCH, 2003.

CY17032 **3-0-0 (3)**

Advances in Industrial Catalysis

Pre-Requisites:

Course Outcomes:

CO-1	Understand the synthesis and properties of Molecular sieves
CO-2	Classify catalysts based on the properties
CO-3	Analyze mechanisms of new catalytic reactions
CO-4	Evaluate the mechanisms of enzymatic catalysis
CO-5	Modify the catalyst to meet the required industrial applications

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	-	-	-	-	-
CO-2	1	1	-	-	-	-
CO-3	1	1	-	-	-	-
CO-4	-	1	-	-	-	-
CO-5	1	-	-	-	-	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chapter-1: Introduction: The Phenomenon Catalysis; Mode of Action; Turnover Number, Turnover Frequency, Selectivity, Classification of Catalysts, Comparison of Homogeneous and Heterogeneous Catalysis and Langmuir Hinshelwood mechanism of Heterogeneous catalysis.

Chapter-2: Catalysts Preparation Methods: Ceramic Method; Microwave Method; Sol-gel Method; Co-Precipitation Method; Hydrothermal Method, Chemical Vapour deposition Method; Examples, Advantages, Limitations and Applications.

Chapter-3: Characterization of Catalysts: Elemental Analysis (Surface and Bulk), Low and Wide angle XRD, SEM – EDAX, TEM, TG/DTA, TPD-NH3, TG-MS, BET-Surface area, FT-IR, Raman, ESR, UV-Vis., XPS, MASNMR, and Cyclic voltammetry.

Chapter-4: Catalysis by Solid acids/bases/redox and multifunctional catalysts: Liquid phase, and Gas phase Catalysis, Examples, Solid acids/base: Alkylation, Cracking, Isomerization, Aromatization, and Methanol to olefin reaction. Solid redox catalysts: Phenol & Benzene hydroxylation, Ammoxidation, Alkane oxidation, Alcohol oxidation, Alkene epoxidation, Oxidative dehydrogenation, and Dye degradation. Multifunctional: Photocatalysis, Electrocatalysis, Applications in Petrochemical and Fine Chemical synthesis and one pot multicomponent synthesis.

Chapter-5: Other Industrially important catalysts and processes: Wilkinson catalyst, Zeigler Natta catalyst, Zeolites, Mesoporous materials, Hollow Silica, Metal Organo Framework, Nanocomposites, Fisher trope synthesis, Heck reaction, Suzuki coupling reaction, Haber process, Bio-diesel production

Chapter–6: Biocatalysis: Mechanisms and Applications: Introductions, Mechanisms, Applications of Enzymes in Organic Synthesis, Oxidoreductase, Transferase, Hydrolase, and Lyase.

Learning Resources:

Text Books:

1. B. Viswanathan, S. Sivasanker, A.V. Ramaswamy, Catalysis: Principles and Applications, , Narosa Publishing House, New Delhi 2007.
2. Jens Hagen, Industrial Catalysis: A Practical Approach, Wiley-VCH, Verlag GmbH & Co. KGaA, 2006.

Reference Books:

1. R. Szostak, Van Nostrand Reinhold catalysis series, Molecular sieves of synthesis and Identification, New York, 1989.
2. R. Szostak, Hand book of molecular sieves, International zeolite association, 2010.
3. Mark E. Davis, Mesoporous Zeolites, Preparation, Characterization and Applications, Wiley-VCH, Verlag GmbH & Co. KGaA, 2015.
4. Lesley Smart and Elaine Moore, Solid State Chemistry an Introduction, Stanley Thomes (Publishers) Ltd., 2004, 2nd Edition.

CY17034 **3-0-0 (3)**

Microscopic and Diffraction Methods

Pre-Requisites: Basic physical chemistry at bachelor level

Course Outcomes:

CO-1	Analyze electron microscopic images for morphological and in-depth material characteristics
CO-2	Interpret X-ray and particle diffraction patterns in assigning the crystallographic aspects of materials
CO-3	Understand the concepts of X-ray spectroscopy and electron microscopy for qualitative and quantitative analysis of solid samples
CO-4	Evaluate atomic arrangements and interatomic forces in solid materials
CO-5	Choose an appropriate microscopic and diffraction technique along with sample preparation methodology for analysis of materials

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	2	2	1	3
CO-2	1	2	1	3	2	1
CO-3	3	1	3	1	–	2
CO-4	1	3	–	1	3	1
CO-5	2	–	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Scanning Electron microscopy: Scanning electron microscopy, instrumentation, electron sources – Thermionic and Field emission guns, electromagnetic lenses, resolution and contrast, environmental SEM, FE-SEM, Sample preparation, Backscatter and secondary electron detectors, Energy dispersive X-ray spectrometry (EDX), Environmental SEM, Applications.

Transmission Electron Microscopy: Transmission electron microscopy (TEM): Principle, instrumentation, Sample preparation, imaging, electron diffraction, reflection electron microscopy, applications.

Probe microscopy: Scanning tunneling microscopy (STM), principles, basic parameters, atomic resolution, surface imaging, lithography. Atomic force microscopy: Principles, Static and dynamic probes, Contact and Non-contact operation modes, Advantages and applications. Chemical force microscopy, AFM Lithography, applications.

Diffraction methods: Introduction, X-ray diffraction, small-angle X-ray diffraction, Electron diffraction, Principle, Instrumentation, Applications. Reflection high-energy electron diffraction (RHEED), Principle, Instrumentation, and Applications.

Learning Resources:

Text Books:

1. S. Holler, Crouch, Principles of Instrumental Analysis, Cengage Learning, 2020.
2. R F Egerton Physical principles of electron microscopy: an introduction to TEM, SEM and AEM, Springer, 2016.
3. J Goldstein, D Newbury, D Joy, C Lyman, P Echlin, E Lifshin, L Sawyer, J R Michael, Scanning electron microscopy and X-ray microanalysis, Springer, 2003 and 3rd Edition.

Reference Books:

1. J. C Vikerman, I. Gilmore, Surface Analysis: The Principal Techniques, Wiley 2009, 2nd Edition.
2. A. Rouessac, F. Rouessac Chemical Analysis – Modern Instrumentation Methods and Techniques, John Wiley, 2010, 6th edition.

CY17036 **3-0-0 (3)**

Supramolecular Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the importance of non-covalent interactions in chemistry
CO-2	Identify the importance of cation and anion complexation in organic chemistry
CO-3	Identify the significance of supramolecular interactions in guest recognition
CO-4	Explain how supramolecular chemistry is used in organic chemistry, materials science, chemical biology and nanotechnology
CO-5	Discuss how supramolecular chemistry can be used to facilitate sustainable development

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	1	1	1	3
CO-2	3	2	2	1	1	3
CO-3	2	1	1	1	2	2
CO-4	1	1	2	1	2	3
CO-5	2	2	2	1	1	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Non-covalent interactions: Ion pairing, Ion-Dipole Interactions, Dipole-Dipole interactions, Dipole-Induced Dipole and Ion-Induced Dipole interactions, *vander Waals* or Dispersion Interactions, Hydrogen bonding, Cation-p interactions, Anion-p interactions, p-p interactions, Closed shell interactions, Aromatic-Aromatic Interactions

Cation Complexation and applications: The High Dilution Rule, Templated Cyclizations, Crown Ether, Cryptands, Spherand and Hemipherand, Calixarenes, ion channels; complexation by ammonium ions.

Anion Complexation: Halide Ion Receptors, Complexation Properties of Macrocyclic Polyamines, Ditopic Receptors, Anion Receptors, Guanidinium Ions, Complexation of Ion Pairs

Applications of cation and anion complexation: Phase Transfer Catalysis and Anion Activation, Cation and Anion Sensors, Molecular Switches, Ion Selective Membrane Electrodes, Applications in Chromotographic Separations, Allosteric Effects; Rotaxanes and Catenane,

Complexation of Neutral molecules: Hydrophobic Pockets at the Active Sites of Enzymes and Antibodies, Cyclophane Receptors, Electronic Effects in Cyclophane Complexes with Aromatic Substrates and polyaromatic Hydrocarbons, Combination of Apolar Binding and Ion Pairing; Cryptophanes for Neutral Guest and Onium Ion Inclusion

Hydrogen Bonding: Synthons, Secondary Electrostatic Interactions in Hydrogen Bonding Arrays, Hydrogen Bonding Receptors, Hydrogen Bonding in Cleft-Type Synthetic Receptors, Macrocyclic

Hydrogen Bonding Receptors, Chiral Recognition in Supramolecular Complexes, Carbohydrate Recognition

Learning Resources:

Text Books:

1. J. W. Steed, J. L. Atwood, Supramolecular Chemistry, John Wiley & Sons Ltd., 2nd Edition, 2013.
2. J. M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, VCH, Weinheim, 1st Edition, 1995.

Reference Books:

1. G. R. Desiraju, T. Steiner, The Weak Hydrogen Bond, Oxford Science Publications, 1999.
2. H. J. Schneider, A. Yatsimirsky, Principles and Methods in Supramolecular Chemistry, Wiley, Chichester, 2nd Edition. 2000.

CY17044 **3-0-0 (3)**

Green Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the principles of Green Chemistry
CO-2	Explain pollution causes and its prevention measures
CO-3	know about the renewable and non-renewable sources
CO-4	Apply concepts of green chemistry in organic synthesis
CO-5	Adopt green protocols for sustainable environment

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	1	1	1	2
CO-2	2	1	2	1	2	1
CO-3	2	1	2	2	1	3
CO-4	2	3	2	1	2	3
CO-5	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Green chemistry: Basic principles of Green Chemistry and their illustrations with examples. Prevention of waste/by-products, Prevention/Minimization of hazardous/toxic products, Atom Economy, Green metrics, Designing safer chemicals - different basic approaches, Selection of appropriate auxiliary substances (solvents, separation agents etc), Energy requirements for reactions-use of microwave, ultrasonic energy, Selection of starting materials—use of renewable starting materials.

Examples of green synthesis/reactions: Green starting materials, Green reagents, real world cases (Traditional processes and green ones): Ibuprofen, Paracetamol, Seldinafil, Nylons, Pregabalin, and Prostaglandin. Hazard assessment and mitigation in chemical industry, Future trends in Green Chemistry: OHSA rules, Oxidation-reduction reagents and catalysts; biomimetic, multifunctional reagents; Combinatorial green chemistry (MCRs); Proliferation of solvent less reactions; Noncovalentderivatization. Biomass conversion, emission control.

Green solvents: Aqueous medium: Enhancement of selectivity, efficiency, and industrial applicability, Ionic liquids, Supercritical fluids, Solvent free neat reactions in liquid phase, Solvent free solid phase reactions, Flourous phase reactions, Flourous separating techniques, isolation of soybean oil and caffeine. Nonconventional energy sources: Microwave assisted reaction, Ultrasound assisted reactions, photochemical reactions using sunlight.

Green catalysis: Heterogeneous catalysis: Use of zeolites, silica, alumina, clay, polymers, cyclodextrin, and supported catalysts, Biocatalysis: enzymes, microbes, Phase-transfer catalysis (micellar/ surfactant etc), Green industrial processes- case studies, Green analytical methods.

Learning Resources:

Text Books:

1. V. K. Ahluwalia, M. Kidwai, New trends in green chemistry, Springer, 2012, 1st Edition.
2. R. Sanghi, M.M Srivastava, Green Chemistry: Environment Friendly Alternatives, Alpha Science International, 2009, 4th Edition.

Reference Books:

1. P.T. Anastas, J.C. Warner. Green Chemistry: Theory and Practice, Oxford University Press, 2000, 1st Edition.

CY17046 **3-0-0 (3)**

Polymer Chemistry

Pre-Requisites: Organic Reactions and Mechanism, Thermodynamics and Kinetics

Course Outcomes:

CO-1	To understand the relationships between polymer molecular weight, molecular weight distribution, and the properties of various polymers
CO-2	To demonstrate an ability to distinguish different polymerization reactions, mechanisms and kinetics of polymerization process
CO-3	To analyze polymerization data and predict the conversion, which will lead to critical thinking about how to improve the setup for better polymerization
CO-4	To expand their skills in performing and analyzing the thermal and mechanical properties of polymers, and demonstrate an ability to predict how the molecular weight and other parameters will affect these properties
CO-5	To propose plan on plastic manufacturing from resins and polymers

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	–	–	–	1	1	2
CO-2	1	1	–	–	2	3
CO-3	2	2	1	–	2	3
CO-4	1	2	3	1	2	3
CO-5	1	–	3	–	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to polymers: Classification, physical and chemical properties.

Polymerization methods: Step, chain, and living radical polymerization, thermoplastic and thermosetting, polymerization techniques and kinetics

Characterization methods, structure-activity relationships

Reactions of macromolecules

Specialty polymers

Plastic processing and fabrication

Learning Resources:

Text Books:

1. P. Bahadur, N. V. Sastry, Principles of Polymer Science, Narosa Publishing House, 2002.

2. M. P. Stevens, Polymer Chemistry, An introduction, Oxford University Press, 1999, 3rd Edition,

Reference books:

1. Mark, James E., Physical Properties of Polymer Handbook, 2nd edition, Springer, 2007
2. George Odian, Principles of Polymerization, 4th Edition, 2004

CY17048 **3-0-0 (3)**

Chemistry of Nanomaterials

Pre-Requisites: Basics of materials chemistry

Course Outcomes:

CO-1	Understand the history of nanoscience
CO-2	Classify nanomaterials based on structural properties
CO-3	Model suitable nanomaterials with desired shape, size and structure towards diverse applications
CO-4	Select an appropriate technique for characterizing new nanomaterial
CO-5	Predict the impact of nanomaterials on the environment

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	-	-	-	-
CO-2	-	1	-	-	-	-
CO-3	1	-	1	1	-	2
CO-4	-	3	-	3	-	-
CO-5	2	-	-	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Nanostructure - an overview, Quantum confinement, dimensionality and size dependent phenomena, surface to volume ratio, surface dependent properties at nanoscale, Dimensionality based classification.

Synthesis and Characterization of Nanomaterials: Bottom-up approach: Sol-gel, microemulsions, co-precipitation, hydrothermal-solvothermal methods. Top-down approach: High energy ball milling, photolithography, waste to wealth creations; Characterization of nanomaterials using diffraction and microscopic methods, adsorption, light-scattering and electroanalytical techniques,

Applications: Solar energy harvesting and storage, catalysis, nanoelectronics, topological insulator, environmental remediations i.e CO_2 reduction, organic waste degradation.

Learning Resources:

Text Books:

1. T. Pradeep, Textbook of Nanoscience and Nanotechnology, Tata McGraw Hill Education Pvt. Ltd, 2012, 1st Edition
2. G. Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2013, 2nd Edition

Reference Books:

1. C. N. R. Rao, A. Muller, K. Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.
2. G. Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Applications, Imperial College Press, 2007.

CY17050 **3-0-0 (3)**

Industrial Applications of Organic Chemistry

Pre-Requisites: **Organic synthesis and reaction mechanism**

Course Outcomes:

CO-1	Understand the concepts of organic chemistry to synthesize value added chemicals from various sources
CO-2	Apply the knowledge in industrial chemical transformations
CO-3	Analyse synthetic approaches economically viable industrial transformation
CO-4	Design the synthetic process using sustainable approach
CO-5	Develop industrially significant chemicals

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	–	1	–	2	2
CO-2	2	–	2	–	2	2
CO-3	2	1	2	–	3	3
CO-4	2	–	3	1	3	3
CO-5	3	1	3	2	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Value-added chemicals from non-renewable resources and further organic transformations.

Natural gas: conversion to value-added chemicals and materials.

Chemicals derived from renewable resources: Source, value-added chemicals, and products.

Bulk preparation methods.

Industrial chemicals derived by the Fermentation process.

Surface Active Agents, detergents, and pharmaceuticals.

Learning Resources:

Text Books:

1. M. A. Benvenuto, Industrial Organic Chemistry, Berlin, Boston: De Gruyter, 2017.
2. B. G. Reuben, J. S. Plotkin, H. A. Wittcoff, Industrial Organic Chemicals, Wiley, 3rd Edition, 2012

Reference Books

1. H. H. Szmant, Organic Building Blocks of the Chemical Industry, Wiley & Sons, 1989.

2. E. R. Riegel, J. A. Kent. Riegel's Handbook of Industrial Chemistry, 2007

CY17052 **3-0-0 (3)**

Statistical Treatment of Data and Quality Control

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the significance of statistical concepts in chemical analysis
CO-2	Identify the type of errors occurring in the measurements and minimize them
CO-3	Apply appropriate calibration method in achieving results with highest precision
CO-4	Evaluate statistical tools for improving the quality of analytical measurements
CO-5	Develop a standard method for optimizing experimental procedures in analytical chemistry laboratories

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	2	2	-	1	1	1
CO2	2	1	-	1	3	2
CO3	3	1	-	2	-	2
CO4	2	3	-	2	2	1
CO5	2	-	1	1	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Significance tests: Comparison tests, t-test, paired t-test, t-test for means, F-test (one sided, two sided), Outliers, Q-test, G-test, ANOVA calculations

Quality of Analytical Measurements: Propagation of error, Quality control methods-property control charts, Precision control charts, Collaborative tests and uncertainty of measurements, Numerical calculations

Analytical methods Metrological Quality: Various types of analytical methods, Regression analysis, Limit of detection, Limit of quantification, Random error, Calibration of equipment and instruments, Curvilinear and outlier analysis.

Standard Method Development and Validation: Optimization of experimental procedures in analytical chemistry, Standard addition, External standard, internal standard and dilution methods, Experimental design-fractional factorial designs, Validation testing parameters and their calculation with numerical examples

Learning Resources:

Text Books:

1. J. N. Miller, J. C. Miller, Statistics and Chemometrics for Analytical Chemistry, Pearson, 2005, 5th Edition.

2. P. C. Meier, R. E. Zund, Statistical Methods in Analytical Chemistry, John Wiley & Sons, 2000, 2nd Edition.

Reference Books:

1. P. Konieczka, J. Namiesnik, Quality Assurance and Quality Control in the Analytical Chemical Laboratory, CRC Press, 2009, 2nd Edition.
2. D. B. Hibbert, Quality Assurance in the Analytical Chemistry Laboratory, Oxford University Press, New York, 2007, 1st Edition.

CY17054 **3-0-0 (3)**

Surface Analytical Techniques

Pre-Requisites: Understanding of general and physical chemistry. Familiarity with instrumental analyses is recommended

Course Outcomes:

CO-1	Understand the basic principles and instrumentation of surface analytical techniques
CO-2	Illustrate the methodology and applications of surface analytical techniques
CO-3	Identify suitable analytical technique for studying surface characteristics of diverse materials
CO-4	Analyze the data obtained from the analytical techniques to know the surface properties
CO-5	Design appropriate instrumental techniques for analysis of samples

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	1	1	1	1
CO-2	2	2	1	1	1	1
CO-3	1	1	3	2	1	1
CO-4	1	1	1	1	2	3
CO-5	1	1	1	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Surface structural analysis: Introduction to surface structural analysis and surface heterogeneity. Atomic force microscopy. Electron Spectroscopy for Chemical Analysis (ESCA) and Auger Electron

Spectroscopy (AES): Principles, Instrumentation, Quantification methods and standards,

Analytical Applications. Depth Profile Analysis.

Secondary Ion Mass Spectrometry (SIMS): Principle, Instrumentation, Specific Applications.

Surface-Enhanced Raman Spectroscopy (SERS): Principles, Electromagnetic theory of SERS, Sensitivity factor, Quantitative analysis, SERRS of Ag and Au metal colloids.

Electron Energy Loss Spectroscopy (EELS) and Electron Microprobe Analysis (EMPA): Principle, Instrumentation, Specific Applications.

Low Energy Ion Scattering Spectroscopy (LEISS): Principle, Instrumentation, Specific Applications.

Learning Resources:

Text Books:

1. J. F Watts, J. Wolstenholme, An introduction to surface analysis by XPS and AES, Wiley, 2003, 2nd Edition.
2. S. Schlucker, W. Kiefer, Surface enhanced Raman spectroscopy, Wiley VCH, 2011.

Reference Books::

1. D J O'Connor, Brett A Sexton, Roger S C Smart, Surface analysis methods in materials science, Springer Series in surface sciences, 2010, 2nd Edition.
2. J. C Vikerman, I. Gilmore, Surface Analysis: The Principal Techniques, Wiley, 2009, 2nd Edition.

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Chemical and Electrochemical Energy Systems

Pre-Requisites: Fundamentals in chemistry. Knowledge in electrochemistry is recommended.

Course Outcomes:

CO-1	Understand basic concepts of thermochemistry and chemical kinetics of energy Sources
CO-2	Illustrate principles of electrochemical energy storage systems and their applications
CO-3	Interpret principles of solar energy harnessing for promising applications
CO-4	Design new materials based on band gap engineering for energy harvesting
CO-5	Develop pilot devices for energy storage applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	–	1	–	1
CO-2	1	1	–	3	–	2
CO-3	1	1	–	3	1	2
CO-4	1	–	–	3	2	2
CO-5	–	1	–	3	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Thermochemistry and Chemical Kinetics of Energy Sources: Heats of Combustion of Fuels; Differential Scanning Calorimetry; Ignition Point, Flash Point; Coal Carbonization and Gasification; Chemical Energy Sources; Chemistry of Conventional and Non-Conventional Energy Materials: Petroleum Products, Petroleum Refinery; Biomass and Gober Gas; Hydrogen as a Fuel.

Electrochemical Energy Systems: Battery & Supercapacitors: Introduction about batteries, Solid state and molten solvent batteries, Metal ion batteries, Metal-air Battery, Supercapacitors and its applications. Fuel cells: Current-Voltage and Current Interrupt measurements; Porosity, Solid Oxide Fuel Cells.

Band gap engineering of materials for Solar Energy Harnessing: Concept of metal, semiconductor, insulator and their band structure. P-N junction and its behaviour in forward and reverse biasing, Metal semiconductor junctions i.e., schottky junction and ohmic contact and its behaviour in forward and reverse biasing, concept of band bending & band gap engineering. Photovoltaic and Photogalvanic energy storage, Regenerative Photoelectrochemical Cells; Photocorrosion; Electrodes with chemically modified surfaces. Photochemical and Photoelectrochemical Water Splitting: Chemically Modified Electrodes for Water Splitting; E-pH (Pourbaix) diagram of water.

Environmental Concerns and Green Methods of Energy Sources: Quality of Chemical Energy Sources; Monitoring of Energy Extraction from Materials; Nanochemical Methods in Energy Extraction; Modeling of Combustion and Other Energy Tapping from Materials

Learning Resources:

Text Books:

1. F. Vanek, L. Albright, L. Argenent, Energy Systems Engineering – Evaluation and Implementation, Mc Graw-Hill, 2016, 3rd Edition
2. R. Narayan and B. Viswanathan, Chemical and Electrochemical Energy Systems, University Press, 1998

Reference Books:

1. Lucia Gauchia, Javier Sanz, Dynamic Modeling of Electrochemical Energy Systems, LAP Lambert Academic Publishing, 2010
2. Peter Hoffmann, Byron Dorgan, Tomorrow's Energy: Hydrogen, Fuel Cells, and the Prospects for A Cleaner Planet, MIT Press, 2012
3. Piotrowiak, Laurie Peter, Heinz Frei and Tim Zhao, Solar Energy Conversion – Dynamics of Interfacidal Electron and Excitation Transfer, RSC, 2013