Rayat Shikshan Sanstha's

R. B. Narayanrao Borawake College, Shrirampur (Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Department of Chemistry

M.Sc. I (Analytical and Organic Chemistry)

Syllabus as per NEP-2020

Implemented

From

Academic Year: 2023-24

Course Structure of M. Sc. I (Analytical & Organic Chemistry)

(Semester-I)

Year	Semester	Course Type	Course Code	Course Title	Theory/ Practical	Credits	No. of Lectures/ Practicals to be conducted	Page No.
1st	I	Major Core	CH-MJ-511T	Fundamentals of Physical Chemistry	Theory	4	60L	4-8
			CH-MJ-512T	Basic Organic Chemistry	Theory	4	60L	9-11
			CH-MJ-513T	Molecular Symmetry, Group Theory and their Applications	Theory	2	30L	12-13
			CH-MJ-514P	Basic Practical Chemistry-I	Practical	4	24P	14-17
		Major Elective	CH-ME-515T	Theory Elective-I	Theory	2	30L	18-23
			CH-ME-516P	Practical Elective-I	Practical	2	12P	24-26
		Research Methodology	CH-RM-517T	Research Methodology	Theory	4	60L	27-29

Course Structure of M. Sc. I (Analytical & Organic Chemistry)

(Semester-II)

Year	Semester	Course Type	Course Code	Course Title	Theory/ Practical	Credits	No. of Lectures/ Practicals to be conducted	Page No.
1st	II	Major Core	CH-MJ-521T	Molecular Spectroscopy and Molecular Thermodynamics	Theory	2	30L	31-32
			CH-MJ-522T	Photochemistry and Spectroscopic Methods of Structure Determination	Theory	4	60L	33-35
			CH-MJ-523T	Coordination and Bio-inorganic Chemistry	Theory	4	60L	36-39
			CH-MJ-524P	Basic Practical Chemistry-II	Practical	4	24P	40-43
		Major Elective	CH-ME-525T	Theory Elective-II	Theory	2	30L	44-48
			CH-ME-526P	Practical Elective-II	Practical	2	12P	49-51
		OJT	CH-OJT-527	On Job Training	Training	4	-	-

Syllabus for M. Sc. I (Analytical & Organic Chemistry)

Semester I

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-511T): Fundamentals of Physical Chemistry

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-511T - Fundamentals of Physical Chemistry	4	4	--

SECTION – I (30 L)
Energy and Matter

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- At the end of section-I, students should be able to develop a view that energy and matter continuously interact with each other and these interactions lead us to realising some of the basic governing laws of the universe i.e. the thermodynamic laws.
- To understand the concepts of free energy, entropy and how they are significant in establishing the feasibility and spontaneity of physical processes.
- To understand the atomic structure by introducing the concept of energy quantization to study the behaviour of particles at atomic scale by following a quantum mechanical approach.
- To extend the quantum mechanical picture of atomic structure to understand the chemical bond between atoms.

SYLLABUS OF CH-MJ-511T (Section-I):

Unit-1: Introduction to Thermodynamics [08 Hours]

State function, path function, exact differential and inexact differential, internal energy and enthalpy, temperature dependent internal energy and enthalpy, reversible and irreversible adiabatic expansion. The entropy of irreversible changes, the Helmholtz and Gibbs function, Entropy and entropy change in an ideal gas with temperature and pressure, Clausius inequality, chemical potential, chemical potential of a substance in a mixture.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Distinguish between a state function and a path function.

CO-2: Apply laws of differentiation to establish exactness or inexactness of a function.
CO-3: Demonstrate on paper why Internal Energy has to be a state function.
CO-4: Identify various types of process and apply thermodynamic laws to them.
CO-5: State the first and second law of thermodynamics.
CO-6: Define thermodynamic state functions of Internal Energy, Entropy, Free Energy etc. and get familiar to the concept of thermodynamic work only to be able to apply it to various systems and processes.
CO-7: Solve for entropy change and free energy change of mixing of ideal gases and mathematically show the non/spontaneity of these process.
CO-8: Write the fundamental equation of thermodynamics for open systems and define Chemical Potential.

Unit-II: Thermodynamics of Mixing [07 Hours]

Partial molar quantities, thermodynamics of mixing of ideal gases, thermodynamics of solutions, ideal solutions, Raoult's and Henry's law, Colligative properties of solutions: Elevation in boiling point, depression in freezing point and osmosis.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Calculate and interpret partial molar quantities in mixtures.
CO-2: Apply the concept of chemical potential to state the fundamental equation of chemical thermodynamics and also to derive ΔG, ΔS and ΔH of mixing of ideal gases and hence realise the spontaneity of these processes.
CO-3: Define ideal solutions and real solutions.
CO-4: Show that colligative properties depend on no. of solute particles in the solution and not on the the nature of them.
CO-5: Quantify changes in solutions properties as an effect of solute concentration.

Unit-III: Quantum Chemistry [08 Hours]

Introduction to quantum mechanics- blackbody radiation, photoelectric effect, de Broglie hypothesis and uncertainty principle and its experimental evidence. Schrödinger wave equation, particle in one dimensional box, Normalization and orthogonality of wave function, particle in three-dimensional box, hydrogen like atoms (no derivation). Operators: algebra of operators, commutative property, linear operators, commutator operator, the operator ∇ and ∇^2.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Explain specific characteristics of Black Body Radiation Curves.
CO-2: Explain particle nature of light with the help of photoelectric effect.

CO-3: Calculate de Broglie wavelengths of moving objects, uncertainties in their position-momentum and realise why classical view offers limited explanation of phenomena at atomic scale.
CO-4: Determine acceptability of a function as a wavefunction, normalize it and do basic operator algebra with it.
CO-5: Solve particle in 1-D box and realise the emergence of energy quantization.
CO-6: Understand the physical significance of Ψ^2 (probability density) and realise the emergence of atomic orbitals (S, P, D and F) and hence develop a quantum mechanical perspective to look at the atomic structure.

Unit-IV: Chemical Bonding **[07 Hours]**

Valence bond theory, hybrid orbitals, geometry and hybridization, molecular orbital theory for di and tri atomic molecule, linear variation method, approximations underlying Huckel theory, applications to simple π-systems.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Understand Valence bond theory and its shortcomings to explain certain properties of molecules.
CO-2: Describe hybridisation process and its influence on molecular geometry; hence predict hybridisation state and geometry of molecules based on valence bond theory.
CO-3: Sketch molecular orbital diagrams for homo/hetero-nuclear diatomic molecules and predict bond order, stability and magnetic properties of molecules; Hence explain the paramagnetic nature of O_2 molecule.
CO-4: Understand the linear variation method as an approach to solving the Schrödinger equation.
CO-5: Explain the resonance stabilisation of molecule as a result of π-electron conjugation using Huckel's theory and its underlying approximations.

SECTION – II (30 L)

Chemical Kinetics and Reaction Dynamics

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To understand the fundamental concepts involved in governing reaction dynamics at molecular level.
- To develop a clear view of reaction kinetics by focusing on different types of reactions and derive various rate laws applicable to respective reactions.
- To understand roles of various factors affecting rates of reactions.
- To investigate sequences of elementary reactions that comprise complex reactions.

SYLLABUS OF CH-MJ-511T (Section-II):

Unit-I: Rate Laws **[06 Hours]**

Recapitulations of basic concept, the temperature dependent reaction rates, reaction moving towards equilibrium, consecutive reaction.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Know the difference between order and molecularity of a reaction.
CO-2: Calculate the rate of given reaction using concentration data.
CO-3: Calculate activation energy for a given reaction using Arrhenius equation.
CO-4: Apply laws of kinetics to opposing/reversible reactions to obtain the overall rate constant.

Unit-II: Kinetics of Complex Reactions **[06 Hours]**

Fast reactions: flash photolysis, flow technique, stopped flow technique, relaxation method, the steady state approximation, parallel reactions, pre-equilibria, unimolecular reactions.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Understand basic working principles of flash photolysis, flow technique, stopped flow technique, relaxation method
CO-2: Understand the significance of relaxation time for a given reaction and calculate it.
CO-3: Identify the rate determine step of given complex reaction and apply steady state approximation to the intermediate.

Unit-III: Kinetics of Polymerization **[06 Hours]**

Chain reactions, free radical polymerization reaction between H_2 and Br_2 (Initiation, Propagation and Termination), Kinetics of free radical polymerisation, Step growth polymerisation (Polycondensation), Kinetics of step growth polymerization, Cationic and anionic polymerization, Explosive reaction.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Understand types of mechanisms of polymer formation and apply laws of kinetics to obtain overall rate of polymerisation.

Unit-IV: Molecular Reaction Dynamics **[06 Hours]**

Collision theory of bimolecular gas phase reactions, diffusion controlled and activation-controlled reaction in solution, activated complex theory of reaction rate, Eyrings equation.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Understand the significance of effective collisions in determining the rate of reactions.
CO-2: Realise solvent effects in governing overall rate of the reaction.
CO-3: Compare rate constant derived on the basis of Arrhenius Equation and collision theory.
CO-4: Compare rate constant derived on the basis of Arrhenius Equation and collision theory.

Unit-V: Enzyme Catalysis **[06 Hours]**

Michaelis mechanism, effect of pH and temperature on enzyme catalyzed reactions, limiting rate, Lineweaverburk and Eadie equation and plots, inhibition of enzyme action, competitive inhibition and non-competitive inhibition.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Understand the underlying mechanism behind enzyme catalysis and effect of external factors i.e., pH, Temperature on the its rate.
CO-2: Solve and simplify Michael Menten equation to obtain different plots to obtain values of K_m, substrate concertation and enzyme concentration.
CO-3: Distinguish between competitive inhibition and non-competitive inhibition by referring to 1/rate vs 1/[S] graph.

ESSENTIAL/RECOMMENDED READINGS:

1. Physical Chemistry by P.W.Atkin and De Paul, 8th edition.
2. Text book of Physical Chemistry – S. Glasstone, 2nd edition.
3. Physical Chemistry by T. Engel and P. Reid 3rd edition.
4. Physical Chemistry and molecular approach by D. Mequarie and J. Siman, 1st edition.
5. Physical Chemistry for biological sciences by Raymond Chang (Universal books, 2000).
6. Physical Chemistry by Merron and C.F. Prouton, 4th edition.
7. Physical Chemistry by G.M. Barrow, 6th edition.
8. Quantum Chemistry by I. Levine 8. Quantum Chemistry by R.K. Prasad, 5th edition.
9. Physical Chemistry of macromolecules- D. D. Deshpande, Vishal Publications, 1st edition.
10. Polymer Chemistry- F. W. Billmeyer Jr, John-Wiley & Sons, 1971, 3rd edition.
11. Chemical Kinetics and Reaction Dynamics – S. K. Upadhyay, 6th edition.
12. Priciples of Physical Chemistry – Puri, Sharma, Pathania, 8th edition.
13. Chemical Kinetics – Keith J. Laidller, 3rd edition.

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-512T): Basic Organic Chemistry

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-512T - Basic Organic Chemistry	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- They will understand the criteria for aromaticity in nonbenzenoid molecules and other advanced polycyclic aromatics.
- Understand the chemistry of monocyclic heterocycles, nomenclature and reactions.
- Learn the concept stereochemistry and its importance; their rules and the concept of chirality.
- Understand the role of various reaction intermediates like carbocation, carbanion, carbenes, radicals, and nitrenes in organic reactions; concept of NGP.
- Able to describe mechanism of different rearrangement reactions. Appreciates the various steps involved in the molecular rearrangements.
- Use synthetic reagent of oxidation and reduction for solving the problems.

COURSE OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: To understand some fundamental aspects of organic chemistry, to learn the concept aromaticity, to understand the various types of aromaticity.
CO-2: To study heterocyclic compound containing one and two hetero atoms with their structure, synthesis and reactions.
CO-3: To know stereochemistry of organic compounds; able to do interconversion of Fischer to Newmann, Newmann to Sawhorse and vice versa, Able to assign R and S to given molecules; understand stereoselective and stereospecific reactions; acquire knowledge on topicity.
CO-4: To study structure, formation, stability and related name reaction of intermediates like Carbocation, Carbanion, Free Radical, Carbenes and nitrenes; Recognize neighbouring group participation.
CO-5: To study rearrangement reaction with specific mechanism and migratory aptitude of different groups.

CO-6: To understands the basis of redox reaction; acquire knowledge about the reagents which causes selective oxidation / reduction in various compounds; learn the basic mechanism of oxidation / reduction in organic compounds.

SYLLABUS OF CH-MJ-512T:

SECTION-I **(30 Hours)**

Basic Organic Chemistry

Unit-I: Aromatic Compounds- Structure and Reactivity **[05 Hours]**

Aromaticity: Benzenoid and non-benzenoid compounds, Huckel's rule, antiaromaticity, Homoaromaticity. Application to carbocyclic and heterocyclic systems, annulenes, azulenes, current concepts of aromaticity. Aromatic Electrophilic Substitution.

Unit-II: Heterocyclic Chemistry **[10 Hours]**

Five membered heterocycles with one and two hetero atoms: Synthesis, reactivity, aromatic character and importance of following heterocyclic compounds, Furan, Pyrrole, Thiophene, Pyrazole, Imidazole. Six membered heterocycles with one and two heteroatoms: synthesis & reactivity of pyridine, coumarins & diazines.

Unit-III: A brief introduction to Stereochemistry **[15 Hours]**

a) Stereochemical principles, enantiomeric relationship, diastereomeric relationship, R and S, E and Z nomenclature in C, N, S, P containing compounds, Prochiral relationship, stereospecific and stereoselective reactions, optical activity in biphenyls, spiranes, allenes, Topicity,

b) Conformational analysis of di, tri, tetra-substituted 5 -6 membered rings and decalins.

SECTION-II **(30 Hours)**

Unit-I: Structure, Stability and Reactions of Reactive Intermediates **[06 Hours]**

a) Carbocation, Carbanion, Free Radical, Benzyne, Carbenes and nitrenes
b) NGP: Neighboring group participation.

Unit-II: Molecular Rearrangements **[10 Hours]**

Beckmann, Hofmann, Curtius, Schmidt, Wolff, Lossen, Bayer-villiger, Sommelet, Favorskii, Pinacol-pinacolone, Benzil-benzilic acid, Fries, Tiffeneau Demjanov. Claisen, Cope, and Wagner-Meerwein.

Unit-III: Use of Oxidizing and Reducing Agents **[14 Hours]**

Oxidizing agents: CrO_3, PDC, PCC, $KMnO_4$, MnO_2, Swern, SeO_2, $Pb(OAc)_4$, Pd-C, RuO_4, OsO_4, m-CPBA, O_3, $NaIO_4$, HIO_4, TEMPO, IBX, CAN, Dess-Martin, DDQ, Ag_2O.

Reducing agents: $LiAlH_4$, $NaBH_4$ Boranes and hydroboration reactions, MPV reduction and reduction with H_2/Pd-C, Raney-Ni, $NaBH_3CN$, Wilkinson's catalyst, DIBAL-H and Wolff-Kishner reduction, Birch, Clemenson, Dissolving metal.

ESSENTIAL/RECOMMENDED READINGS:

1. Organic Chemistry–by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford), 2nd edition.
2. Advanced Organic Chemistry –by J. March 6th Edition.
3. Advanced Organic Chemistry (Part A) –by A. Carey and R.J. Sundberg, 5th edition.
4. A guidebook to mechanism in organic chemistry – Peter Sykes 6th Ed.
5. Stereochemistry of carbon compound-by E.L. Eliel, 1st edition.
6. Stereochemistry of organic compound-by Nasipuri, 4th edition
7. Stereochemistry conformations and mechanism by P.S. Kalsi, 11th edition.
8. Organic Reaction Mechanism by V. K. Ahluwalia, 4th edition.
9. Heterocyclic chemisty – T. Gilchrist, 5th edition.
10. An introduction to the chemistry of Heterocyclic Compounds, R. M. Acheso, 3rd edition.
11. Heterocyclic Chemistry – II, by R. R. Gupta, M. Kumar, V. Gupta, Springer (India), PVT, 1st edition.

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-513T): Molecular Symmetry, Group Theory and their Applications

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-513T - Molecular Symmetry, Group Theory and their Applications	2	2	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Students get knowledge regarding concept of symmetry and symmetry operations.
- Students should learn the orthogonality theorem and rules for constructing character table.
- They should understand SALC projection operator.
- Student should correlate the application of symmetry to spectroscopy.

CH-MJ-513T: Molecular Symmetry, Group Theory and their Applications

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Student should visualize/ imagine molecules in 3 dimensions.
CO-2: To understand the concept of symmetry and able to pass various symmetry elements through the molecule.
CO-3: Understand the concept and point group and apply it to molecules.
CO-4: To understand product of symmetry operations.
CO-5: To apply the concept of point group for determining optical activity and dipole moment.
CO-6: Student should understand the importance of Orthogonality Theorem.
CO-7: They should able to learn the rules for constructing character table.
CO-8: Using reduction formulae should be able to find out the possible type of hybridization.
CO-9: Student should know the concept of SALC.
CO-10: Student able to find out character for reducible representation.
CO-11: To know about projection operator and apply projection operator to find out the normalized wave function for atomic orbital.
CO-12: Student should correlate the application of symmetry to spectroscopy.

CO-13: From the previous knowledge of symmetry student must able to find out which mode are IR active.
CO-14: Student should able to structure elucidation by ^{19}F NMR and P^{31} NMR spectroscopy.

SYLLABUS OF CH-MJ-413T:

Unit-1: Molecular Symmetry and Symmetry Groups [10 Hours]

Symmetry elements and operations, Symmetry planes and reflections, the inversion centre, proper axes and proper rotations, improper axes and improper rotation, products of symmetry operations, equivalent symmetry elements and equivalent atoms, general relations among symmetry elements and symmetry operations, classes of symmetry operations, symmetry elements and optical isomerism, symmetry point groups, classification of molecular point groups. Defining properties of a group, group multiplication table, some examples of group, subgroups and classes.

Unit-2: Representations of Groups [08 Hours]

Definition of group, Properties of group, group multiplication table, some examples of group, subgroups and classes. Matrix representation and matrix notation for geometric transformation, The Great Orthogonality Theorem and its consequence, character tables (No mathematical part), wave function as basis for irreducible representations.

Unit-3: Symmetry Adapted Linear Combinations [06 Hours]

Projection operators and their use of construct SALC (Construction of SALC for sigma bonding for molecules belonging point groups: D_2h, D_3h D_4h, C_4V, Td,Oh, normalization of SALC, transformation properties of atomic orbital.

Unit-4: IR and NMR spectroscopy for group theory [06 Hours]

Introduction, selection rules, polyatomic molecules, possible vibrations in a linear molecule, bending modes, symmetry of vibrations and their IR activity, Group vibration concept and its limitations, IR spectra related to symmetry of some compounds, IR spectra of complex compounds. Structure elucidation by ^{19}F NMR and P^{31} NMR spectroscopy.

ESSENTIAL/RECOMMENDED READINGS:

1. Symmetry and spectroscopy of molecules by K. Veera Reddy, 2nd edition.
2. Chemical Applications of Group Theory by F. A. Cotton, 3rd edition.
3. Group Theory and its Chemical Application, P.K. Bhattarchrya.
4. Inorganic Chemistry by Shriver and Atkins, 5th edition.
5. Molecular Symmentry and Group Theory by Robert L. Carter, 2nd edition.
6. Inorganic chemistry: principle of structures and reactivity by Huheey, Keiter, Medhi 4th edition.

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-514P): Basic Practical Chemistry-I

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-514P - Basic Practical Chemistry-I	4	--	4

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Understand how kinetics experiments are designed and executed with or without the help of certain instruments e.g., colorimeter, GM counter etc.
- Understanding of the basic working principle of instruments such as colorimeter, spectrophotometer and GM counter.
- Experimental data interpretation, data plotting and data analysis.
- Students should become aware of safety considerations in practical organic chemistry.
- Students should develop a practical hand to setup organic reactions with appropriate stoichiometry, suitable choice of solvents.
- Students should be able to apply appropriate purification methods to obtain the products.

Section I: Physical Chemistry Practicals (12 Experiments)

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Know the concept of hypothesizing and hence perform the experiment accordingly.
CO-2: Do molarity calculations, dilution calculations and prepare solutions of given concentrations.
CO-3: Realise the need for doing calibration and standardisation wherever and whenever necessary while performing experiments.
CO-4: Do graphical presentation and interpretation of experimental data.
1a. Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method) (compulsory).
1b. Demonstration of MICRSOFT EXCEL in the statistical treatment of experimental data. (Calculation of mean, standard deviation, standard error, graph plotting, error bars)

Part-I: Chemical Kinetics: (Any three)

2. Investigate the kinetics of iodination of acetone. **[E]**
3. Determination of an order of a reaction. **[E]**
4. Brönsted primary salt effect. **[E]**
5. Kinetics of oxidation of ethanol by $K_2Cr_2O_7$. **[E]**

Part-II: Non-Instrumental: (Any three)

6. To investigate the adsorption of oxalic acid/acetic acid by activated charcol and test the validity of Freundlich and Langmuir isotherms. **[E]**
7. To determine the energy of activation for the reaction between potassium persulphate and potassium iodide. **[E]**
8. Glycerol radius by viscosity. **[E]**
9. Partial Molar Volume (Polynometry) Determination of the densities of a series of solutions and to calculate the molar volumes of the components. **[E]**

Part-III: Colorimetry and spectrophotometry (Any four experiments)

10. Simultaneous determination of Ni and Co by spectrophotometry (Ref-1) **[E]**
11. Simulations determination of KMnO4 and K2Cr2O7 by spectrophotometry. (Ref-7) **[E]**
12. To study the adsorption of certain dyes such as methyl violet, picric acid or malachite green on charcoal. (Ref-2) **[E]**
13. To determine the indicator constant of bromocresolpuple by half height method. (Ref-8) **[E]**
14. Estimation of Cu(II) by titration with Na2 EDTA by colorimetry. **[E]**
15. a. Determination of energy of n to Π* transition in acetone and study of effect of solvent on energy of this transition by recording absorbance spectra in n-hexane and water. b. To study the effect of the extended conjugation on the λmax of p-nitro phenol by recording spectrum in acidic and alkaline medium (Ref-8). **[E]**

Part -IV: Radioactivity: (Any one)

16. Estimation of Mn in tea leaves by NAA. **[E]**
17. Half-life of a radioactive nuclide and counting errors. **[E]**
18. Determination of E-max of β radiation and absorption coefficients in Al. **[E]**
19. To determine the plateau voltage of the given GM counter. **[E]**

ESSENTIAL/RECOMMENDED READINGS:

1. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.), 1st edition.
2. Experiments in Physical Chemistry, J. M. Wilson, K.J. Newcombe, A. R. Denko. R.M.W. Richett (Pergamon Press), 2nd edition.

3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.), 4th edition.
4. Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003.
5. Physical chemistry by Wien (2001).
6. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut), 6th edition.
7. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House, 2nd edition.
8. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books ents in Al.

Section II: Organic Chemistry Practicals (12 Experiments)

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Students are made aware of safety techniques and handling of chemicals.
CO-2: Students are trained to different purification techniques in organic chemistry like recrystallization, distillation, steam distillation and extraction.
CO-3: Students are made aware of carrying out different types of reactions and their workup methods.
CO-4: This practical course is designed to make student aware of green chemistry and role of green chemistry in pollution reduction.

Introduction to Laboratory Safety: Meaning of safety signs on container of chemicals, safety handling of chemicals, MSDS sheets: Detailed explanation at least for 4 different types of substances (e.g. nitric acid, benzene, potassium dichromate, bromine, etc.), Handling of glassware's and care to be taken, handling of organic flammable as well as toxic solvents in laboratory, use of safety goggles, shoes and gloves, fire extinguisher and its use, action to be taken in accidental cases e.g. cleaning of acid spill over, use eye wash station and bath station in emergency, etc. (compulsory).

Part-I: Purification Techniques (Compulsory) (6 Experiments)

a) Purification of **two** organic solids by recrystallization using solvents other than water. **[E]**
b) Purification of **two** organic liquids by upward/downward/traditional distillation technique. **[E]**
c) Column Chromatography technique should be performed for any one of the following preparations. **[E]**
d) Sublimation technique. **[E]**
e) Thin Layer Chromatography technique. **[E]**

Part-II: Introduction to Green Chemistry (Compulsory 1 Practical)

Concept of green chemistry, twelve principals of green chemistry, applications of green chemistry for sustainable development, Atom economy, monitoring of reaction using TLC. **[E]**

Green Chemistry Experiments (any Four)

1. Preparation of Schiff's bases in aqueous medium. **[E]**
2. Preparation of dihydropyrimidinone under solvent free conditions. **[E]**
3. Preparation of acetanilide from aniline and acetic acid using Zn dust. **[E]**
4. Bromination of trans-stilbene using sodium bromide and sodium bromate. **[E]**
5. Conversion of Cyclohexanol to cyclohexanone. **[E]**

ESSENTIAL/RECOMMENDED READINGS:

1. A Textbook of Practical Organic Chemistry, 4th Edn., A. I. Vogel, ELBS.
2. Organic Synthesis based on Name Reactions – A. Hassner and I. Namboothiri.
3. Modern Organic Synthesis in the Laboratory – Jie Jack Li, Chris Limberakis, Derek A. Pflum.

MAJOR ELECTIVE COURSE (CH-ME-515T): Theory Elective-I

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-ME-515T - Theory Elective-I	2	2	--

Elective Option A

CH-ME-515(A)T

Basics of Material Science (30 Hours)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Students will be able to identify and describe properties of matter including flexibility, strength, Transparency, Hardness, Water resistance, size, Colour, Weight, Texture.
- Students should realise that solid state chemistry lies at the heart of many significant scientific advances from recent decades, characterization and application of inorganic materials.
- Develop a view that chemistry plays a significant role in environmental sustainability.

COURSE OUTCOMES:

At the end of this chapter, a student should be able to-

CO-1: To understand the bonding in solids – band theory.
CO-2: Students will learn how electronic properties of solids emerge.
CO-3: Understand the role of non-stoichiometry, defects in deciding properties of solids.
CO-4: Understand how magnetic properties arise in solids.
CO-5: Realise how advanced solid materials can help in achieving sustainability by understanding recent advances in clean energy harvesting and storage strategies.

SYLLABUS OF CH-ME-515(A)T:

Unit-I: Bonding in Solids and Electronic Properties (Ref-1, 4) [06 Hours]

Recollect the concepts: Crystalline solids, unit cell, and types of unit cells
Introduction, Bonding in Solids-Free Electron Theory, Electronic Conductivity, Bonding in Solids-Molecular Orbital Theory, Simple Metals, Semiconductors-Si and Ge, Photoconductivity,

The P-N Junction-Field-Effect Transistors, Bands In Compounds-Gallium Arsenide, Bands In D-Block Compounds-Transition Metal Monoxides; MnO, TiO_2, ZnO, FeO.

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Unit-II: Defects and Non-Stoichiometry (Ref-1, 4) [06 Hours]

Introduction, point defects—an introduction, defects and their concentration, intrinsic defects, extrinsic defects the concentration of defects, ionic conductivity in solids, solid electrolytes, fast-ion conductors: oxygen ion conductors, fast-ion conductors: sodium ion conductors, Applications: 1) fuel cells, 2) sensors, nonstoichiometric compounds, introduction, non-stoichiometry in wurtzite, the titanium monoxide structure.

Unit-III: Synthesis of Solids (Ref-2 and 3) (Ref-1, 4) [07 Hours]

Introduction, Common Reactions Employed in Synthesis, ,Ceramic Methods, Decomposition of Precursor Compounds, Combustion Synthesis, Sono-chemical methods and Mechano-chemical, Soft Chemistry Routes(Ion Exchange Reactions, Sol–Gel Synthesis, Electrochemical Methods, Hydrothermal, Solvothermal and Ionothermal Synthesis), Atomic Layer Deposition and Chemical Vapour Deposition and, Procedures of synthesis of some nano-materials- Gold and Silver nanoparticles, CdS nanoparticles, Porous Silica nanoparticles and ZnO, TiO_2 and Fe_2O_3 nanoparticles.

Unit-IV: Principles of Instrumentation [05 Hours]

Spectrophotometry, XRD, EXAFS, XPS, SEM, TEM, AFM, application to nanomaterials characterization.

Unit-V: Chemistry and Sustainability (Ref-3, 5) [06 Hours]

Chemistry of climate change and global warming, CO_2 capture techniques, need for clean energy alternatives, Solar cells- Dye Sensitized Photovoltaic Solar Cells, Organic Photovoltaic Cells, Fuel Cells, Hydrogen Generation and Storage, Electrochemical Devices of Energy Storage, recent advances in Li ion Batteries, Na ions Batteries, Supercapacitors.

ESSENTIAL/RECOMMENDED READINGS:

1. Elaine A. Moore, Lesley E. Smart - Solid State Chemistry - an Introduction. Third Ed. / Fourth Ed. CRC Press (2012).
2. C. N. R. Rao, Kanishka Biswas, Essentials of inorganic materials synthesis, Wiley, 2015.
3. Nanotechnology: Principles and Practices, S. K. Kulkarni, Third Ed. Springer.
4. Anthony R. West, Solid State Chemistry and its Applications, Second Edition (Student Edition), Wiley.
8. Handbook of Batteries, Third edition -David Linden Thomas B. Reddy.

Elective Option B

CH-ME-515(B)T

Chemistry of Main Group Elements (30 Hours)

COURSE OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Student should understand the detail chemistry of S and P block elements w.r.t. their compounds, their reactions and applications.
CO-2: To learn the advance chemistry of boranes, fullerene, zeolites, polymers etc.
CO-3: Organometallic chemistry of some important elements from the main groups and their applications.

SYLLABUS OF CH-ME-515(B)T:

Unit-I: Hydrogen and its compounds [03 Hours]
Classification of Hydrides, electron deficient, electron precise and electron rich hydrides. PH_3, SbH_3, AsH_3, Selenides, Tellurides.

Unit-II: Alkali and Alkaline Earth Metals [03 Hours]
Solutions in non - aqueous media, application of crown ether in extraction of alkali and alkaline earth metal.

Unit-III: Boron Group [04 Hours]
Boron Hydrides, preparation, structure and Bonding with reference to LUMO, HOMO, inter conversion of lower and higher boranes, metallo boranes, and carboranes, reactions of organoboranes, STYX rules and structure of higher boranes.

Unit-IV: Carbon Group [04 Hours]
Allotropes of carbon, Diamond, Graphite, Graphene, fullerenes, carbon nanotube with synthesis, properties, Structure- single walled and multi walled and its application, Intercalation compounds of graphite, Silicates, including Zeolites.

Unit-V: Nitrogen Group [04 Hours]
Nitrogen activation, Boron nitride, Oxidation states of nitrogen and their interconversion, PN and SN Compounds, Applications of PN and SN compounds.

Unit-VI: Oxygen Group [03 Hours]
Metal Selenides and Tellurides, oxyacids, and oxoanions of Sulphur and nitrogen. Ring, Cage and Cluster compounds of p-block elements.

Unit-VII: Halogen Group [03 Hours]

Interhalogens, pseudohalogens, Synthesis, Properties and Applications, Structure, Oxyacid's and Oxyanions of Halogens.

Unit-VIII: Noble gases **[02 Hours]**

Occurrence, Compounds of Xenon-with fluorine and Oxygen and its uses.

Unit-IX: Reaction mechanism in co-ordination compounds **[04 Hours]**

Electron transfer reactions, One electron transfer reaction, inner sphere mechanism, outer sphere mechanism, Marcus theory and its applications, Two electron transfer reaction, complimentary and non-complimentary electron transfer reaction.

ESSENTIAL/RECOMMENDED READINGS:

1. Inorganic Chemistry by Shriver and Atkins, 5th edition.
2. Inorganic Chemistry by Catherine Housecraft, 4th edition.
3. Inorganic chemistry by Principle of Structures and Reactivity by Huheey, Keiter, Medhi, 4th edition.
4. Concise Inorganic Chemistry by J. D. Lee, 5th edition.
5. Inorganic Chemistry by Meissler and Tarr, 3rd edition.
6. Organometallics by Christoph Elschenbroich, 3rd edition.
7. Organometallics by A Concise Introduction by Christoph Elschenbroich and Albrecht Salzer.
8. Basic Organometallic Chemistry by B. D. Gupta and A. J. Elias, 2nd edition.

Elective Option C

CH-ME-515(C)T

Introduction to Nanoscience (30 Hours)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Introduce students with the fundamentals of nanoscience.
- Students should understand why nanomaterials exhibit properties that differ from their bulk counterparts.
- Students should get familiar with various methods of synthesizing nanomaterials.
- Students should get familiar with different characterization techniques for characterizing nanomaterials.

COURSE OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Understand why some properties of materials are size dependant.

CO-2: Understand various factors that affect size and shape of nanoparticles.
CO-3: Choose from various characterization techniques to characterise the given nanomaterial after understanding the purpose of each technique.
CO-4: Understand how nanoparticles show distinct/improved optical, electrical, magnetic properties.
CO-5: Have a knowledge of biological nanomaterials and understand the biological factors affecting on them.

SYLLABUS OF CH-ME-515(C)T:

Unit-I: General Introduction **[06 Hours]**

Forms of Matter, Crystal structures, electronic properties of atoms and solids, Surface energy and surface tension, defining nano dimensional materials, 0D, 1D and 2D nanostructures, sizes dependence of properties, special properties resulting from nano dimensionality, Potential uses of nanomaterials.

Unit II: Synthesis of nanomaterials **[06 Hours]**

General approaches, Nucleation process, size of the crystal – Influence of nucleation rate on the size of the crystal, Chemical methods, Sol-gel techniques, Control of grain size, Co-precipitation, Hydrolysis, sonochemical method, Colloidal precipitation, Bottom up and top-down approaches, kinetically confirmed synthesis of nanoparticles.

Unit III: Principle of Instrumentation **06 Hours]**

Spectrophotometry, XRD, EXAFS, XPS, SEM, TEM, AFM, application to nanomaterials characterization.

Unit IV: Optical properties of nanomaterials **[06 Hours]**

UV- Vis, IR absorption, Photoluminescence and stimulated emission, Nonlinear optical mixing, photoconductivity. Magnetic Properties: Concepts of di, para and ferro-magnetism, Exchange correlation, Exchange interaction. Electrical Properties: Electrical conductivity, Hall Effect – charge carrier density, activation energy, electronic properties, field emission properties.

Unit V: Biological nanomaterials **[06 Hours]**

Sizes of building blocks Proteins, DNA double nanowire, Enzymes, Protein synthesis, Micelles and Vesicles, Biomimetic nanostructures, Worm micelles and Vesicles from block copolymers.

ESSENTIAL/RECOMMENDED READINGS:

1. C.P. Poole Jr. F.K. Owens, Introduction to Nanotechnology, John Wiley & Sons, 2003.
2. M.D. Ventra, S.Evoy, J.R. Heflin, Jr., (Eds), Introduction to Nanoscale Science and

Technology, Kluwer Academic, 2004.
3. G. Cao., Nanostructures &Nanomaterials: Synthesis properties and applications, Imperial College Press.
4. B S Murty, P Shankar, Baladev, B BRath and J Murday, Text book of Nano Science and Nanotechnology, University Press, 2012.
5. C.N.R. Rao, A. Muller, A.K. Cheetham (Eds.) The Chemistry of Nanomaterials: Synthesis, Properties ad Applications, WILEY-VCH Verlag GmbH & Co., KGaA, Weinheim, 2004.
6. P. Knauth, J. Schoonman (Eds), Nanostructured Materials: Selected Synthesis Methods, Properties and Applications, KLUWER ACADEMIC, 2002.
7. G. Schmid, Nanoparticle: From Theory to Applications, Wiley-VCH Verlag GmbH & Co. KGaA, 2004.
8. P. Dutta, S.Gupta (Ed), Understanding of Nanoscience and Technology, Global Vision Publishing House, 2006.
9. C.C. Koch, Nanostructured Materials: Processing, Properties and Applications, Jaico Publishing House, 2006.
10. Challa S.S.R. Kumar (Ed) Biological and Pharmaceutical Nanomaterials, John Wiley VerlogCmbh& Co., KgaA, 2006.

MAJOR ELECTIVE COURSE (CH-ME-516P): Practical Elective-I

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-ME-516P - Practical Elective-I	2	--	2

Elective Option A

CH-ME-516(A)P

Material Analysis, Synthesis and Applications

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Student should be able to perform the synthesis of inorganic complexes with appropriate stoichiometry considerations.
- Student should get familiar with methods of elemental determination from various ores.
- Student should be able to design kinetics experiments for photoactive compounds.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Calculate specific elemental content in the given ore.
CO-2: Calculate %yield as well as estimate purity of the synthesized compounds/complexes.
CO-3: Demonstrate photoactivity of inorganic complexes using spectrophotometer.
CO-4: Design and conduct kinetic experiments for photocatalysis of dyes and be able to rationalise the experimental data.

PRACTICALS for CH-ME-516(A)P:

Part-I: Inorganic Analysis (Ref. -1)

1. Determination of Silica and Iron from hematite ore.
2. Determination of Silica and Manganese from pyrolusite ore.
3. Determination of Aluminum and Silica from Bauxite ore.
4. Determination of copper and iron from Chalcopyrite ore.

Part-II: Alloy Analysis (at least two of the following) (Ref. -1)

5. Determination of tin and lead from solder alloy.
6. Determination of iron and chromium from stainless steel alloy.

7. Determination of copper and nickel from cupranickel alloy.

Part-III: Synthesis of solid-state materials/nano-materials (Ref- 2 and 3)

8. Synthesis of ZnO from zinc oxalate - precursor method and determine band gap by absorption spectroscopy.
9. Synthesis of Colloidal silver nanoparticles and determine band gap by absorption spectroscopy.
10. Synthesis of TiO_2 $TiCl_4$ or Ti-Isopropoxide by Sol-gel method and determine band gap by absorption spectroscopy.
11. Synthesis of Cerium Oxide nanoparticles and determine band gap by absorption spectroscopy.
12. Synthesis of Fe_2O_3 nanoparticles sol-gel/coprecipitation/hydrothermal (any one method).
13. ZnO, TiO_2, Fe_2O_3 nanoparticles powder XRD, SEM, TEM (at least one spectral analysis should be done).

Part-IV: Applications of Solid-State Materials

14. Removal and kinetics of photocatalytic dyes, degradation (methylene blue) by ZnO, TiO_2 photocatalysis (Ref-2).
15. Study of adsorption of phosphate ion on alfa-Fe_2O_3 (Ref-2).

ESSENTIAL/RECOMMENDED READINGS:

1. Text book of Quantitative Analysis by A.I. Vogel 3rd edn (1963).
2. Experimental Inorganic Chemistry by Mounir A. Malati, Horwood.
3. Nanotechnology by S. K. Kulkarni.

Elective Option B

CH-ME-516(B)P

Chemical Biology-I Practicals

PRACTICALS for CH-ME-416(B)P :

1. Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method) – Compulsory.

Perform at least 10 Practical from the following

1. Preparation of biological buffers.
2. Qualitative analysis of carbohydrates.
3. Qualitative analysis of Lipids.
4. Qualitative analysis of amino acids.
5. Paper chromatographic / TLC separation of mixture of amino acids and their detection.

6. Paper chromatographic separation of mixture carbohydrates and their detection.
7. Quantitative estimation of Glucose by dinitro salicylic acid by using calorimetric method.
8. Quantitative estimation of proteins by Loawry's method.
9. Kjeldahl method of Protein Determination.
10. Saponification number of fats.
11. Iodine value of oil.
12. Isolation Quantitative estimation of DNA by Diphenyl amine method.
13. Determination of Inorganic Phosphate in Biological Samples.

ESSENTIAL/RECOMMENDED READINGS:

1. A reference book of biochemistry practicals by Sadashivam.
2. Practical approach to biochemistry by Plummer.
3. Martin Holtzhauer, Basic Methods for the Biochemical Lab, First Edition, Springer.

RESEARCH METHODOLOGY COURSE (CH-RM-517T): Research Methodology

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-RM-517T - Research Methodology	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Students should know the importance of Philosophy and ethics in research.
- Students should know the process of the literature survey.
- Students should know methods of writing scientific Research papers.
- Students should be aware of the Chemical Safety and Ethical Handling of Chemicals.
- Students should know various methods of data analysis.

COURSE OUTCOMES:

After completion of this course students will able to;

CO-1: Understand the various methods of literature survey by offline & digitally.

CO-2: Understand the chemical safety and ethical handling of chemicals.

CO-3: Know the various methods of handling the data of research.

CO-4: Know the methods of the data analysis.

CO-5: Develop the writing skill of scientific manuscripts and be aware of scientific research methods.

CO-6: Understand the Philosophy and ethics in research.

SYLLABUS of RESEARCH METHODOLOGY (CH-RM-517T)

Unit-I: Ethics in Research **[8 Hours]**

A) Philosophy and Ethics: Introduction to Philosophy, definition, nature and scope, concept, branches; Ethics: definition, moral Philosophy, nature of moral judgment and reactions.

B) Scientific conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconduct: Falsification and plagiarism; Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data.

Unit-II: Publication Ethics **[7 Hours]**

1) Publication ethics: definition, introduction and importance.
2) Best practices/standards setting initiatives and guidelines: COPE, WAME.
3) Conflicts of interest.
4) Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types.
5) Violation of publication ethics, authorships and contributor-ship.
6) Identification of publication misconduct, complaints, and appeals.
7) Predatory publishers and journals.

Unit-III: Literature Survey **[15 Hours]**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC Infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki- Databases, Chem Spider, Science Direct, SciFinder, Scopus. Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Unit-IV: Methods of Scientific Research and Writing Scientific Papers **[15 Hours]**

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

Unit-V: Chemical Safety and Ethical Handling of Chemicals **[10 Hours]**

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Unit-VI: Data Analysis **[5 Hours]**

The Investigative Approach: Making and Recording Measurements. SI Units and their uses, Scientific method and design of experiments, Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests.

ESSENTIAL/RECOMMENDED READINGS:

1) Philosophy of Science, Routledge-Bird A
2) A short story ethics-MacIntyre, Alasdair, London
3) Research Methodology - C. R. Kothar
4) Handbook of Research Methodology – Shanti Bhusan Mishra, Shashi Alok
5) Vogel's Practical Organic Chemistry – F. Brian S Furnis
6) Handbook of Reactive Chemical Hazards - Bretherick
7) Big Data: A Revolution - Kenneth Cukier and Viktor Mayer-Schönberger

Syllabus for M. Sc. I (Analytical & Organic Chemistry)

Semester II

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-521T): Molecular Spectroscopy and Molecular Thermodynamics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-521T - Molecular Spectroscopy and Molecular Thermodynamics	2	2	--

Molecular Spectroscopy and Thermodynamics (30 L)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To be able to extend the concept of total energy quantization to various form of energy that a molecule may possess i.e. Rotational Energy, Vibrational Energy and Electronic Energy.
- To understand the fact that each type of energy transition between quantized energy levels of a molecule is a unique feature of it. Hence, these features can be utilized to identify/characterize the given molecule. (This is the basis of Spectroscopy where energy in the form of light interacts with a molecule)
- To understand the link between microscopic properties of matter and its bulk properties. It requires the understanding of a statistical concept called partition function (derived from Boltzmann distribution of populations of energy levels) which is used to extract the thermodynamic information about the system.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: To be able to extract key information such as bond length, rotational constant, vibrational constant, bond dissociation energy, functionalities of a molecule by interpreting its microwave, vibrational, Raman and electronic spectra.
CO-2: To understand the principle, instrumentation and application of Mossbauer Spectroscopy.
CO-3: To be able to construct partition function and obtain thermodynamic information from it.

SYLLABUS OF CH-MJ-521T:

Unit-I: Microwave Spectroscopy **[04 Hours]**

Types of molecules on the basis of moment of inertia and rotational spectra of di- and poly-atomic molecules.

Unit-II: Infra-red Spectroscopy [07 Hours]

The vibrating diatomic molecule, harmonic and Anharmonic oscillator, the diatomic vibrating rotator, breakdown of the Born-Oppenheimer approximation, The vibrations of polyatomic molecule, Fourier transform spectroscopy and its advantages, The carbon dioxide laser, Applications.

Unit-III: Raman Spectroscopy [06 Hours]

Quantum and classical theory of Raman effect, pure rotational Raman spectra, vibrational Raman spectra, polarization of light and Raman effect, structure determination from Raman and Infra-red spectroscopy, applications.

Unit-IV: Electronic Spectroscopy of molecules [05 Hours]

Electronic spectra of diatomic molecules - The Born- Oppenheimer approximation, Vibrational coarse structure, Frank- Condon principle, dissociation energy and dissociation product, Rotational fine structure of electronic-vibration transition, The fortrat diagram, Pre-dissociation, molecular photoelectron spectroscopy.

Unit-V: Mossbauer Spectroscopy [02 Hours]

Principle, Instrumentation and Applications of Mossbauer Spectroscopy.

Unit-VI: Molecular Thermodynamics [06 Hours]

Molecular energy levels, Boltzmann distribution law, partition functions and ensembles, translational, rotational and vibrational partition function of diatomic molecule, obtaining energy, heat capacity, entropy and equilibrium constants from partition functions, Maxwell- Boltzmann, Fermi-Dirac and Bose-Einstein statistics.

ESSENTIAL/RECOMMENDED READINGS:

1) Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCash, 3rd edition.
2) Physical Chemistry and molecular approach by D. Mequarie and J. Siman, 1st edition.

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-522T): Photochemistry and Spectroscopic Methods of Structure Determination

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-522T - Photochemistry and Spectroscopic Methods of Structure Determination	2	2	--

SECTION – I: Photochemistry and Pericyclic Reactions (30L)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To understand photochemical reactions, types and mechanism.
2. To understand the concept of pericyclic reactions and various methods of analysis.
3. To understand the correlation diagram and FMO method.

COURSE OUTCOMES

After completion of this course student will able to;

CO1: Show the photochemical reaction and their mechanism
CO2: Understand the various pericyclic reaction.
CO3: Analyze the pericyclic reaction by various methods.

SYLLABUS OF CH-MJ-522T (Section-I):

Unit-I: Photochemistry **[15 Hours]**

Principles of photochemistry, photochemistry of carbonyl compounds, Norrish type-I, Norrish type-II, Paterno buchi reaction, Photochemistry of alkenes and dienes, di-pi methane rearrangement, oxo di-pi methane rearrangement, photochemistry of aromatic compounds, photo fries rearrangement, Barton reaction.

Unit-II: Pericyclic Reactions **[15 Hours]**

Cycloaddition reaction, Diels-Alder reaction, analysis by correlation diagrams, FMO approach, Woodward Hoffmann selection rule, Electrocyclic reaction, Sigmatropic reaction, Hydrogen shift, ene reaction,1,3-dipolar additions.

SECTION – II (30 L)

Organic Spectroscopic Methods for Structure Determination

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Students should able to calculate l max of organic compounds. Students should able to correlate IR bands with functional groups using numerical data as well as spectral data.
- Students should able to solve ^{1}H-NMR problems and should also able to draw the ^{1}H-NMR spectrum for simple organic compounds.
- Students should able to use ^{13}C-NMR data to interpret the structure.
- Students should able to solve Problems based on UV, IR, MS, ^{1}H-NMR,^{13}C-NMR

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COURSE OUTCOMES

At the end of this chapter, a student should be able to understand-

CO1: To understand the basic principle of spectroscopic methods.
CO2: To understand the applications of spectroscopic methods.
CO3: Structure elucidation of organic compounds using given spectroscopic data or spectra.

SYLLABUS CH-MJ-522T (Section-II):

Unit-I: UV and IR Spectroscopy [05 Hours]

UV: Principal and terms used in of UV spectroscopy, Calculation of λ_{max} of aromatic compounds. IR spectra of important functional groups 1. With and without conjugation, 2. Ring size effect 3. Effect of H-bonding, 4. Resonance effect, 5. Inductive effect. Problems on IR spectroscopy.

Unit-II: ^{1}H-NMR [10 Hours]

Understanding of basic principle, chemical and magnetic nonequivalence, Homotopism, Enantiotopism, diastereotopism, chemical shifts and factors influencing chemical shift: electronegativity, NMR solvent polarity, temperature, anisotropic effect, chemical shifts of acidic protons, D_2O exchange, Multiplicity patterns and Coupling Constants: Pascal's triangle, Proton ratio, understanding of tree diagram, complex splitting patterns in aromatic, vinylic, saturated monocyclic compounds.

Problems: complex problems based on multiple coupling constants should be discussed and drawing of expected 1H-NMR spectrum along with complex multiplicity patterns and coupling constants. Drawing of multiplicity patterns and determination of coupling constants of complex multiplets should be discussed.

Unit-III: ^{13}C-NMR **[05 Hours]**

Basic of 13C-NMR: Chemical shift and factors affecting chemical shifts in 13C NMR, off resoanance and proton decoupled spectra. Simple problems on ^{13}C-NMR

Unit-IV: Mass spectrometry (MS) **[05 Hours]**

Basic principle of MS, significance of M+ (m/z) in determination of molecular formula, Rule of 13. Genesis of m/z fragments: alkanes (cyclic and acyclic), alcohols, amines, Problems: Based on 2-3 fragments of above-mentioned functional groups should be discussed.

Unit-V: Combined problems **[05 Hours]**

Problems based on UV, IR, MS, ^{1}H-NMR, ^{13}C-NMR should be solved.

ESSENTIAL/RECOMMENDED READINGS:

1. Advanced Organic Chemistry Part A by F. A. Carey and R. J. Sundberg, 5th edition.
2. Organic Reaction Mechanism by V. K. Ahluwalia, 4th edition.
3. Introduction to Spectroscopy by Donald L. Pavia and Gary M. Lampman, 3rd edition.
4. Organic Reaction Mechanism by Morrison Boyd and Bhattacharjee, 7th edition.
5. UV-VIS Spectroscopy and Its Applications by Perkampus, Heinz-Helmut
6. NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry by Harald Günther, 3rd edition.
7. Basic One- and Two-Dimensional NMR Spectroscopy by Horst Friebolin, 3rd edition.
8. Applications of NMR Spectroscopy by Atta-ur-Rahman, M. Iqbal Choudhar
9. Solving Problems with NMR Spectroscopy by Atta-ur-Rahman Muhammad Choudhary Atia-ul-Wahab

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-523T): Coordination and Bio-inorganic Chemistry

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-523T - Coordination and Bio-inorganic Chemistry	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Student should understand Hund's rules for arranging the terms according to energy.
- Student should be able to find out the no. of microstates and meaningful term symbols, construction of microstate table for various configuration, interelectronic repulsion, concept of weak and strong ligand field.
- To draw correlations diagram for various configurations in Td an Oh ligand field.
- They should understand basic d-d transition, d-p mixing, charge transfer spectra, spectro chemical series and Nephelauxetic series.
- Various experimental methods to find out magnetic moment, magnetism and their temperature dependence and quenching of orbital angular momentum.
- They should understand importance and role of bioinorganic chemistry.

SECTION – I
Coordination Chemistry

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Student should able to find out the no of microstates and meaningful term symbols, construction of microstate table for various configuration
CO-2: Hund's rules for arranging the terms according to energy.
CO-3: Student should understand interelectronic repulsion.
CO-4: Student should know the concept of weak and strong ligand field.
CO-5: Student able to find out splitting of the free ion terms in weak ligand field and strong ligand field.
CO-6: To draw correlations diagram for various configurations in Td an Oh ligand field.

CO-7: Student should know basic instrumentation and selection rules and relaxation in rules.
CO-8: Student should know basic d-d transition, d-p mixing, charge transfer spectra.
CO-9: Interpretation of electronic spectra for spin allowed oh and td complexes using Orgel diagram.
CO-10: Understand the concept of Spectro chemical series and Nephelauxetic series.
CO-11: Should able to solve numerical based on crystal field parameters.
CO-12: Understand the various terms involved in magnetochemistry, various phenomena of magnetism and their temperature dependence.
CO-13: Various experimental methods to find out magnetic moment.
CO-14: Understand the various Quenching of orbital angular momentum.

SYLLABUS OF CH-MJ-523T (Section-I):

Unit-I: Concept and Scope of Ligand Fields [07 Hours]

Quantum numbers, Free ion Configuration, Terms and States, Energy levels of transition metal ions, free ion terms, microstates, spin-orbits coupling.

Unit-II: Ligand Field Theory of Coordination Complexes [08 Hours]

Effect of ligand field on energy levels of transition metal ions, weak cubic ligand field effect on Russell- Saunders terms, Orgel diagrams, strong field effect, correlation diagrams, Latimer diagram: Construction of the diagram, non-adjacent species and disproportionation. Frost Diagram: Construction and interpretation.

Unit-III: Electronic spectra of Transition Metal Complexes [08 Hours]

Introduction, band intensities, band energies, band width and shapes, transition metal spectra of 1st, 2ndand 3 rd row ions and complexes, electronic spectra of Lanthanide and Actinide, spectrochemical and nephelauxetic series, charge transfer and luminescence spectra, calculations of Dq, B, β parameters, percentage of covalent character for metal complexes.

Unit-IV Magnetic Properties of Coordination Complexes [07 Hours]

Origin magnetism, types of magnetism, Curie law, Curie-Weiss Law, Magnetic properties of Complexes-Para magnetism, 1^{st} and 2^{nd} Ordered Zeeman effect, quenching of orbital angular momentum by Ligand fields, Magnetic properties of A, E and T ground terms in complexes, spin free and spin paired equilibria, temperature dependence of magnetism.

ESSENTIAL/RECOMMENDED READINGS:

1. Ligand field theory and its applications by B. N. Figgis and M.A. Hitachman, Wiley India Edition
2. Symmetry and spectroscopy of moleculesby K. Veera Reddy, 2^{nd} edition.
3. Elements of Magnetochemistry by R. L. Datta and A. Syamal, 2^{nd} edition.

SECTION – II
Bio-inorganic Chemistry

LEARNING OUTCOMES

At the end of this chapter, a student should be able to understand-

CO-1: Role of metals in Metalloprotein and metalloenzymes.
CO-2: Similarities in coordination theory for metal complexes and metal ions complexed with biological ligands.
CO-3: Importance and transport of metal ions.
CO-4: Passive transport metal ions by ionophores and gramicidin.
CO-5: Mechanism for active transport of Na^+ and K^+
CO-6: Nerve impulse generation in rod cell of retina.
CO-7: Importance and function of Ca, Fe and Mg in metalloprotein
CO-8: Catalytic role of Mn in photosynthesis.

SYLLABUS OF CH-MJ-523T (Section-II):

Unit-I: Overview of Bioinorganic Chemistry [05 Hours]
Introduction, historical Background and current relevance, role of Cu, Fe, Mn and Mo in metalloprotein, and metalloenzymes.

Unit-II: Concepts of Inorganic Chemistry in Bioinorganic Chemistry [10 Hours]
Thermodynamic aspects - HSAB concept, chelate effect and Irving-William series, pKa values of coordinated ligands, Tuning of redox potential, Biopolymer effects. Kinetic aspects- Electron transfer reaction, Reactions of coordinated ligands and Template effect, concept of spontaneous self-assembly model compounds.

Unit-III: Functions and Transport of Alkali and Alkaline Earth Metal Ions [05 Hours]
Importance of alkali and alkaline earth metals, Distribution of cationic and anionic electrolytes in blood plasma and intracellular fluid, Ionophores: Natural and Synthetic, Application of ionophores, Different mechanism involved in exchange of ions across cell wall, Na^+/K^+-ATPase ion pump for active transport of Na^+ and K^+.

Unit-IV: Biochemistry of following: [10 Hours]
(a) Porphyrin based system.
(b) Metal complexes in medicine
(c) Magnesium in Photosystem I
(d) Manganese in Photosystem II
(e) Iron-Sulphur clusters
(f) Ca in Blood coagulation.

ESSENTIAL/RECOMMENDED READINGS:

1. Principle of Bioinorganic Chemistry by S.J. Lippard and J. M. Berg, 1st edition.
2. Chemistry: Inorganic Elements in Chemistry of Life by W. Kaim and B. Schwederski, 2nd edition.

DISCIPLINE SPECIFIC CORE COURSE (CH-MJ-524P): Basic Practical Chemistry-II

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-MJ-524P - Basic Practical Chemistry-II	4	--	4

Section-I: Inorganic Chemistry Practicals (12 Experiments)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Student should be able to perform the synthesis of inorganic complexes with appropriate stoichiometry considerations.
- Student should able to establish the purity of their products by performing suitable titration method
- Student should be able to demonstrate and justify the photoactivity of certain inorganic complexes

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Calculate %yield as well as estimate purity of the synthesized compounds/complexes
CO-2: Demonstrate photoactivity of inorganic complexes using spectrophotometer.
CO-3: Demonstrate strength of complexes based on spectrochemical series.

Part-I: Synthesis of coordination complexes (Ref. 2)

1. Synthesis and Purity of $[Mn(acac)_3]$ **[E]**
2. Synthesis and Purity Chloropentaamminecobalt(III) chloride. **[E]**
3. Synthesis and Purity Nitro pentaamminecobalt(III) chloride. **[E]**
4. Synthesis and Purity Bis[TrisCu(I)thiourea] **[E]**

Part-II: Inorganic Conductometry

5. Structural determination of metal complexes by conductometric measurement. *(Ref-3)* **[E]**

6. To study complex formation between Fe(III) with sulfosalicylic acid by conductometry *(Ref-3).* **[E]**
7. To verify the Debye Huckel theory of ionic conductance for strong electrolytes KCl, $BaCl_2$, K_2SO_4 and $[K_3Fe(CN)_6]$ *(Ref-3)* **[E]**
8. Determination of Pb(II) in solution with Na_2SO_4 solution and determination of solubility product of $PbSO_4$ *(Ref-4)* **[E]**

Part-III: Inorganic characterization techniques

9. Determination of equilibrium constant of M – L systems Fe(III)–Sulphosalicylic acid or Fe(III)–β–resorcilic acid by Job's continuous variation method. *(Ref.-3,5)* **[E]**
10. Solution state preparation of $[Ni(en)_3]S_2O_3$, $[Ni(H2O)_6]Cl_2$, $[Ni(NH_3)_6]Cl_2$. Record absorption spectra in solution of all three complexes and calculate 10 Dq. Arrange three ligands according to their increasing strength depending on your observations. *(Ref-5)* **[E]**
11. Determination of magnetic susceptibility (χg and χm) of mercury tetracyanato cobalt or $Fe(acac)_3$ or Ferrous ammonium sulfate by Faraday or Gouy method. *(Ref. -3, 5)* **[E]**

Part-IV: Inorganic Kinetics Experiment

12. Synthesis and photochemistry of $K_3[Fe(C_2O_4)_3].3H_2O$. *(Ref-4)* **[E]**
13. Kinetics of substitution reaction of $[Fe(Phen)_3]^{2+}$ *(Ref-3)* **[E]**
14. Kinetics of formation of Cr(III)-EDTA complex *(Ref-3)* **[E]**

Part-V: Ion – Exchange Chromatography

15. Separation of mixture of Zn(II) and Mg(II) using Amberlite IRA 400 anion exchanger and quantitative estimation of separated ions Zn(II) and Mg(II). **[E]**
16. Separation of mixture of Zn(II) and Cd(II) using Amberlite IRA 400 anion exchanger and quantitative estimation of separated ions Zn(II) and Cd(II) **[E]**

ESSENTIAL/RECOMMENDED READINGS:

1. Vogel's Textbook of Inorganic quantitative analysis, 5th edition.
2. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999, 1st edition.
3. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
4. General Chemistry Experiments, Anil. J Elias, University press (2002)
5. Ligand Field Theory, B. N. Figgis, 1st edition.

Section -II: Organic Chemistry (12 Experiments)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- This course is designed to make students aware of how to perform organic compounds in laboratory.
- The course includes synthesis of some derivatives and organic compounds, which will help them while working in research laboratory in future.
- Making derivatives of organic compounds will help them in industry or while doing research in medicinal chemistry for Drug development.
- This practical course is also designed to make student aware of green chemistry and role of green chemistry in pollution reduction.
- The students learn how to avoid solvents and do solvent free reaction and also the work-up procedure in many experiments is made more eco-friendly to environment.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: To make students aware of how to perform organic compounds in laboratory.
CO-2: To make student aware of green chemistry and role of green chemistry in pollution reduction.
CO-3: The course includes synthesis of some derivatives and organic compounds, which will help them while working in research laboratory in future

Organic Chemistry (11 Experiments)

Section -II: Organic Chemistry (12 Experiments)

1. Base catalyzed aldol condensation using $LiOH.H_2O$ as a Catalyst. **[E]**
2 Chlorobenzene to 2,4-dintro chlorobenzene **[E]**
3. [4+2] cycloaddition reaction in aqueous medium at room temperature **[E]**
4. Benzil-Benzilic acid rearrangement under solvent free condition **[E]**
5. Clay catalyzed solid state synthesis of 7-hydroxy-4-methylcoumarin **[E]**
6. Ecofriendly nitration of phenols and its derivatives using Calcium nitrate **[E]**
7. Bromination of acetanilide using ceric ammonium nitrate in aqueous medium **[E]**
8. Green approach for preparation of benzopinacolone from bezopinacol using iodine catalyst. **[E]**
9. Preparation of 1, 1-bis-2-naphthol under grinding at room temperature. **[E]**
10. Solvent free aldol condensation between 3,4-dimethoxybenzaldehyde and 1-indanone **[E]**
11. Preparation of azlactone from hippuric acid **[E]**
12. Preparation of thioamide from benzaldehyde in water. **[E]**

Note: Students should perform a) Relevant chemical analysis. b) Column chromatography. c) Elemental analysis. d) Spectroscopic interpretation. e) How to draw schemes and mechanism using Chem Draw / ISIS Draw etc.

1. Use molar concentrations for volumetric /estimations/synthesis experiments.

2. Use optimum concentrations and volumes

3. Two burette method should be used for volumetric analysis (Homogeneous mixtures)

4. Use of microscale technique is recommended wherever possible

ESSENTIAL/RECOMMENDED READINGS:

1. Comprehensive Practical Organic Chemistry by V. K. Ahluwalia and Renu Aggarwal
2. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST)
3. Advanced Practical Organic Chemistry, N. K. Vishnoi, 3rd edition.
4. Systematic Identification of Organic Compounds, 6th edition, R. L. Shriner, R. C. Fusson and D. Y. Cutin, Wiley.

DISCIPLINE SPECIFIC CORE COURSE (CH-ME-525T): Theory Elective-II

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-ME-525T - Theory Elective-II	2	2	--

Elective Option A

CH-ME-525(A)T

Organometallic and Inorganic Reaction Mechanism

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Students should able to understand basic concepts of Organometallic and Inorganic Reaction Mechanism.
- Students should be introduced with interdisciplinary study.
- To get awareness of applied courses of Chemistry.
- To understand detailed study of Organometallic Reactions and Catalysis, Coordination Compounds, Reactions and Mechanism

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: To understand bonding in Organometallic Molecules.
CO-2: To study the organic ligands, Nomenclature and bonding between metal atoms and organic pi system.
CO-3: To understand catalysis: Hydroformylation, Monsanto acetic acid process, Wacker Process, Hydrognation by Willkinsons catalyst.
CO-4: To get information of History and principles, Substitution reactions: Inert and labile complexes, mechanism of substitution. Kinetics Consequences of reaction pathway.

SYLLABUS OF CH-ME-525(A)T:

Unit-I: Introduction to bonding **[02 Hours]**

Types of bonds, Transitions between the main types of Ionic bonds, Covalent bonds, Oxidation, Numbers, Coordinate bonds, Double and triple bonds, Metallic bonds and metallic structure.

Unit-II: Organometallic Chemistry [06 Hours]

Organic ligands and nomenclature, 18 electron rule: counting electrons, ligands having extended pi system, bonding between Metal Atoms and organic pi systems: linear pi system, cyclic pi system, **s**pectral analysis and characterization of organometallic complexes: IR and NMR, examples.

Unit-III: Organometallic Reactions and Catalysis [10 Hours]

Reactions involving gain and loss of ligands: ligand dissociation and substitution, oxidative addition, reductive elimination, nucleophelic displacement, **r**eactions involving modification of ligands: insertion, carbonyl insertion, 1-2 insertion, hydride elimination, abstraction, organometallic catalysis: Hydroformylation, Monsanto acetic acid process, Wacker Process, Hydrognation by Willkinsons catalyst, Olefin metathesis, heterogeneous catalysis: Ziegler Natta Polymerization, Water gas reduction.

Unit-IV: Coordination Compounds: Reactions and Mechanism [12 Hours]

History and principles, Substitution reactions: Inert and labile complexes, mechanism of substitution, Kinetics Consequences of reaction pathway: dissociation, interchange, association, Experimental evidences in Octahedral Substitution: dissociation, linear free energy relationship, associative mechanism, the conjugate base mechanism, the kinetic chelate effect, Stereochemistry of reactions: substitution in trans complexes, substitution in cis complexes, isomerisation of chelate rings, substitution reactions in Sq. Pl. Complexes.

ESSENTIAL/RECOMMENDED READINGS:

1. Inorganic Chemistry: Gary Miessler and Donald A. Tarr, Third Ed., Pearson (Chapter-12, 13 and14 pages: 422 to 561)
2. IUPAC Nomenclature of Organometallic Compounds of Transition Metals by Salzer http://publications.iupac.org/pac/1999/71_08_pdf/7108salzer_1557.pdf

Elective Option B

CH-ME-525(B)T

Nuclear and Radiation Chemistry

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To be able to identify and define various types of nuclear transmutations including fission, fusion and decay reactions.
- To learn the differences and similarities of between a nuclear change and a chemical change.

- Application of first order kinetics to the nuclear decay and understanding the principle of radiochemical dating.
- To learn about various practical applications of radioactivity.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Understand various types and characteristics of nuclear decay.
CO-2: Understand the interaction of radiation with matter.
CO-3: Understand the nuclear fission processes.
CO-4: Understand various practical applications of radioactivity.

SYLLABUS OF CH-ME-525(B)T:

Unit-I: Radioactivity **[06 Hours]**

Types of radioactive decay, general characteristics of radioactive decay, decay kinetics, general expression for the activity of a daughter nuclide, Geiger- Nuttalis law, α-decay: A problem in classical physics, Internal conversion and the Auger effect.

Unit-II: Elements of Radiation **[07 Hours]**

Chemistry: Interaction of radiation with matter, interaction of γ radiation with matter, units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radicals in water radiolysis, Radiolysis of some aqueous solutions.

Unit-III: Nuclear Fission: **[07 Hours]**

The discovery of nuclear fission, the process of nuclear fission, fission fragments and their mass distribution, charge distribution, Ionic charge of fission fragments, fission energy, fission cross-section and threshold, fission neutrons, theory of nuclear fission, Neutron evaporation and spallation.

Unit-IV: Applications of Radioactivity **[10 Hours]**

Typical reaction involved in the preparation of radioisotopes, The Szillard- Chalmers reaction, Radiochemical principles in the use of tracers, Isotopes in elucidating reaction mechanism and structure determination, physic-chemical research - The solubility of a sparingly soluble substances, surface area of a powder or precipitate rates of diffusion, Analytical applications-Isotope dilution analysis, Neutron activation analysis, Radiometric titrations, Medical applications-Thyroiditis, Assessing the volume of blood in a patient, Industrial applications thickness measurements and control, friction and wear out, gamma radiography.

ESSENTIAL/RECOMMENDED READINGS:

1) Elements of Nuclear Chemistry by H. J. Arnikar, 4th edition
2) Source book of atomic energy by S. Glasstone and D. Van, 2nd edition

Elective Option C

CH-ME-525(C)T

Industrial Chemistry

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Students should develop a broad insight regarding the considerations and requirements in chemical industry.
- Students should be able to identify different raw materials used in the chemical industry and understand their characteristics, resources and the concept of integral utilization of materials.
- Students should acquire knowledge about the energy requirements of the chemical industry.
- Students should be able to analyse the manufacturing processes, raw materials, and uses of products in both small scale as well as large scale chemical industries.
- Students should gain an insight into the commercial aspects of initiating a chemical industry.
- Students should analyse case studies of industrial accidents, such as the Bhopal gas tragedy. They should understand the causes of accidents and learn about preventive measures to ensure industrial safety.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Apply the fundamental principles and concepts of industrial chemistry to analyse and understand problems related to chemical processes, reactor design, raw material selection, energy utilization, and safety protocols.
CO-2: Develop the ability to evaluate and design chemical processes in various industrial sectors.
CO-3: Aassess the efficiency, yield, and selectivity of industrial reactions, optimize process conditions, and incorporate principles of sustainability and waste reduction.
CO-4: Understand industrial safety practices and regulations. They will be able to identify potential hazards, assess risks and the need for implementing appropriate safety measures.

SYLLABUS OF CH-ME-525(C)T: **(30 L)**

Unit-I: Principles of Chemical Technology [06 Hours]

Introduction, basic principles of chemical technology, importance of chemical technology, classification of technological process, designing and modeling of chemical plants, unit process and unit operations. Basic requirements of industrial reactors, choice and selectivity of reactor,

basic principles of homogeneous and heterogeneous processes and reactors with examples.

Unit-II: Raw Materials and Energy for Chemical Industry [06 Hours]

Raw materials, Characteristics of raw materials and their resources, methods of raw material concentration, integral utilization of raw materials. Energy for chemical industry, power and fuels, classification of fuels, coal, fuel gases and liquid fuels, petroleum, cracking, chemical corrosion, types of corrosion and preventive measures.

Unit-III: Small Scale Chemical Industries [06 Hours]

Electro-thermal and electro-chemical industries: electroplating, surface coating industries, oils, fats and waxes, soaps and detergents, cosmetics. Match industries and Fire Works: Manufacture of some industrially important chemicals like potassium chlorate, potassium nitrate, barium nitrate and red phosphorous, metal powders.

Unit-IV: Large Scale Chemical Industries [06 Hours]

Manufacturing process, raw materials, composition and uses of products in Portland cement, ceramics, plastics, synthetic fibers, synthetic rubber, fertilizers, insecticides and pesticides, photo film industries, commercial aspects of starting an industry

Unit-V: Industrial Safety [06 Hours]

Safety signs and colours used in industries – Industrial Hazards and Accidents – Classification of Hazards, Physical, chemical Biological, Ergonomic and stress Hazards, Causes, prevention and control, case study on industrial accidents, Bhopal gas Tragedy, Heat stress, sources and control, Noise pollution in industry, sources and control.

ESSENTIAL/RECOMMENDED READINGS:

1. Mukhlynov (ed.), Chemical Technology, Vol.1, Mir Publication, Moscow, III edn., 1979.
2. A. K. De, Environmental Chemistry, Wiley Eastern Ltd., II edn., Meerut 1989, Chs, 5 – 7. *Placed at the meeting of Academic Council held on 26.03.2018* 17
3. R.K. Goel, Process know-how and material of construction for Chemical Industries, S.B. Publ., Delhi, 1977.
4. B.N. Chakrabarthy, Industrial Chemistry, Oxford and IBH Publ., Now Delhi, 1984.
5. R. Norris Shreve and J.A. Brink, Jr. Chemical Process Industries, IV edn., McGraw Hill, Tokyo, 1977.
6. Industrial Safety and Environment – A.K. Gupta – University Science press, New Delhi.

DISCIPLINE SPECIFIC CORE COURSE (CH-ME-526P): Practical Elective-II

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
CH-ME-526P - Practical Elective-II	2	--	2

Elective Option A

CH-ME-526(A)P

Electrochemical Methods of Analysis (Any 12 Experiments)

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- Understand how experiments are designed and executed with or without the help of certain instruments.
- Understanding of the basic working principle of instruments.
- Experimental data interpretation, data plotting and data analysis.

LEARNING OUTCOMES

At the end of this chapter, a student should be able to-

CO-1: Know the concept of hypothesizing and hence perform the experiment accordingly.
CO-2: Do molarity calculations, dilution calculations and prepare solutions of given concentrations.
CO-3: Realise the need for doing calibration and standardisation wherever and whenever necessary while performing experiments.
CO-4: Do graphical presentation and interpretation of experimental data.

PRACTICALS for CH-ME-526(A)P:

Part-I: Conductometry: (Any three)
1. Hydrolysis of NH4Cl or CH3COONa or aniline hydrochloride. **[E]**
2. Determination of λ_0 or λ_α and dissociation constant of acetic acid. **[E]**
3. Hydrolysis of ethyl acetate by NaOH. **[E]**
4. Determination of ΔG, ΔH, and ΔS of silver benzoate by conductometry. **[E]**
5. Determination of critical micellar concentration (CMC) and ΔG of micellization of sodium Lauryl Sulphate / Detergent **[E]**

Part-II: Polarography (any one)
6. Determination of half wave potential $E_{1/2}$ and unknown concentration of Cu/Pb or Zn ion. **[E]**

7. Amperometric titration of $Pb(NO_3)_2$ with $K_2Cr_2O_7$. **[E]**

Part-III: Potentiomerty: (Any three)
8. Stability Constant of a complex ion. **[E]**
9. Solubility of a sparingly soluble salt. **[E]**
10. To determine the ionic product of H2O **[E]**
11. Estimation of halide in mixture. **[E]**
12. To determine the vitamin C concentration in fruit juice or medicinal tablets. **[E]**

Part-IV: pH metry (any two**)**
13. Determination of the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid. **[E]**
14. Determination of dissociation constants of tribasic acid (phospheric acid) **[E]**
15. Construct pH curve for titration of strong base – strong acid, strong base - weak acid and predict the best indicator in these titrations (methyl orange, methyl orange, brocresol green, phenolphthalein, etc.) **[E]**

Part-V: Table Work (any two)
16. Analysis of powder XRD of $SrTiO_3$ and Ag metal or any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data)**[E]**
17. Cyclic voltamogram of $K_3Fe(CN)_6$ in KCl/H2O/Ferrocene in TEAP//MeCN **[E]**
18. Detailed interpretation of Raman spectra of diatomic molecules **[E]**

ESSENTIAL/RECOMMENDED READINGS:

1. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.), 1st edition.
2. Experiments in Physical Chemistry, J. M. Wilson, K.J. Newcombe, A. R. Denko. R.M.W.
1. Richett (Pergamon Press), 2nd edition.
2. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.), 4th edition.
3. Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003.
4. Physical chemistry by Wien (2001)
5. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut), 6th edition.
6. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House, 2nd edition.
7. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books ents in Al.

Elective Option B

CH-ME-526(B)P

Chemical Biology-II Practicals

PRACTICALS CH-ME-526(B)P:

Perform at least 11 Practical

1. Dialysis and Reverse dialysis of protein salt solution **[E]**
2. Separation of protein by Gel filtration method **[E]**
3. Separation of protein by affinity chromatography method **[E]**
4. Separation of protein by Ion exchange chromatography **[E]**
5. Native and SDS PAGE of proteins **[E]**
6. Separation of amino acids by paper chromatography **[E]**
7. Separation of nucleic acid by Agarose gel electrophoresis **[E]**
8. Effect of pH on enzyme activity **[E]**
9. Effect of Temperature on enzyme activity **[E]**
10. Effect of substrate concentration on enzyme activity **[E]**
11. Detection of λ Max of proteins **[E]**
12. Detection of λ Max of Nucleic acid **[E]**

ESSENTIAL/RECOMMENDED READINGS:

1. A reference book of Biochemistry Practicals by Sadashivam.
2. Practical approach to biochemistry by Plummer.
3. Martin Holtzhauer, Basic Methods for the Biochemical Lab, First Edition, Springer.