**SYLLABUS**

**FOR**

**FIVE-YEAR INTEGRATED M.Sc. PROGRAMME**

**IN**

**APPLIED CHEMISTRY**



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| **NAAC – A Grade** |

**DEPARTMENT OF CHEMISTRY**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

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**Semester-1**

**Core 1: Inorganic Chemistry-I (IPCCH101)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. The course explains the behaviour and interactions between, matter and energy at the atomic and molecular levels using standardized names and symbols to represent atoms, molecules, ions and chemical reactions.
2. Student can predict atomic structure, chemical bonding or molecular geometry based on accepted models.
3. Students can apply quantitative reasoning skills to determine quantities of matter and energy involved in physical and chemical changes.

**Syllabus**

**Module-I**

Atomic structure: Introduction (quantum mechanical treatment) de-Broglie matter waves, Uncertainty principle, Schrodinger wave equation (excluding derivations), significance of ψ and ψ2, quantum numbers and its significance, Normalized and orthogonal wave functions. Radial and angular wave functions for hydrogen atom, spherical harmonics, Radial and angular distribution curves, shapes of s, p, d orbitals, Hund’s rule, Pauling exclusion principle and electronic configuration of elements.

**Module-II**

Periodic properties: Screening effect, effective nuclear charge, size of atoms and ions, ionization potential, electron affinity, electronegativity (Calculation using Pauling’s, Mulliken’s, Allred Rachow’s and Mulliken-Jaffe’s electronegativity scale) variable valence, oxidation states and inert pair effect, horizontal, vertical and diagonal relationship of the above properties.

**Module-III**

Chemical bonding- I: Ionic bond, structure of ionic solids and its properties, lattice energy and Born- Haber cycle, solvation energy and solubility of ionic compounds, Lewis theory, octet rule and its deviations. Fajan’s rule, Dipole moment and its application, percentage of ionic character from dipole moment and electronegativity. Covalent bond and dative bond.

Chemical bonding- II: Orbital concept of bonding; Valency Bond Theory (VBT), hybridization, VSEPR theory, Molecular Orbital Theory (MOT) (homo and heteronuclear diatomic molecule), Resonance, Metallic bond (free electron and band theories) Hydrogen bond, vander-Waals force.

**Essential Readings:**

1. Concise Inorganic Chemistry, J.D. Lee, Wiley India, 5thEdn., 2008.
2. Inorganic Chemistry Principle, Structure and Reactivity, Huheey, Keiter and Keiter, Harper Collins College, 4thEdn.,1997.
3. Inorganic Chemistry R.D. Madan, S. Chand, 4thEdn.,1987.
4. Basic Inorganic Chemistry, F. A. Cotton, G. Willikinson, P. L. Gaus, Wiley, 3rdEdn., 1996.
5. Atkins’ Physical Chemistry, Atkins, P.W., Paula, J. Oxford University Press, Oxford, New York, 8th Edn., 2006.

**Course Outcomes**

* Fundamental principles of measurement, matter, atomic theory, chemical periodicity, chemical bonding, general chemical reactivity and solution chemistry can be applied to subsequent courses in science, engineering, technology, allied health and various other related disciplines that depend upon these principles for successful comprehension.
* Essential chemical concepts and math skills can be applied towards successful completion of applied science and engineering courses.

**Core 2: Physical Chemistry-I (IPCCH102)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. The course aims to provide a precise understanding of dilute solutions, homogeneous equilibrium, chemical kinetics and thermodynamics.
	2. Students are required to apply mathematical skills (derivations and integrations) and basic physics to understand chemical reactions and related processes.
	3. Students will gain a good foundation of knowledge and skills for further study in Physical Chemistry.

**Syllabus**

**Module-I**

Gaseous State: Kinetic theory of gases, deviation from ideal behavior, Van der Waal’s equation of state. Critical phenomena: PV isotherm of real gases, continuity of states, the isotherms of Van der Waal’s gas equation, relationship between Van der Waals constant and critical constants, the law of corresponding states, reduced equation of state.

Molecular velocities and the relation between them, qualitative discussion on Maxwell’s distribution of molecular velocity, collision number, mean free path and collision diameter, Joule-Thomson effect, liquefaction of gases.

**Module-II**

Liquid state: Intermolecular forces, structure (qualitative description), determination of properties of the liquids (density, viscosity, surface tension, vapour pressure) liquid crystals: Difference between liquid crystals, solids and liquids. Classification, structure of nematic and cholesteric phases.

Colloidal state: Introduction, classification based on state of aggregation, affinity of the two phases and nature of dispersed phases, preparation of colloids, characteristic and properties of colloidal solution (dynamic, optical and electrical properties), stability of colloids emulsions. Applications of colloids.

**Module-III**

Chemical Kinetics and catalysis: Introduction, rate, rate laws, order, molecularity and half-life Discussion on differential and integrated form of rate expression for zero, first, second and pseudo first order reactions. Kinetics of complex titration reaction; (i) Opposing reactions (ii) parallel reactions (iii) consecutive reactions with rate equations (steady state approximation in reaction mechanism) and (iv) chain reactions.

Catalysis: Types of catalyst, specificity and selectivity, mechanism of catalysed action at solid surfaces (effect of particle size and efficiency of nano particle as catalyst), enzyme catalysis, Michaelis- Menten mechanism, Acid –Base catalysis characteristic of catalyzed reactions, classification of catalysis (homogeneous and heterogeneous catalysis) and industrial applications.

**Essential readings:**

1. Elements of Physical Chemistry, P.W. Atkins and Julio de Paula, Oxford University Press, 10thEdn., 2014.
2. An Introduction to Chemical Kinetics, M. R. Wright, John Wiley & Sons Ltd, 3rdEdn.,2005.
3. Kinetics and Mechanism of Chemical Transformations, J. Raja Ram, and J. C. Kuriacose, Mac Millan Indian Ltd., 4thEdn., 2011.
4. Chemical Kinetics & Catalysis, R. I. Masel, Wiley-Interscience; 1stEdn., 2001.
5. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co, 47th Edn., 2017.

**Course Outcomes:** Students are able to

* Analyse the behaviour of gases in different conditions of temperature and pressure.
* Distinguish the difference between liquid crystal, solid and liquid
* Know the application of colloids in industrial processes
* Analyse the mechanism and kinetics of a chemical reaction

**GE 1: Physics-I (IOEPH101)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To know what central, conservative and central-conservative forces mathematically understand the conservative theorems of energy, linear momentum and angular Momentum.
	2. To know the importance of concepts such as generalized coordinates and constrained motion
	3. To establish that Kepler’s laws are just consequences Newton’s laws of gravitation and that of motion
	4. To know about various types of oscillation undamped, damped and forced oscillations.

**Syllabus**

**Module-I**

Motion of a system of particles: centre of mass, velocity, acceleration, momentum, Equation of motion, Kinetic energy and angular momentum of centre of mass. Conservation of linear momentum and angular momentum for system of particles, moment of inertia, parallel axis theorem perpendicular axis theorem. Moment of inertia of cylinder and sphere. Rotational kinetic energy and power, g by compound pendulum (bar pendulum). Gravitational force, field potential energy and potential, gravitational potential and field at a point due to a thin spherical shell and a solid sphere.

**Module-II**

Central force motion, reduction of two body problems into an equivalent one body problem, general characteristics of central force motion. Derivation of Kepler’s laws of planetary motion from gravitational force.

Relation between elastic constants. Torsion of a cylinder, bending of beams, expression for bending moment, equation for bending, depression occurring at nth e free ends of a light, heavy cantilever. Viscosity of liquids, laminar flow through a narrow tube and poisseuille’s formula surface tension-pressure difference across curved membrane.

**Module-III**

Oscillation and Waves: Simple harmonic oscillator, damped harmonic oscillator, power loss, Q-factor, overdamped motion, critical damping, forced vibration, resonance, sharpness of resonance. Mathematical description of travelling waves, wave equation. Tansverse waves in a stretched string longitudinal waves in a gaseous medium, composition of simple harmonic waves. Lissajous figures.

**Essential readings:**

1. Classical Mechanics- H Goldstein (Narosa)
2. Classical Mechanics-Rana and Joag (TMH)
3. Introduction to Classical Mechanics- Takwale & Purnaik(TMH)
4. Mechanics- K R Simon (Addision Wesley)
5. Mechanics-D. S Mathur (S. Chand)
6. Properties of matter- Searle and Neaman (Arnold Publication)
7. Classical Mechanics- M. Das, P.K Jena (Sri krishna Publication)
8. Classical Mechanics- Kibble

**Course Outcomes**

* State the conservation principles involving momentum, angular momentum and energy and understand that they follow from the fundamental equations of motion
* Have a deep understanding of Newton’s laws, properties of matter.
* Solve for the solutions and describe the behavior of a damped and driven harmonic oscillator in both time and frequency domains
* Describe the behavior of waves at interfaces (reflection, transmission, impedance) and their behavior in dissipative media (damping)

**GE 2: Mathematics –I (IOEMH101)**

**Course Objectives:**

1. Identify essential characteristics of ordinary differential equations.
2. Develop essential methods of obtaining closed form solutions numerical solutions.
3. Explore the use of differential equations as models in various applications.
4. Explore the use of series methods to solve problems with variable coefficients.
5. Explore methods of solving initial value problems by transform methods.

**Module-I:**

Basic Concepts of Differential Equation: Origin and Classification of Differential equation, Solution of Differential Equation, Kinds of solution, Initial and Boundary value problem, Existence and uniqueness of solution, Formation of Differential equation. First Order First Degree Equation: Variable separable, Homogenous Equation, Exact Differential equation, Integrating Factors, Linear equations, Equation reducible to linear form. Equations of First order but of Higher Degree: Equations solvable for p, Equation solvable for y, Equation solvable for x,

**Module-II:**

Linear Equations with Constant coefficient: Linear differential equation of nth order, Homogenous Linear equation with constant coefficient, Non- Homogenous Linear equation with constant coefficient, Operators and its use to solve linear differential equations with constant coefficient, Method of Variation of Parameter, Linear Differential Equation with variable coefficient: Method of reduction of order, method based on the removal of the first derivatives. Existence and Uniqueness of solution: Picard’s method of successive Approximation, Existence and uniqueness Theorem.

**Module-III:**

Series Solution and special function: Power series, Radius of convergence of power series, Ordinary point, singular point and regular singular point (only definition), Series solution about an ordinary point, Legendre equation and Legendre polynomial, Orthogonality, Power series method about singular point, Bessel ‘s equation and Bessel’s function, Orthogonality in Bessel function. Boundary value problem for Ordinary Differential Equation; Sturm –Liouville Problems.

**Text Books:**

1. A Course on Ordinary and Partial Differential Equation by J. Sinha Roy, S Padhy, Kalyani Publisher.Chapters: 1(1.1-1.4), 2(2.1-2.7), 3(3.1-3.4), 4(4.1-4.6), 6(6.1,-6.3), 7(7.1,7.2,7.3.1,7.4.1)), 10 (10.1,10.2).

**Reference Books:**

1. Ordinary Differential Equation by P C Biswal (Pub- PHI).

**Course Outcomes:**

After the successful completion of this course the students will be able to

1. Identify and apply initial and boundary values to find solutions to first-order, second-order, and higher order homogeneous and non-homogeneous differential equations by manual and technology-based methods and analyze and interpret the results.
2. Select and apply series techniques to solve differential equations.
3. Select and apply appropriate methods to solve differential equations.

**AECC 1: English for Communication (IOEMH102)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To introduce engineering students to the theory and practice of communication.
	2. To equip them with both theoretical vocabulary and basic tools which will help them develop as better communicators.
	3. To initiate them to select literary texts and establish how these texts contribute to the afore-mentioned objectives.

**Syllabus**

**Module-I**

Introduction to Communication:

1.1 Importance of Communication in English

1.2 The process of communication and factors that influence the process of communication:

Sender, receiver, channel, code, topic, message, context, feedback, ‘noise’.

1.3 Principles of Communication.

1.4 Barriers to Communication & Communication Apprehension

1.5Verbal (Spoken and Written) and non-verbal communication, Body language and its importance in communication.

**Module-II**

Phonetics and Functional Grammar

2.1 Sounds of English: Vowels (Monopthongs and Diphthongs), Consonants

2.2 Syllable division, stress (word, contrastive stress) & intonation

2.3 MTI and problem sounds

2.4Review of Parts of Speech

2.5 Subject and Predicate, Tense, Voice Change

2.6 Idioms and Phrasal Verbs

(Note: This unit should be taught in a simple, non-technical, application-oriented manner, avoiding technical terms as far as possible.)

**Module-III**

Reading Literature

Prose:

* 1. Stephen Leacock: My Financial Career
	2. Mahatma Gandhi: from My Experiments with Truth.
	3. O’Henry: The Last Leaf

Poetry:

1. Nissim Ezekiel: Professor
2. Jack Prelutsky: Be glad your nose is on your face.
3. Maya Angelou: Still I rise (Abridged)

**REFERENCE BOOKS:**

1. Paul V. Anderson, Technical Communication, Cengage Learning, 2014.
2. Leech, Geoffrey and Ian Swartik., A Communicative Grammar of English, Longman, 2003.
3. O’Connor, J.D., Better English Pronunciation, Cambridge University Press, 1980.
4. Wren & Martin, English Grammar and Composition, S. Chand,1995.

**SEC 1: Fundamentals of computers & Programming in C (IOECS101)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. Develop a greater understanding of the issues involved in programming language design and implementation
	2. Develop an in-depth understanding of functional, logic, and object-oriented programming paradigms
	3. Implement several programs in languages other than the one emphasized in the core curriculum
	4. Understand design/implementation issues involved with variable allocation and binding, control flow, types, subroutines, parameter passing
	5. Develop an understanding of the compilation process

**Syllabus**

**Module-I:**

Digital Logic Fundamentals: Logic Gates, Introduction to Multiplexer, De-multiplexer, Encoder, Decoder & Flip-Flops.

Introduction to Computer Fundamentals: Basic architecture of computer, Functional units, Operational concepts, Bus structures, Von Neumann Concept

Instruction code, Instruction set, Instruction sequencing, Instruction cycle, Instruction format, addressing modes, Micro instruction, Data path, hardwired controlled unit, Micro programmed controlled unit. Generation of Programming languages, Compiler, Linker, Loader

**Module-II:**

C language fundamentals: Character set, Key words, Identifiers, data types, Constants and variables, Statements, Expressions, Operators, Precedence and associativity of operators, Side effects, Type conversion, Managing input and output

Control structures: Decision making, branching and looping.

Arrays: one dimensional, multidimensional array and their applications, Declaration, storage and manipulation of arrays

Strings: String variable, String handling functions, Array of strings

Functions: Designing structured programs, Functions in C, Formal vs. actual arguments, Function category, Function prototype, Parameter passing, Recursive functions.

Storage classes: Auto, Extern, register and static variables

**Module-III:**

Pointers: Pointer variable and its importance, pointer arithmetic and scale factor, Compatibility, Dereferencing, L-value and R-value, Pointers and arrays, Pointer and character strings, Pointers and functions, Array of pointers, pointers to pointers, Dynamic memory allocation

Structure and union: declaration and initialization of structures, Structure as function parameters, Structure pointers, Unions.

File Management: Defining and opening a file, Closing a file, Input/output Operations in files, Random Access to files, Error handling

**Essential Readings:**

1. Computer Organization and Architecture, William Stalling, Pearson Education
2. C Programming, Balagurusamy, Tata McGraw-Hill
3. Computer Architecture and Organization, J. P. Hayes, McGraw Hill Education India.
4. Mastering C, K. R. Venugopal, McGraw-Hill Education India
5. C the complete reference, H. Schildt, McGraw-Hill

**Lab 4 (AECC Lab 1): English for Communication Laboratory (ILCMH101)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. The laboratory experience for this course aims at acquainting the learners with their strength and weakness in expressing themselves, their interests and academic habits.
2. To improve their skills of LSRW (Listening, Speaking, Reading and Writing) through mutual conversation and activities related to these skills.
3. To promote the creative and imaginative faculty of the students through practice before the teacher-trainer.

There will be 10 sessions of 2 hours each. Lab sessions will give a platform for the students to indulge in activities based on the first two modules of theory taught in the class room. All the lab classes will be divided in such a manner that all the four aspects of language (LSRW) are covered.

**Ist session:**

Speaking: Ice-breaking and Introducing each other (1 hour), Writing: Happiest and saddest moment of my life (1 Hour)

**IInd session:**

Listening: Listening practice (ear-training): News clips, Movie clips, Presentation, Lecture or speech by a speaker (1 Hour), Speaking: Debate (1 Hour)

**IIIrd session:**

Reading: Reading comprehension (1 Hour), Writing: Creative writing (Short story: Hints to be given by the teacher) (1 Hour)

**IVth session:**

Reading: Topics of General awareness, Common errors in English usage (1 Hour), Writing: Construction of different types of sentences (1 Hour)

**Vth session:**

Speaking: Practice of vowel and consonant sounds (1 Hour), Writing: Practice of syllable division (1 Hour)

**VIth session:**

Speaking: My experience in the college/ or any other topic as per the convenience of the student (1 Hour), Writing: Phonemic transcription practice (1 Hour).

**VIIth session:**

Listening: Practice of phonetics through ISIL system and also with the help of a dictionary (1Hour), Speaking: Role-play in groups (1 Hour)

**VIIIth session:**

Speaking: Practice sessions on Stress and Intonation (1Hour), Writing: Practice sessions on Grammar (Tense and voice change) (1 Hour)

**IXth session:**

Speaking: Extempore, (1 Hour), Writing: Framing sentences using phrasal verbs and idioms (1 Hour).

**Xth session:**

Watching a short English movie (1 Hour), Writing: Critical analysis of the movie (1 Hour).

**REFERENCE BOOKS:**

1. Lab Manual Cum Workbook, *English Language Communication Skills*, Cengage Learning, 2014.

**Note: 70 marks will be devoted for sessions, 10 marks for record submission, 10 marks for viva-voce and 10 marks for project work.**

**End term assignment:** Students are required to make a project report of at least5 pages on a topic on the following broad streams: Technology, General awareness, Gender, Environment, Cinema, Books and the like. The assignment should involve data collection, analysis and reporting.

**Course Outcome:**

**Lab 1 (Core Lab-1): Physical Chemistry Laboratory-I (ILCCH101)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide hands-on opportunities to develop fundamental laboratory analytical skills and apply this knowledge in executing project work and solving basic industrial problems in future.

**Syllabus**

1. ***Titrimetric Analysis***
	1. Calibration and use of apparatus
	2. Preparation of solutions of different Molarity/ Normality of titrants
2. ***Acid-Base Titrations***
	1. Estimation of carbonate and hydroxide present together in mixture.
	2. Estimation of carbonate and bicarbonate present together in a mixture.
3. ***Oxidation-Reduction Titrimetry***
	* 1. Standardisation of KMnO4 with standard sodium oxalate.
		2. Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution.
		3. Estimation of oxalic acid and sodium oxalate in a given mixture.
		4. Estimation of Fe(II) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) and external indicator.

**Essential Reading**

1. Vogel’s Quantitative Chemical Analysis, J. Mendham, 6thEdn, Pearson, 2009.

**Course Outcome:**

Develop knowledge of concepts and applications of physical chemistry, quantitative analysis using common laboratory techniques including acid/base titrations, redox titration.

**Lab 2 (GE Lab 1): Physics Laboratory-I (ILCPH102)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* + 1. To introduce different experiments to test the basic understanding of physics concepts.

**Syllabus**

1. Determination of accurate weight of a body using balance by Gauss method.
2. Error analysis using vernier caliper, screw gauge and spherometer.
3. Determination of velocity of sound by resonance column method.
4. To determine acceleration due to gravity by bar pendulum and study of the effect of amplitude on time period.
5. To determine the acceleration due to gravity by Kater’s pendulum.
6. Verification of laws of vibration of string using sonometer.
7. Determination of Young’s modulus of wire by Searle’s method.
8. Determination of rigidity modulus of rod by static method.
9. Determination of surface tension of water by using capillary rise method.
10. Determination of viscosity of liquid by Poisuelies method.
11. Determination of specific heat of solid/liquid applying radiation correction.
12. To study the velocity of sound by Kundt’s tube.
13. Calculate surface tension of mercury by using capillary rise method.
14. To determine the moment of inertia of a flywheel about its axis of rotation.
15. To determine the Young’s modulus of a wire using optical lever method.

**Course Outcome:** The hands-on exercises undergone by the students will help them to apply physics principles.

**Lab 3 (DSE Lab 1): Programming in C Laboratory (ILCCS101)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

**Syllabus**

**Experiment No. 1**

1. Write a C program to find the sum of individual digits of a positive integer.
2. A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence.
3. Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.

**Experiment No. 2**

* + - 1. Write a C program to calculate the following Sum:
1. Sum=1-x2
2. /2! +x4
3. /4!-x6
4. /6!+x8
5. /8!-x10/10!
	* + 1. Write a C program to find the roots of a quadratic equation.

**Experiment No. 3**

1. Write C programs that use both recursive and non-recursive functions
	1. To find the factorial of a given integer.
	2. To find the GCD (greatest common divisor) of two given integers.
	3. To solve Towers of Hanoi problem.

**Experiment No. 4**

* + - 1. Write a C program to find both the larges and smallest number in a list of integers.
1. Write a C program that uses functions to perform the following:
	* 1. Addition of Two Matrices
		2. Multiplication of Two Matrices

**Experiment No. 5**

* + - 1. Write a C program that uses functions to perform the following operations:
	1. To insert a sub-string in to given main string from a given position.
	2. To delete n Characters from a given position in a given string.
		+ 1. Write a C program to determine if the given string is a palindrome or not

**Experiment No. 6**

1. Write a C program to construct a pyramid of numbers.
2. Write a C program to count the lines, words and characters in a given text.

**Experiment No.7**

1. Write a C program that uses functions to perform the following operations:
2. Reading a complex number
3. Writing a complex number
4. Addition of two complex numbers
5. Multiplication of two complex numbers

(Note: represent complex number using a structure.)

**Experiment No. 8**

1. Write a C program which copies one file to another.
2. Write a C program to reverse the first n characters in a file.

(Note: The file name and n are specified on the command line.)

**Experiment No. 9**

Computer programs based on numerical methods for

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.

**Essential Reading**

1. Project Using C PVN. Varalakshmi, Scitech Publish

**Course Outcome:**

**Semester-2**

**Core 3: Inorganic Chemistry-II (IPCCH201)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* + 1. To introduce certain key aspects of inorganic chemistry, including solid state structures, the chemistry of Group 15, materials and transition metal chemistry and noble gases.
		2. To provide practice in answering some basic concepts in inorganic chemistry through assessed problem sheets.
		3. Apply current chemistry models/theories to understand and predict the physical/electronic properties, bonding, and reactivity that occur in inorganic complexes with emphasis on coordination complexes containing transition metals.
		4. Construct qualitative sets of molecular orbitals for simple molecules and inorganic complexes.
		5. To introduce basic ideas about inorganic polymers, and general principles of metallurgy.

**Syllabus**

**Module-I**

***General principle of metallurgy:***

Cheap modes of occurrence of metals based on standard electrode potential. Ellingham diagram for reduction of metal oxides using carbon and carbon monoxide as reducing agents, electrolytic reduction, hydrometallurgy. Methods of purification of metals; electrolytic kroll process, parting process, van Arkel-de Boer process and Mond’s process, Jone refining.

***s-block elements:*** Comparative study, diagonal relationships, salient features of hydrides, halides, oxides,hydroxides, sulphates, carbonates & bicarbonates anomalous behavior complexation tendencies including their function in biosystems, an introduction to alkyls and aryls.

**Module-II**

***p-block elements****:* Comparative study (including diagonal relationship) of group 13-17 elements, compounds like hydrides, oxides, oxy-acids and halides of groups 13-16, hydrides of boron-diborane and higher boranes, fullerenes, carbides, fluorocarbons, Borazines, S4N4, basic properties of halogens, interhalogens and polyhalides.

**Module-III**

***Chemistry of noble gases:*** Chemical properties, chemistry of xenon, structure and bonding in xenon compounds.

***Inorganic Polymers:*** Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes, Boron nitrides silicates and phosphagens and polysulphates.

**Essential readings:**

1. Concise Inorganic Chemistry, J.D. Lee, Blackwell, 5thEdn.,2008.
2. Inorganic Chemistry Principle: Structure and Reactivity, Huheey, Keiter and Keiter, Harper Collins College, 4th Edn., 1997.
3. Inorganic Chemistry, R.D.Madan, S.Chand, 4thEdn.,1987.
4. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson, P. L. Gaus, Wiley, 3rdEdn., 1996.
5. Inorganic Chemistry, G.L. Miessler, A.T. Donald, Pearson, 4thEdn., 2010.

**Course Outcome:**

* To develop expertise relevant to the professional practice of chemistry.
* To establish an appreciation of the role of inorganic chemistry in the chemical sciences.
* To develop an understanding of the role of the chemist in measurement and problem solving in inorganic chemistry.
* To provide an understanding of chemical methods employed for problem solving involving inorganic systems.
* To provide experience in some scientific methods employed in inorganic chemistry.
* To develop skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
* To develop some understanding of the professional and safety responsibilities residing in working with inorganic systems.

**Core 4: Organic Chemistry-I (IPCCH202)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* + 1. To provide a bridge between basic and advanced organic chemistry knowledge. It also makes connection from chemical principles to the structures and functions of different organic molecules.
		2. Apply principle and knowledge in stereo chemical aspects of different organic molecules and reactions.
		3. To provide basic idea on the reactions and mechanisms involving aliphatic and aromatic hydrocarbons.

**Syllabus**

**Module-I**

***Basics of Organic Chemistry***

*Classification and Nomenclature:* Organic compounds including open chain, cyclic, polycyclic bridged, spiro and others special structures. Hybridisation and shapes of molecules.

*Electronic Displacement in Organic Molecules*: Inductive, electromeric, and mesomeric effects. Delocalised chemicalbonding, conjugation, cross conjugation, hyperconjugation and their applications.

*Reagents and Intermediates*: Homolytic and heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Reactive Intermediates: Carbocations, carbanions, free-radicals, carbenes and nitrenes structure, stability and reactions

*Reactions and Mechanism:* Introduction to types of organic reactions: Addition, elimination substitution and rearrangement reactions (basic ideas only).

**Module-II**

***Stereochemistry***

*Conformational and Geometrical Isomerism*: Fischer, Newman and Sawhorse projection formulae and their interconversions. Baeyer strain theory, conformational analysis of acyclic systems (Pitzer strain) and cyclohexane systems, conformation of mono and disubstituted cyclohexane their relative stability and chirality. Energy diagrams of cyclohexane: Chair, boat and twist boat form, (relative stability with energy diagrams). Geometrical isomerism: C.I.P rules, cis–trans, syn-anti and E/Z notations.

*Optical Isomerism*: Optical activity, specific rotation, chirality/asymmetry, enantiomers. Molecules with two or more chiral-centres, distereoisomers, meso structures, racemic mixture and method of resolution. Relative and absolute configuration: D/L and R/S designations, optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.

**Module-III**

***Chemistry of Aliphatic and Aromatic Hydrocarbons*** (Mechanism of all the reactions to be discussed)

*Carbon-Carbon σ Bonds (Alkanes):* Kolbe’s reaction. Free radical halogenation (relative reactivity and selectivity), alternant and non-alternant hydrocarbons.

*Carbon-Carbon π Bonds (Alkenes and Alkynes):* Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

*Reactions of Alkenes*: Electrophilic additions (addition of X2, HX) their mechanisms (Markownikoff/ Anti Markownikoff addition), oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction, syn and anti-hydroxylation (oxidation), 1,2-and 1,4-addition reactions in conjugated dienes, allylic and benzylic bromination.

*Reactions of Alkynes*: Acidic nature of terminal alkynes, electrophilic and nucleophilic additions. hydration, alkylation of terminal alkynes.

*Aromatic Hydrocarbons:* Aromaticity and Hückel’s rule, armaticity in benzenoid non-benzenoid compounds, annulenes, cyclic carbocations/carbanions and heterocyclic compounds. Anti-aromaticity, homo-aromaticity. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft’s alkylation/acylation and the effect of directing groups.

**Essential Readings:**

1. Stereochemistry: Conformation and Mechanism, P. S. Kalsi, New Age, 9th Edn., 2017.
2. Advanced Organic Chemistry, Jagadamba Singh and L.D.S. Jadav, Pragati Prakashan, 3rd Edn., 2009.
3. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Jerry March, Wiley, 4th Edn., 2006.
4. Organic Chemistry, Jonathan Clayden, Nick Greeves, and Stuart Warren, Oxford press, 2nd Edn., 2012.
5. Organic Chemistry, P.Y. Bruice, Pearson, 8th Edn., 2017.
6. Advanced Organic Chemistry, Francis A **Carey**, Richard J. **Sundberg, Springer, 2nd Edn., 2007.**
7. **Stereochemistry by D. Nasipuri, New Academic Science, 4th Edn. 2012.**

**Course Outcome:**

* Understand the formation, stability and structure of different reaction intermediate.
* Able to identify the type of reaction and mechanism.
* Knowledge of the basic mechanisms of elimination (E1, E2, E1cb, electron transfer)
* Naming and identifying the structures including configurational isomers (stereo-isomers and geometric isomers) and conformational isomer.
* Apply stereo chemical aspects to reaction mechanism.

**GE 3: Physics-II (IOEPH201)**

**Prerequisite:**

**Purpose:**

**Course Objectives:**

1. The abstraction from forces to fields using the examples of the electric and magnetic fields, with some applications
2. The connection between conservative forces and potential energy
3. The close connection between electricity and magnetism, leading to the discovery of electromagnetic waves.
4. The integral form of Maxwell's Equations
5. The course will provide the students about the electronic Components diode, transistor, Oscillators
6. It will give the knowledge of switching circuit.
7. The abstraction from forces to fields using the examples of the electric and magnetic fields, with some applications

**Module-I**

Scalar and vector triple product. Differentiation of a vector with respect to a scalar. The gradient operator. The divergence and curl of vector. Gauss divergence theorem, Strokes theorem. Gauss law in electrostatics and application, Computation of file due to linear spherical and plane charge distribution, Differential form of Gauss law, the energy of a point charge, discrete and continuous distribution,

**Module-II**

Energy-density, dielectrics, Susceptibility, permeability, dielectric constant. Magnetic field B, Lorentz force law, The Boisvert law B due to a straight, circular, and solenoidal currents. The vector potential, Ampere, circuital law & its differential form. Differential form of electromagnetic induction.

**Module-III**

Maxwell equation and physical significance. Wave equation, Electromagnetic waves. wave properties, speed, growth and decay current in RC and LR circuits. Phase diagram, impedance, Power in ac circuit, power factor, series and parallel resonant circuits, Sharpness of resonance, Bandwidth and Q-factor.

**Module-IV**

Rectifier: Half wave & full wave rectifier (semiconductor devices) Principle, circuit, operation & theory. Use of L & π filters in rectifier circuits (qualitative idea) Amplifier: Classification of amplifier, comparison, Voltage& power gain in CB, CE &CC configuration. RC coupled amplifier, Class B Push/pull amplifier (principle of amplification circuit description operation, theory and frequency response curve) Necessary of feedback, positive & negative feedback, criteria for sustained oscilation, Hartly and colpitt’s oscillator (principle, circuit, operation, theory and use), feedback Amplifier: Basic circuit, operation, advantage of negative feedback, Modulation & demodulation: Principle of modulation. A.M&F.M (Theory and differences between them), Principle of demodulation Function & basic theory of linear diode detectors.

**Essential readings:**

1. Introduction to Electrodynamics- D. J Griffiths (PHI)
2. Foundation of electromagnetic theory- Ritz and Milford (Narosa)
3. Electricity and magnetism- E. Purcell (Berkely Physics Course) TMH
4. Electronics- Chattopadhyay & Rakshit (New Age)
5. Electronics- B. B Swain
6. Electricity and magnetism- D. C Tayal
7. Electricity and magnetism- Satyaprakash

**Course Outcomes**

* The use of Coulomb's law and Gauss' law for the electrostatic force
* The relationship between electrostatic field and electrostatic potential
* The use of the Lorentz force law for the magnetic force
* The use of Ampere's law to calculate magnetic fields
* The use of Faraday's law in induction problems
* The basic laws that underlie the properties of electric circuit elements
* The study of electronics devices makes the base of student in the electronic field.

**GE 4: Mathematics –II (IOEMH201)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

To understand concepts of real numbers, open sets and closed sets.

Demonstrate knowledge and understanding of sequences, their convergence conditions, limits of sequences

Demonstrate knowledge and understanding of groups, subgroups, cosets of a subgroup, normal subgroup, quotient groups.

To build concept of group homomorphism and isomorphism.

Demonstrate knowledge and understanding of permutation groups and their properties.

**Syllabus**

**Module I**

Bounded and unbounded sets, Infimum and Supremum of a set and their properties, Order completeness property of R, Archimedian property of R, Density of rational and irrational numbers in R.

Neighbourhood, Open set, Interior of a set, Limit point of a set, Closed set, Countable and uncountable sets, Derived set, closure of a set, Bolzano- Weierstrass theorem for sets.

**Module II**

Sequence of real numbers, Bounded sequence, limit points of a sequence, limit interior and limit superior convergent and non-convergent sequences, Cauchy’s sequence, Cauchy’s general principle of convergence.

Infinite series and its convergence, Test for convergence of positive term series, Comparison test, Ratio test, Cauchy’s root test**.**

**Module III**

Preliminary Notations, Group Theory**:** Algebraic structures, Groups, Some Examples of Groups, Subgroups, A Counting Principle, Cosets, Normal Subgroups and Quotient Groups,

Group Homomorphisms, Isomorphisms, Automorphisms, Permutation Groups. Ring Theory : Definition & Example of Rings, Some Special Classes of Rings.

**Text Books**

1. Fundamentals of Mathematical Analysis, G. Das & S. Pattnaik, TMH
2. Topics In Algebra, by I. N. Herstein, Wiley Eastern.Ch. 1, Ch. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.10, Ch. 3.1, 3.2, 3.3, 3.4

**Reference Books**

1. Introduction to Real Analysis, R. G. Bartle and D.R. Sherbert, Wiley.4th Edition
2. Elementary Analysis: The Theory of Calculus, Under graduate Texts in Mathematics, K. A. Ross, Springer (SIE), Indian reprint, 2004.
3. A course in Calculus and Real Analysis, Limaye, Undergraduate Text in Mathematics, Sudhir R Ghorpade and Balmohan V.., Springer (SIE). Indian reprint, 2004.
4. Modern Algebra by A. R. Vasishtha, Krishna, Prakashan Mandir, Meerut.
5. Topics in Algebra by P.N. Arora, Sultan Chand & Sons.

**Course outcomes:** After the successful completion of this course the students will be able to

1. determine if sets are open, closed. Recognize convergent, divergent, bounded, Cauchy and monotone sequences.
2. recognize alternating, convergent, conditionally and absolutely convergent series.
3. determine if a function is discontinuous, continuous, or uniformly continuous.
4. use various canonical types of groups (including cyclic groups and groups of permutations)
5. produce rigorous proofs of propositions arising in the context of abstract algebra

**SEC 2: Data Structure using C (IOECS201)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To impart the basic concepts of data structures and algorithms.
2. To understand concepts about searching and sorting techniques.
3. To understand basic concepts about stacks, queues, lists, trees and graphs.
4. To understanding about writing algorithms and step by step approach in solving problems with the help of fundamental data structures.

**Syllabus**

**Module I**

Introduction to data structures: storage structure for arrays, sparse matrices, Stacks and Queues: representation and application. Linked lists: Single linked lists, linked list representation of stacks and Queues. Operations on polynomials, Double linked list, circular

list.

**Module II**

Dynamic storage management-garbage collection and compaction, infix to post fix conversion, postfix expression evaluation. Trees: Tree terminology, Binary tree, Binary search tree, General tree, B+ tree, AVL Tree, Complete Binary Tree representation, Tree traversals, operation on Binary tree-expression Manipulation.

**Module III**

Graphs: Graph terminology, Representation of graphs, path matrix, BFS (breadth first search), DFS (depth first search), topological sorting, Warshall’s algorithm (shortest path algorithm.) Sorting and Searching techniques – Bubble sort, selection sort, Insertion sort, Quick sort, merge sort, Heap sort, Radix sort. Linear and binary search methods, Hashing techniques and hash functions.

**Essential readings:**

1. Gilberg and Forouzan: “Data Structure- A Pseudo code approach with C” by Thomson Publication
2. Data structure in C by Tanenbaum, PHI publication / Pearson publication.
3. Pai: Data Structures & Algorithms; Concepts, Techniques & Algorithms Tata McGraw Hill.
4. Fundamentals of data structure in C” Horowitz, Sahani & Freed, Computer Science Press. Fundamental of Data Structure” (Schaums Series) Tata-McGraw-Hill.

**Course Outcomes** After the successful completion of this course the students will be able to

* choose appropriate data structure as applied to specified problem definition.
* handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures.
* apply concepts learned in various domains like DBMS, compiler construction etc.
* use linear and non-linear data structures like stacks, queues, linked list etc.

**AECC 2: Communication in Practice (IOEMH202)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* + 1. To introduce students to various building blocks of communication, both within and outside their formal articulations.
		2. To train students in the basic science of writing and help them use the same in various sites such as report, paragraph etc.
		3. To create conditions in the classroom that encourages students to engage in meaningful conversation.

**Syllabus**

**Module - I**

**Basics of Communication in Practice**

* 1. Types of Communication in an organization: Formal (internal and external) and Informal (grapevine)
	2. Communication Channels: Upward, Downward, Diagonal and Horizontal

1.3 Introduction to cross-cultural communication.

1.4 Bias-free communication & use of politically correct language in communication

1.5 Importance of reading and ethics of writing

1.6 Negotiation Skills, Argumentation & Consensus building.

**Module-II**

**Business Writing**

2.1 Skills of Writing: Coherence, Cohesion, Sentence Linkers, Clarity of Language and stylistic

 variation, process of writing

2.2 Paragraph writing: Topic Sentence, Supporting sentence & Concluding sentence,

 Logical structuring (Inductive approach and deductive approach)

2.3 Letters, Applications

2.4 Reports and Proposals

2.5 Memos, Notices, Summaries, Abstracts& e-mails

2.6 Writing a CV/Resumeˈ: Types of CV

2.7 Writing a Cover letter

**Module -III**

**Speaking and Presentation**

3.1 Oral Presentation: 4 P’s of presentation, PPT

3.2 Group Discussion: Structured and Un-structured, Various types of topics (abstract, absurd, contemporary etc.)

3.3 Types of Interview: Preparing an Interview and techniques

3.4 Grooming and dress code, Personality development

**REFERENCE BOOKS:**

1. Carol M Lehman, Debbie D Dufrene and Mala Sinha., *Business Communication*, Cengage Learning. 2nd Edition. 2016.
2. Anderson, Paul.V, Technical Communication, Cengage Learning, 2014.
3. Bovee, Courtland. L. et al., *Business Communication Today*, Pearson, 2011.
4. Jeff Butterfield, *Soft Skills for Everyone*, Cengage Learning, 2015

**Lab 5 (Core Lab 2): Inorganic Chemistry Laboratory-I (ILCCH201)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide the students a competence in the laboratory skills required for accurate and precise chemical analysis.
2. The students will know the theoretical basis of qualitative inorganic analysis containing common and less common ions.

**Syllabus**

1. **Qualitative Inorganic Analysis**:
2. **Identification of acid radicals**:

Radicals: CO32-, SO32-, S2-, NO2-, Cl- , Br- , l- , NO3 - , SO42- & PO43-

1. **Identification of Basic Radicals**: Radicals: Ag+ , Pb2+, Hg22+, Cu2+, Hg2+, Bi3+, As3+, Sb3+, Sn2+, Al3+, Fe3+, Cr3+, Co2+, Ni2+, Zn2+, Mn2+, Ba2+, Ca2+& Sr2+, NH4+, Mg2+, K+ and Na+ (Dry Tests only).
2. **Wet tests for basic radicals**: Wet tests for the following basic radicals be done.
3. Group-I basic radicals: Ag+ , Pb2+, Hg22+
4. Group-II basic radicals: Hg2+, Cu2+, Bi3+, As3+, Sb3+, Sn2+ & Sn4+
5. Group-IIIA basic radicals: Fe3+, Al3+& Cr3+
6. Group-IIIB basic radicals: Co2+, Ni2+, Zn2+& Mn2+.
7. Group-IV basic radicals: Ba2+, Ca2+& Sr2+
8. Group-V basic radicals: NH4+ , Mg2+, K+ , Na+ .

 [For Identification of unknown basic radicals both dry and wet tests are to be performed]

1. **Crystallisation**
2. Preparation of CuSO4, 5H2O crystal from CuCO3.
3. Preparation of Mohr’s Salt (FeSO4 , (NH4 )2SO4 , 6H2O] crystal
4. Preparation of potash alum [K2SO4 , Al2(SO4)3 , 24H2O] crystal.

**Essential Reading**

1. Vogel’s Qualitative Chemical Analysis, J. Mendham, 6thEdn, Pearson, 2009.

**Course Outcome:**

The student will gain the laboratory skills in qualitative analysis of different acid and basic radicals.

**Lab 6 (GE Lab 2): Physics Laboratory-II (ILCPH202)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To introduce different experiments to test the basic understanding of physics concepts

**Syllabus**

1. Determination of wavelength of sodium light by using Newton’s ring method.
2. Determination of grating element of grating spectra.
3. Determination of wave length of Laser using diffraction grating.
4. Determination of magnifying power of a microscope.
5. Determination of magnifying power of a telescope.\
6. Figure of merit of a Galvanometer.
7. Resistance of a resistor using meter bridge (applying end correction).
8. Study the charging and discharging process of a capacitor through resister.
9. LCR impedance apparatus.
10. Calibration of CRO.
11. To determine self-inductance of a coil by Rayleigh’s method.
12. To determine the mutual inductance of two coils by absolute method.
13. To determine self-inductance of a coil by Anderson’s bridge.
14. Conversion of voltmeter to ammeter and vice-versa.
15. To study the force experienced by a current carrying conductor placed in a

magnetic field (Lorentz’s force) using a mechanical balance.

**Essential Reading**

**Course Outcome:** The hands-on exercises undergone by the students will help them to apply physics principles.

**Lab 7 (AC Lab 1): Data Structure using C Laboratory (ILCCS201)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:1**

**Syllabus**

***Experiment No.1***

Write a C program to perform matrix multiplication using array.

***Experiment No.2***

(a) Write a C program to create a stack using an array and perform

(i) push operation (ii) pop operation

(b) Write a C program to create a queue and perform

i) Push ii) pop iii) Traversal

***Experiment No. 3***

Write a C program that uses Stack operations to perform the following:

i) Converting infix expression into postfix expression

ii) Evaluating the postfix expression

***Experiment No. 4***

Write a C program that uses functions to perform the following operations on Single linked list:

i) Creation ii) Insertion iii) Deletion iv) Traversal in both ways

***Experiment No. 5***

Write a C program that uses functions to perform the following operations on Double linked list:

i) Creation ii) Insertion iii) Deletion

***Experiment No. 6***

Write a C program that uses functions to perform the following operations on Binary Treei)

Creation ii) Insertion iii) Deletion

***Experiment No. 7***

Write C programs that use both recursive and non-recursive functions to perform the Linear

search operation for a Key value in a given list of integers:

i) Linear search

***Experiment No. 8***

Write C program that use both recursive and non-recursive functions to perform the Binary

Search operation for a Key value in a given list of integers:

***Experiment No.9***

Write a C program that implement Bubble Sort method to sort a given list of integers in

descending order.

***Experiment No.10***

Write a C program that implement Quick Sort method to sort a given list of integers in

ascending order:

**Essential readings:**

1. Data structure using C” by Sudipta Mukherjee, TMH Publication

**Course Outcome:**

**Lab 8 (AECC Lab-2): Communication in Practice Laboratory (ILCMH201)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To enable the students, engage in polite, negotiating and argumentative conversation.
2. To train the learners in writing CV, Report, Minutes, Business Letters etc.
3. To give students an opportunity of power point presentation relating to topical issues.

**Syllabus**

There will be 10 lab sessions of 2 hours each. Lab sessions will be used to give the students an in-hand experience of communication taking place in an organization. This will help the students to understand the requirement of communication in the workplace. Students will be encouraged to brush-up themselves in activities based on all the modules of theory taught in the class room. Special emphasis will be given to speaking and writing business correspondences.

**Ist session:**

Speaking: Greeting an acquaintance/ friend, introducing oneself, introducing a third person to a friend, breaking off a conversation politely, leave-taking, describing people, objects, places, processes etc. (1 Hour), Writing an application (1 Hour)

**IInd session:**

Speaking: making and responding to inquiries; expressing an opinion; expressing agreement/ disagreement, contradicting/ refuting an argument; expressing pleasure, sorrow, regret, anger, surprise, wonder, admiration, disappointment etc (1 Hour), Writing an informal letter/Business Letter (1 Hour)

**IIIrd session:**

Speaking: Narrating or reporting an event (1 Hour), Writing a Report (1 Hour)

**IVth session:**

Speaking: Ordering / directing someone to do something, Making requests; accepting / refusing a request, Expressing gratitude; responding to expressions of gratitude, Asking for or offering help; responding to a request for help, Asking for directions (e.g. how to reach a place, how to operate a device etc.) and giving directions, Speaking: asking for and granting/ refusing permission, prohibiting someone from doing something, suggesting, advising, persuading, dissuading, making a proposal, praising, complimenting, felicitating, expressing sympathy (e.g. condolence etc.), Complaining, criticizing, reprimanding etc., (1 Hour), Writing a proposal (1 Hour)

**Vth Session:**

Speaking:Understanding and interpreting graphs, flowcharts, pictograms, pictures, curves etc., (1 Hour), Writing: Describing, explaining and interpreting graphs, flowcharts, pictograms, pictures, curves etc.

**VIth session:**

Speaking: Group discussion (1 Hour), Writing a memo, notice and circular (1 Hour)

**VIIth session:**

Speaking: In-house communication on work-related situations (1 Hour), Writing a CV (1 Hour)

**VIIIth session:** Presentation 1 (Students will make and present a topic in power point on a pre-assigned topic) (1 Hour), Writing an e-mail (1 Hour)

**IXth session:** Presentation 2 (Students will make and present a topic in power point on a pre-assigned topic) (1 Hour), Writing an abstract (1 Hour)

**Xth session:** Presentation 3 (Students will make and present a topic in power point on a pre-assigned topic) (1 Hour), Writing a summary (1 Hour)

**REFERENCE BOOKS:**

* 1. Kumar, Sanjay & Lata, Pushp, *Communication Skills A Workbook*, OUP,2018

**Semester-3**

**Core 5: Organic Chemistry-II (IPCCH301)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide basic and through idea on the chemistry of halogenated hydrocarbons (aliphatic and aromatic) their relative reactivity. It also offers the mechanism involved in nucleophilic and electrophilic substitution, their relative reactivity based on the reaction conditions.
2. To offer knowledge on aliphatic and aromatic alcohols, their preparation methods, reactivity and methods to distinguish them.
3. To provide a detail study on compounds containing carbonyl groups such as aldehydes and ketones, their preparation and their reactivity.
4. To provide a detail study on compounds containing carbonyl groups such as aldehydes and ketones, their preparation and their reactivity.

**Syllabus**

**Module-I**

***Halogenated Hydrocarbons***

*Alkyl Halides:* Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvents. Nucleophilic substitution vs. elimination.

*Aryl Halides:* Preparation (including preparation from diazonium salts). Nucleophilic aromatic substitution; SNAr and benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

**Module-II**

***Alcohols, Phenols, Ethers and Epoxides***

*Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3°alcohols, Bouvaelt-Blanc reduction. Preparation and properties of glycols (oxidation by periodic acid and lead tetraacetate)

*Phenols:* Preparation and properties; acidity and factors effecting it. Ring substitution reactions: Reimer–Tiemann and Kolbe’s–Schmidt reactions, Claisen rearrangements with mechanism.

*Ethers and Epoxides:* Preparation, reactions of ethers, reactions of epoxides with alcohols, ammonia derivatives and LiAlH4.

**Module-III**

***Carbonyl Compounds***

*Aldehydes and Ketones:* Structure, reactivity and preparation; nucleophilic additions, nucleophilic addition-elimination reactions with ammonia derivatives. Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro, Wittig reaction, Haloform reaction, Baeyer Villiger oxidation, α-substitution reactions, Clemmensen and Wolff-Kishner reductions. Reactions to distinguish aldehydes and ketones. Addition reactions of unsaturated carbonyl compounds: Michael addition.

*Compounds Containing Active Methylene Groups:* Introduction, Keto-enol tautomerism, acidic character of such compounds. Preparation of aceto acetic ester and malonic ester and their application towards the synthesis of monocarboxylic acid, dicarboxylic acid, keto acids, ketones, diketones, unsaturated acids, heterocyclic compounds.

**Module-IV**

***Acid and Acid Derivatives***

*Carboxylic Acids and their Derivatives:* Preparation, physical properties and reactions of monocarboxylic acids. Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.

*Preparation and Reactions of Acid Chlorides, Anhydrides, Esters and Amides:* Comparative study of nucleophilic sustitution at acyl group, mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann, Reformatsky reactions and Hofmann-bromamide degradation.

**Essential readings:**

1. Organic reaction mechanism, V.K.Alluwalia, R.K.Parashar, Narosa Publising House. 4th Edn., 2010.
2. Organic Chemistry, Mehta & Mehta, PHI learning pvt ltd , 2nd Edn., 2015.
3. Organic Chemistry, Jonathan Clayden, Nick Greeves, and Stuart Warren, Oxford press, 2nd Edn., 2012.

**Course Outcomes**

* Understand the preparation and properties of halogenated hydrocarbons.
* Able to identify the favorable conditions essential for SN, SNAr and elimination reaction.
* Offers the knowledge of aliphatic and aromatic alcohols their synthesis method and relative reactivity.
* Get knowledge on the synthesis of carbonyl compounds their reactivity and methods to distinguish them.
* Able to know the synthetic utility of active methylene compounds.
* Able to understand about acid and acid derivatives, their preparation, properties and relative reactivity.

**Core 6: Physical Chemistry-II (IPCCH302)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To know the basic concepts in classical thermodynamics.
	2. To learn the thermodynamic aspects of various processes and reactions
	3. To provide an insight into the thermodynamic and kinetic aspects of chemical reactions and phase equilibria.

**Syllabus**

**Module-I**

***Chemical Thermodynamics***

Intensive and extensive variables; state and path functions; isolated, closed and open systems; Zeroth law of thermodynamics.

***First law of thermodynamics***

Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

***Thermochemistry***

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff’s equations) and pressure on enthalpy of reactions.

**Module-II**

***Second Law of Thermodynamics***

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; Calculation of entropy change for reversible and irreversible processes. Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

**Module-III**

***Third Law of Thermodynamics***

Statement of third law, molecular and statistical interpretation of entropy concept of residual entropy, calculation of absolute entropy of molecules.

***Systems of Variable Composition***

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of gases.

**Module-IV**

***Chemical Equilibrium***

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; Thermodynamic derivation of relationsip between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment);

**Essential Readings:**

1. Atkin’s Physical Chemistry, P. Atkins & J. D. Paula, Oxford University Press, 10th Edn., 2014.
2. A Textbook of Physical Chemistry, K.L. Kapoor, Vol. 2, Mc Graw Hill Education, India, 2019.
3. Physical Chemistry, G. W. Castellan, Narosa Publishing House, 4th Edn., 2004.
4. Physical Chemistry, T. Engel, P. Reid, Prentice-Hall, 3rd Edn., 2012.
5. Molecular Thermodynamics, D.A. McQuarrie, J.D. Simon, Viva Books Pvt. Ltd. New Delhi, 2nd Edn, 2004.
6. Physical Chemistry, I. N. Levine, Tata Mc Graw Hill, 6th Edn., 2010.

**Course Outcomes**

* Learn fundamental chemical thermodynamics and be able to use this in experimental and theoretical work with chemical systems.
* Explain chemical equilibrium processes involved in a chemical reaction

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| --- |
| **IPCCH302: Physical Chemistry-II** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  | \* |  |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  | \* |  |  |

**Core 7: Inorganic Chemistry-III (IPCCH303)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. The proposed course aims to provide basic idea about Non aqueous solutions, general considerations about transition and inner transition elements.
	2. Essential idea about super critical fluids used as inorganic solvents, potential energy diagrams of Latimer, Frost–Ebsworth and their interpretations are explained.
	3. To make the students apply the knowledge of electronic spectra of transition and inner transition elements and magnetic moment data in interpretation of various physical and chemical changes.

**Syllabus:**

**Module-I**

***Non-aqueous media***: Classification of solvents, General properties and chemical reactions of ionizing solvents. Liquid ammonia as solvent: Physical properties, Self-ionization, Reactions in liquid NH3, Solutions of s-block metals in liquid NH3, Redox reactions in liquid NH3

Liquid sulfur dioxide as solvent: Precipitation, neutralization salvation, complex formation, redox reactions, reaction with organic compounds.

Dinitrogen tetraoxide: Physical properties, Reactions in N2O4

Liquid hydrogen fluoride: Physical properties, Acid-base behavior in liquid HF, Electrolysis in liquid HF, redox reactions.

Bromine trifluoride: Physical properties, Behaviour of fluoride salts and molecular fluorides in BrF3, Reactions in BrF3

Sulfuric acid and fluorosulfonic acid: Physical properties of sulfuric acid, Acid-base behavior in liquid H2SO4, Physical properties of fluorosulfonic acid

Supercritical fluids: Properties of supercritical fluids and their uses as solvents, Supercritical fluids as media for inorganic chemistry.

**Module-II**

***d-Block metal chemistry: general considerations:*** Topic overview; Ground state electronic configurations: d-block metals versus transition elements, Electronic configurations; Physical properties; The reactivity of the metals; Characteristic properties: a general perspective; Colour, Paramagnetism, Complex formation, Variable oxidation states and their stability (Latimer diagram), Frost–Ebsworth diagrams and their relationship to potential diagrams and its interpritation; Electroneutrality principle.

Chemistry of first row transition series in various oxidation states with special reference to the following compounds: peroxo compounds of chromium, potassium dichromate, potassium permanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside and sodium cobaltinitrite.

**Module-III**

***Chemistry of Elements of Second and Third Transition Series:*** General Characteristics, comparative treatment with their 3d-analogous in respect of ionic radii, Lanthanide contraction, oxidation states, magnetic behaviour, spectral properties and stereochemistry.

**Module –IV**

***f-block metals: Lanthanoids and Actinoids:*** Introduction, f-orbitals and oxidation states, Atom and ion sizes, Coordination numbers, Spectroscopic and magnetic properties, Electronic spectra and magnetic moments: lanthanoids, Luminescence of lanthanoids complexes, Electronic spectra and magnetic moments: actinoids, Sources of the lanthanoids and actinoids: Occurrence and separation of the lanthanoids and the actinoids

Inorganic compounds and coordination complexes of the lanthanoids: Halides, Hydroxides and oxides, Complexes of Ln (III)

**Essential readings:**

1. Concise Inorganic Chemistry, J.D. Lee, Blackwell Science Wiley India, 5th Edn., 2017.
2. Theoretical Inorganic Chemistry, M.C. Day & J. Selbin, East-West Press, 2nd Edn.,1998.
3. Inorganic Chemistry: Principles of Structure and Reactivity (4th impression), J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, Pearson Education, 2008.
4. Concepts and Models of Inorganic Chemistry, B. Douglas, D. McDaniel and J. Alexander, John Wiley (New York), 3rd Edn., (Reprint) 1993.
5. Inorganic Chemistry, R.D.Madan, S.Chand Publication, 4th Revised Edn. 1987.
6. Inorganic Chemistry, C.E.Housecroft, A.G.Sharpe, Pearson, 5th Edn., 2019.
7. Advanced Inorganic Chemistry, F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochmann, Wiley India, 6th Edn, 2012.
8. Inorganic Chemistry, G. L. Miessler, P.J Fisher & D. A. Tarr, Pearson, 5th Edn., 2014.
9. Shriver Atkins’ Inorganic Chemistry, P.W Atkins, T.Overton, J.Rourke, M. Weller and F. Armstrong, Oxford Univ. Press, 5th Edn., 2012.

**Course Outcomes**

* Fundamental principles of non-aqueous solvents, electronic and magnetic property data interpretation can be applied to subsequent inter disciplinary subjects for successful comprehension.
* Essential chemical theoretical concepts about various uses of transition and inner transition elements can be applied towards successful completion in applied fields.

**GE 5: Physics-III (IOEPH301)**

**Prerequisite:** Nil

**Syllabus**

**Module –I**

Fermat’s principle, reflection and refraction at plane interference, cardinal points of a coaxial optical system, cardinal points of combination of two thin lenses, elementary ideas of monochromaticaberrations and remedies, chromatic aberration, achromatic combination, Ramsden’s and Huygens’s eyepieces,

**Module –II**

Wave theory of light, Huygen’s principle, condition of interference, division of wave front, biprism, colour of thin films, Newton’s ring, determination of wave length of monochromaticlight by Newton’s ring.

Diffraction of light, Fresnel and Fraunhoffer diffraction, Fresnel’s half period zones, Zone plate act as a convex lens. Fraunhoffer diffraction by a single slit, Electromagnetic nature of light, Polarized and unpolarized light. Plane polarized, circularly polarized and elliptically polarized light. Polarization by reflection and refraction, Brewster’s law, Malus’s law. Double refraction, ordinary and extraordinary rays, construction, working and uses of Nicol prism. Half wave plate and quarter wave plate.

**Module –III**

Inadequacy of classical physics: review of black body radiation. Particle nature of wave, photoelectric effect, Compton effect, dual nature of radiation. Wave nature of particle – De Broglie hypothesis and wave - particle duality. Superposition of two waves, group velocity and phase velocity, wave packet. Experimental confirmation of matter waves (Davisson – Germer experiment). Heisenberg’s uncertainty principle and applications (Ground state energy of harmonic oscillator, Time dependent Schrodinger equation in one and three dimension. The wave function, equation of continuity, probability current density and probability density. Normalization of the wave function, Expectation value of an observable

**Books:**

1. Optics -A.K. Ghatak
2. Principle of optics – B.K. Mathur
3. Optics – P.K. Chakravarty
4. Physics for degree students – VOL III and IV (Sri krishna Prakashan)
5. Introduction to Quantum mechanics – M. Das, P.K. Jena (Sri krishna Prakashan)
6. Quantum mechanics –J.L. Powell, B. Crasemann

**GE 6: Mathematics –III (IOEMH301)**

**Prerequisite:** Nil

**Syllabus**

**Module-I:**

The complex number system: The real numbers, The field of complex numbers, the complex plane, polar representation and roots of complex numbers, Line and half planes in the complex plane.

Asymptotes in Cartesian coordinates, intersection of curve and its asymptotes, asymptotes in polar coordinates, curvature, radius of curvature for Cartesian curves, polar curves, Newton’s method, centre of curvature, circle of curvature, chord of curvature. Cusp, Nodes & conjugate points, Types of cusps, Tracing of curves in Cartesian, Parametric, and Polar coordinates, Trace (Folium of Descartes, Strophoid, Astroid, Cycloid, Cardioids, Lemniscates of Bernoulli)

**Module-II:**

General equation of the Sphere, intersection of a sphere and a plane, intersection of two spheres, family of spheres, Intersection of a sphere and a line, Tangent plane, condition of tangency, equation of a cone, Enveloping cone of a sphere, cylinder, Enveloping cylinder of a sphere, Right circular cone & cylinder.

**Module-III:**

Functions of several variables, Limit and Continuity, Partial derivatives, Differentiability, Chain rule, Directional derivatives, Gradient vectors, tangent planes, Extreme values and saddle points, Lagrange multiplier,

Vector differential calculus: vector and scalar functions and fields, Derivatives, Curves, tangents and arc length, double integral, triple integral, gradient, divergence, curl

Vector integral calculus: Line Integrals, Green Theorem, Surface integrals, Gauss theorem and Stokes Theorem.

**Text Books:**

1. Differential Calculus by Shanti Narayan & P K Mittal, S. Chand Publication, Chapters 14 (14.1-14.6), 15, 16, 17
2. Calculus by M.J. Strauss, G.L. Bradley & K.J. Smith, 3rd edition, Pearson, Chapters 10 (10.1-10.2), 11 (11.1-11.8), 12, 13
3. Analytical Geometry of Quadratic Surfaces by B P Acharya & D C Sahu, Kalyani publisher Chapters: 2, 3
4. Functions of one Complex variable- J. B. Conway (springer Verlag, International student edition, Narosa Publishing house. Chapter-1 (1.1-1.5)

**Reference Books:**

1. Analytical Solid Geometry by Shanti Narayan
2. Calculus and Analytic Geometry by G.B. Thomas and R.L. Finney, 9th edition, Addison-Wesley Publishing Company.
3. Function of Several Variables by N C Bhattacharya
4. Complex Variable; Theory & Application: Kasana, PHI

**Course outcomes:**

1. Compute partial differentiation of various functions and determine their maximum and minimum values
2. Apply gradient to solve problems involving steepest ascent and normal vectors to level curves
3. Apply Fundamental Theorem of Line Integrals, Green’s Theorem, Stokes’ Theorem, or Divergence Theorem to evaluate integrals.
4. Write equation of conics and identify conics from a given equation. Give geometrical interpretation of many mathematical problems.
5. Explain the fundamental concepts of complex analysis and their role in modern mathematics and applied contexts

**Lab 9 (Core Lab 3): Inorganic Chemistry Laboratory-II (ILCCH301)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. Study the principles of Iodometric and Iodimetric titration
2. Prepare Inorganic compounds

**Syllabus**

1. **Iodo / Iodimetric Titrations.**
2. Standardisation of sodium thiosulphate solution by standard K2Cr2O7 solution
3. Estimation of Cu (II) using sodium thiosulphate solution (Iodometrically).
4. Estimation of i) arsenite and ii) antimony in tartar-emetic iodimetrically.
5. **Inorganic preparations.**
	1. Cuprous chloride, Cu2Cl2
	2. Preparation of manganese(III) phosphate, MnPO4:H2O:
	3. Preparation of aluminium potassium sulphate K2SO4:Al2(SO4)2.24H2O (Potash alum).
	4. Preparation of Lead chromate, (PbCrO4)

**Essential readings:**

1. A Textbook of Quantitative Inorganic Analysis, A. I. Vogel, ELBS, 5th Edn, 2004.
2. Practical Inorganic Chemistry, G. Pass & H. Sutcliffe, Chapman & Hill, 2nd Edn., 1974.

**Course Outcome:**Students are able to

* Distinguish the difference and practical application of Iodometric and Iodimetric titration
* Prepare normal and double salts

**Lab 10 (Core Lab 4): Organic Chemistry Laboratory-I (ILCCH302)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the techniques of element detection in organic compounds.
2. To apply the skill in identification of functional groups.
3. To learn the techniques of purification by recrystallisation.

**Syllabus**

1. Detection of elements including physical tests such as state, colour, solubility, ignition, acidity, alkalinity.
2. Detection of functional groups containing C, H, X (X= N, O, S and halides) in known organic compounds.
3. Detection of functional groups containing C, H, X (X= N, O, S and halides) in unknown organic compounds.
4. Purification of organic compounds by crystallization using the following solvents:
5. Water
6. Alcohol
7. Alcohol-Water.

**Essential readings:**

1. Practical Organic Chemistry, F.G. Mann, & B.C. Saunders, Pearson Education, 4th Edn., 2009.
2. Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith, & A.R. Tatchell, Pearson, 5th Edn., 2012.
3. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V.K. Ahluwalia, & R. Aggarwal, University Press, 2000.
4. Comprehensive Practical Organic Chemistry: Qualitative Analysis, V.K. Ahluwalia, S. Dhinger, University Press, 2000.

**Course Outcome:**

* To learn elemental analysis in organic compounds.
* To familiarize the systematic procedures of organic substances analysis
* To familiarize the solubility nature of organic substances of different functional group.
* To familiarize the test involving identification of special elements
* To understand the techniques involving drying and recrystallization by various method

**Lab 11 (Core Lab 5): Physical Chemistry Laboratory-II (ILCCH303)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To expose students about different laboratory experiments related Thermochemistry.

**Syllabus**

* + - 1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
			2. Enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
			3. Determination of integral enthalpy (endothermic and exothermic) solution of salts.
			4. Determination of basicity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
			5. Determination of enthalpy of hydration of copper sulphate using a thermal analyzer
			6. Study of the solubility of benzoic acid in water and determination of ∆H.

**Essential readings:**

Senior Practical Physical Chemistry, B. D. Khosla, V. C. Garg, & A. Gulati, R. Chand & Co.: New Delhi 1st Edn., 2008.

Experimental Physical Chemistry, V. D. Athawale, & P. Mathur, New Age International: New Delhi, 2nd Edn, 2001.

**Course Outcome:**Students are able to

* Determine heat capacity of calorimeter of different volume
* Find out the basicity of polyprotic acid.
* Determine the heat of solution

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| **ILCCH303: Physical Chemistry Laboratory-II** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* | \* | \* |  | \* |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Lab 12 (GE Lab 3): Physics Laboratory-III (ILCPH351)**

**Prerequisite: Nil**

**Purpose:**

**Course Objectives:**

**Syllabus**

**Heat, Optics and Electromagnetism**

1. Angle of minimum deviation (I-D curve) using spectrometer.
2. Determination of resolving power of a telescope
3. Optical rotation of sugar solution by polarimeter.
4. Refractive index of glass slab using travelling microscope.
5. Refractive index of water using travelling microscope.
6. Determination of radius of curvature of a spherical mirror by Kohlrausch’s method.
7. Determination of dispersive power of the material of the prism.
8. To measure voltage and Frequency of a sinusoidal wave form using a CRO and to find unknown frequency by producing Lissajous figure.
9. To study parallel resonant LCR circuit.
10. To study series resonant LCR circuit.

**Essential Reading**

**Course Outcome:**

**Semester-4**

**Core 8: Physical Chemistry-III (IPCCH401)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To learn ionic equilibria and electrical properties of ions in solution.
	2. To learn the concepts of acids and bases, pH and buffer solutions.
	3. To study phase diagrams and elementary idea of photochemistry.

**Syllabus**

**Module-I**

***Ionic Equilibria:*** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts pH, Buffers solutions Henderson equation and its applications. Solubility, solubility products of. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators.

**Module-II**

***Solutions and Colligative Properties:*** Dilute solutions; lowering of vapour pressure, Raoult’s and Henry’s Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure, and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

**Module-III**

***Phase Equilibria:*** Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

**Module-IV**

***Photochemistry****:* Characteristics of electromagnetic radiation, Lambert-Beers law and its limitations, physical significance of absorption coefficients. Laws of photochemistry,

Photochemical process quantum yield, Mechanism of decay of excited single state quenching. Resonance transfer energy

**Essential Readings:**

1. Physical Chemistry, P. W. Atkins, & J. de Paula, Oxford University Press, 10th Edn., 2014.
2. A Textbook of Physical Chemistry, Vol. 3, K. L. Kapoor, Mc Graw Hill Education (India), 2019.
3. Physical Chemistry, G. W. Castellan, Narosa, 4th Edn., 2004.
4. Physical Chemistry, T. Engel & P. Reid, Prentice-Hall, 3rd Edn., 2012.
5. Molecular Thermodynamics, D. A. McQuarrie & J. D. Simon, Viva Books Pvt. Ltd., New Delhi, 2004.
6. Physical Chemistry, D. W. Ball, Cengage India, 2012.
7. Physical Chemistry, R. G. Mortimer, Elsevier, NOIDA, UP, 3rd Edn., 2009.
8. Physical Chemistry, I. N. Levine, Tata McGraw-Hill, 6th Edn., 2011.
9. Physical Chemistry, C. R. Metz, Tata McGraw-Hill, 2nd Edn., 2009.

**Course Outcome:**

* Describe various properties of dilute solutions like boiling point, freezing point, osmotic pressure, vapour pressure etc.
* Explain chemical equilibrium processes involved in a chemical reaction.
* Explain phase diagrams and elementary idea of photochemistry.

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| **IPCCH401: Physical Chemistry-III** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  | \* |  |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Core 9: Organic Chemistry-III (IPCCH402)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To provide knowledge on sulphur containing compounds, their preparation and properties
	2. To provide knowledge on nitrogen containing functional groups such as Nitro Compounds, amines, nitriles, Isonitriles, anilines etc, their preparation methods, reactivity and methods to distinguish them. It also discusses about polynuclear hydrocarbons and their structural elucidation.
	3. To provide a detail study on heterocyclic compounds, their aromaticity, preparation methods and relative reactivity.
	4. To provide basic idea on alkaloids and terpenoids, their structural elucidation and their medicinal importance.

**Syllabus**

**Module-I**

***Sulphur containing compounds:***

Preparation and reactions of thiols, thioethers and sulphonic acids.

**Module-II**

***Nitrogen Containing Functional Groups***

*Nitro Compounds:* Preparation and important reactions of nitro compounds. *Nitriles, Isonitriles. Alkyl Amines, Anilines*: Effect of substituent and solvent on basicity. Preparation and properties: Gabriel phthalimide synthesis, carbylamine reaction, Mannich reaction, Hoffmann’s exhaustive methylation, Hofmann-elimination reaction. Distinction between 1°, 2° and 3°amines with Hinsberg reagent and nitrous acid. *Diazonium salts*: Preparation and their synthetic applications.

*Polynuclear Hydrocarbons:* Reactions of naphthalene, phenanthrene and anthracene. Preparation and structure elucidation of naphthalene and anthracene.

**Module-III**

***Heterocyclic Compounds:***

*Introduction*: Classification, nomenclature, structure and aromaticity.

*Preparation and properties:* Five membered heterocyclic compounds (pyrrole, furan and thiophene), six membered heterocyclic compounds (pyridine) and fused heterocyclic system (quinoline, isoquinoline and indole).Reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander’s synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction. Derivatives of furan: Furfural and furoic acid.

**Module-IV**

***Alkaloids***

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann’s exhaustive methylation, Emde’s modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

***Terpenes***

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol

**Essential readings:**

1. Organic Chemistry, B. Mehta and M. Mehta, PHI learning Pvt. Ltd, 2nd Edn., 2015.
2. Organic Chemistry, R. Morrison, R. Boyd, S. Bhattacharjee, 7th Edn., 2009.
3. Heterocyclic Chemistry, J. A. Joule, K. Mills and G.F. Smith, Willy publishing, 5th Edn., 2010.
4. Organic Chemistry, J. Clayden, N. Greeves, and S. Warren, Oxford press, 2nd Edn., 2012.
5. Natural Product Chemistry, J. Singh, J.S.M. Ali, Singh, J. Prajati Parakashan, 2010.

**Course Outcomes**

* Able to understand thiols, thioethers, sulphonic acids and their preparation, properties.
* Able to distinguish the reactions of different Nitrogen containing compounds such as nitro, nitriles, isonitriles, anilines etc.
* Offers the knowledge poly-nuclear hydrocarbon and their structural elucidation.
* Able to identify heterocyclic compounds, their physical and chemical properties.
* Able to understand the synthesis of natural products and their medicinal importance.

**Core 10: Quantum Chemistry (IPCCH403)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn basic mathematical methods in chemistry and their applications in quantum chemistry.
2. To learn on basis postulates of quantum mechanics and to derive the selection rules for electronic transitions based on the concept of the Schrodinger equation and particle in one-dimensional box.
3. To predict the solutions of Shrodinger equation for hydrogen and hydrogen like atoms and importance of quantum numbers.
4. To predict the molecular properties of small molecules based on quantum mechanical concepts of molecular theories.

**Syllabus**

**Module-I**

***Matrix Algebra:*** Matrices, determinants, matrix rank, orthogonal and unitary transformations, eigenvalues and eigenvectors, diagonalization of matrices, spectral theorem, few applications.

***Vectors and Tensors:*** Introduction to vectors; vector operations; coordinate system transformation; covariant and contravariant vector components; few applications; Vector spaces, inner products, linear independence, bases.

***Ordinary Differential Equations:*** Linear first and second order ODEs, homogeneous and inhomogeneous ODEs with constant coefficients, system of linear ODEs, power series solution of differential equations and special functions.

**Module-II**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

**Module-III**

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

**Module-IV**

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H2+. Bonding and antibonding orbitals. Qualitative extension to H2. Comparison of LCAO-MO and VB treatments of H2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH2, H2O) molecules. Qualitative MO theory and its application to AH2 type molecules.

**Essential readings:**

* Atkins, P., Paula, Julio de, & Keeler J., Atkins' Physical Chemistry, volume-2, 11th edition, 2018.
* Chandra, A. K. Introductory Quantum Chemistry, 4th edition, Tata McGraw-Hill (2017).
* Levine, Ira N., Quantum Chemistry, 7thedition, PHI Learning PVT. Ld-New Delhi (2018).
* House, J. E. Fundamentals of Quantum Chemistry 3rdEd. Academic Press: USA (2017).
* Lowe, J. P. & Peterson, K. Quantum Chemistry, 3rd edition, Academic Press (2005).

**Course Outcomes**

* Utilize the mathematical methods for quantum mechanical calculations.
* Derive the selection rules of electronic transitions based on postulates of quantum mechanics and particle in one-dimensional box.
* Find out the solutions of the Schrodinger equation for hydrogen and hydrogen-like atoms and understand the significance of quantum numbers.
* Predict the molecular properties of small molecules based on quantum mechanical concepts**.**

**DSE 1: Polymer Chemistry IPECH401**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To demonstrate the principles of polymerisation and techniques used for polymerisation reactions.
2. To estimate the degree of polymerization and determination of their properties.
3. To illustrate on plastics and to describe the applications of polymers.
4. To know the structure of polymer

**Syllabus**

**Module I**

***Introduction and history of polymeric materials:*** Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

**Module II**

***Mechanism and Kinetics of Polymerization:*** Mechanism of and kinetics of addition polymerization - free radical, cationic, anionic and coordination polymerization (Ziegler-Natta catalyst), copolymerization., condensation polymerization, ring opening polymerization

***Crystallization and crystallinity:*** Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

***Nature and structure of polymers****-*Structure Property relationships.

**Module III**

***Determination of molecular weight of polymers-*** molecular weight - Mn, Mw, Mv, Mz and MWD. Determination of molecular weight: end group analysis, viscometry, osmometry, light scattering and spectral analysis. Molecular weight distribution and its significance. Polydispersity index.

***Glass transition temperature (Tg) and determination of Tg****,* Free volume theory, WLFequation, Factors affecting glass transition temperature (Tg).

**Module IV**

***Polymer Solution*** *–* Criteria for polymer solubility, Solubility parameter, Thermodynamicsof polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

***Properties of Polymer****s* (Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, PVC, PVAc, polyacrylamide, PTFE, polyamide (nylon-6, nylon-66, nylon-610), thermosetting polymers, phenol formaldehyde resins, polyurethanes, conducting polymers (polyacetylene, polyaniline), Brief outline of biodegradable polymers

**Essential Readings:**

1. Test Book of Polymer Science, Jr. Billmeyer, Fred, W. John, Wiley & Sons, New York, l984.
2. Polymer Characterization: Physical Techniques, D. Campbell, R. A. Pethrick, J. R. White, CRC Press, 2nd Edn, 2012.
3. Principles of Polymer Systems, F. Rodrigues, M. Elpaw, Hill Book Company, 2nd Edn, l982.
4. Organic Polymer Chemistry, K.J. Saunders, Chapman & Hall, London, 1973.
5. Handbook of Biopolymer-Based Materials: From Blends and Composites to Gels and Complex Networks. S. Thomas and Dominique Durand, Wiley – VCH, 2013.

**Course Outcomes:**

* Reveal the principles of polymerization and techniques used for polymerization reactions.
* Determine the degree of polymerization, physical properties and describe their properties.
* Distinguish between polymers and plastics; depict the applications of polymers.

**GE 7: Mathematics –IV (IOEMH401)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* + - 1. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
			2. Apply numerical methods to obtain approximate solutions to mathematical problems.
			3. It is shown that majority of problems can be converted to computable forms (discretized) using three fundamental ideas in the approximation theory, namely Taylor series expansion, polynomial interpolation and least square approximation.
			4. In addition, the student is expected to clearly understand role of the following four fundamental tools Linear Algebraic Equation Nonlinear Algebraic Equations Ordinary Differential Equations- Initial Value Problem Optimization.
			5. Understand the concept of Linear system of equations using matrices and vector space.

**Syllabus**

**Module-I**

Preliminaries of Matrices, Linear systems of equations, linear independence, rank of a matrix, inverse of a matrix, Gauss elimination and Gauss-Jordan elimination, Eigenvalues, eigenvectors, symmetric, skew-symmetric and orthogonal matrices, Eigen basis, Diagonalization. Vector space, linear dependence of vectors, basis and dimension.

Errors, Algorithms and Convergence, Transcendental and polynomial equations: Introduction, Bisection method, Regula-falsi method, Secant method, Fixed Point iteration, Newton-Raphson method, Rate of convergence. Error Analysis for iterative methods,

System of Linear Algebraic Equations: Pivoting Strategies, Matrix inversion, LU-Decomposition, Gauss Jacobi, Gauss –Seidel Method, Relaxation Techniques.

**Module-II**

Interpolation and Approximations: Introduction, Langrages and Newton Interpolation, Least Square Approximation, Uniform Approximation. Differentiation.

**Module-III**

Numerical Integration: Newton Cotes Algorithm, Trapezoidal rule, Simpson’s rule, Gauss – Legendre Integration Method, Ordinary Differential Equations: Euler’s Method, Euler Modified Method, Runge -Kutta Method.

**Text Book:**

1. Numerical Mathematics and Computing: by W. Cheney, David Kincaid, Cengage.
2. Numerical Methods for Scientific and Engineering Computation; M.K. Jain, S.R.K. Iyengar, R.K. Jain.
3. Advanced Engineering Mathematics by E. Kreyszig, John Willey & Sons Inc. 10th Edition (For First Part of Module I)

**Reference Book**

1. Numerical Methods by B.P. Acharya & R.N. Das.
2. A Introduction to Numerical Analysis by K.Aitkinson ,Wiley
3. Linear algebra and its applications by Gilbert Strang, Cengage learning.

**Course Outcome:** After the successful completion of this course the students will be able to

1. Devise and Implement an algorithm to solve it numerically;
2. Describe classic techniques and recognize common pitfalls in numerical analysis;
3. Analyze an algorithm’s accuracy, efficiency and convergence properties.
4. Apply the concept of eigen value and eigen vector to solve various problems.

**Lab 13 (Core Lab 6): Organic Chemistry Laboratory -II (ILCCH401)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the techniques of determination of melting point and boiling point of organic compounds.
2. To study the effect of impurities on melting point and mixed melting point of two unknown compounds.
3. To learn the methods of preparation of simple organic compounds.

**Syllabus**

1. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
2. Effect of impurities on the melting point – mixed melting point of two unknown organic Compounds.
3. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
4. Preparation of derivatives of organic compounds (derivatives of carbonyl compounds)
5. Hydrolysis of amides.
6. Benzil-Benzilic acid rearrangement.
7. Fridelcraft alkylation/acylation
8. Distinguish between three types of amines: Hinsberg Test, Ninhydrin Test.

**Essential readings:**

1. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Publishers, 5th Edn., 2013.
2. Practical Organic Chemistry, F.G. Mann & B.C. Saunders, Pearson Education, 4th Edn., 2009.
3. Practical Organic Chemistry, B.S. Furnis, A.J. Hannaford, P.W.G. Smith,& A.R. Tatchell,, Pearson, 5th Edn., 2012.
4. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V.K. Ahluwalia, & R. Aggarwal, University Press, 2000.
5. Comprehensive Practical Organic Chemistry: Qualitative Analysis, V.K. Ahluwalia, S. Dhinger, University Press, 2000.

**Course Outcome:**

* Able to learn the method of melting point and boiling point determination of organic compounds.
* To familiarize with systematic procedures of preparation of simple organic compounds.
* To learn how to carryout important organic reactions.

**Lab 14 (Core Lab 7): Computational Chemistry Laboratory-I (ILCCH402)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To get conversant with drawing the structures uniformly using Chemdraw softwares.
2. To predict the molecular properties based on different quantum mechanical theories using Gaussian9 softwares.
3. To apply Gaussian softwares for molecular modelling studies.

**Syllabus**

1. Practicing Chem-Draw software to draw the structures.
2. Use of Gaussian9 software to predict the energies, bond angle, bond length, spectral properties of some small molecules using different methods and basis sets.

**Essential Readings:**

1. Introduction to Computational Chemistry, F. Jensen, John Wiley & Sons Ltd, 2nd edn, 2007.
2. Essentials of Computational Chemistry, C. J. Cramer, Wiley & Sons ltd., 2nd edn, 2004.
3. Computational Chemistry, D. C. Young, Wiley-Interscience, 1st edn, 2001.

**Course Outcomes:**

* Develop expertise on drawing the structures uniformly using Chemdraw softwares.
* Project molecular properties based on different quantum mechanical theories using Gaussian9 softwares.
* Perform molecular modelling studies using Gaussian9 softwares.

**Lab 15 (Core Lab 8): Physical Chemistry Laboratory III (ILCCH403)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To expose students about different laboratory experiments related to critical solution temperature and phase equilibria.
	2. To expose students about different laboratory experiments related to acid and base hydrolysis.

**Syllabus**

* + - 1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
			2. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
	1. simple eutectic and
	2. congruently melting systems.
		+ 1. Distribution of acetic/ benzoic acid between water and cyclohexane.
			2. Study the equilibrium of at least one of the following reactions by the distribution method:

 I2(aq) + I -→ I3-(aq)2+

 Cu2+(aq) + *n*NH3 → Cu(NH3)*n*

* + - 1. Study the kinetics of the following reactions.
				1. Initial rate method: Iodide-persulphate reaction
				2. Integrated rate method:
				3. Acid hydrolysis of methyl acetate with hydrochloric acid.
				4. Saponification of ethyl acetate.
			2. Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis of methyl acetate.

**Essential Readings:**

1. Senior Practical Physical Chemistry*,* B. D. Khosla, V. C. Garg & A. Gulati, R. Chand & Co., New Delhi, 2011.
2. Experiments in Physical Chemistry, C. W. Garland, J. W. Nibler & D. P. Shoemaker, McGraw-Hill, New York, 8th Edn., 2003.
3. Experimental Physical Chemistry, A. M. Halpern & G. C. McBane, W. H. Freeman & Co., New York, 3rd Edn., 2003.

**Course Outcomes**

The students will be having hand-on experience of kinetics of a reaction, phase rule and critical solution temperature.

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| **ILCCH403: Physical Chemistry Laboratory III** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  |  |  | \* | \* | \* |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Lab 16 (DSE Lab 2): Polymer Chemistry Laboratory (ILCCH404)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To prepare polymers of different types.
	2. To determine the molecular mass of polymers

**Syllabus**

1. Free radical solution polymerization of
2. Styrene (St)
3. Methyl Methacrylate (MMA) / Methyl Acrylate (MA)
4. Acrylic acid (AA)

2. Preparation of Nylon 66

3. Redox polymerization of acrylamide

4. Precipitation polymerization of acrylonitrile

5. Preparation of urea-formaldehyde resin

6. Preparation of Novalac resin.

7. Determination of molecular weight by viscometry:

(a) Polyacrylamide-aq.NaNO2 solution

(b) Poly vinyl proplylidine (PVP) in water

**Essential readings:**

1. Polymer Chemistry: An Introduction, Malcohm P. Stevens, Oxford University Press, 3rd Edn. 2005.
2. Contemporary Polymer Chemistry, Harry R. Allcock, Frederick W. Lampe and James E. Mark, Prentice-Hall, 3rd Edn, 2003.
3. Textbook of Polymer Science, Fred W. Billmeyer, Wiley-Interscience, 3rd Edn. 1984.
4. Polymer Science and Technology, Joel R. Fried, Prentice-Hall, 2nd Edn. 2003.
5. Introduction to Macromolecular Science, Petr Munk and Tejraj M. Aminabhavi, John Wiley & Sons 2nd Edn. 2002.
6. Introduction to Physical Polymer Science, L. H. Sperling, John Wiley & Sons, 4th Edn. 2005.

**Course Outcomes:** Students are able to know

* Different techniques to prepare addition and condensation polymer and the suitable conditions for that.
* The techniques to determine the molecular mass of the polymer

**Semester-5**

**AECC 3: Environmental Science (IMCCH501)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To know various factors for ecological balance.
	2. Study about various types of pollutants/ wastes and their treatment
	3. To know safety measures during different types of accidents.

**Syllabus**

**Module – I**

Ecological Concepts: Biotic components, Ecosystem Process: Energy, Food Chain, Water cycle, Oxygen cycle, Nitrogen cycle, carbon cycle, Environmental gradients, Tolerance levels of environment factor, EU, US and Indian Environmental Law. Chemistry in Environmental Engineering: Atmospheric chemistry, Soil chemistry. Noise pollution- Noise standards, measurement and control. Water Treatment: water quality standards and parameters, Ground water. Water treatment processes, Pre-treatment of water, Conventional process, Advanced oxidation process.

**Module – II**

(a) Waste Water Treatment: COD and BOD of Waste water treatment process, pretreatment, primary and secondary treatment of waste water, Activated sludge treatment: Anaerobic digestion, Reactor configurations and methane production.

(b) Air Pollution : Air pollution and pollutants, criteria of pollutants, Acid deposition, Global climate change –greenhouse gases, air pollution meteorology, Atmospheric dispersion. Industrial Air Emission Control. Flue gas desulphurization, NOx removal, Fugitive emissions.

(c) Solid waste, Hazardous waste management including Nuclear solid wastes. Solid Waste Management, Source classification and composition of MSW: Separation, storage and transportation, Reuse and recycling, zero waste management, Hazardous Waste Management, Hazardous waste and their generation, Transportation and treatment: Incinerators, super critical liquids, Inorganic waste treatment. E.I.A., Environmental auditing,

**Module – III**

Occupational Safety and Health Acts, Safety procedures, Type of Accidents, Chemical and Heat Burns, Prevention of Accidents involving Hazardous substances, Human error and Hazard Analysis. Hazard Control Measures in integrated steel industry, Petroleum Refinery, L.P.G. Bottling, Pharmaceutical industry. Fire Prevention – Detection, Extinguishing Fire, Electrical Safety, Product Safety. Safety Management- Safety Handling and Storage of Hazardous Materials, Corrosive Substances, Gas Cylinders, Hydro Carbons and Wastes. Personal Protective Equipments.

**Selected Text / Reference Books:**

1. Environmental Engineering Irwin/ McGraw Hill International Edition, 1997, G. Kiely
2. Industrial Safety Management, L. M. Deshmukh, Tata McGraw Hill Publication.
3. Chemistry for Environmental Engineering and Science, Clair N. Sawyer, Perry L. Mc Carty and Gene F. Parkin, 5th edition, Mc GrawHill
4. Environmental Engineering by Arcadio P. Sincero & Gergoria A. Sincero PHI Publication
5. Principles of Environmental Engineering and Science, M. L. Davis and S. J. Masen, McGraw Hill International Edition, 2004
6. Environmental Science, Curringham & Saigo, TMH,
7. An Introduction to Environmental Engineering and Science by Gilbert M. Masters & Wendell P. Ela - PHI Publication.
8. Industrial Safety Management and Technology, Colling. D A – Prentice Hall, New Delhi.

**Course Outcomes:** Students are able to

* Realise the importance of ecological balance.
* Know how to minimise waste for a better environment.
* Follow proper procedure for waste treatment
* Take safety measures in their house, workplace etc.

**Core 11: Molecular Spectroscopy (IPCCH501)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To know the rotational, vibrational and Raman spectra of complex systems with symmetry considerations.
2. To understand the theory and applications of magnetic resonances.
3. To learn about theory of Mossbauer spectra and their application to simple systems.

**Syllabus**

**Module-I**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

***Rotation spectroscopy:*** Selection rules, intensities of spectral lines, Rotational spectra of simple polyatomic molecules (linear, non-linear- symmetric top and spherical top, prolate and oblate types) Stark effects on rotational spectrum Fundamental and overtone bands. Isotope effects.

Symmetry and normal modes of vibration. Determination of normal modes from Symmetry for AB2, AB3, AB4, AB5 and AB6 systems, symmetry of overtones and combination bands.

**Module-II**

***Vibrational spectroscopy:*** Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

***Raman spectroscopy:*** Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

***Electronic spectroscopy:*** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

**Module-III**

***Nuclear Magnetic Resonance (NMR) spectroscopy:*** Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high resolution spectra, factors influencing coupling constant ‘J’. Classification (ABX, AMX, ABC, A2B2 etc.), spin decoupling; basic ideas about instrument, 1-D NMR studies of nuclei other than proton–13C, 19F and 31P. FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.

***Electron Paramagnetic (Spin) Resonance (EPR or ESR) Spectroscopy***

Basic principles, zero field splitting and Kramer’s rule, factors affecting the ‘g’ value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship.

**Module-III**

***Principles of Mossbauer spectroscopy:*** Basic principles, spectral line shape and natural line width, characteristics of Mossbauer nuclides, Doppler’s effect, parameters to evaluate Mossbauer spectra: chemical shift or isomeric shift, quadruple interaction, Magnetic field interaction. Application of Mossbauer spectra to Fe and Sn system with respect to oxidation states.

**Essential Readings:**

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, Tata McGraw Hill, 5thEdn., 2013.
2. J. M. Hollas, Modern Spectroscopy, Wiley, 4th edn, 2003.
3. Spectra of Atoms and Molecules, P. F. Bernath, Oxford Univ. Press, 2ndEdn., 2005.
4. Molecular Spectra, I. A. Levine, Wiley, 1stEdn., 1975.
5. Modern Spectroscopy, J.M. Hollas, JohnWiley,4thEdn.,2004.
6. Electron Paramagnetic Resonance: Elementary Theory and Practical Applications, J. A. Weil, J. R. Bolton and J. E. Wertz, Wiley Interscience, New York,1994.
7. Mossbauer Spectroscopy, N.N. Greenwood and T.C. Gibb, Chapman&Hall,1971.

**Course Outcomes**

* Predict the rotational, vibrational and Raman spectra of complex systems; apply symmetry considerations to vibrational and Raman spectra.
* Understand the theories of magnetic resonances and apply these to predict the structure of molecules/compounds/ions etc.
* Understand the functioning of Mossbauer spectra and their application to ascertain the oxidation states of Fe and Sn systems.

**Core 12: Organic Chemistry-IV (IPCCH502)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provides basic idea about carbohydrates, reducing and non-reducing sugar, their nomenclature and their configurations.
2. To provide knowledge on amino Acids, Peptides, Proteins and nucleic Acids, their nature, synthesis methods etc.
3. To provide a detail study on fats, oils and detergents. Their physical properties. It also provides idea about dyes, their classification and their methods of synthesis.
4. To provide a detail study on Pharmaceutical Compounds, their Classification, structure and therapeutic uses.

**Syllabus**

**Module-I**

***Carbohydrates***

Classification and nomenclature. Monosaccharides, reducing non redcing sugars mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and shortening of aldoses, configuration of monosaccharides, conversion of glucose into mannose, formation of glycosides, ethers and esters. Determination of ring size of monosaccharides. Cyclic structure of D(+)-glucose. Mechanism of mutarotation.

**Module-II**

***Amino Acids, Peptides, Proteins***

*Amino Acids:* Classification, structure and stereochemistry of amino acids, acid-base behaviour, isoelectric point and electrophoresis. Preparation and reactions of α-amino acids.

*Peptides and Proteins:* Structure and nomenclature of peptides and proteins. Name of the specific synthesis methods end group analysis, selective hydrolysis of peptides (including enzymatic). Classical peptide synthesis, solid-phase peptide synthesis.

***Nucleic Acids***

Components of nucleic acids, Nucleosides and nucleotides;

Structure and synthesis of Adenine, Guanine, Cytosine, Uracil and Thymine. (Purine base from 2,6,8-trichloropurine, thiourea, formamidine and pyrimidine base from urea, thiourea and maleic acid)

Structure of polynucleotides

**Module-III**

***Fats, Oils and Detergents***

Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils. Saponification value, iodine value, acid value. Soaps and synthetic detergents (alkyl and aryl sulphonates).

***Synthetic dyes***

Colour and constitution (electronic concept), classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo dyes.

**Module-IV**

***Pharmaceutical Compounds: Structure and Importance***

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis),

Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

**Essential readings:**

1. Bio-Chemistry, D. Voet & J. G. Voet, John Wiley & Sons, 4th Edn., 2010.
2. Principles of Bio-Chemistry, Zubay, Medtech Publishing, 5th Edn., 2017.
3. Bio-Chemistry, S. C. Rastogi, Tata McGraw Hill Education, 2nd Edn., 2003.
4. Polymer Science, V. R. Gowariker, N. V. Viswanathan & J. Sridhar, New age Int. Publishers, 2nd Edn., 2015.
5. Principles of Bio-Chemistry, Lehinger, Nelson and Cox, W. H Freeman and Co., 7th Edn., 2017.
6. Harper’sIllustrated Biochemistry. R.K. Murray, D.K. Granner, P.A. Mayes, and V.W. Rodwell, Lange Medical Books/ McGraw-Hill. 18th Edn. 2009.

**Course Outcomes**

* Able to understand about carbohydrates, reducing and non-reducing sugar, their nomenclature and their configurations.
* Able to get knowledge on amino Acids, Peptides, Proteins and nucleic acids, their nature, synthesis methods etc.
* Offers the knowledge on Fats, Oils and Detergents and synthetic dyes.
* Able to identify heterocyclic compounds, their physical and chemical properties.
* Able to understand the Pharmaceutical Compounds and their therapeutic uses.

**Core 13: Physical Chemistry-IV (IPCCH503)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the basic concept of electro chemistry mechanism of electrode reaction.
2. To learn the concepts of the activity coefficients and electrochemical cell.
3. To learn the basic concept of electrical dipole moments, polarizabilities & polarization.

**Syllabus**

**Module-I**

***Transport properties of electrolyte***

***Conductance-I****:* Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Waldens rules. Quantitative aspects of Faradays laws of electrolysis, applications of electrolysis in metallurgy and industry

**Module – II**

***Conductance-II****:* Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

**Module-III**

***Thermodynamics properties of Electrolytes*** Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of halfcells. rules of oxidation/reduction of ions based on half-cell potentials, Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes.

**Module-IV**

***Molecular structure and electrical properties and interaction of Molecule***

Electrical Dipole moments, Polarizabilities, Polarization

**Essential Readings:**

1. Atkin’s Physical Chemistry, P. W. Atkins & J. de Paula, Oxford University Press, 10th Edn., 2014.
2. A Textbook of Physical Chemistry- Vol. 1, K. L. Kapoor, Mc Graw Hill Education (India), 2019.
3. An Introduction To Electrochemistry, S. Glasstone, Maurice Press, 2008.
4. Physical Chemistry, G. W. Castellan, Narosa, 4th Edn., 2004.
5. Physical Chemistry, R. G. Mortimer, Elsevier, NOIDA, UP, 3rd Edn., 2009.
6. Physical Chemistry, G. M. Barrow, Tata McGraw Hill, New Delhi, 5th Edn., 2006.
7. Physical Chemistry, T. Engel & P. Reid, Prentice-Hall, 3rd Edn., 2012.
8. Concise Physical Chemistry, D. W. Rogers, Wiley, 2010.
9. Physical Chemistry, R. J. Silbey, R. A. Alberty & M. G. Bawendi, John Wiley & Sons, Inc., 4th Edn., 2005.

**Course Outcomes**

* Explain the behaviour of, and interactions between, matter and energy at the atomic and molecular levels.
* Understand the principles of kinetics and thermodynamics as applied to rates and equilibrium positions of chemical reactions.
* Use quantitative measures of solution concentration in describing colligative, acid-base, solubility, and electrochemical principles of aqueous solutions.
* Culture a basic understanding of how computational chemistry can be used to determine atomic and molecular properties.
* Apply probability principles to the behaviour of large ensembles of atoms or molecules, and to use this to predict thermodynamic properties of a system.
* Examine basic principles of kinetics, and tie thermodynamics and kinetics together rudimentary.

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| **IPCCH503:Physical Chemistry-IV** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  | \* |  |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**DSE 2: Analytical Technique-I (IPECH501)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn on data accuracy and their uses in various experiments; various standard methods for calculating the multifunctional parameters.
2. To gain knowledge on basic principles of chromatography and separation techniques for purifying samples.
3. To understand the basic principles on various thermal and electroanalytical techniques and their applications.
4. To study the basic principles of fluorescence and optical activity techniques and their applications.

**Syllabus**

**Module I**

***Data Handling:*** Errors and Statistics: significant figures, rounding off, accuracy and precision, determinate and indeterminate errors, standard deviation, propagation of errors, non-linear least square fittings, confidence limit, test of significance, rejection of a result.

**Module II**

***Separation Techniques:*** Solvent Extraction: distribution coefficient, distribution ratio, solvent extraction of metals, multiple batch extraction, counter current distribution. Chromatographic Techniques: classification, theory of chromatographic separation, distribution coefficient, retention, sorption, efficiency and resolution. - Column, ion exchange, paper, TLC & HPTLC: techniques and application. - Gas

***Chromatography:*** retention time or volume, capacity ratio, partition coefficient, theoretical plate and number, separation efficiency and resolution, instrumentation and application.

**Module III**

***Thermal Analysis:*** TGA, DTA and DSC: Basic principles, instrumentation and their applications.

***Electroanalytical Methods:*** Classification of electroanalytical methods, principles and applications of voltammetry, cyclic voltaammetry, anodic stripping voltammetry, polarography, amperometry, coulometry, conductometry and ion selective electrodes (Extensive instrumentations are to be excluded).

**Module IV**

***Fluorescence Spectroscopy****;* Basic principles of fluorescence spectroscopy; quantum yield and lifetime; static & dynamic quenching; the Stern-Volmer equation, fluorescence anisotropy. Basic idea on green fluorescent protein.

***Optical Activity and ECD Spectroscopy:*** Optical activity; absorption and dispersion; principles of circular dichroism; CD of small molecules.

**Essential Readings:**

* 1. Quantitative Chemical Analysis, D. C. Harris, W. H. Freeman, 8th Edn., 2010.
	2. Instrumental Analysis, G. D.Christian & J. E. OReily, Allyn & Balon, 2nd Edn., 1986.
	3. Instrumental Analysis, D. A. Skoog, F. J. Holler, S. R. Crouch, Cengage Learning, 11th Edn., 2012.
	4. Principle and Applications of Thermal Analysis, P. Gabbott, Blackwell Publshing, 1st Edn., 2009.
	5. Structure Determination of Organic Compounds, E. Pretsch, P. Bühlmann, M. Badertscher, Springer, 4th Edn., 2009.
	6. Introduction to Modern Liquid Chromatography, Lloyd R. Snyder, Joseph J. Kirkland, Wiley, 3rd Edn., 2009.
	7. Gas Chromatography, Ian A. Fowlis, John Wiley & Sons, 2nd Edn., 1995.
	8. Validating Chromatographic Methods: A Practical Guide, D. Bliesner, John Wiley & Sons, 2nd Edn.,2006.
	9. Principles of Fluorescence Spectroscopy J. R. Lakowicz, 3rd Edn., 2006.
	10. NMR Spectroscopy, James Keeler, Wiely, 2nd Edn., 2011.
	11. Introduction to Thermal Analysis: Techniques and Application, Brown, Michael Ewart, Kluwer Academic Publishers, 2nd Edn. 2001.
	12. An Introduction to Error Analysis, J. R. Teller, University Science book, 2nd Edn. 1997.
	13. Data reduction and Error Analysis for the Physical Sciences, P. Bavington and D.K. Robinson, McGraw-Hill, 3rd Edn., 2003.

**Course Outcomes**

* Demonstrate on data accuracy principles and their uses in various experiments; various standard methods for calculating the multifunctional parameters.
* Understand the basic principles of chromatography and separation techniques for purifying samples.
* Acquire comprehensive knowledge on the basic principles of various thermal and electroanalytical techniques and their applications.
* Validate photochemical laws through fluorescence spectroscopic techniques and optical activity experiments.

**Lab 17 (Core Lab 9): Organic Chemistry Laboratory -III (ILCCH501)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the functional group analysis of carbohydrates.
2. To learn preparation of some organic compounds by nitration and oxidation reaction.
3. To learn the skill of synthesis of Pharmaceutical compounds.

**Syllabus**

1. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
2. Nitration of any one of the following:

 a. Acetanilide/nitrobenzene by conventional method

 b. Salicylic acid by green approach (using ceric ammonium nitrate).

1. Preparation of glucose from cane sugar.
2. Isolation of Casein and lactose from milk.
3. Organic comp preparations:
4. Oxidation of ethanol/ isopropanol (Iodoform reaction).
5. Preparation of Picric acid
6. Synthesis of Pharmaceutical Compounds
* Antipyretics: Paracetamol
* Analgesics: Ibuprofen
* Antimalarials: Chloroquine.

**Essential readings:**

1. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Publishers, 5th Edn., 2013.
2. Practical Organic Chemistry, F.G. Mann & B.C. Saunders, Pearson Education, 4th Edn., 2009.
3. Quantitative Organic Analysis*,* A. I. Vogel, A.I. Part 3, Pearson, 2012.
4. Practical Organic Chemistry, O.P. Agarwal, Krishna’s Educational Publishers, 13th Edn. 2013
5. Practical Organic Chemistry, B.S. Furnis, A.J. Hannaford, P.W.G. Smith,& A.R. Tatchell,, Pearson, 5th Edn., 2012.
6. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V.K. Ahluwalia, & R. Aggarwal, University Press, 2000.
7. Comprehensive Practical Organic Chemistry: Qualitative Analysis, V.K. Ahluwalia, S. Dhinger, University Press, 2000.

**Course Outcomes**

* Able to analyse carbohydrates.
* Able to prepare carbohydrates from natural resources.
* Get familiarize with organic compound preparations and synthesis of pharmaceuticals.
* To learn how to carryout important organic reactions

**Lab 18 (Core Lab 10): Inorganic Chemistry Laboratory-III (ILCCH502)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To estimate metal ions by complexometric titration
	2. To estimate metals gravimetrically in different compounds
	3. To prepare several inorganic compounds
	4. To separate metal ions chromatographic technique

**Syllabus**

1. **Complexometric titrations using disodium salt of EDTA.**
2. Estimation of Mg2+, Zn2+
3. Estimation of Ca2+ by substitution method
4. **Chromatography of metal ions:** Paper chromatographic separation of following metal ions
5. Ni(II) and Co(II)
6. Fe(III) and Al(III)
7. **Gravimetric Analysis:**
8. Estimation of nickel (II) using dimethyl glyoxime (DMG)
9. Estimation of copper as CuSCN
10. Estimation iron as Fe2O3 by precipitating iron as Fe(OH)3
11. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxin)3 (aluminium oxinat)
12. **Inorganic Preparation:**
13. Cis and trans [KCr(C2O4)2.(H2O)2]
14. Tetraamminecarbonatocobalt(III) ion
15. Potassiumtris(oxalate)ferrate(III)

**Essential Readings:**

1. Vogel’s Qualitative Inorganic Analysis, G. Svehla. Pearson Education, 2002.
2. Inorganic Semi-micro Qualitative Analysis, V.V. Ramanujam, National Publishing Company, Madras, 3rd Edn., l990.
3. A text book of quantitative analysis, A.I. Vogel, ELBS 1986

**Course Outcomes:** Students are able to

* Know the principles of complexometric titration and estimate several ions quantitatively by this technique.
* Use paper chromatographic technique to separate metal ions.
* Prepare several complexes.
* Estimate gravimetrically metal ions from its compounds.

**Lab 19 (Core Lab 11): Physical Chemistry Laboratory IV ILCCH503**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To determine relative strength of acids, rate constant & order of reactions pKa value of a weak acid potentiometric titration and conductometric titration.

**Syllabus**

**pH meter titration**

1. Calibration of pH meter using NBS buffers.
2. Acid-base titration using pH meter (only HCl)
3. Acid-base titration using pH meter (mixture, HCl and CH3COOH)

**Conductometry**

1. Determination of cell constant
2. Determination of equivalent conductance of a uni-univalent electrolyte at infinite dilution
3. Conductometric titrations:
	1. Strong acid vs. strong base
	2. Weak acid vs. strong base
	3. Mixture of strong acid and weak acid vs. strong base
	4. Strong acid vs. weak base

**Potentiometric Titration**

* 1. Strong acid vs. strong base
	2. Sliver nitrate with KCl
	3. Dibasic acid vs. strong base
	4. Determination of pK of weak acid

**Essential Readings:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* *8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd* *Ed.;* W.H. Freeman & Co.: New York (2003).

**Course Outcomes**

* To the preparation for each experiment by studying lab handouts and links therein.
* To know about the safety requirements and lab skills to perform physico-chemical experiments.
* An appreciation for modern problems and scientific controversies in physical chemistry.
* How to design and perform experiments to determine the rate, order, and activation energy of chemical reactions by varying concentrations and/or temperature.
* Methods to measure equilibrium concentrations and equilibrium constants for acid-base, solubility, and complexation reactions given initial concentrations of reactant.
* To the preparation of buffer solutions at a required pH, given a choice of solutions of acid/conjugate base pairs.
* To know the principle and mechanism of Conductormetric and potentiometric titrations.

|  |
| --- |
| **ILCCH503:Physical Chemistry Laboratory IV** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  | \* | \* |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Lab 20 (DSE Lab 3): Analytical Technique Laboratory-I (ILCCH504)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. Make familiar with spectroscopic technique
2. Hands on practice on STA, CV, HPLC, Flame photometry, Gas Chromatography, Potentiometer
3. Determine the composition of complexes

**Syllabus**

1. Spectroscopic determination of:
* Iron/ copper/ nickel in minute quantities by UV-Vis spectrophotometry
* Principles of colorimetric analysis: determination of iron content of an unknown sample.
1. Spectroscopic determination of:
* Phosphate in water sample and cola drinks
* Chromium(VI) in water sample
1. Determination of composition of a complex using Job’s method
2. Thermal decomposition of CuSO4.5H2O
3. Redox behavior of potassium ferricyanide by cyclic voltammetry
4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometrictechniques.
5. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption Spectroscopy
6. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
7. Separation of Carbohydrates by HPLC
8. Determination of Caffeine in Beverages by HPLC
9. Potentiometric Titration of a Chloride-Iodide Mixture

**Essential Readings:**

1. Principles of Instrumental Analysis, D.A Skoog,. F.J Holler. & T.A Nieman,. Cengage

Learning India Edn.

1. Instrumental Methods of Analysis, H.H Willard, L.L Merritt, J Dean,. & F.A.Settoe,

Wadsworth Publishing Company Ltd., Belmont, California, USA, 7th Edn. 1988.

1. Vogel's Qualitative Inorganic Analysis, G., Svehla, Orient Longman New Delhi, 6th Edn. l987.
2. Inorganic Semi-micro Qualitative Analysis, V.V. Ramanujam, National Publishing Company, Madras, 3rd Edn., l990.
3. Vogel’s text book of Quantitative Chemical Analysis, J. Bassett, G. H. Jeffery and J. Mendham, and R. C. Denny, Longman Scientific and Technical 5th Edn, (1999).
4. Hand-outs prepared for the laboratory experiments: collections from various literature sources
5. A Collection of Interesting General Chemistry Experiments, A. J Elias Universities Press, (India) Pvt. Ltd., 2002.
6. Chemical Curiosities: spectacular experiments and inspired quotes, H W Roesky, K Möckel, VCH, 1996.

**Course Outcomes**

* Able to analyse minute amount of chemicals quantitatively present in any sample
* Exposed to various instruments and their use in different fields of analysis
* Able to find out the formula of any complex.

**Semester-6**

**Core 14: Inorganic Chemistry-IV (IPCCH601)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. This course aims to provide reaction mechanism and a basic approach to Organometallic compounds.
	2. Students can explain & interpret the bond properties in valence bond and crystal field approach to various coordination compounds.
	3. The various information about the frontier uses of Organometallic compounds and their reaction kinetics & mechanism can be gained by the students.

**Syllabus**

**Module I:**

***Coordination Chemistry-I:*** Introduction, Werner’s coordination theory and its experimental verification, effective atomic number concept, chelates, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes. Limitations of valence bond theory, An elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters, tetragonal distortions from octahedral geometry Jahn-Teller theorem

**Module II:**

***Coordination Chemistry-II***

***Reaction Kinetics and Mechanism:*** Introduction to inorganic reaction mechanisms (d,I,Id,Ia). Substitution reactions in square planar complexes, Trans-effect and its applications, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes.

**Module III**

***Organometallic Compounds:*** Organic ligands and nomenclature, The 18-Electron rule, Carbonyl complexes: General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.Pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect.

Zeise’s salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Hydride and dihydrogen complexes, Bonding between Metal atoms and Organic pi- system (linear, cyclic system), Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene.Complexes containing M-C, M=C and M≡C Bonds (alkyl, carbene, carbyne complexes), Spectral analysis of Organometallic compounds (IR and NMR spectra)

**Module IV**

***Catalysis by Organometallic Compounds:*** Catalysis: Catalytic Deuteration, Hydroformylation, Monsanto Acetic acid process, Wacker Process, Hydrogenation by Wilkinson’s Catalyst, Olefin metathesis, Heterogeneous catalysis (Ziegler-Natta Polymerization, Water gas reaction)

**Essential Readings:**

1. Shriver Atkins’ Inorganic Chemistry, P. W Atkins, T.Overton, J.Rourke, M. Weller and F. Armstrong, Oxford Univ. Press, 5th Edn., 2012.
2. Mechanism of Inorganic Reactions, D. Katakis & G. Gordon, John Wiley & Sons, New York, 1987.
3. Inorganic Chemistry: Principles of Structure and Reactivity (4th impression), J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, Pearson Education, 2008.
4. Advanced Inorganic Chemistry*,* F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochmann, Wiley India, 6th Edn, 2012.
5. The Study of Kinetics and Mechanism of Reactions of Transition Metal Complexes*,* R. G. Wilkins, Allyn & Bacon, Boston, 1974.
6. Reaction Mechanisms of Inorganic and Organometallic Systems*,* Robert B. Jordan, Oxford University Press, 1998.
7. Fundamental Concept of Inorganic Chemistry*,* Vol. 3 and 4, A.K. Das and M. Das, CBS Publisher & Distributor Pvt. Ltd., New Delhi, 2nd Edn., 2014.

**Course Outcomes**

* To provide experience to use HSAB principles for various acid base reactions .
* To develop understanding about the coordination compounds their various theories of bonding and their interpretation.
* To develop some understanding about Organometallic compounds and their kinetic studies and mechanisms

**Core 15: Chemical Biology (IPCCH602)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To introduce the structure and function of selected biomolecules.
2. To learn the fundamentals on bioenergetics and metabolism of glucose.
3. To study the introductory idea on ion-channel and transport phenomena on biosystem.
4. To know the essential knowledge on enzymes, their functions and enzyme kinetics.

**Syllabus**

**Module I**

***Introduction to Biomolecules****:*

Structure and Function: Carbohydrates (Monosaccharide, oligosaccharides, polysaccharides (starch, Glycogen, Cellulose); Lipids: Saturated and unsaturated fatty acids, triacylglycerols, phosphoglycerides, sphingolipids, waxes and sterol; amino acids and peptides, proteins - hierarchy of protein architecture, Ramachandran plot

**Module II**

***Nucleic acids:*** DNA, RNA, double helix model of DNA, denaturation and renaturation of DNA; replication, transcription and translation of DNA; hormones and vitamins.

**Module III**

***Principle of Bioenergetics****:* Bioenergetics and Thermodynamics; Phosphoryl group transfer and energy currency-ATP; Biological Oxidation and reduction reactions

Metabolic processes: Introduction to metabolism of carbohydrates: Glycolysis, TCA Cycle, Gluconeogenesis.

**Module IV**

***Transport Mechanism***

Introduction to ion-channel, Na+/K+ transport (Ion pump); CO2 transport by carbonic anhydrase.

***Enzymes****:* Properties of enzyme, classification of enzymes, mechanism of enzyme action, kinetics of enzyme action, activation energy, enzyme inhibition, coenzyme, apozyme and holozyme.

**Essential Readings:**

1. Principle of Bio-Chemistry, Alberf L. Lehninger, David L. Nelson, and Michael M. Cox. Worth Publishers: 33 Irving Place, 2nd Edn., 1993.
2. Biochemistry, Jeremy M Berg, John L Tymoczko, and Lubert Stryer, New York: W H Freeman, 5th Edn., 2002.
3. Fundamentals of Biochemistry, D. Voet, J. G. Voet and C.W. Pratt, Wiley, 2nd Edn, 2011.
4. Biochemistry, C. B. Powar & G. R. Chatwal, Himalaya Publishing House, 5th Edn., 2017.
5. Biochemistry, S. C. Rastogi, Tata McGraw Hill, 3rd Edn, 2010.

**Course Outcomes**

* Understand the structure and function of selected biomolecules.
* Get the knowledge on working of bioenergetics and metabolism of glucose.
* Identify the ion-channel and transport phenomena on biosystem.
* Get comprehensive knowledge on the enzymes, their functions and kinetics.

**DSE 3: Industrial and Green Chemistry (IPECH601)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To make aware about various industrial effluent.
2. To know the principles of green chemistry.
3. To Synthesize some important compounds by green technique

**Syllabus**

**Module I**

***Industrial Gases and Inorganic Chemicals***

*Industrial Gases:* Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

*Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

***Industrial Metallurgy***

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

**Module II**

***GREEN CHEMISTRY***

***Introduction to Green Chemistry***

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

***Principles of Green Chemistry and Designing a Chemical synthesis***

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

**Module III**

***Examples of Green Synthesis/ Reactions***

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, mparacetamol, furfural.

2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzole acid), Oxidation (of toluene, alcohols).

Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation. Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2- dihydrotriazine derivatives; benzimidazoles.

3. Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.

**Module IV**

***Future Trends in Green Chemistry***

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

**Essential readings:**

1. Industrial Chemistry, Vol-I, E. Stocchi: Ellis Horwood Ltd. UK.
2. Elementary Principles of Chemical Processes, R.M. Felder, R.W. Rousseau: Wiley Publishers, New Delhi.
3. Handbook of Industrial Chemistry, J. A. Kent: Riegel’s, CBS Publishers, New Delhi.
4. New Trends in Green Chemistry, V.K. Ahluwalia, M.R. Kidwai:, Anamalaya Publishers 2005.
5. Oxford Green Chemistry- Theory and Practical, P.T. Anastas & J.K. Warner:, University Press, 1998.
6. Introduction to Green Chemistry, A.S. Matlack: Marcel Dekker, 2001.

**Course Outcomes:** Students are able to

* know the ill effects of effluents from industry
* optimize / modify the process of manufacture.
* know different techniques to carry out different reactions

**DSE 4: Analytical Technique-II (IPECH602)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To follow the principles of various spectroscopic techniques and mass spectrometry.
2. To predict the spectral data for various organic and inorganic compounds based on these principles.
3. To predict the structure of organic and inorganic compounds based on various spectral data.

**Syllabus**

**Module I**

Introduction to spectroscopic techniques for structure elucidation. Electromagnetic radiation, absorption of energy by organic compounds, types of spectroscopic methods for structural elucidation of organic and inorganic molecules.

***IR – Spectroscopy*** – Basic principles, characteristic frequencies of common functional groups.

UV – Visible Spectroscopy: Basic principles. Born-Oppenheimer approximation, Frank Condon principle, laws of photochemical equivalence. Application of UV – Visible spectroscopy to organic structure elucidation, Woodward – Fisher rules.

**Module II**

***Nuclear Magnetic Resonance (NMR)Spectroscopy:*** JJ coupling, vicinal and germinal coupling,Applications of 1H and 13C NMR spectroscopy in the structural determination of organic compounds. One-dimensional NMR of common heteroatoms present in organic compounds (N, F and P).

***Electron Spin Resonance (ESR) Spectroscopy:*** Analysis of ESR spectra of systems in liquid phase, radicals containing single set, multiple sets of protons, triplet ground states. Transition metal ions/complexes.

**Module III**

***Mass spectrometry:*** Basic principles of mass spectrometry, fragmentation and rearrangements (including McLafferty rearrangement) of organic molecules, basics of high-resolution mass spectrometry, ionization potential and isotopic distribution, experimental setup, application of mass spectrometry to organic and inorganic compounds in structural determination.

**Module IV**

Problem solving exercises involving UV, IR, NMR & MS data: Problems involving interpretation of spectral details of organic compounds.

**Essential Readings:**

1. Structural Methods in Inorganic Chemistry, E. A. O. Ebsworth, Blackwell Scientific Publications, 2nd Edn., 1991.
2. Physical Methods in Chemistry, R. S. Drago, Saunders Co., 2nd Edn., 1992.
3. Introduction to Magnetic Resonance, Carrington, A. & McLachlan, A. D. Chapman & Hall, 3rd Edn., 1983.
4. Magnetism and Transition Metal Complexes, F. E. Mabbs, & D. J. Machin, Chapman and Hall, 2nd Edn., 2008, .
5. Spectrometric Identification of Organic Compounds, R. M. Silverstein and F. X. Webster, John Wiley and Sons.Inc., 6th Edn., 1997.
6. Organic Spectroscopy, W. Kemp, MacMillon, 3rd Edn., 1994.
7. Introduction to Spectroscopy, Pavia, Lampman and Kriz, Brooks/Cole Pubs. Co., 3rd Edn., 2000.
8. Spectroscopic Methods in Organic Chemistry, D. H Williams and Ian Fleming, Tata McGraw Hill, 6th Edn., 2014.
9. Spectroscopy of Organic Compounds, P. S. Kalsi, New Age Intl., 6th edn., 2006.
10. Electron Paramagnetic Resonance: Elementary Theory and Practical Applications, J. A. Weil, J. R. Bolton and J. E. Wertz, Wiley Interscience, New York, 1994.
11. Basic One and Two Dimensional NMR Spectroscopy, H.Friebolin, Wiley VCH, 1991

**Course Outcomes**

* Knowledge on principles of various spectroscopic techniques and mass spectrometry.
* Envisage the spectral data for various organic and inorganic compounds based on these principles.
* Deduce the structure of organic and inorganic compounds based on various spectral data.

**Lab 21 (Core Lab 12): Inorganic Chemistry Laboratory-IV (ILCCH601)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To identify more than one acid and basic radicals present in a mixture.
	2. To prepare and qualitatively analyze various complexes.
	3. Determine the crystal structure of solids.

**Syllabus**

1. **Qualitative Semi micro analysis**: Mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: CO3 2- , NO2 - , S 2- , SO3 2- ,S2O3 2- , CH3COO- , F - ,Cl- , Br- , I - , NO3 - , BO3 3- , C2O4 2- , PO4 3- , NH4 + , K + , Pb2+ , Cu2+ , Cd2+ , Bi3+ , Sn2+ , Sb3+ Fe3+ , Al3+ , Cr3+ , Zn2+ , Mn2+ , Co2+ , Ni2+ , Ba2+, Sr2+ , Ca2+ , Mg2+ .Mixtures should preferably contain one interfering anion, or insoluble component (BaSO4 , SrSO4 , PbSO4 , CaF2 or Al2O3 ) or combination of anions e.g. CO3 2-and SO3 2- , NO2 - and NO3 - Cl -and Br- , Cl -and I - , Br -and I - , NO3 - and Br- , NO3 – and I – .
2. **Preparation and quantitative analysis of complexes**
3. Cis-potassium diaquabis(oxalate)chromate(III) complex [analysis of oxalate and chromium]
4. Hexamine nickel(II)chloride [analysis of nickel]
5. Copper(I) chloride [ analysis of copper]
6. Potassium tris-(oxalato)aluminate(III) [ analysis of aluminium]
7. Tetraaminecopper(II) sulphate. [ analysis of copper]
8. Determination of crystal structure of Inorganic complexes by Single crystal XRD.

**Essential readings:**

1. Vogel's Qualitative Inorganic Analysis, G., Svehla, Prentice Hall, 7th Edn., l996.
2. Quantitative Analysis, R.A. Day (Jr) and A.L. Underwood, Prentice Hall of India, 6th Edn., 1991.
3. Inorganic Semi-micro Qualitative Analysis, V.V. Ramanujam, National Publishing Company, Madras, 3rd Edn., l990.
4. Vogel’s text book of Quantitative Chemical Analysis J. Bassett, G. H. Jeffery and J. Mendham, and R. C. Denny, Longman Scientific and Technical, 5th Edn., 1999.
5. Analytical Chemistry - An Introduction, D. A. Skoog and D. M. West, CBS Publishing Japan Ltd., 4th Edition 1986.
6. Inorganic Synthesis, G. W. Parshall, Vol. 15, Tata McGraw-Hill Education, 1974.
7. Hand-outs prepared for the laboratory experiments: collections from various literature sources
8. A Collection of Interesting General Chemistry Experiments, A. J Elias, Universities Press, (India) Pvt. Ltd., 2002.
9. Chemical Curiosities: spectacular experiments and inspired quotes, H W Roesky, K Möckel, VCH, 19

**Course Outcomes:** Students are able to

* Detect presence of common radicals present in any unknown sample
* Prepare and analyze different complexes qualitatively.

**Lab 22 (Core Lab 13): Organic Chemistry Laboratory -IV (ILCCH602)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the skill of estimation of a functional group.
2. To know the methods of determination of equivalent weight, molecular weight of organic compounds.
3. To learn the techniques of synthesis of dyes.

**Syllabus**

1. Estimation of Organic Compounds
2. Phenol
3. Glycine
4. Glucose
5. Determination of Equivalent weight of a carboxylic acid
6. By silver salt method (Gravimetric method)
7. By volumetric method
8. Analysis of oils and fats.
9. Determination of molecular weight of an organic compound. (RAST’S Method).
10. Synthesis of dyes
11. Methyl Orange
12. Phenolphthalin
13. Eosin

**Essential readings:**

1. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Publishers, 5th Edn., 2013.
2. Practical Organic Chemistry, F.G. Mann & B.C. Saunders, Pearson Education, 4th Edn., 2009.
3. Quantitative Organic Analysis*,* A. I. Vogel, A.I. Part 3, Pearson, 2012.
4. Practical Organic Chemistry, O.P. Agarwal, Krishna’s Educational Publishers, 13th Edn. 2013
5. Practical Organic Chemistry, B.S. Furnis, A.J. Hannaford, P.W.G. Smith,& A.R. Tatchell,, Pearson, 5th Edn., 2012.
6. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V.K. Ahluwalia, & R. Aggarwal, University Press, 2000.

**Course Outcomes**

* Able to know the estimation methods for organic compounds.
* Able to determine equivalent weight and molecular weight of organic compounds.
* Able to synthesize organic dyes.

**Lab 23 (Core Lab 14): Chemical Biology Laboratory (ILCCH603)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To get practical knowledge in estimating proteins, DNA and RNA by spectroscopic techniques.
2. To practice the separation of different biomolecules following standard procedures.
3. To study on enzyme activity and enzyme kinetics.

**Syllabus**

1. Spectroscopic/Colorimetric estimation of protein using Lowry’s and Bartford methods.
2. Spectroscopic estimation of DNA using DPA method
3. Spectroscopic estimation of RNA using Orcinol method
4. Estimation of Iodine number and saponification value of fatty acids
5. Separation of amino acids by paper chromatography
6. Separation of sugars by thin layer chromatography
7. Separation of proteins by SDS-PAGE.
8. Assay of Enzyme activity: Protease from bacteria.
9. Assay of enzyme activity: Amylase from plant tissue & saliva.
10. Determination of Km and Vmax of enzyme catalysed reaction.

**Essential Readings:**

1. Introduction to Practical Biochemistry, Plummer Mu, David T. Plummer, Tata McGraw-Hill Education, 3rd Edn., 2008.

**Course Outcomes**

* Estimate proteins, DNA and RNA by spectroscopic techniques.
* Learn separation techniques for separating different biomolecules.
* Understand the enzyme activity and enzyme kinetics.

**Lab 24 (DSE Lab 4): Analytical Technique Laboratory II (ILCCH604)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To identify functional group by qualitative analysis
2. To characterize functional groups of organic compounds by IR spectroscopy.
3. To characterize functional groups of organic compounds by IR spectroscopy.

**Syllabus**

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
2. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).

**Essential Readings:**

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic* *Chemistry, 5th Ed.,* Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:* *Preparation and Quantitative Analysis,* University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry:* *Qualitative Analysis,* University Press (2000).

**Course Outcomes:** Students are able to

* Detect various functional groups present in organic compounds
* Detect various functional groups by studying their vibrational peaks by IR technique.
* Able to distinguish different types of proton by NMR technique.

**Semester-7**

**Core 16: Organic Chemistry-V (IPCCH701)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To provides basic idea about the role of oxidizing and reducing agents for various organic transformations. It also discusses the stereochemistry of the products.
	2. To provide knowledge on various types of molecular rearrangements. It gives the idea of migratory aptitude.
	3. To provide a detail study on physical organic chemistry discussing the Kinetic and thermodynamic control of a reaction.

**Syllabus**

**Module I**

***Organic Transformations and Reagents:*** Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic).

***Reductions***

Stereochemistry, stereo selection and mechanism of catalytic hydrogenation and metal-liquid ammonia reductions, reduction by dissolving metals, photo-reduction, enzymatic-reduction. Hydride transfer reagents: Sodium borohydride, sodium cynoborohydride, lithium aluminium hydride, alkoxy substituted LAH agents, DIBAL. Application of hydroboration (reductions, oxidations, carbonylations), Diborane (diisoamylborane, 9BBN). Homogeneous hydrogenations: Mechanism and applications using Rh, Ru and other metal complexes.

**Module II**

***Oxidations***

Scope of the following oxidizing agents with relevant applications and mechanism: DDQ, DCC, PCC, PDC, osmium tetroxide, selenium dioxide, KMnO4, manganese (IV) oxidants, chromium (VI) oxidants, tertiary-butyl hydro peroxide, Swern oxidation, oxidation with per-acids, enzyme or microbial oxidation (Bio-oxidation).

**Module III**

***Molecular rearrangements***

General mechanistic considerations, nature of migration, migratory aptitude, memory effects, A detailed study of the following rearrangements: Pinacol-Pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Ester Synthesis, The von Richter, Sommelet-Hauser and Smiles, Neber, Beckmann, Hoffman, Curtius, Schmidt, Bayer-Villiger, Fries and Shapiro.

**Module-IV**

***Physical Organic Chemistry****:* Kinetic and thermodynamic control, Hammond’s postulate, Curtin-Hammett principle, potential energy diagrams, transition states and intermediates. Methods of determining reaction mechanisms, isotope effects. Hard and soft acids bases concept and its application in organic synthesis. Quantitative treatment, Hammet equation and linear free energy relationships, substituent and reaction constants, Taft equation, The NGP mechanism, NGP by π and σ bonds, anchimeric assistance.

**Essential readings:**

1. March’s Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, Wiley, 7th Edn., 2013.
2. Advanced Organic Chemistry Part A: Structure and Mechanisms, Francis A.**Carey**, Richard J **Sundberg**, Springer International, 5th Edn., 2007.
3. Organic reaction mechanism: V.K.Alluwalia and R.K.Parashar, Narosa Publising House. 4th Edn., 2010.
4. Modern Organic Reactions, H. O. House, Benjamin-Cummings Publishing Co., Subs. of Addison Wesley Longman, US; 2nd Edn., 1972.
5. Principles of Organic Synthesis, R. O. C. Norman and J.M. Coxon, CRC press, 3rd Edn., 1993.
6. Organic Chemistry, Jonathan Clayden, Nick Greeves, and Stuart Warren, Oxford press, 2nd Edn., 2012

**Course Outcomes**

* Able to understand about oxidizing and reducing agents and their role in various organic transformations.
* Able to understand molecular rearrangements and migratory aptitude.
* Able to get knowledge on physical organic chemistry.

**Core 17: Physical Chemistry-V (IPCCH702)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To know the basic concepts in classical thermodynamics.
2. To learn the thermodynamic aspects of various processes and reactions.
3. To understand the different aspects of statistical thermodynamics and its applications.

**Syllabus**

**Module-I**

***Classical Thermodynamics****.* Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient. Standard States for Gases, Liquids and Solids and its Applications. Free Energies, Enthalpies and Entropies of Ions in Solutions.Debye Huckel theory of activity coefficient . Activity and Mean Activity Coefficients of Electrolytes and their Determinations, Debye-Huckel Limiting Law. Thermodynamics of Mixing–Mixtures of Volatile Liquids– ideal and Real Solutions and -Excess Functions.

**Module-II**

***Equilibrium Thermodynamics:*** Thermodynamic Derivations of Gibbs equation Phase Rule, Applications to two component (eutectic) & three component systems i nvolving solids and liquids (Acetic Acid – Chloroform - Water, NaCl-Na2SO4-H2O, NH4NO3-(NH4)2SO4-H2O.

***Non Equilibrium Thermodynamics:*** Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the properties of and forces, non equilibrim stationary states, phenomenological equations.

**Module-III**

***Statistical Thermodynamics:*** Thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging, Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers) Distribution laws Maxwell, max-well boltz mann, Fermi-Dirac, Bose –Einstein Partition functions-translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition function. Fermi-Dirac statistics, distribution law and application to metal. Bose-Einstein statistics - distribution law and application to helium.

**Module-IV**

***Chemical Dynamics:*** Theory of Reaction: Potential energy surfaces. reaction rates, Conventional transition state theory (CTST); CTST as applied to ionic reactions. dynamics of unimolecular reactions (Lindemann- Hinshelwood and Rice Rampsberger - Kassel Marcus (RRKM) theories of unimolecular reactions). Dynamics chain (hydrogen-bromine reaction, , decomposition of ethane), photochemical (hydrogen -bromine and hydrogen - chlorine reactions) and oscillatory reactions (Belousov- Zhabotinski reaction), homogeneous catalysis, . General features of fast reactions, study of fast reactions by flow methods, relaxation methods, Flash photolysis. Dynamics of barrier less chemical reactions in solution. kinetic salt effects

**Essential Readings:**

1. Physical Chemistry, P.W. Atkins and J. D. Paula, Oxford Univ. Press, 10th edition, 2014
2. A textbook of Physical Chemistry – H.K. Moudgil, PHI Learning Pvt. Ltd. 2nd Edn. 2014.
3. Physical Chemistry, T. Engel and P. Reid, Pearson, New Delhi, 1st edition, 2006
4. Thermodynamics, G. N. Lewis and M. Randall, McGraw Hill, 2nd edition, New York. 1961
5. Molecular Thermodynamics, D. A. McQuarrie and Simon. Viva New Delhi, 1st edition, 2009
6. Non Equilibrium Thermodynamics, S.R. de Groot and Mazur, Dover, New York.
7. Introductory Statistical Thermodynamics, T. Hill, Dover, New York. 1986
8. Statistical Thermodynamics, Oxford, Oxford Chemistry Primer vol. 58, 1997.
9. Introduction to Statistical Mechanics, R. Bowley and M. Sanchez, Clarendon press,
10. Statistical Mechanics and Thermodynamics, C. Garrod, Oxford Univ. Press, New York. 1995
11. Introduction to thermodynamics of irreversible processes, Interscience, New York. 2nd Edn, 1961.
12. Introduction to of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co, 47th Edn., 2017.
13. Chemical Kinetics, Keith J Ladder. Pearson, 4th Edn ,1997.

**Course Outcomes**

* Understand and correctly use thermodynamic terminology.
* Define the concepts of heat, work, and energy.
* Explain fundamental thermodynamic properties.

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| **IPCCH702:Physical Chemistry-V** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* | \* |  |  |  |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Core 18: Inorganic Chemistry–V (IPCCH703)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. This course aims to provide theories of acids and bases
2. To provide a systematic approach for frontiers in theories and rules of bonding. Deep idea about molecular symmetry and its application.
3. To study deeply about the applications of group theory.

**Syllabus**

**Module I**

***Theory of Acids and Bases:*** Bronsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

**Module II**

***Bonding in Main group compounds:*** Structure of compounds containing lone pair of electron, Walsh diagram, Bent’s Rule, Structure and bonding in phosphates, silicates, cyclophosphazenes and S-N cyclic compounds.

Wade’s rule, styx number, application to Boron compounds and Carboranes

***Metal-Ligand Bonding:*** Crystal field theory, Splitting of d- orbitals in linear, triangular, tetrahedral, square planar, trigonal bipyramidal, square pyramidal, Octahedral and pentagonal bipyramidal fields of similar and dissimilar ligands, Crystal field stabilization energies in weak field and strong field environments. MOT: energy level diagram of sigma and pi bonding Oh, Td and Square planar complexes.

**Module III**

***Molecular Symmetry:***

Symmetry Elements and operations, Group, Subgroup, Classes, Matrix representation of symmetry operations, Point groups.

Representation of groups - Character - Reducible and Irreducible Representations - Great Orthogonality Theorem - Construction of Character Tables – Cyclic groups, Direct Products –Projection Operators – Constructions of Symmetry adapted Linear Combinations.

**Module IV**

***Applications***

Application of Group Theory: Symmetry species of hybrid orbitals for sigma and pi bonding, Transition moment integrals - selection rule for spectral transitions - Mutual exclusion principle, Molecular Vibrations – Woodward-Hoffmann Cyclization rules.

**Essential Readings:**

1. F. A. Cotton: Chemical Applications of Group Theory, Wiley Eastern, 1985.
2. A. M. Lesk, Introduction to symmetry and group theory for chemists, Kluwer, NY, 2004.
3. A. Vincent, Molecular Symmetry and Group theory, A Programmed Introduction to chemical applications, Wiley, New York, 2001.
4. R. L. Carter, Molecular Symmetry and Group theory, Wiley, NY, 1997.
5. R. B. Woodward and R. Hoffmann, Conservation of Orbital symmetry, Verlag Chemie GmbH, NY, 1970.
6. Symmetry and Spectroscopy of Molecules, 2nd Edtion, K. V. Reddy, New Age International Publishers
7. Shriver Atkins’ Inorganic Chemistry, P.W Atkins, T.Overton, J.Rourke, M. Weller and F. Armstrong, Oxford Univ. Press, 5th Edn., 2012.
8. Mechanism of Inorganic Reactions, D. Katakis & G. Gordon, John Wiley & Sons, New York, 1987.
9. Inorganic Chemistry: Principles of Structure and Reactivity (4th impression), J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, Pearson Education, 2008.
10. Advanced Inorganic Chemistry*,* F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochmann, Wiley India, 6th Edn, 2012.
11. The Study of Kinetics and Mechanism of Reactions of Transition Metal Complexes*,* R. G. Wilkins, Allyn & Bacon, Boston, 1974.
12. Reaction Mechanisms of Inorganic and Organometallic Systems*,* Robert B. Jordan, Oxford University Press, 1998.

**Course Outcomes**

* To develop understanding about deep knowledge in structure and bonding of main group elements.
* To gain experience in finding molecular symmetry elements and their applications.
* To interpret the group theoretical knowledge in finding properties of the compounds.

**PE 1: Solid State Chemistry (IPECH701)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide an introductory idea on structure of solids, their classification and importance of lattice energy.
2. To encompass the electronic properties of solids and to understand various types of defects in solids.
3. To elucidate the structure of solids by different characterization techniques such as optical and electron microscopy and X-ray diffraction methods

**Syllabus**

**Module I**

Chemical crystallography: Introduction, Space lattice, Crystal point groups, space group (working knowledge), Packing in solids, Crystal structures of representative systems, Silicates and Zeolites, Cements, Glasses, Quasicrystals, Nanostructures.

***Bonding in solids and Crystal energetics:*** Crystal classifications, Madelung constant and Lattice energy.

**Module II**

***Electronic properties and Band theory of solids:*** Metals, insulators and semiconductors, electronic structure of solids- Band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors (Low temperature superconductor, BCS theory, High temperature superconductor).

***Defects, Nonstoichiometry and Diffusion:*** Perfect and imperfect crystals, intrinsic and extrinsic defects–point defects- vacancies Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry defects, line defect- edge dislocation and Screw Dislocation and Plane defects- Grain boundaries, Tilt boundaries Diffusion mechanisms, Fick’s law, Kirkenall effect.

**Module III**

***Characterization techniques***

***Optical Microscopy:*** Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Stereomicroscopy, Photomicroscopy, Colour metallography, Specimen preparation, Applications.

***Electron Microscopy:*** Interaction of electrons with solids, Scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.

**Module IV**

***X-ray Diffraction Methods:*** Generation of X-rays, Properties of X-rays: Continous spectrum, characteristic spectrum, Filters, Bragg condition, Miller indices, Structure factor and its relation to intensity, identification of unit cells from systematic absences in diffraction pattern. Structure factor calculation for NaCl and KCl. Description of the procedure for an X-ray structure analysis, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, indexing of crystals.

***Surface Analysis:*** Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.

**Essential Readings:**

1. Materials Characterization Techniques, Sam Zhang, Lin Li, Ashok Kumar, CRC Press, 2nd Edn., 2009.
2. Elements of X-Ray Diffraction, B.D. Cullity, and R.S. Stock, Prentice-Hall, 3rd Edn., 2001.
3. Solid State Chemistry and Its Applications, A. R. West, John Wiley & Sons, 2nd Edn., 2014.
4. Solid State Chemistry: An Introduction, L. Smart and E. Moore, Chapman and Hall, 4th Edn., 2012.
5. New Directions in Solid State Chemistry, C. N. R. Rao and J. Gopalkrishanan, Cambridge Univ. Press, 2nd Edn., 2010.
6. Basic Solid-State Chemistry, A.R. West, Wiley, 3rd Edn., 2012.

**Course Outcomes:**

* Distinguish the structure of solids, their classification and the significance of lattice energy.
* Define the electronic properties of solids and various types of defects in solids.
* Characterize the structure of solids by different characterization techniques such as optical and electron microscopy and X-ray diffraction methods.

**Lab 25 (Core Lab-15): Organic Chemistry Laboratory-V (ILCCH701)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the preparation methods of important organic compounds.
2. To determine the ascorbic acid concentration.
3. To determine the number of methoxy group.

**Syllabus**

**Qualitative Analysis**

1. Preparation of Aspirin (Acetylation)
2. Preparation of Methyl benzoate.
3. Preparation of Soap from fat.
4. Preparation of benzil from benzoin.
5. Preparation of o-iodobenzoic acid from anthranilic acid, furoic acid from furfural.
6. Determination of Ascorbic acid concentration.
7. Determination of number of Methoxy group.

**Essential readings:**

1. Experiments and Techniques in Organic Chemistry, D. J. Pasto, C. R. Johnson & M. J. Miller, Pearson, 1992.
2. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Publishers, 5th Edn., 2013.
3. A Hand Book of Organic Analysis, Qualitative & Quantitative, H. T. Clarke, 4th Edn., 2007
4. Text book of Practical Organic Chemistry, A.I. Vogel, ELBS, London, 5th Edn., l989.
5. Macroscale and Microscale Organic Experiments, K. L. Williamson, K.M. Masters, Cengage Learning, 6th Edn., 2011.

**Course Outcomes**

* Able to know preparation methods for organic compounds such as Asprin, soap etc.
* Able to determine ascorbic acid concentration and also number of Methoxy group.

**Lab 26 (Core Lab-16): Physical Chemistry Laboratory-V (ILCCH702)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide hands-on opportunities to develop fundamental laboratory analytical skills and apply this knowledge in executing project work and solving basic problems in future.
2. To make students capable of understanding and studying about surface tension
3. To make students capable of understanding and studying about polarimeter.

**Syllabus**

1. Determination of surface tension: (i) drop number (ii) drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration.
3. Spectrophotometric determination of the acid dissociation constant.
4. Inversion of sucrose using polarimeter.
5. Polarizability from refractive index measurements.
6. Composition of a complex by Job’s method.
7. Determination of turbidity of solution
8. Determination of density, viscocity and sound velocity of liquids and make a relation with the variation of these properties with temperature.

**Essential Readings:**

1. Experimental Physical Chemistry, V. D Athawale, & P Mathur, New Age International: New Delhi, 2001.
2. Laboratory Manual of Organic Chemistry’ B. B. Dey, and M. V. Sitharaman, Revised by T.R. Govindachari, Allied Publishers Ltd., New Delhi. 4th Revised Edn. l992.
3. Experiments in Physical Chemistry’, D. P. Shoemaker, C. W. Garland & J. W. Nibber, McGraw Hill 5th Edn., 1989.
4. Text book of Practical Organic Chemistry’, A. I. Vogel, 5th Edn. ELBS, London l989.
5. Senior Practical Physical Chemistry, R. Chand & Co. B. D. Khosla, V. C. Garg, & A Gulati, New Delhi, 2011.

**Course Outcomes**

The student will be able to determine

* Surface property of liquids and solutions
* Composition of unknown complexes
* Density and related parameters of liquid mixtures
* Polarizability of solutions

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| **ILCCH702:Physical Chemistry Laboratory-V** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  | \* | \* | \* | \* |  |  |  |  |  |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Lab 27 (Core Lab-17): Inorganic Chemistry Laboratory-V (ILCCH703)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To understand the principles of qualitative analysis of inorganic salts mixture and practice these for identification of radicals.
2. To carry out synthesis of simple complexes and pursue the quantitative analysis of metals or the ligands in those complexes.

**Syllabus**

1. Semi micro qualitative analysis of inorganic mixtures containing anions, common cations (Six radicals), less familiar element (W, Mo, Ce, Th, Zr, V and U), insoluble (sulphate, oxides, halide).
2. Preparation and quantitative analysis of complexes
* Preparation of pentamminechloro cobalt(III)chloride.
* Chrome alum
* Tris(thiourea) copper(I) complex
* Hexaaminecobalt (III) chloride.

**Essential Readings:**

1. Vogel's Qualitative Inorganic Analysis, G. Svehla, Orient Longman, 6th Edn., l987.
2. Inorganic Semi-micro Qualitative Analysis, V. V. Ramanujam, National Publishing Company, 3rd Edn., 1990.
3. A Collection of Interesting General Chemistry Experiments, Elias, A. J., Universities Press, (India) Pvt. Ltd., 1st Edn., 2002.
4. Experimental Inorganic Chemistry, Palmer
5. Experimental Inorganic/Physical Chemistry, Woodhead Publishing,1st Edn.,1999.

**Course Outcomes**

* Identify the acid and basic radicals in a mixture of inorganic salts based on the principles of qualitative analysis.
* Synthesize of simple complexes and analyze quantitatively the metal or ligand components in the complexes.

**Semester-8**

**Core 19: Organic Chemistry-VI (IPCCH801)**

**Prerequisite: Nil**

**Purpose:**

**Course Objectives:**

* 1. To provides basic idea on disconnection approach. It discusses about synthons and synthetic equivalents.
	2. To provide the knowledge the concept of reversal Polarity and protecting groups.
	3. To provide knowledge on one group C-C disconnection an, two group C-C disconnections.

**Syllabus**

**Module I**

***Disconnection Approach:*** An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemo-selectivity.

**Module II**

***Reversal Polarity and Protecting Groups***

Umplong approach, cyclization reactions, amine synthesis.

*Protecting Groups:* Principle of protection and deprotection of alcohol, amine, carbonyl and carboxyl groups and their application in organic synthesis.

**Module III**

***One Group C-C Disconnection:***

Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

***Two Group C-C Disconnections:***

Diels-Alder reaction, 1,3–difunctionalized compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalized compounds. Micheal addition and Robinson annulation.

**Module IV**

***Ring Synthesis:***

Saturated heterocycles, synthesis of 3, 4, 5 and 6 membered rings, aromatic heterocycles in organic synthesis.

***Synthesis of Some Complex Molecules:***

Application of the above protocols in the synthesis of Camphor and Vitamin D.

**Essential readings:**

1. Organic Synthesis-The Disconnection Approach, S. Warren, Wiley, 2nd Edn., 2011.
2. Organic Synthesis: Concepts, Methods and Starting Materials, J. Fuhrhop and G. Penzlin, VCH, Weinheim, Germany, 2nd Edn., 1993.
3. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press, 4th Edn., 2004.
4. Modern Synthetic Reactions, H. O. House,. Benjamin Cummings Publishing, 2nd Edn., 1972.
5. March’s Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, Wiley, 7th Edn., 2013.
6. Principles of Organic Synthesis, R.O.C. Norman, J. M. Coxon, CRC Press, 3rd Edn., 1993.
7. Advanced Organic Chemistry Part B: Structure and Mechanism, Francis A. **Carey**, Richard J. **Sundberg**, Springer, 5th Edn., 2008.
8. Organic Synthesis: The Disconnection Approach, S. Warren and P. Wyatt, Wiley India Pvt. Ltd, 2nd Edn., 2008.

**Course Outcomes**

* Able to understand retro-synthetic analysis and will get idea about synthons and synthetic equivalents.
* Able to understand the concept of reversal Polarity and protecting groups.
* Able to understand ring synthesis and synthesis of some complex molecules.

**Core 20: Physical Chemistry-VI (IPCCH802)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To study the chemistry of surfaces and different types of surface phenomena.
2. To get an idea about the various techniques employed for the characterization of surfaces.
3. To have an idea about the important aspects of photochemistry.

**Syllabus**

**Module-I**

***Surface Chemistry:******(a) Adsorption:*** Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation). Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electrokinetic phenomenon), catalytic activity at surfaces.

***(b) Micelles:*** Surface active agents, classification of surface active agents, ionic and non-ionic micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants counter ion binding to micelles, thermodynamics of micellization, phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

**Module-II**

***Advanced Electrochemistry:******(a) Ion-Solvent interactions:*** Nonstructural treatment of ionsolvent interaction, quantitative measure of ion solvent interactions. The Born model, Electrostatic potential at the surface of a charged sphere. The electrostatics of charging and discharging spheres. The Born expression for the free energy of ion-solvent interactions, the interaction of a single ionic species with the solvents and solvent, limitation of Born theory. Structural treatment of the ion-solvent interactions, structure of water near an ion, Iondipole model of ion solvent interaction, limitation of ion-dipole theory of salvation, water molecule as electrical quadrupole, ion-quadrupole model of ion-solvent interaction, Ion-induced dipole interactions in the primary salvation sheath, Limitation of ion-quadrupole theory of solvation. (Cyclic Voltametry ???)

**Module-III**

***Electrodics:*** Thermodynamics of electrified interface equations. Derivation of electrocapiliarity; Lippmann equations (surface excess), methods of determination, Structure of electrified interfaces. Overpotentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot, interfaces-theory of double layer at semiconductor-electrolyte solution interfaces. Effect of light at semiconductor solution interface. Electrocatalysis-influence of various parameters. Diffusion layer. The limiting current density and its practical application. Corrosion, Battery and Fuel cell.

**Module IV**

***Advanced Photochemistry:***

Bimolecular Photophysical Processes: Photo-induced electron-transfer and charge transfer processes, excimer and exiplex, fluroscence quenching. Radiative, Forster type and Dexter type enegy transfer.

**Essential Readings:**

1. Physical Chemistry, P.W. Atkins and J. D. Paulo, Oxford, New Delhi. 10th Edn., 2014.
2. Physical Chemistry, T. Engel and P. Reid, Pearson New Delhi, 1st Edn., 2006.
3. Physical chemistry of the surfaces, A.W. Adamson and A.P. Gast, John Wiley New York, 6th Edn, 1997.
4. Adsorption and Catalysis, D.K. Chakraborty, Narosa, New Delhi. 1st Edn. 1992.
5. Surfactants and Polymers in aqueous solution, Krister Holmberg, Bo J¨onsson, Bengt Kronberg and Bj¨orn Lindman, John Wiley, Sussex, 2002.
6. Surfactants and interfacial phenomena, M.J. Rosen, John Wiley, New Jersey. 2nd Edn.,2013.
7. Chemical Kinetics, Keith J Ladder. Pearson, 4th Edn.,1997.
8. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan. 3rd Edn., 2010.
9. Modern Electrochemistry Vol. I and Vol. II. J.O.M. Bockris and A.K.N. Reddy, Plenum London, 3rd Edn., 1997.
10. Chemical Kinetics and Dynamics, JI Steinfild, J.S. Fransis Co, W.L. Hase , Beutic Hall 2nd Edn., 1999.

**Course Outcomes**

* Use different theories to calculate surface and interfaces tensions and use this to estimate e.g. wetting and other system characteristics.
* Identify mechanisms for adhesion between surfaces and materials and use different methods to estimate this.
* Describe the most important and fundamental theories in surface chemistry.
* Explain micellation of surfactants, know how to measure this and calculate dependencies of salt concentration, system temperature and surfactant chain length.
* Compare and understand adsorption in gas-liquid and solid-liquid surfaces and perform quantitative adsorption calculations.

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| **IPCCH802**: **Physical Chemistry-VI** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  | \* |  |  |  |  |  |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Core 21: Inorganic Chemistry–VI (IPCCH803)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide basic idea about electronic spectra and finding out various parameters of transition and inner transition metals.
2. To apply the knowledge for magnetic properties of the metals and their property interpretation.
3. To provide the general aspects for reactions of Organometallic compounds, idea about their stability constants and their determination by various methods.

**Syllabus**

**Module I**

***Electronic Spectra of Coordination Compounds***

Spectroscopic ground states, term symbols for dn ions, Racah parameters, selection rules and intensities of bands, Orgel diagram, correlation and Tanaube-Sugano diagrams, spectra of 3d metal-aqua complexes of trivalent metal ions (d1-d6), divalent (Mn, Co and Ni), Calculation of Dq, B and β parameters, CT spectra. Spectral properties of lanthanide and actinide metal complexes.

**Module II**

***Magnetic properties of coordination compounds***

Types of magnetic behaviour, magnetic susceptibility and its determination by Gouy, Faraday and VSM method, Pascal's constants and constitutive corrections, paramagnetism, Curie-Weiss law, Van Vleck's equation (derivation excluded) and its applications, spin-orbit coupling, ferro- and anti-ferromagnetism coupling, super paramagnetism, high and low spin equilibria. Anomalous magnetic moments, magnetic exchange coupling and spin crossover. Magnetic properties of Lanthanide and Actinide metal complexes.

**Module III**

***Organometallic reactions***

Reactions involving gain or loss of electrons (Ligand dissociation and substitution, Oxidative addition, Reductive Elimination, Nucleophilic Displacement), reactions involving modification of ligands (Insertion, Carbonyl Insertion, 1,2-Insertion, Hydride Elimination, Abstraction)

***Fluxional Organometallic Compounds***

Fluxionality and dynamic equilibria in compounds such as η2\_ olefin, η3\_ allyl and dienyl complexes.

**Module IV**

***Metal-ligand Equilibria in Solution***

Stability of metal complexes, compositions of metal complexes by Job’s method. Stepwise and overall stability constant, factors affecting the stability constant, Determination of stability constants by (pH metry and spectroscopic methods) and their applications.

***Inorganic Reaction Mechanism***

Inert and labile complexes, factors affecting the reactivity of complexes, mechanisms of substitution (acid, base hydrolysis and anation) reactions of octahedral complexes, redox reactions: mechanism of one election transfer reaction (inner sphere and outer-sphere), Marcus theory for outer-sphere reactions.

**Essential Readings:**

1. Inorganic Chemistry, D. F. Shriver, P. W. Atkins, Oxford University Press, 3rd Edn., 1999.
2. Chemistry of the Elements, N. N. Greenwood, A. Earnshaw, Pergamon Press, 2nd Edn., 2002.
3. Concepts and Models of Inorganic Chemistry, B. Douglas, D. McDaniel, and J. Alexander, John Wiley (New York), 3rd Edn., 1993.
4. Inorganic Chemistry –Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Pearson Education (New Delhi), 1st Impression, 2006.
5. Advanced Inorganic Chemistry, F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochmann, John Wiley, 6th Edn,1999.
6. Reaction Mechanisms of Inorganic and Organometallic Systems, Robert B. Jordan, Oxford University Press, 3rd Edn., 1998.
7. Fundamental Concept of Inorganic Chemistry, A. K. Das and M. Das, Vol. 4 and 5, CBS Publisher & Distributor Pvt. Ltd., 2nd Edn., 2014.

**Course Outcomes**

* Ability to understand and interpret the various parameters relating to electronic spectra and determination of various parameters related to it.
* Understand various laws equations related to magnetic properties of transition & inner transition elements.
* To interpret kinetics and mechanism of octahedral complexes. And to apply it to the interdisciplinary field of research.

**PE 2: Materials Chemistry (IPECH801)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To provide knowledge in understanding various common materials of industrial importance and their basic properties.
	2. To describe the basic principles for which the materials could exhibit dielectric and magnetic behaviour.
	3. To demonstrate the electronic and magnetic properties of materials.

**Syllabus**

**Module I**

***Materials and their classification:*** Matter, materials science, broad classification of materials, -metal and alloys, polymers and elastomers, ceramics and refractories, semiconducting and electronic materials, super metal and super conductors, materials for nuclear technology and for aero-space technology, magnetic materials, dielectric materials, optical and opto-electronic materials, bio- medical materials, thermo- electrical materials, structural and construction engineering materials, special and nanomaterials, SMART materials.

**Module II**

***General Strategies for preparation and production of materials:*** Wet chemical processes, the sol-gel route, precursor synthesis, carbo-thermic and thermo- chemical treatments, hydrothermal, pyrochemical, metallurgical and chemical routes, heat treatment methods, surface deposition and film formation methods, special fabrication and processing techniques.

Elementary ideas on basic properties of important materials (overview only): Mechanical properties and impact properties, brittle, malleable and ductile properties, crystalline, poly crystalline materials. Phase rule and phase diagram its applications.

**Module III**

***Dielectric and Magnetic Materials-I:*** Dielectric materials: Electrical dipole moment, dielectrics, dielectric constants and polarization, microscopic displacement, temperature and frequency dependence of dielectric constant, dielectric break down. Synthetic strategies for preparation of dielectric materials. Ferro electrics. Piezoelectric. Pyroelectrics. Application of dielectric materics. Magnetic materials: Concept/ origin of magnetism, dimagnetism, paramagnetism, ferromagnetism, hysteresis- soft and hard magnets. Synthetic strategies. Ferrites, ortho-ferrites and plumba ferrites. Applications of magnetic material, magnetic bubbles.

**Module IV**

***Dielectric and Magnetic Materials-II:*** Semiconductor and electronic materials: Band concept for insulator, conductor and semi - conductor(elementary), intrinsic and extrinsic semi-conductor, conductivity, n- and p- type semiconductor, carrier and hole mobility and concentration Fermi level, density of electrons in the conduction band and density of holes in valence band, concentration of electrons in the CB of n- type and holes in VB of p-type semiconductor. Hall effect- hall voltage and Hall coefficient and application. Fabrication and processing of semiconductors. Film formation and surface coating techniques. Application of semiconductors. Film formation and surface coating techniques. Applications of semiconductors. Preparation of single crystals.

**Essential Readings:**

1. Calister’s Material Science and Engineering, R. Balasubramaniam, Wiley-India, 2nd Edn., 2014.
2. Magnetic and Dielectric Properties of Materials: Basics, Theories and Experiments, M. M. Rahman, LAP LAMBERT Academic Publishing, 1st Edn., 2012
3. Chemical Processing of Advanced Materials: L. L. Hench and J. K. West, John Wiley, 1st Edn., 1992.
4. Preparative Methods in Solid State Chemistry, P. Hagnmuller (ed), Academic Press, 1st Edn., 1972.
5. Sol-Gel Science, C. J. Brinker & G. W. Scherer, Academic Press, 1st Edn., 1980.
6. Semiconductor Material and Device Characterization, Dieter K. Schroder, Springer, 3rd Edn., 2006.
7. Introduction to Semiconductor Materials and Devices, M.S.Tyagi , John Wiley & Sons, 3rd Edn., 2008.
8. The Materials Science of Semiconductors, Angus Rockett, Springer, 1st Edn., 2008.

**Course Outcomes:**

* Identify various common materials of industrial importance and know their basic properties.
* Understand the basic principles of the dielectric and magnetic materials.
* Reveal the electronic and magnetic properties of materials for their applications.

**Lab 28 (Core Lab 18): Physical Chemistry Laboratory-VI (ILCCH801)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. The course aims to provide a rigorous basic understanding of partial molar properties.
2. Students are required to apply spectroscopic and polarographic techniques to understand chemical reactions and related processes.
3. Students will gain a good foundation of knowledge and skills for further study in physical chemistry.

**Syllabus**

1: Thermodynamics

1. Determination of partial molar volume of solute (e.g., KCl) and solvent in a binary mixture.
2. Determination of the temperature dependence of the solubility of a compound in two solvents having similar intermolecular interactions (benzoic acid in water and in DMSO-water mixture) and calculate the partial molar heat of solution.

2: Spectroscopy

1. Determination of pKa of an indicator (e.g., methyl red) in (a) aqueous and (b) micellar media.
2. Determination of stoichiometry and stability constant of inorganic (e.g. ferric – salicyclic acid) and organic (e.g. amine-iodine) complexes.

3: Polarography

1. Estimation of Pb2+ and Cd2+ / Zn+ and Ni2+ ions in a mixture of Pb2+ and Cd2+  / Zn+ and Ni2+ by polarography.
2. Determination of dissolved oxygen in aqueous solution of organic solvents.

4: Determination of CMC of surfactants by (Anionic, cationic &Neutral) different methods.

5: Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

6: Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:

a. simple eutectic and congruently melting systems.

7: Study of fast reactions by Stopped Flow Spectrophotometry. (Ferric (III) +Thiocyanide)

**Essential Readings:**

1. A. Senior Practical Physical Chemistry, B. D Khosla, V. C Garg, & R Gulati, S Chand & Co.: New Delhi, 2011.
2. Experiments in Physical Chemistry, C. W. Garland, J. W Nibler,. & D. P Shoemaker, McGraw-Hill: New York, 8th Edn. ,2003.
3. Experimental Physical Chemistry, A. M Halpern, & G. C. McBane, W.H. Freeman & Co.: New York, 3rd Edn., 2003.

**Course Outcomes**

* Student can able to perform experiments related to partial molar volumes, pKa of an indicator, and polarography.

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| **ILCCH801 :Physical Chemistry Laboratory-VI** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  | \* | \* | \* | \* |  |  |  |  |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |  |

**Lab 29 (Core Lab 19): Inorganic Chemistry Laboratory-VI (ILCCH802)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To carry out volumetric analysis of metals in a mixture of their salts.
2. To measure the crystal field splitting energy
3. To study various aspects on reactivity of complexes

**Syllabus**

Qualitative analysis of inorganic salts mixture containing different acid and basic radicals in addition to insoluble mixture will be performed.

1. Volumetric analysis
2. Volumetric estimation of Fe and Cu in a mixture
3. Volumetric estimation of Zn and Cu in a mixture.
4. Volumetric estimation of Ni and Zn in a mixture.
5. Spot tests to be done whenever possible
6. Measurement of 10Dq by spectrometric method
7. Verification of spectrochemical series
8. Controlled synthesis of two copper oxalate hydrate complex: Kinetic vs thermodynamic stability
9. Preparation of acetylacetanato complexes of Cu2+/Fe3+. Find the λmax of the complex.
10. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetyl acetone, DMG, glycine) by substitution method.

**Course Outcome:**

* Quantitatively analyze the metals in a mixture of their salts by volumetric methods.
* Able to calculate the splitting energy by spectrometric method
* Able to verify the spectrochemical series
* Able to synthesize and find the λmax of the complex

**Lab 30 (Core Lab 20): Organic Chemistry Laboratory-VI (ILCCH803)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To learn the chromatographic techniques for separation, purification and identification of compounds.
2. To learn isolation techniques for various organic compound from natural resources.
3. To study the steam distillation methods in isolation of natural compounds.

***List of Experiments:***

1. Identification of organic compounds, separation, purification and identification of compounds of binary mixture using
2. Thin Layer Chromatography (TLC)
3. Column chromatography.
4. Paper Chromatography
5. Isolation of Lycopene from Tomatoes.
6. Isolation of Piperine from Pepper.
7. Isolation of Caffeine from Tea leaves.
8. Application of steam distillation in isolation of essential oil (clove) and perfume (rose).

**Essential readings:**

1. Experiments and Techniques in Organic Chemistry, D. J. Pasto, C. R. Johnson & M. J. Miller, Pearson, 1992.
2. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Publishers, 5th Edn., 2013.
3. A Hand Book of Organic Analysis, Qualitative & Quantitative, H. T. Clarke, 4th Edn., 2007
4. Text book of Practical Organic Chemistry, A.I. Vogel, ELBS, London, 5th Edn., l989.
5. Macroscale and Microscale Organic Experiments, K. L. Williamson, K.M. Masters, Cengage Learning, 6th Edn., 2011.

**Course Outcomes**

* Able to learn the chromatographic techniques for separation, purification and identification of mixture of organic compounds.
* Able to learn isolation techniques for isolation of organic compounds from natural resources.

**Semester-9**

**Core 22: Organic Chemistry-VII (IPCCH901)**

**Prerequisite:** Nil

**Syllabus**

**Module-I**

***Coupling Reactions***

*Coupling Reactions*: Carbon-carbon bond formation through coupling reactions (Heck, Suzuki, Stille and Sonogoshira), Carbon-hetero atom bond forming reactions using transition metals (Cu, Pd, Rh, Ru, Ni, Fe etc.)

**Module-II**

***Synthetic Strategies:***

Umpolung reactivity – formyl and acyl anion equivalents. Selectivity in organic synthesis – chemo, regio and stereoselectivity. Concepts of asymmetric synthesis – resolution (including enzymatic), desymmetrization and use of chiral auxilliaries. Carbon-carbon bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Stereoselective addition to C=O groups (Cram and Felkin-Anh models).

**Module III**

***Pericyclic Reactions-I:***

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system, classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO and PMO approach. Electrocyclic reactions: Conrotatory and disrotatory motion, 4n, 4n+2 and allyl systems.

**Module IV**

***Pericyclic Reactions-II and Photochemistry:***

Cycloadditons: Antarafacial and suprafcial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions.

Sigmatropic rearrangements: Suprafacial and antarafacial shifts of H, Sigmatroic shifts involving carbon carbon moieties, [3,3] and [5,5], Claisen, Cope and aza-Cope rearrangements, fluxional tautomerism, ene reaction. Norrish type-I and type-II and Paterno-Buichi reaction.

**Essential readings:**

1. Advanced Organic Chemistry Part A & B: F. A. **Carey**,R.J. **Sundberg**, Spr. Inter., 5th Edn., 2007.
2. Principles of Organic Synthesis, R. O. C. Norman, J.M. Coxon, CRC Press, 3rd Edn., 1993.
3. Organic Synthesis: J. Clayden, N. Greeves, S. Warren, Oxford University, 2nd Edn., 2012.
4. Classics in Total Synthesis III: Further Targets, Strategies, Methods, K. C. Nicolaou, Jason S. Chen, Wiley-VCH, 1st Edn., 2011.
5. The Way Of Synthesis, T. Hudlicky and J. W. Reed, Wiley-VCH, 1st Edn., 2007.

**PE 3: Chemical Binding and Molecular Modeling (IPECH901)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To describe principles of quantum mechanics
2. To make a theoretical approach for the geometric and electronic structure of molecules.
3. To make familiar about different methods and basis sets for computational chemistry
4. To make aware about different measurable quantities

**Syllabus**

**Module I**

***Electronic structure of diatomic molecules:***

Review of basic principles of quantum mechanics, atomic structure and term symbols (He, Li), variation and perturbation methods, Linear Combination of Atomic Orbitals (LCAO), Born-Oppenheimer approximation, molecular orbitals of ground state and excited states of H2+. Molecular orbitals of homo and heteronuclear diatomic molecules (qualitative treatment only), Term Symbols for diatomic molecule.

**Module II**

***Electronic structure and polyatomic molecules:*** Brief introduction to Self-Consistent Field (SCF) methods, qualitative SCF-MO and Hartree-Fock treatment of closed shell systems and applications to molecules (H2O, NH3, CH4); potential surface and equilibrium geometry, molecular vibrational frequencies. Brief introduction to density functional theory, General overview on semi-empirical and molecular mechanics treatment of molecules, Huckel molecular orbital theory for conjugated organic molecules and its applications to ethylene, butadiene, benzene; delocalization energy and stability

**Module III**

***Molecular modeling:*** What is molecular modeling? Computable quantities, stationary points, transition states, geometry optimization, normal modes of vibration, Introduction to molecular dynamics simulations and Monte.

**Module IV**

Hands-on experience for using different simulations methods and algorithms pertaining to the course with computational chemistry software such as Gaussian, Schrödinger, Gamess, Gromacs etc.

**Essential Readings:**

* 1. Modern Quantum Chemistry: introduction to advanced Electronic Structure, A. Szabo and N. S. Ostlund, Dover, 1996.
	2. Molecular Quantum Mechanics, P. W. Atkins and R. S. Friedman, Oxford University Press, 3rd Edn., 1997.
	3. Quantum Chemistry, I. N. Levine, Pearson Education, 5th Edn., 2000.
	4. Essentials of Computational Chemistry, C. J. Cramer, Wiley, 2004.
	5. Molecular Modelling, A. R. Leach, Prentice Hall, 2001.
	6. Introduction to Computational Chemistry, F. Jensen, John Wiley & Sons, 2007.

**Course Outcomes: Students are able to**

* acquire knowledge within quantum chemistry, molecular mechanics.
* know the electronic structure of polyatomic molecules
* use different simulations methods and algorithms
* use different molecular modeling software

**OE 1: Pharmaceutical Chemistry – I (IOECH901)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To demonstrate the basic principles of medicinal chemistry, QSAR and drug metabolism.
2. To describe the classification of drugs and their synthesis of drugs acting on autonomic, somatic and central nervous system.
3. To underline the synthesis of some selected antihistamine and analgesic drugs.

**Syllabus**

**Module -I**

1. **Basic Principles of Medicinal Chemistry:** Physico-chemical aspects (Optical, geometric and bioisosterism) of drug molecules and biological action
2. **Brief concept on Quantitative Structure Activity Relationship (QSAR): Hansch analysis –** its derivation and discussion on different parameters like electronic parameters, steric factor, and partition coefficient. Free Wilson model.

**Virtual drug screening techniques and their applications.**

**3-D QSAR Analysis:** Receptor independent 3-D QSAR Analysis, Receptor dependent

3-D QSAR Analysis

1. **Basic concepts of**: Drug metabolism, Prodrugs, Receptors and drug receptor interaction

**Module II**

Classification, mode of action, uses and structure activity relationship of the following classes of drugs. Synthesis of those compounds only exemplified against each class.

* 1. **Drugs acting on autonomic nervous system:**
1. **Cholinergics and Anticholinesterase:** Acetylcholine, Carbachol, Bethanechol, methacholine and Neostigmine.
2. **Adrenergic drugs and adrenergic blocking agents:** Adrenaline, Salbutamol, Naphazoline, Propranolol, Atenolol
3. **Antispasmodic and antiulcer drugs:** Homatropine, Cyclopentolate, Diclomine, Tropicamide.
	1. **Drugs acting on somatic nervous system:**
4. **Neuromuscular blocking agents:** Gallamine, succinylcholine
5. **Local Anaestahetics:** Benzocaine, Procaine, Lignocaine, Dibucaine.

**Module -III**

1. **Drugs acting on the Central Nervous System:**
2. **General Anaesthetics:** Ananesthetic ether, Halothane, Thiopental sodium.
3. **Hypnotics and Sedatives:** Phenobarbitone, Cyclobarbitone, Glutethimide, Diazepam
4. **Opioid analgesics:** Pethidine, Methadone.
5. **Anticonvulsants:** Phenytoin, Ethosuximide, Primidone, Carbamazepine
6. **Antiparkinsonism drugs:** Levodopa, Amantidine
7. **CNS stimulants:** Nikethemide, Ethamivan, Amphetamine
8. **Psychopharmacological agents** (neuroleptics, antidepressants, anxiolytics): Chlorpromazine, Haloperidol, Impiramine, Phenelzine, Chlordiazepoxide, Alprazolam.

**Module -IV**

1. **Autacoids:**
2. **Antithistamines:** Diphenhydramine, Mepyramine, Chlorpheniramine, Promethazine, Chlorcyclizine, Ranitidine.
3. **Eicosanoids:** Occurrences, Chemical nature, Medicinal applications
4. **Analgesic – antipyretics, anti-inflammatory (non-steroidal) agents:** Aspirin, Paracetamol, Ibuprofen, Naproxan, Diclofenac sodium.

**Essential Readings:**

1. Text Book of Organic Medicinal and Pharmaceutical Chemistry, J. M Beale, John Block, Lippincott Williams & Wilkins, 12th Edn., 2011.
2. Foye’s Principles of Medicinal Chemistry, Lippincott Williams & Wilkins, 7th Edn., 2012.
3. A Text Book of Medicinal Chemistry: Synthetic and Biochemical Approach, S. N. Pandeya, Vol.2, S. G. publisher, 1st Edn., 2009.
4. Medicinal Chemistry, Ashutosh Kar, New Age International Publishers, 5th revised and expanded Edn., 2010.
5. Bentley’s and Driver’s Text Book of Pharmaceutical Chemistry, Oxford Medical Publications, 8th illustrated Edn., 1969.
6. Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford, 6th dn., 2017.

**Course Outcomes:**

* Develop an understanding on the basic principles of medicinal chemistry, QSAR and drug metabolism.
* Categorize the classification of drugs and elaborate the synthesis of some selected drugs acting on autonomic, somatic and central nervous system.
* Describe the synthesis of some selected antihistamine and analgesic drugs.

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| **IOECH901: Pharmaceutical Chemistry – I** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  |  |  |  |  |  | \* |  |  | \* | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  |  | \* |

**OE 1: Chemical Rate Processes (IOECH902)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To describe various techniques for measurement of fast reactions, types of chain reactions and effect of solvents on reactions.
	2. To illustrate on oscillatory reactions and various models.
	3. To emphasizes the dynamics of chemical reactions.
	4. To provide an introductory idea on femtosecond kinetics.

**Syllabus**

**Module -I**

Kinetic Measurements: General features of fast reactions; study of fast reactions by relaxation methods (ultrasonic, pulse radiolysis, NMR); flash photolysis; solvent effects on reactions in solutions.

Chain Reactions: Features of chain reactions; thermal and photochemical reactions (hydrogen-bromine reaction, decomposition of aldehydes and ketones).

**Module-II**

Kinetics of oscillatory reactions: introduction to oscillatory reactions; Belousov- Zhabotinsky and Field-Koros-noyes models.

**Module-III**

Rate Theory: Concept of potential energy surfaces, transition state theory including its statistical mechanical treatment, phenomenological theories of unimolecular reactions (Lindemann, Hinshelwood), statistical mechanical theories of unimolecular reactions (RRKM).

Chemical Dynamics: Collision theory and Reaction Dynamics, Reaction Cross section and rate constant, Brief idea of Molecular Beam Scattering, Dynamics in condensed phase.

**Module-IV**

Femtochemistry: Concepts and perspectives; applications to studies of dynamics and control of chemical reactions.

**Essential Readings**

* 1. Physical Chemistry, I. Levine, Tata McGraw Hill, 5th Edn., 2007.
	2. Physical Chemistry: A Molecular Approach, D. A. McQuarrie and J. D. Simon, University Science Books, 1997.
	3. Chemical Kinetics and Dynamics, J. I. Steinfeld, J. S. Francisco and W. L. Hase, Prentice Hall, 1999.
	4. Chemical Dynamics in Condensed Phases: Relaxation, Transfer and Reactions in Condensed Molecular Systems, A. Nitzan, Oxford Univ. press, 2006.
	5. Basic Chemical Kinetics, H. Eyring, S. H. Lin and S. M. Lin, John Wiley & Sons, New York, 1980.
	6. The World of Physical Chemistry, K. J. Laidler, Oxford University press, 1993.

**Course outcomes**

* Understand the principles of fast reactions and various techniques to study these reactions.
* Acquire knowledge on oscillatory reactions and their concepts.
* Exhibit understanding on the chemical dynamics of reactions.
* Envisage femtosecond kinetics.

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| **IOECH902: Chemical Rate Processes** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  | \* |  | \* |  | \* |  |  |  | \* |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  |  | \* |

**OE 1: Chemistry of Natural Products (IOECH903)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To provide a brief introduction to types of natural products
2. To explore various synthetic routes for synthesis of some selected natural products.
3. To enumerate the total synthetic approaches for synthesis of some selected drugs.

**Syllabus**

**Module-I**

Introduction to natural products: Isolation and structure elucidation of terpenes, alkaloids, flavonoids, xanthones.

**Module-II**

Structural elucidation of strychinine, tylophorine, morphine, abietic acid.

**Module-III**

Biosynthetic aspects and Synthesis of selected natural products of biological and structural importance: benzylisoquinoline alkaloids, colchicines, quinine, terpenes (mono, di and tri), isoflavones, anthraquinones.

**Module IV**

Total Synthesis: Taxol, erythronolide B, penicillin V, Prostaglandins F2-alpha and E2.

**Essential Reading:**

1. Classics in Total Synthesis III: Further Targets, Strategies, Methods, K. C. Nicolaou, Jason S. Chen, Wiley-VCH, 1st Edn., 2011.
2. The Way Synthesis, T. Hudlicky and J. W. Reed, Wiley-VCH, 1st Edn., 2007.
3. The Logic of Chemical Synthesis, E. J. Corey and X-M. Cheng, John-Wiley & Sons, 1st Edn.,1989.
4. Comprehensive Natural Products Chemistry, D.H. R. Barton, K. Nakanishi, O. Meth-Cohn, Elsevier,Vols 1-9, 1999.
5. Chemistry of Natural Products, N. R. Krishnamurty, University Press, 2nd Edn., 2010.
6. Organic Chemistry of Natural Products. Vol.-I and II, G.R. Chatwal, Himalaya Publishing House

**Course outcomes:**

* Identify different types of natural products, their occurrence, structure, importance as medicines) and properties.
* Demonstrate various synthetic routes for synthesis of some selected natural products.
* Describe the total synthetic approaches for synthesis of some selected drugs.

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| **IOECH903**: **Chemistry of Natural Product** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  |  |  |  | \* |  |  |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  |  | \* |

**OE 2: Pharmaceutical Chemistry – II (IOECH904)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To describe the classification, structure, mode of action, uses and synthesis of some selected drugs like steroid, thyroid, anti-thyroid, insulins.
	2. To delineate the mechanism of action of some drugs like diuretics, cardiovascular and some anticoagulants.
	3. To define the chemistry and chemotherapy of some common drugs.

**Syllabus**

**Module–I**

Classification, mode of action, uses and structure activity relationship of the following classes of drugs. Synthesis of those compounds only exemplified against each class.

***Steroids and Related Drugs:*** General study on Steroidal nomenclature and stereochemistry, Androgens and anabolic agents, Estrogens and progestational agents. Synthesis of Progesterone from diosgenin, Diethyl satilboestrol, Synthesis of Testosterone from Cholesterol, General study of structural formula and therapeutic uses of steroidal ant-inflammatory agents.

***Thyroid and Anti thyroid drugs****:* Thyroxine, Liothyronine, Propythiouracil, Carbimazole

***Insulin, Insulin preparations and oral hypoglycaemic agents:*** Chloropropamide, Tolbutamide, Glibenclamide, Phenformin.

**Module-II**

***Diuretics:*** Acetazolamide, Chlorthiazide, Furosemide.

***Cardiovascular drugs: Antihypertensives, Anti-anginal agents, Anti-arrhythmics and Antilipidemics:*** Clonidine, Methyldopa, Procainamide, Nifedipine, Prazosin, clofibrate.

***Anticoagulants:*** Heparin, Coumarins, Phenindione derivatives.

**Module-III**

***Chemistry of Chemotherapy:***

***Sulphonamides****:* Sulphadiazine, Sulphamethoxazole, Sulphacetamide sodium.

General study of Qunolones and Fluoroqunolones.

***Antibiotics****:* General study of β-Lactum antibiotics (Penicillins and Cephalosporins), Aminoglycosides, Tetracyclines, Macrolides, Lincomycins, Polypeptides, Anticancer antibiotics: synthesis of Methecillin, Ampicillin.

***Anti-TB and anti-leprosy Drugs****:* Isoniazid, Ethambutrol, Pyrazinamide. Antifungal agents: Griseofulvin, Nystatin, Ketoconazole, Amphotericin B.

**Module–IV**

***Anti-Malarial Drugs****:* Chloroquine, Pamaquine, Mepacrine, Proguanil, Pyrimethamine

***Anti-amoebic agents****:* Metronidazole, Diloxamide furoate

***Anti-viral including anti-HIV agents****;* Acyclovir, Zidovudine

**Essential books**

1. Wilson and Grisvold’s Text Book of Organic Medicinal and Pharmaceutical Chemistry, J.M. Beale, Jr. J.H. Block, Lippincott Williams & Wilkins, 12th Edn, 2011.
2. Foye’s Principles of Medicinal Chemistry, Lippincott Williams & Wilkins, 7th Edn, 2012.
3. A Text Book of Medicinal Chemistry: Synthetic and Biochemical Approach, S.N. Pandeya, Vol.2, S. G. publisher, 1st Edn, 2009.
4. Medicinal Chemistry, Ashutosh Kar, New Age International Publishers, 5th revised and expanded Edn, 2010.
5. Text Book of Pharmaceutical Chemistry, A.O. Bentley, and J.E. Driver, Oxford Medical Publications, 8th illustrated Edn., 1969.
6. Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford, 6th Edn., 2017.

**Course Outcomes:**

* Demonstrate the classification, structure, mode of action, uses and synthesis of some therapeutic drugs like steroid, thyroid, anti-thyroid, insulins.
* Understand the mechanism of action of some drugs like diuretics, cardiovascular and some anticoagulants.
* Describe the chemistry and chemotherapy of some common drugs.

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| **IOECH904: Pharmaceutical Chemistry – II** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  |  |  |  |  |  | \* |  |  | \* | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  |  | \* |

**OE 2: Functional Materials (IOECH905)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To discuss the salient features of combinatorial chemistry and its applications for synthesis of combinatorial libraries.
2. To describe the composites, their functions and uses.
3. To delineate the synthetic strategies for synthesis of some selected artificial important organic compounds.

**Syllabus**

**Module I**

Combinatorial chemistry: Resins, protecting groups, solid-phase synthetic strategies, synthesis of peptides, synthesis of some novel biologically important N-heterocyclic building blocks using amino acids, techniques for preparation of combinatorial libraries.

**Module II**

Composites: Micro and macro composites, fibre -reinforced composites (FRPs), matrix based composites. Polymer- matrix composites (PMCs), metal- matrix composite (MMCs), ceramic- matrix composites (CMCs) as in construction materials, carbon- carbon composites (CCCs), hybrid composites. Uses of composites.

**Module III**

Cardiovascular drugs, such as Alapril (lisinopril), Captoril (captopril), antiulcerants cimetidine. artificial sweetener Aspartame (N-L-α-Aspartyl-L-phenylalanine 1-methyl ester), riboflavin (B2), and thiamine (B1)

**Essential Readings**

1. Eco-friendly Synthesis of Fine Chemicals, Edited by Roberto Ballini, James H. Clark and George A. Kraus, from RSC Green Chemistry Series, Royal Society of Chemistry, 1st Edn., 2009.
2. Aqueous Microwave Assisted Chemistry: Synthesis and catalysis, Ed. V. Polshettiwar and R. S. Verma, from RSC Green Chemistry Series, Royal Society of Chemistry, 1st Edn., 2010.
3. Fundamentals of Asymmetric Synthesis, G. L. David Krupadanam, Universities Press, 1st Edn. 2013.
4. W. Bannwarth, B. Hinzen, Combinatorial Chemistry - From Theory to Application

Wiley-VCH, 2nd edition, 2006.

1. Michael Pirrung, Molecular Diversity and Combinatorial Chemistry, Elsevier, 2004.

**Course Outcomes:**

* Understand the salient features of combinatorial chemistry and its applications for synthesis of combinatorial libraries for drug discovery.
* Illustrate the facets of composites, their functions and uses.
* Demonstrate the synthetic strategies for synthesis of some selected artificial important organic compounds.

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| **IOECH905:Functional Materials** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* | \* |  | \* |  |  |  |  |  | \* |  |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  |  | \* |

**OE 2: Nuclear Chemistry (IOECH906)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To describe various types of radioactive decay and detectors.
	2. To explain the theories of nucleus and different types of nuclear reactions.
	3. To demonstrate the principles of functioning of nuclear reactors and knowhow for nuclear waste management.
	4. To discuss on radiation chemistry and the wide-spread applications of radioisotopes.

**Syllabus**

**Module I**

General Aspects of Nuclear Chemistry: Discovery- Types of decay-Decay kinetics: Decay constant, half-life period, mean life Parent daughter decay-growth relationships-Secular and transient equilibrium-Units of radioactivity- Alpha, beta and gamma decay: Theory of decay, energies and properties-Artificial radioactivity- Detectors: Ionization chamber, electron pulse counters, scintillation detectors, semiconductor, detectors, thermo luminescence detectors and neutron detectors. Bethe notation-Types of nuclear reactions: The compound nucleus theory-Reaction cross section- Transmutation reactions, elastic and inelastic scattering, spallation, fragmentation, stripping and pick-up, fission, fusion, photonuclear reactions, Thermonuclear reactions.

**Module II**

Nuclear Disintegration and Reactors: The fission energy – Reproduction factor - Classification of reactors- Based on Moderators, Coolant, Phase of Fuel and Generation -Principle of Thermal nuclear Reactors: The four factor formula - Reactor power – Critical size of a thermal reactor – Excess reactivity and control - Breeder reactor - Reprocessing of spent fuels - Nuclear waste management – Safety culture – Active and passive safety, containment building, nuclear criticality safety, ionizing radiation protection – enforcement agencies.

**Module III**

Radiation chemistry – Passage of radiation through matter – Units for measuring radiation absorption – Radiation dosimetry – Radiolysis of water – Free radicals in Water Radiolysis –Chemical dosimetry: Radiolysis of Fricke Dosimeter Solution.

Application of radioisotopes: probing by isotopes, reactions involved in the preparation of radioisotopes, The Szilard-Chalmer’s Reaction – Radiochemical principles in the use of Tracers – Applications of radioisotopes as tracers- Chemical investigations, analytical applications, agricultural and industrial applications -Neutron Activation Analysis – Carbon and Rock Dating – Use of nuclear reactions- Radioisotopes as source of electricity – Nuclear medicines.

**Essential Readings**

1. Essentials of Nuclear Chemistry, Arnikar, H. J., New Age International Publishers Ltd., New Delhi, 4th Edn., 1995.
2. Nuclear and Radiochemistry, K. H. Lieser, Wiley-VCH, 2nd revised Edn, 2001.
3. Radiochemistry and Nuclear Chemistry, G. Choppin, J. O Liljenzin and J. Rydberg. Butterworth-Heinemann, Oxford, 3rd Edn., 2002.
4. Modern Nuclear Chemistry, [Walter D. Loveland](http://www.amazon.com/Walter-D.-Loveland/e/B001HD1KZI/ref%3Ddp_byline_cont_book_1), [David J. Morrissey](http://www.amazon.com/s/ref%3Ddp_byline_sr_book_2?ie=UTF8&field-author=David+J.+Morrissey&search-alias=books&text=David+J.+Morrissey&sort=relevancerank), Wiley, 2nd Edn. 2006.

**Course Outcomes:**

* Encompass various types of radioactive decay and detectors.
* Illustrate the fundamental theories of nucleus and different types of nuclear reactions.
* Explain the principles of functioning of nuclear reactors and processes followed for nuclear waste management.
* Understand radiation chemistry and describe the wide-spread applications of radioisotopes.

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| **IOECH906: Nuclear Chemistry** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  |  |  |  | \* |  |  |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  |  | \* |

**Lab 31 (PE Lab 1): Computational Chemistry Laboratory - II (ILCCH901)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To get conversant with drawing the structures uniformly using Chemdraw softwares.
2. To predict the molecular properties based on different quantum mechanical theories using Gaussian9 softwares.
3. To apply Gaussian softwares for molecular modelling studies.

**Syllabus**

1. Practicing Chem-Draw software to draw the structures.
2. Use of Gaussian9 software to predict the energies, bond angle, bond length, spectral properties of some small molecules using different methods and basis sets.

**Essential Readings:**

1. Introduction to Computational Chemistry, F. Jensen, John Wiley & Sons Ltd, 2nd edn, 2007.
2. Essentials of Computational Chemistry, C. J. Cramer, Wiley & Sons ltd., 2nd edn, 2004.
3. Computational Chemistry, D. C. Young, Wiley-Interscience, 1st edn, 2001.

**Course Outcomes:**

* Develop expertise on drawing the structures uniformly using Chemdraw softwares.
* Project molecular properties based on different quantum mechanical theories using Gaussian9 softwares.
* Perform molecular modelling studies using Gaussian9 softwares.

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| **ILCCH901: Computational Chemistry Laboratory - II** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  |  | \* | \* | \* |  | \* |  |  |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  | \* |  |  |

**Lab 32 (Core Lab 21): Environmental Chemistry Laboratory (ILCCH902)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To determine the physical properties of water.
	2. To estimate the dissolved impurities in water.
	3. To verify the quality of water for their applications.

**Syllabus**.

***Water Quality Analysis***

1. Determination of pH
2. Determination of turbidity.
3. Determination of alkalinity and acidity.
4. Determination of Optimum dose of coagulants by jar test.
5. Determination of Total Hardness.
6. Determination of Total solids and suspended solids.
7. Determination of Residual chlorine.
8. Determination of Chloride, phosphate and sulphate.
9. Chemical Oxygen Demand.
10. Determination of Biochemical Oxygen Demand.
11. Determination of Dissolved Oxygen.

**Essential readings:**

1. A Laboratory Manual for Environmental Chemistry, R. Gopalan, Amirtha Anand, R. Wilgred Sugumar, I. K. International Pvt Ltd, 1st Edn., 2008.
2. Principles of Environmental Chemistry, James E Girard, Jones & Bartlett, 2nd Edn., 2009.

**Course Outcomes:**

* Ascertain the physical properties of water.
* Determine quantitatively the amount of dissolved impurities in water.
* Establish the quality of water for their applications.

**Seminar: Seminar & Scientific Writing (ISECH901)**

**Prerequisite: Nil**

**Purpose:**

**Course Objectives:**

1. To develop the attitude and to build confidence for presenting scientific facts and or theories etc.
2. To get the opportunities to explore own potentials on creative thinking through learning and writing skill.

**Course Outcomes:**

* Attain proper attitude and confidence for presenting scientific facts and or theories etc.
* Determine own potentials on creative thinking through learning and writing skill.

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| **ISECH901:Seminar & Scientific Writing** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  |  |  |  |  |  |  | \* | \* |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  | \* |  |  |

**Semester-10**

**PE 4: Bioinorganic & Supramolecular Chemistry (IPECH001)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

* 1. To explain the importance of metal ions in living system and describe their storage and transport mechanisms.
	2. To discuss various types of metalloenzymes and their roles in biological systems.
	3. To explain the pathways of biological systems like nitrogen fixation and photosynthesis and to delineate the mechanism of oxygen transport and its storage.
	4. To define the supramolecular chemistry, molecular recognition and some selected building blocks referred in supramolecular chemistry.

**Syllabus**

**Module I**

***Metal ions in biological systems and its storage transport and biomineralization:*** Essential and trace elements, Ferritin, transferrin, and siderophores.

***Calcium in Biology:*** Transported regulation, Intracellular Ca2+ transport, Ca2+ATpase, Na+/Ca2+ exchange, mitochondrial influx and efflux. Inositol triphosphate, Ca2+ regulated intracellular processes: Calmodulin, Troponin C.

**Module II**

***Metalloenzymes:*** Zinc enzymes: Carboxypeptidase and carbonic anhydrase; Iron enzymes: catalase peroxidase and cytochromes, Cyt-P450; Copper enzymes: Superoxide dismutase; Molybdenum oxatransferase enzymes: xanthine oxidase. Coenzyme vitamin B12. sulphur proteins

**Module III**

***Nitrogen fixation:*** Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

***Photosynthesis****:* Chlorophylls, photo system I and photo system II in cleavage of water.

***Transport and storage of dioxygen****:* Heme proteins and oxygen uptake, structure and function of hemocyanin and hemerythrin, model synthetic complexes of iron, cobalt and copper.

**Module IV**

***Supramolecular Chemistry****.*

Introduction-the meaning of supramolecular chemistry, phenomenon of molecular recognition and their quantification

Building blocks of supramolecular chemistry- acyclic receptors for neutral and charged guests, macrocycles and crown ethers, macrobicycles and cryptands, macropolycycles, cucurbiturils and cyclodextrins

**Essential Readings:**

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J. M. Berg., University Science Books. 1994
2. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valenting, University Science Books.
3. Progress in Inorganic Chemistry, Vols 18 and 38 ed, by J. J. Lippard, Wiley.
4. Bioinorganic Chemistry, Asim K. Das, Books and Allied, 2nd Edn., 2007.
5. Supramolecular Chemistry, J. W. Steed and J. L. Atwood, Willey, 2nd Ed., 2009.
6. Bioinorganic and Supramolecular Chemistry, P. S. Kalsi, J. P. Kalsi, New Age International, 2nd Edn., 2012.
7. An Introduction of Supramolecular Chemistry, Asim K. Das, Books and Allied, 1st Edn., 2017.
8. Supramolecular Chemistry: Concepts and Perspectives, J.M. Lehn, VCH, Weinheim, 1995
9. Principles and Methods in Supramolecular Chemistry, H. J. Schneider and A. Yatsimirsky, Wiley, New York, 2000.
10. Supramolecular Chemistry - Fundamentals and Applications, Ariga, Katsuhiko & Kunitake, Toyoki, Iwanami Shoten Publishers, Tokyo, 2006,

**Course Outcomes:**

* Understand the role of metal ions in living system and depict their storage and transport mechanisms.
* Describe various types of metalloenzymes and their roles in biological systems.
* Demonstrate pathways of biological systems like nitrogen fixation and photosynthesis and explain the mechanism of oxygen transport and its storage.
* Illustrate supramolecular chemistry, molecular recognition and enumerate some selected building blocks referred in supramolecular chemistry.

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| **IPECH001:Bioinorganic & Supramolecular Chemistry** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes | \* |  |  |  |  |  |  |  |  |  | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  |  | \* |  |

**Major Project: Project & Literature Search (IPRCH001)**

**Prerequisite:** Nil

**Purpose:**

**Course Objectives:**

1. To expose the students to handle the instruments to know their practical uses.
2. To get knowledge on scientific advances in a particular field of research.
3. To improve upon the technical writing skills on presenting the research outcomes.

A student has to carry out an original and innovative research work according to his/her area of interest in applied chemistry under the guidance of faculty member of CET and or in collaboration with expert(s) from other institutes. He/she has to submit a report of the findings and present the outcome of the research work.

**Course Outcomes:**

* Create interest on R&D activities.
* Get experience in handling of instruments for their practical applications.
* Garner knowledge on scientific advances in a particular field of research.
* Improve upon the technical writing skills on presenting the research outcomes

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| IPRCH001: **Project & Literature Search** |
| 1 | Program Outcomes | a | b | c | d | e | f | g | h | i | j | k |
| 2 | Mapping of Course Outcomes with Program Outcomes |  | \* |  | \* |  | \* | \* | \* | \* | \* | \* |
| 3 | Category | Core | Allied Elective | Free Elective |
|  | \* |  |  |