Parvatibai Chowgule College of Arts and Science
(Autonomous)

DEPARTMENT OF CHEMISTRY
COURSE STRUCTURE 2019 - 2020
THREE YEAR B.Sc. DEGREE COURSE IN CHEMISTRY

PROGRAMME OUTCOMES

Programme Outcomes (PO)	Short Title of the POs	Description of the Programme Outcomes Graduates will be able to :
PO-1	Problem Analysis and Solutions	Think critically, identify, analyze problems/ situations and further attempt to design/ develop solutions that meet the specified goals.
PO-2	Use of Technology	Apply appropriate IT tools efficiently in their daily activities of communication and academics.
PO-3	Environment and Sustainability	Analyze and attempt solutions to environmental issues and commit themselves to sustainable development in the local/ national and global context.
PO-4	Ethics	Recognize and understand professional ethics /human values and be responsible for the same.
PO-5	Individual and Team work	Function effectively at various levels, capacities and situations.
PO-6	Communication	Communicate proficiently (oral and written) as a responsible member of society.
PO-7	Research Aptitude	Understand general research methods and be able to analyse, interpret and derive rational conclusions.
PO-8	Life Skills	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of domain specific change.

PROGRAMME SPECIFIC OUTCOMES (PSO)

On Successful completion of the BSc Chemistry programme, the students will be able to

PSO-1	Acquire the skills in preparation of chemical solutions, inorganic complexes, planning the procedures and performing experiments in the laboratory.
PSO-2	Handle scientific instruments like spectrophotometer, pH meter, Conductometer, Potentiometer, etc.
PSO-3	Develop basic theoretical principles of chemistry and writing skills applicable for higher studies and research
PSO-4	Operate efficiently within a group during their project and assignments and hence develop important skills such as communication, negotiation, influence, advising and interpreting
PSO-5	Appreciate the central role of chemistry in our society by understanding the safe handling of chemicals, environmental issues and key issues faced in energy, health and medicine.
PSO-6	Elucidate various spectra, X Ray Diffractograms, TG-DTA curves and identify surface morphology by SEM/TEM images.

COURSE OUTCOMES

On successful completion of the course, the student will be able to

	Course Code	Course Title	Course Outcomes
1.	CHE-I.C-1	General Physical and Inorganic Chemistry	**CO1 :** Demonstrate and evaluate the rate and order of a reaction. **CO2 :** Utilize mathematical concepts to solve chemical problems. **CO3 :** Develop expertise in the preparation of chemical solutions based on normality, molarity and molality. **CO4 :** Interpret the PV isotherms of gases and identify the critical temperature. **CO5 :** Delineate atomic structure, periodic table and covalent bonding. **CO6 :** Sketch hybridization and molecular orbital diagrams.
2.	CHE-I.C-2	General Organic and Inorganic Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Name the organic compounds using IUPAC nomenclature. **CO2 :** Identify and classify the different organic reactions. **CO3 :** Apply the theoretical knowledge to synthesize alkanes and alkenes. **CO4 :** Write 3D structures of organic molecules using 2D surface. **CO5 :** Identify the given unknown organic compound by carrying out various chemical tests.
3.	CHE-II.C-3	Concepts in Physical and Analytical Chemistry	On successful completion of the course, the student will be able to: **CO1:** Describe the basic concepts of thermodynamics and its applications. **CO2 :** Interpret the pressure temperature diagrams in unary and binary systems. **CO3 :** Explain the concept of surface tension and viscosity in liquids. **CO4 :** Explain role of analytical chemistry in sciences, calculations based on chemical stoichiometry. **CO5 :** Sketch titration curves and solve numericals. **CO6 :** Explain theory on precipitation and complex formation titrations.
4.	CHE-II.C-4	Concepts in Organic and Inorganic chemistry	On successful completion of the course, the student will be able to: **CO1 :** Categorize the compounds as aromatic, non-aromatic and anti-aromatic. **CO2 :** Apply the theoretical knowledge to write the synthesis of alkynes, alkyl halides, aromatic compounds. **CO3 :** Discuss and describe the steps involved

			in the mechanism of nitration, sulphonation, halogenation and Friedel Crafts reactions of aromatic compounds. **CO4 :** Explain and outline the different properties of transition elements. **CO5 :** Compare 4d and 5d analogues. **CO6 :** Describe crystalline solids in terms of their structure, ionic radii and coordination. **CO7 :** Interpret crystal structures. **CO8 :** Describe lattice energy, Born-Haber's cycle, Fajan's rule and defects in solids. **CO9 :** Explain trends in periodic properties of d-block elements with respect to their ionic radii, oxidation state, spectral properties, magnetic properties. **CO10 :** Describe crystalline solids in terms of their structure, ionic radii and coordination there by able to interpret crystal structure.
5.	CHE-III.C-5	Comprehensive Chemistry-I (Physical & Inorganic Chemistry)	On successful completion of the course, the student will be able to: **CO1 :** Understand Second and Third law of Thermodynamics **CO2 :**Calculate equilibrium constant and formulate conditions for maximum yield in industrial processes **CO3 :** Explain theory of strong and weak electrolytes. **CO4 :** Explain trends in periodic properties of f-block elements with respect to its size of atoms or ions, reactivity, oxidation state, complex formation, colour, magnetic properties. **CO5 :** Name coordination compounds and to able to draw the structure based on its name. **CO6 :** Describe the shape and structures of coordination complexes based on different coordination numbers. **CO7 :** Explain merits and demerits of different theories of acids and bases and to explain the properties of a solvent that determines their utility.
6.	CHE-IV.C-6	Comprehensive Chemistry-II (Organic & Analytical Chemistry)	On successful completion of the course, the student will be able to: **CO1 :** Identify and classify diverse organic compounds containing C, H and O elements. **CO2 :** Predict the chemical reactivities of several organic compounds containing CHO elements. **CO3 :** Outline the preparations of several compounds belonging to different classes of organic compounds having CHO elements. **CO4 :** Apply the important reactions involved in each class of organic compounds with CHO elements. **CO5 :** Design scheme for an analytical process. **CO6 :** Use proper techniques of sampling of

			solids, liquids & gases. **CO7 :** Apply statistical treatment to analytical data.
7.	CHE-V.C-7	Advanced Chemistry-I: Physical and Inorganic Chemistry	On successful completion of the course, the student will be able to: **CO1:** Understand the interactions of electromagnetic radiation and matter in IR and Raman spectroscopy and their applications. **CO2 :** Explain applications and harmful effects of nuclear radioisotopes. **CO3 :** Demonstrate a sound knowledge of the photochemistry principles and their application. **CO4 :** Employ the theories that govern metal ligand bonding. **CO5 :** Interpret the types of crystal field splitting and calculate the crystal field stabilization energy. **CO6 :** Discuss the types of d-d transitions and its theory.
8.	CHE-VI.C-8	Advanced Chemistry-II: Organic and Analytical chemistry	On successful completion of the course, the student will be able to: **CO1 :** Assess conditions for obtaining maximum efficiency of extraction. **CO2 :** Classify chromatographic methods. **CO3 :** Apply chromatographic method for separation, qualitative and quantitative estimation. **CO4 :** Predict the stereochemistry of products for various reactions using the mechanisms involved in the course. **CO5 :** Explain the reactivity of organic compounds containing nitro, amino and cyano functional groups. **CO6 :** Name and classify the carbohydrates and analyze its chemical reactivities. **CO7 :** Name and classify the organosulfur and organophosphorous compounds and analyze its chemical reactivities. **CO8 :** Apply the important reactions involved for the synthesis of other similar compounds.
9.	CHE-III.E-1	Name Reactions and Synthetic Methodologies	On successful completion of the course, the student will be able to: **CO1 :** Describe condensation reactions involving nucleophilic addition to carbonyl compounds. **CO2 :** Define and describe various name reactions and rearrangements along with their mechanisms. **CO3 :** Predict the product for various reactions involving these name reactions/rearrangements. **CO4 :** Apply these mechanisms towards the formation of complex molecules. **CO5 :** Discuss and describe the steps involved

			in the mechanism of Friedel-Crafts reactions, Reimer-Tiemann reaction, Vilsmeier-Haack reaction, Gattermann-Koch reaction and Kolbe-Schmidt reaction. **CO6 :** List the different oxidising and reducing agents. **CO7 :** Apply the theoretical knowledge to identify the reagents used to bring about a particular chemical reaction.
10.	CHE-III.E-3	Surface Chemistry and Catalysis	**Course Objectives:** On successful completion of the course, the student will be able to: **CO1 :** Understand the behavior of solid surfaces. **CO2 :** Differentiate between surface energy and surface tension in case of solids. **CO3 :** Classify and interpret various types of adsorption isotherms. **CO4 :** Estimate surface area of a solid. **CO5 :** Predict the mechanistic behavior of catalytic reactions. **CO6 :** Evaluate conditions under which a catalysed reaction changes rate dependence.
11.	CHE-III.E-4	Bioinorganic Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Elucidate the role of metal ions that are involved in different processes like oxygen transport, electron-transfer reactions etc. in biological systems. **CO2 :** Apply the concepts of coordination chemistry to metallobiomolecules which are based on iron and copper ions. **CO3 :** Evaluate the role of metal centres in the metalloenzymes that are involved in the catalysis of various biological reactions and thus predict the reaction mechanisms. **CO4 :** Develop skills to prepare model systems which mimic the role of metal ions in biological systems. **CO5 :** Discuss the importance of essential and trace elements in biological processes and evaluate their role in biology. **CO6 :** Explain the biologically important compounds like proteins, carbohydrates etc. and to interpret their biological importance. **CO7 :** Compare different mechanisms of ion transport across cell membrane and classify different biomolecules which help in the transport of ions and to illustrate PS-I and PS-II approach of photosynthesis. **CO8 :** Analyze how metals are used as diagnostic agents and application of Au, Cu, Zn, Pt-complexes as anti-cancer drug and in medicine.
12.	CHE-IV.E-5	Pharmaceutical	On successful completion of the course, the

		Chemistry	student will be able to: **CO1 :** Understand the significance of chemistry in Pharmaceutical chemistry. **CO2 :** Develop an understanding of the physico-chemical properties of drugs. **CO3 :** Explain molecular mechanism of drug action and metabolism. **CO4 :** Draw comparison between medicinal chemistry and pharmaceutical chemistry. **CO5 :** Synthesize some of the important drugs reported in literature. **CO6 :** Identify and define the drug classes and some pharmacological properties.
13.	CHE-IV.E-6	Polymer and Colloid Science	On successful completion of the course, the student will be able to: **CO1 :** Distinguish between different types of solutions in terms of solute dimensions. **CO2 :** Evaluate properties of colloids. **CO3 :**.Explain properties of gels and emulsions. **CO4 :** Calculate molecular weight of a polymer. **CO5 :** Design synthesis of a polymer. **CO6 :** Measure molecular weight of a polymer. **CO7 :** Understand solid state properties of polymers.
14.	CHE-IV.E-7	Spectroscopic Techniques	On successful completion of the course, the student will be able to: **CO1 :** Outline and interpret the deviation from Beer-Lambert's Law and to identify the validity and limitations. **CO2:** Interpret the spectroscopic methods for qualitative and quantitative analysis; discuss the principle instrumentation; compare the Colorimeter and Spectrophotometer and employ UV-Visible Spectrophotometer. **CO3:** Outline the principle on which inductively coupled plasma spectroscopy works and illustrate the instrumentation involved in the technique. **CO4:** Employ inductively coupled plasma spectroscopy technique and identify its limitations.
15.	CHE-V.E-9	Heterocyclic Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Identify, name and classify the various heterocyclic compounds. **CO2 :** Describe the structure, different reactions and preparations of selected nitrogen and oxygen containing aliphatic heterocycles. **CO3 :** Describe the structure, diverse reactions and syntheses of pyrrole, furan, thiophene and pyridine heterocycles. **CO4 :** Describe the structure, diverse reactions and synthetic routes with mechanisms of numerous condensed heterocycles. **CO5 :** Predict the reactivities of complex

			heterocyclic compounds containing the structural motif of these simple heterocycles. **CO6 :** Apply the synthetic methodologies for the synthesis of complex heterocycles.
16.	CHE-V.E-10	Nanomaterials and Solid State Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Recall the history, occurrence and technological development of nanomaterials and classify them. **CO2 :** Compare different synthesis techniques of nanoparticles like biological, chemical and physical and design various nanomaterials. **CO3 :** Evaluate XRD data, and calculate its parameters; carry out analysis of TG-DTA curves; assess morphology and particle size from SEM/TEM images. **CO4 :** Express the physical and chemical properties of solids like magnetic, electrical and dielectric and interpret the applications of materials in various field like catalysis, ferrofluids, etc.
17.	CHE-V.E-11	Organometallic Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Illustrate metal-ligand interaction in formation of different metal carbonyls based on valence bond theory. **CO2 :** Explain and rationalize the synthesis, structure, bonding, properties of organometallic compounds of main group elements. **CO3 :** Apply the EAN concept and Wade's rules to any organometallic system and predict its stability, structure and bonding. **CO4 :** Understand the chemical behavior and predict the reaction mechanism of organometallic compounds. **CO5 :** Illustrate the catalytic cycles using an organometallic compound as a catalyst for industrial synthesis of some organic compounds. **CO6 :** Interpret IR spectra of metal carbonyls and predict their structure.
18.	CHE-VI.E-13	Spectroscopic Methods in Organic Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Describe the principles of IR, UV and Mass spectroscopy. **CO2 :** Calculate UV maxima of any given organic compound using Woodward-Fieser rules. **CO3 :** Predict the presence of various functional groups in a given organic compound using IR spectroscopy. **CO4 :** Interpret the mass spectra of various organic compounds. **CO5 :** predict the structures of organic

			compounds based on the given ^{1}H NMR and ^{13}CMR data. **CO6 :** interpret the ^{1}H NMR and ^{13}CMR spectra of organic compounds.
19.	CHE-VI.E-14	Environmental Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Delineate how pollutants are transported and accumulated in the environment. **CO2 :** Recognize different types of toxic substances and analyze toxicology. **CO3 :** Describe water purification and waste treatment processes. **CO4 :** Apply knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil. **CO5 :** Apply basic chemical concepts to analyze chemical processes involved in different environmental problems. **CO6 :** Develop skills in procedures and few instrumental methods applied in analysis of soil and water pollution.
20.	CHE-VI.E-15	Selected Topics in Inorganic Chemistry	On successful completion of the course, the student will be able to: **CO1 :** Differentiate between thermodynamic stability and kinetic stability and apply it to transition metal complexes. **CO2 :** Apply the concepts to determine the reaction mechanism of transition metal complexes. **CO3 :** Determine the factors that govern the stability and lability of transition metal complexes. **CO4 :** Illustrate the chemistry and function of some of the technologically useful materials like liquid crystals, superconductors and fullerides. **CO5 :** Understand the properties and classify the polymers **CO6 :** Explain the preparation, structure and bonding and applications of polymers comprising of B, P, Si and S. **CO7 :** Analyze the magnetic properties of the transition metal complexes as well as interpret the effect of temperature on magnetic properties. **CO8 :** Determine the magnetic susceptibility by using Guoy's balance. **CO9 :** Identify and apply the symmetry elements in molecules and to evaluate the Point groups in molecules with appropriate examples.

COURSE STRUCTURE

SEMESTER	CORE COURSES		ELECTIVE COURSES			
I	CHE-I. C-1 General Physical and Inorganic Chemistry	CHE-I. C-2 General Organic and Inorganic Chemistry	---	---	---	---
II	CHE-II. C-3 Concepts in Physical and Analytical Chemistry	CHE-II. C-4 Concepts in Organic and Inorganic Chemistry	---	---	---	---
III	CHE-III. C-5 Comprehensive Chemistry –I (Physical & Inorganic Chemistry)	---	CHE-III. E-1 Name Reactions and Synthetic Methodologies	CHE-III. E-2 Industrial Chemistry	CHE-III. E-3 Surface Chemistry and Catalysis	CHE-III. E-4 Bioinorganic Chemistry
IV	CHE-IV. C-6 Comprehensive Chemistry –II (Organic and Analytical chemistry)	---	CHE-IV. E-5 Pharmaceutical Chemistry	CHE-IV. E-6 Polymer and Colloid Science	CHE-IV. E-7 Spectroscopic Techniques	CHE-IV. E-8 Chemistry of Natural Products
V	CHE-V. C-7 Advanced Chemistry – I (Physical & Inorganic Chemistry)	---	CHE-V. E-9 Heterocyclic Chemistry	CHE-V. E-10 Nanomaterials and Solid State Chemistry	CHE-V. E-11 Organometallic Chemistry	---
VI	CHE-VI. C-8 Advanced Chemistry – II (Organic and Analytical chemistry)	---	CHE-VI. E-13 Spectroscopic Methods in Organic Chemistry	CHE-VI. E-14 Environmental Chemistry	CHE-VI. E-15 Selected Topics in Inorganic Chemistry	---

SYLLABUS OF THE FOLLOWING UNDERGRADUATE COURSES :

SEMESTER- I

CORE COMPULSORY MAJOR PAPER

THEORY
Paper Title: General Physical and Inorganic Chemistry + Laboratory Course-1
Paper Code: CHE- I. C-1
Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
CO1 : Demonstrate and evaluate the rate and order of a reaction.
CO2 : Utilize mathematical concepts to solve chemical problems.
CO3 : Develop expertise in the preparation of chemical solutions based on normality, molarity and molality.
CO4 : Interpret the PV isotherms of gases and identify the critical temperature.
CO5 : Delineate atomic structure, periodic table and covalent bonding.
CO6 : Sketch hybridization and molecular orbital diagrams.

Learning outcome:
1. Will have a working knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. Will help to get better understanding about the basics of Physical and Inorganic Chemistry.
3. Will be able to carry out experiments with required skills.

SECTION- I (PHYSICAL CHEMISTRY)

1. Mathematical Preparations for Chemists **06 L**
Logarithmic relations curve sketching: linear graphs, and calculation of slopes. Differentiation of functions: Kx, e^x (exponential), sin x, log x, maxima and minima. Integration of some useful functions.

2. Chemical Kinetics **08 L**
Rate of reaction, factors influencing rate of the reaction- concentration, temperature, pressure, solvent, light, catalyst. Concentration dependence of rates. Zero, first, second order kinetics. Half life and average life. Determination of order of reaction: Integrated rate equation method, graphical method, differential method, half-life method and isolation method. Effect of temperature on the rate of the reaction, Arrhenius equation and concept of activation energy.
(Numerical expected)

3. Solid State **08 L**
Introduction, difference between crystalline and amorphous solids, laws of crystallography: law of constancy of interfacial angles, law of symmetry and law of rationality of indices, Symmetry and crystal systems, elements of symmetry, introduction to point groups, lattice and unit cells, The Bravais lattices, the seven crystal systems, Miller and Weiss indices. Bragg's equation, Inter planar distance.
(Numerical expected)

4. Gaseous State **08 L**
Gas laws (to introduce), Ideal gas equation, compressibility factor, PV isotherms of real gases. kinetic molecular theory of gases, its postulates and derivation of kinetic gas equation. the van der Waal's equation of state. Berthelot Equation (derivation not expected). qualitative discussion of the Maxwell's distribution of molecular velocities. Critical phenomena: relationship between critical constants and van der Waal's constants, the law of corresponding states and reduced equation of state, Joule-Thomson effect . Liquefaction of gases
(Numerical expected)

SECTION- II (INORGANIC CHEMISTRY)

1. Atomic Structure and the Periodic Table **05 L**

Atomic spectra of hydrogen, Bohr©s model of hydrogen atom, probability picture of electron, dual nature of electrons, Heisenberg uncertainty principle, Schrodinger wave equation, quantum numbers, shapes of s, p, d, orbitals, Aufbau and Pauli exclusion principles, Hund's rule of maximum multiplicity, sequence of energy levels and arrangement of elements in groups in the periodic table, periodic trends and effective nuclear charge.

2. Covalent Bonding **10 L**

Covalent bond: Valence Bond Theory (VBT) and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, Valence Shell Electron Pair Repulsion Theory (VSEPR) applied to NH_3, H_3O^+, SF_4, ClF_3, ICl_2^- and H_2O, Molecular Orbital Theory, homonuclear and heteronuclear diatomic molecules(CO and NO), multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

PRACTICALS
Paper Title: General Physical and Inorganic Chemistry + Laboratory Course-1
Paper Code: CHE- I. C-1
Marks: 25
Credits: 1

List of experiments:
PHYSICAL CHEMISTRY

1. Preparation of standard solutions based on normality, molarity, molality. Also further dilutions from a standard solution to a volume of 50 mL.
2. To investigate the order of the reaction between $K_2S_2O_8$ and KI using equal initial concentrations of both the reactants.
3. To study hydrolysis of Methyl acetate using two different initial concentrations in presence of mineral acid **(**HCl) as catalyst
4. To determine the relative strength of two acids i.e. HCl and H_2SO_4 by using them as catalysts for the hydrolysis of methyl acetate.
5. To study the solubility of benzoic acid at room and below room temperature by volumetric method.

INORGANIC CHEMISTRY

1. Preparation of standard 0.1M $K_2Cr_2O_7$ solution and carry out the dilution to 0.05, 0.01, 0.001 M in 50 mL standard volumetric flask
2. To prepare 100 ppm of Manganese solution using $KMnO_4$ and carry out the further dilutions like 5, 10, 20 ppm in 50 mL standard volumetric flasks
3. To prepare 0.1 N $Na_2C_2O_4$ solution and use it to standardize the given $KMnO_4$ solution.

CORE COMPULSORY MAJOR PAPER

THEORY
Paper Title: General Organic and Inorganic Chemistry + Laboratory Course-2
Paper Code: CHE-I. C-2
Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Name the organic compounds using IUPAC nomenclature.
CO2 : Identify and classify the different organic reactions.

CO3 : Apply the theoretical knowledge to synthesize alkanes and alkenes.
CO4 : Write 3D structures of organic molecules using 2D surface.
CO5 : Identify the given unknown organic compound by carrying out various chemical tests.

Learning outcome:

1. Students will learn about the basic concepts in Organic Chemistry like the hybridisation in organic molecules, molecular interaction.
2. Students will briefly learn about the types of reaction, reactive intermediates and reaction mechanism in organic chemistry.
3. Students will learn how to name different classes of organic compounds using IUPAC nomenclature.
4. Students will learn how to represent 3 D of organic molecule on 2 D surfaces. Also how the orientation of a molecule in space can give a compound different reactivity.
5. Students will learn two important classes of organic compounds like alkanes and alkenes.
6. Develop skills to carry out related experiments.

SECTION- I (ORGANIC CHEMISTRY)

1. IUPAC Nomenclature of Organic Compounds 02 L

Basic rules of IUPAC nomenclature, nomenclature of the compounds- alkanes, cycloalkanes, alkenes, alkynes, haloalkanes, acids, alcohols, ethers, aldehydes, ketones, nitriles, acid halides, esters, anhydrides, amides.

Nomenclature of aromatic compounds, mono and di substituted benzene with two functional groups, bridged cycloalkanes.

2. Structural Theories and Reactivities of Organic Compounds 10 L

Bond formation in organic compounds; sp sp^2, sp^3 with respect to methane, ethene and acetylene (hybridisation concept), discussion on shape, bond length, bond angles of organic molecules.

Polar covalent bonds, electronegativity and bond dipoles in organic molecules, introduction and examples of Van der Waal's forces, inductive effect, field effect, hyperconjugation and resonance, hydrogen bonding.

Curved arrows in organic chemistry, homolytic and heterolytic bond breaking, types of reagents, electrophiles and nucleophiles, types of organic reactions: addition, elimination, substitution, oxidation, reduction and rearrangement with examples. Introduction to reactive intermediates: carbocations, carbanions, free radicals, carbenes, arynes and nitrenes with shape, stabilities, methods of formation and reaction. Methods of determination of reaction mechanisms: Determination of structure, intermediates, isotope effects, kinetic and stereochemical studies.

3. Stereochemistry 08 L

Isomerism, types of isomers: constitutional, conformational and configurational isomerism. Chirality, chiral centre, enantiomers and diastereomers (with example of threo and erythro diastereomers, meso compounds). Representation of configuration by- 3D Projection (Wedge and dotted projection), Fischer projection, Newmann projection and Saw horse projection. R/S configuration (Can-Ingold-Prelog sequence rules to be exlained). E/Z nomenclature.

4. Study of alkanes, cycloalkanes and alkenes 10 L

Alkanes and Cycloalkanes**:** Physical properties of alkanes and cycloalkanes, sources of alkanes and cycloalkanes, chemical properties: combustion and pyrolysis of alkanes, methods of preparation: Corey-House reaction, Wurtz reaction.

Alkenes: Physical properties and relative stabilities of alkenes, preparation of alkenes, elimination reactions, dehydration of alcohols, regioselectivity in alcohol dehydration: The Zaitsev rule, rearrangement in alcohol dehydration, dehydrohalogenation: E1 and E2 mechanisms, reactions of alkenes: hydrogenation, addition of halides and hydrogen halides, regioselectivity of hydrogen halide addition, hydroboration and oxidation reactions, oxymercuration- demercuration reactions, epoxidation of alkenes, ozonolysis of alkenes.

SECTION- II (INORGANIC CHEMISTRY)

1. Chemistry of s- block elements **05 L**

General properties, comparative study within groups, diagonal relationship, salient features of hydrides, solvation and complexation tendencies and biological importance, introduction to alkyls and aryls

2. Chemistry of p- block Elements **10 L**

Comparative study within group and diagonal relationship of groups 13, 14, 15, 16, 17, Hydrides of Boron, diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), phosphazenes, tetra sulfur tetranitride, basic properties of halogens, inter halogens and polyhalides.

PRACTICALS
Paper Title: General Organic and Inorganic Chemistry + Laboratory Course-2
Paper Code: CHE- I. C-2
Marks: 25
Credits: 1

List of experiments:
ORGANIC CHEMISTRY

1. Purification techniques for organic solid compounds
   A. **Crystallization:** a. Benzoic acid from water
      b. m-Dinitrobenzene from ethanol
   B. **Sublimations:** a. Naphthalene b. Anthracene c. Camphor (**Any 2**)
2. **Organic synthesis:** a. Benzoylation of -naphthol and aniline. (**Any 2**)
   b. Bromination of aromatic compounds using $KBrO_3$
   c. Anthraquinone from anthracene (Oxidation reaction)
3. **Qualitative Analysis (Solids) (Any 4)**
   Acids: Benzoic, salicylic, phthalic
   Phenols: α-Naphthol, β-naphthol
   Bases: p-Toluidine, diphenylamine, o-, m- and p-nitroanilines
   Anilides: Acetanilide, benzanilide
   Hydrocarbons: Naphthalene, anthracene
   Amides: Benzamide, urea
   Haloarenes: p-Dichlorobenzene
   Nitro Compounds: m-Dinitrobenzene, p-nitrotoluene
   Carbohydrates: Glucose, fructose, mannose

INORGANIC CHEMISTRY

1. To prepare 0.001 M EDTA and separately estimate the amount of Zn^{2+} ion from $ZnCO_3$, Mg^{2+} ion from MgO.
2. Volumetric estimation of Fe^{2+} using internal indicator by potassium dichromate method
3. Determination of alkali content in antacid tablet using Standard HCl solution

SEMESTER- II

CORE COMPULSORY MAJOR PAPER

THEORY
Paper Title: Concepts in Physical and Analytical Chemistry + Laboratory Course-3
Paper Code: CHE-II. C-3
Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Describe the basic concepts of thermodynamics and its applications.
CO2 : Interpret the pressure temperature diagrams in unary and binary systems.
CO3 : Explain the concept of surface tension and viscosity in liquids.
CO4 : Explain role of analytical chemistry in sciences, stoichiometric calculations and apply for numerical.
CO5 : Sketch titration curves and solve numerical.
CO6 : Explain theory on precipitation and complex formation titrations.

Learning Outcome:
1. Will have knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. Will be able to understand the principles of titrimetric methods.
3. Attain practical skills.

SECTION- I (PHYSICAL CHEMISTRY)

1. Thermodynamics **10 L**

Thermodynamic terms: system, surrounding, types of systems, intensive and extensive properties, State and path functions and their differentials, Thermodynamic process, Concept of work and heat, First law of thermodynamics: Definition and statements of internal energy and enthalpy, Heat capacities at constant volume and pressure and their relationships, Joule's law, Joule Thomson coefficient and inversion temperature, Calculation of w, q, dU, dH, for the expansion of ideal gases under isothermal and adiabatic conditions for reversible processes Thermochemistry: Standard state, standard enthalpy of formation, Hess's law of heat summation and its applications, Heat of reaction at constant pressure and at constant volume, Enthalpy of neutralisation, bond dissociation energy and its calculation from thermodynamical data, Temperature dependence of enthalpy, Kirchoff's equation. (Numerical expected)

2. Liquid State and Applications **07 L**

The Intermolecular forces, structure of liquids (qualitative description), structural differences between solids, liquids and gases, Physical properties of liquids: vapour pressure, surface tension, surface tension by capillary rise method, drop number method using stalagmometer, Viscosity of liquids, Poiseuille equation, determination of viscosity using Ostwald's viscometer, Introduction to l iquid crystals.(Numerical expected)

3. Phase Equilibria **06 L**

Statement, meaning of terms: phase, components, degrees of freedom, Gibbs phase rule, derivation of Gibbs phase rule, Phase equilibria of one component system: water system, sulphur system, Phase equilibria of two component system, simple eutectic system, Pb/Ag system. Nernst distribution law, deviations from Nernst distribution law, applications of the law.

SECTION- II (ANALYTICAL CHEMISTRY)

1. Introduction to Analytical Chemistry and some basic concepts **04 L**

Analytical Chemistry and its role in sciences. some important units of measurement, solutions and their concentrations, stoichiometric calculations. (Numericals expected)

2. Titrimetric methods of analysis **05 L**

Some general aspects of volumetric titrimetry, standard solutions, volumetric calculations. Variables that influence the magnitude of salt effect, activity coefficients, titration curves in titrimetric methods. (Numericals expected)

3. Theory and applications of neutralization titrations **05 L**

Solutions and indicators for acid/base titrations, titration curves for strong acids and strong bases, buffer solutions, titration curves for weak acids, titration curves for weak bases, composition of buffer solutions as a function of pH. Reagents for neutralization titrations, applications of neutralization titrations. (Numericals expected)

4. Titration curves for polyfunctional acids and polyfunctional bases **04 L**

Polyfunctional acids and polyfunctional bases, titration curves for polyfunctional acids, titration curves for polyfunctional bases, composition of solutions of a polyprotic acid as a function of pH. (Numericals expected)

5. Precipitation and Complex formation titrations **04 L**

Titration curves, end points for argentometric titrations, applications of standard silver nitrate solutions. Complex formation reactions, titrations with aminopolycarboxylic acids.
(Numericals expected)

PRACTICALS
Paper Title: Concepts in Physical and Analytical Chemistry + Laboratory Course-3
Paper Code: CHE- II. C-3
Marks: 25
Credits: 1

List of experiments:
PHYSICAL CHEMISTRY

1. To determine the partition coefficient of I_2 between $C_2H_4Cl_2$ and H_2O.
2. To determine the amount of strong acid (HCl) present in the given solution by conductometric titration using standard NaOH solution.
3. To determine the amount of weak acid (CH_3COOH) present in the given solution by conductometric titration using standard NaOH solution.
4. To determine viscosity of a given liquid using Ostwald's Viscometer.

ANALYTICAL CHEMISTRY

1. To standardize hydrochloric acid against sodium carbonate.
2. To standardize sodium hydroxide against potassium hydrogen phthalate.
3. To determine hardness in water.
4. To standardize sodium thiosulphate solution against copper.

CORE COMPULSORY MAJOR PAPER

THEORY
Paper Title: Concepts in Organic and Inorganic Chemistry + Laboratory Course-4
Paper Code: CHE-II. C-4
Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Categorize the compounds as aromatic, non-aromatic and anti-aromatic.
CO2 : Apply the theoretical knowledge to write the synthesis of alkynes, alkyl halides, aromatic compounds.
CO3 : Discuss and describe the steps involved in the mechanism of nitration, sulphonation, halogenation and Friedel Crafts reactions of aromatic compounds.
CO4 : Explain and outline the different properties of transition elements.

CO5 : Compare 4d and 5d analogues.
CO6 : Describe crystalline solids in terms of their structure, ionic radii and coordination.
CO7 : Interpret crystal structures.
CO8 : Describe lattice energy, Born-Haber's cycle, Fajan's rule and defects in solids.
CO9 : Explain trends in periodic properties of d-block elements with respect to their ionic radii, oxidation state, spectral properties, magnetic properties.
CO10 : Describe crystalline solids in terms of their structure, ionic radii and coordination there by able to interpret crystal structure.

Learning Outcome:
1. Students will learn a important classes of organic compound: Alkynes.
2. Students will briefly learn about the aromatic chemistry involving different types of reaction can aromatic compounds undergoes. Also they will learn about the mechanism involve in reactions having aromatic compounds.
3. Students will also learn chemistry of alcohols and alkyl halides
4. Will have an understanding of crystalline solids in terms of their structure, ionic radii and coordination there by able to predict crystal structure.

SECTION- I (ORGANIC CHEMISTRY)

1. Study of alkynes **03 L**

Alkynes: Sources of alkynes, physical properties of alkynes, acidity of acetylene and terminal alkynes, preparation of alkynes by elimination reactions, alkylation of acetylene and terminal alkynes, reactions of alkynes: hydrogenation, metal-ammonia reduction, addition of hydrogen halides, hydration of alkynes.

2. Arenes and Aromaticity **08 L**

The aryl group, structure of benzene: Molecular formula and Kekule structure, stability and carbon-carbon bond lengths of benzene, resonance structure, molecular orbital picture, Huckel's rule, polycyclic aromatic hydrocarbons, physical properties of arenes, electrophilic aromatic substitution reactions-reactions and mechanisms of nitration, halogenations, sulphonation and Friedel Craft's reactions, activating and deactivating substituents, orientation and ortho/para ratio, side chain reactions of benzene derivatives, Birch reduction.

3. Study of Alcohols and Alkyl Halides **12 L**

Alcohols: Classification, structure and bonding, physical properties, methods of preparation- catalytic hydrogenation, metal hydride reduction, Grignard reaction (using formaldehyde, other aldehydes, ketones, esters, nitriles and epoxides), reactions of alcohols- oxidation reactions using chromic acid, $KMnO_4$, PCC and PDC (structures of PCC and PDC), conversion of alcohols to ethers, Fischer Esterification.
Diols: Classification, methods of preparation (syn and anti diols), reactions of vicinal diols- Pinacol-Pinacolone rearrangement and periodic oxidative cleavage.
Alkyl Halides: Classification, structure and bonding, physical properties, methods of preparation- using alcohols and hydrogen halides, $SOCl_2$, PCl_3, halogenation of alkanes, mechanism for chlorination of methane, relative reactivity and selectivity with respect to chlorination and bromination, mechanisms of nucleophilic substitution reactions of alkyl halides, S_N1 and S_N2 reactions with energy profile diagrams.

SECTION- II (INORGANIC CHEMISTRY)

1. Chemistry of transition elements **12 L**

Chemistry of elements of the first transition series: properties, their binary compounds, oxidation states and their stability, coordination number and geometry, comparative study with 4d and 5d analogues with respect to their ionic radii, magnetic behaviour, oxidation states and spectral properties.

2. Ionic Solids: Structure and Bonding **10 L**

Introduction to bonding in solids, types of bonds, properties of ionic substances, structure of ionic solids (NaCl, CsCl, ZnS, CaF_2, TiO_2- rutile), lattice energy and Born- Haber's Cycle, factors affecting radii of ions, packing efficiency, radius ratio and coordination number, limitations of radius ratio, Fajan's rules, defects in solids: point defects, color centres, extended defects, non-stoichiometric defects, conductivity in ionic solids;

PRACTICALS
Paper Title: Concepts in Organic and Inorganic Chemistry + Laboratory Course-4
Paper Code: CHE- II. C-4
Marks: 25
Credits: 1

List of experiments:
ORGANIC CHEMISTRY
1. Purification techniques for organic compounds (Liquids) and determination of physical constant.
   Distillation: a. Separation of acetone and toluene
   b. Separation of ethyl acetate and nitrobenzene
2. Organic synthesis: a. p-Bromo acetanilide from aniline **(Any 2)**
   b.oxidising agent PCC (Pyridinium Chlorochromate)
   c. Oxime from cyclohexanone

3. Qualitative Analysis (Liquids) **(Any 3)**
   Haloalkane and haloarene: Chloroform, carbon tetrachloride, chlorobenzene, bromobenzene
   Nitro Compounds: Nitrobenzene
   Alcohols: Methanol, ethanol, 2-propanol, cyclohexanol
   Phenols: Phenol
   Carbonyl compounds (Neutral compounds): Benzaldehyde, acetone
   Esters: Methyl acetate, ethyl acetate, ethyl benzoate, methyl salicylate
   Bases: Aniline, N-methylaniline

INORGANIC CHEMISTRY
1. Semi-micro qualitative analysis: To analyse 2-3 inorganic mixtures containing four ions only (two cations and two anions).
   Cations : Pb^{2+}, Cu^{2+}, Cd^{2+} , Sn^{2+} , Fe^{2+} , Fe^{3+}, Al^{3+}, Cr^{3+} , Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{2+} , Ca^{2+}, Mg^{2+}, $(NH4)^{+}$, K^{+}
   Anions: Cl^{-} , Br^{-} , I^{-}, NO_2^{-}, NO_3^{-}, SO_3^{2-}, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}
2. Gravimetric estimation of Ba as $BaSO_4$
3. Gravimetric estimation of Fe as Fe_2O_3

REFERENCES

PHYSICAL CHEMISTRY
TEXTBOOKS

1. Atkins, P., Paula, J. D. *Atkin's Physical Chemistry*, Oxford University Press.

ADDITIONAL READING

1. Bahl A., Bahl B.S. and Tuli, G.D. *Essentials of Physical Chemistry*, S. Chand & Company Ltd., New Delhi.
2. Puri B.R., Sharma L. R. and Pathania M. S. *Principles of Physical Chemistry*, Vishal Publishing Co.
3. Raj G. *Advanced Physical Chemistry*, Goel Publishing House, Meerut.

ORGANIC CHEMISTRY
TEXT BOOK

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K. *Organic Chemistry*, Pearson India.

ADDITIONAL READING

1. Bruice, P. Y. *Organic Chemistry*, Pearson India.
2. Carey, F. C. and Giuliano, R. M. *Organic Chemistry*, Tata McGraw-Hill India.
3. Finar, I. L. *Organic Chemistry*, Pearson India.

INORGANIC CHEMISTRY
TEXT BOOKS

1. Lee, J. D. Concise Inorganic Chemistry, ELBS Publications.

2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F. *Shriver & Atkins' Inorganic Chemistry*, Oxford University Press.

ADDITIONAL READING

1. Greenwood, N. N., Earnshaw, A. *Chemistry of Elements*, Pergamon, Oxford.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson.
3. Cotton, F. A., Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley Publications.
4. Puri, B. R., Sharma, L. R., Kale, K. C. *Principles of Inorganic Chemistry*, Vallabh Publications.
5. Sharpe and Emilus, Inorganic Chemistry.
6. Housecroft, C. E. and Sharpe, A. G. *Inorganic Chemistry*, Prentice Hall.

ANALYTICAL CHEMISTRY

TEXT BOOK

1. Skoog, D. A., West D.M. and Holler, F. J. *Analytical Chemistry An Introduction*, Saunders College Publishing

BOOKS SUGGESTED FOR LABORATORY COURSE

1. Yadav, J. B. *Advanced Practical Physical Chemistry*, Krishna Prakashan Media (P) Ltd. Meerut.
2. Chondhekar, T. K. and Rajbhoj, S.W. *Systematic Experimental Physical Chemistry*, Anjali Publication, Aurangabad.
3. Furniss, B. Brian, S. *Vogel©s textbook of practical organic chemistry*, Pearson education.
4. Vishnoi, N. K. *Advanced Practical Organic Chemistry*, Vikas Publishing House Pvt Ltd.
5. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Orient Longman.
6. Jeffery, G. H. Bassett, J. *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley & Sons Inc

SEMESTER III

CORE COURSE

THEORY
Course Title: Comprehensive Chemistry - I
Course Code: CHE- III. C-5
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Understand Second and Third law of Thermodynamics
CO2 : Calculate equilibrium constant and formulate conditions for maximum yield in industrial processes
CO3 : Explain theory of strong and weak electrolytes.
CO4 : Explain trends in periodic properties of f-block elements with respect to its size of atoms or ions, reactivity, oxidation state, complex formation, colour, magnetic properties.
CO5 : Name coordination compounds and to able to draw the structure based on its name.
CO6 : Describe the shape and structures of coordination complexes based on different coordination numbers.
CO7 : Explain merits and demerits of different theories of acids and bases and to explain the properties of a solvent that determines their utility.

Learning Outcome:
1. Will learn principles of Physical Chemistry and its applications in various processes.
2. Will obtain a comprehensive and detail understanding of the properties and compounds of the f-block elements i.e. the lanthanides and actinides.
3. Will gain a basic understanding of coordination compounds, their nomenclature and the types of coordination compounds.
4. Will be able to describe different crystal structures of ionic solids and the types of defects which can occur in a crystal.
5. Will be able to get a deeper understanding of the theory with practical knowledge.

SECTION –I (PHYSICAL CHEMISTRY)

1. Thermodynamics **10 L**
Second law of thermodynamics: Different statements of the law; Carnot cycle and its efficiency, Carnot theorem; Thermodynamic scale of temperature; Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, entropy change in physical processes, entropy as a criteria of spontaneity and equilibrium; Entropy change for ideal gases. Third law of thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data; Gibbs and Helmholtz functions; A and G as criteria for thermodynamic equilibrium and spontaneity, their advantages over entropy change; Variation of G and A with P, V and T.

2. Chemical Equilibrium **05 L**
Reversible reactions, equilibrium constant, Equilibrium constant and free energy; Thermodynamic derivation of law of mass action; Reaction isotherm and reaction isochore - Clapeyron equation and Clausius - Clapeyron equation; Le Chatelier's principle and its applications to some industrial processes.

3. Electrochemistry **08 L**
Electrical transport-conduction in metals and in electrolyte solutions, weak and strong electrolytes; conductance, specific conductance and equivalent conductance and measurements; variation of specific and equivalent conductance with dilution; Arrhenius theory of electrolyte dissociation and its limitations; Ostwald©s dilution law, its uses and limitations; Migration of ions and Kohlrausch law; Debye-Huckel-Onsager's equation for electrolytes; Transport number, determination of transport number by Hittorf's method, Applications of conductance measurements: degree of dissociation, dissociation constant of acids; Solubility and solubility product of a sparingly soluble salts; Conductometric titrations (e.g. Strong acid and strong base).

SECTION –II (INORGANIC CHEMISTRY)

1. Chemistry of f-block elements **09 L**

Electronic structure, oxidation states and ionic radii; physical and chemical properties; occurrence and isolation of lanthanides from monazite ore; Lanthanide compounds; General properties and chemistry of actinides; Chemistry of extraction of Thorium and Uranium from its ore; Compounds of Th and U; comparison between lanthanides and actinides

2. Introduction to Coordination Compounds **08 L**

Werner's coordination theory; effective atomic number concept; nomenclature of coordination compounds; constitution and geometry; Isomerism and chirality in coordination compounds; chelates and macrocyclic effect

3. Acids, Bases and Non-aqueous solvents **05 L**

Arrhenius concept and Bronsted theory; Lewis concept of acid and bases; Physical properties of a solvent; Solvents and their general characteristics; Reactions in non aqueous solvent with respect to NH_3

PRACTICALS:
Course Title: Comprehensive Chemistry - I
Course Code: CHE- III. C-5
Maximum Marks: 25
Credit: 1

List of experiments:
PHYSICAL CHEMISTRY EXPERIMENTS (Any 4 experiments to be performed)

1. To verify Ostwald's dilution law by determining the equivalent conductance of a weak monobasic acid at different concentrations
2. To determine the equivalent conductance of a strong electrolyte at several concentrations and hence verify Onsager's equation.
3. To determine solubility product of sparingly soluble salt by conductometric method
4. To determine hydrolysis constant of sodium acetate by conductometric method
5. To determine G, H and S of silver benzoate by solubility product method conductomtrically
6. To study the molecular condition of benzoic acid between toluene and water at room temperature by partition method
7. To study the solubility of benzoic acid in water at different temperatures and to calculate the heat of solution
8. To determine energy of activation for acid catalysed hydrolysis of methyl acetate

INORGANIC CHEMISTRY EXPERIMENTS

1. Preparation of Tetraamine copper (II) sulphate monohydrate
2. Estimation of Copper (II) from teraamine copper (II) sulphate by iodometry
3. Preparation of Hexamine nickel (II) chloride complex
4. Estimation of Nickel in hexamine nickel (II) chloride by EDTA method
5. Gravimetric estimation of Nickel as Ni-DMG
6. Volumetric Estimation of Calcium by EDTA method
7. Volumetric Estimation of dissolved oxygen in water sample

TEXT BOOK (PHYSICAL CHEMISTRY):

Raj Gurdeep, Advanced Physical Chemistry; Goel Publishing House, Meerut, 27th Edition

REFERENCE BOOK:

Puri B.R., Sharma L.R., Pathania M. S., Principles of Physical Chemistry

TEXT BOOK (INORGANIC CHEMISTRY):

Shriver D.F. and Atkins P. W., Inorganic Chemistry, 5th Edition, Oxford University Press

REFERENCE BOOKS (INORGANIC CHEMISTRY):

1. Cotton F. A. and Wilkinson G, Advanced Inorganic Chemistry, 5th Edition, John Wiley
2. Lee, J. D. Concise Inorganic Chemistry, 5th Edition, Wiley Blackwell Science Publications

SEMESTER III

ELECTIVE COURSES

THEORY
Course Title: Name reactions and Synthetic methodologies
Course Code: CHE-III. E-1
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Describe condensation reactions involving nucleophilic addition to carbonyl compounds.
CO2 : Define and describe various name reactions and rearrangements along with their mechanisms.
CO3 : Predict the product for various reactions involving these name reactions/rearrangements.
CO4 : Apply these mechanisms towards the formation of complex molecules.
CO5 : Discuss and describe the steps involved in the mechanism of Friedel Crafts reactions, Reimer-Tiemann reaction, VilsmeierHaack reaction, Gattermann-Koch reaction and Kolbe-Schmidt reaction.
CO6 : List the different oxidising and reducing agents.
CO7 : Apply the theoretical knowledge to identify the reagents used to bring about a particular chemical reaction.

Learning outcome:
1. Students will learn importance of name reactions in organic chemistry.
2. Students will learn different types of reactions in organic chemistry through name reactions.

1. Name reactions involving nucleophilic addition to carbonyl compounds 17 L
Structure and reactivity of carbonyl group; General mechanism of nucleophilic addition to carbonyl group; Introduction to condensation reactions; Reactions and mechanisms of: Aldol condensation, Claisen-Schmidt condensation, Claisen condensation, Dieckmann condensation, Perkin condensation, Knoevenagel condensation, Doebner modification, Stobbe condensation, Benzoin condensation, Michael addition.

2. Name reactions involving electrophilic aromatic substitutions 10 L
Introduction to general mechanism involved, reactivity of arenes, product distribution, ipso-attack and orientation in benzene with more than one substituent
Reactions and mechanisms of: Friedel-Crafts alkylation and acylation, Vilsmeier-Haack reaction, Gattermann-Koch reaction, Reimer-Tiemann reaction and Kolbe-Schmitt reaction.

3. Name reactions involving rearrangement 06 L
Reactions and mechanisms of: Beckmann rearrangement, Curtius rearrangement, Hofmann rearrangement, Pinacol-Pinacolone rearrangement, Wagner-Meerwin rearrangement, Claisen rearrangement.

4. Oxidation reactions 06 L
Oppenauer oxidation (with mechanism), aromatisation and dehydrogenation; Chromium and manganese compounds as oxidising agents: Preparation and applications of PCC and PDC, oxidation of alcohols, aldehydes, C-C double bonds and C-H bonds in hydrocarbons.

5. Reduction reactions 06 L
Catalytic hydrogenation: Different catalysts, solvents and equipments; functional group reductions and homogeneous catalytic hydrogenation; Reductions by hydride transfer reagents and related reactions: $NaBH_4$ and LAH reduction (with mechanism); reductions with borane and dialkylboranes;
Other methods of reductions: Clemmensen's reduction, Wolff-Kishner reduction (with mechanism).

PRACTICALS
Course Title: Name reactions and Synthetic methodologies
Course Code: CHE-I. E-1
Maximum Marks: 25
Credit: 1

List of experiments: (Any 8)
1. Preparation of chalcone using benzaldehyde and acetophenone.
2. Preparation of dibenzalacetone.
3. Preparation of nitrostyrene using nitromethane and benzaldehyde.
4. Preparation of benzoin using benzaldehyde and thiamine hydrochloride.
5. Oxidation of benzoin to benzil.
6. Preparation of 2,4-DNP hydrazone of acetophenone
7. Preparation of oxime of cyclohexanone
8. Preparation of PCC and PDC
9. Reduction of m-dinitrobenzene to m-nitroaniline
10. Nitration of nitrobenzene
11. Nitration of acetanilide
12. Preparation of Cinnamic acid
13. Preparation of Michael adduct between cyclohexanone and nitrostyrenes
14. Oxidation of alcohols using PCC
15. Oxidation of alcohol using PDC

TEXT BOOK:
1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K. Organic Chemistry, Pearson India.

REFERENCE BOOKS:
1. Bruice, P. Y. Organic Chemistry, Pearson India.
2. Carey, F. C. and Giuliano, R. M. Organic Chemistry, Tata McGraw-Hill India.
3. Finar, I. L. Organic Chemistry, Pearson India.
4. March Jerry, Advanced Organic Chemistry Reaction, Mechanism and Structure, 4th Edition, Wiley Publications.

PRACTICAL TEXT BOOK
Furniss, B. Brian, S. Vogel©s Textbook of Practical Organic Chemistry, Pearson education

ELECTIVE COURSE

THEORY
Course Title: Introduction to Industrial Chemistry
Course Code: CHE-III.E-2
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Describe the importance of catalysts in industrial processes.
CO2: Explain the composition of various materials such as alloys, glass, etc. and understand the process of corrosion and its prevention.
CO3: Discuss several common industrial processes such as halogenations, nitration and sulphonation.
CO4: Classify and discuss boilers, heat exchangers and paints.
CO5: Describe diverse effluent treatments for waste management and apply the knowledge of safety in industries.

Learning Objectives: The main objective of this course is to study the selected key industrial processes, waste management, properties of selected solid materials and industrial safety.

Unit I: Fundamentals of industrial chemicals and need for greener processes **04L**
Relevance of catalysis in modern industrial processes.

Unit II: Materials Science **08L**
A. Mechanical properties of materials and change with respect to temperature
B. Metals and alloys – important metals and alloys
C. Glass – types, composition, manufacture, physical and chemical properties applications.
D. Corrosion – various types of corrosion relevant to chemical industry – Mechanism, Preventive methods.

Unit III: Introduction to electroplating **04L**
Introduction: definition, fundamental principles- Faraday's laws, mechanism of deposition, surface preparation for electroplating of Zinc and Tin. Testing of electrodeposits: for thickness, adhesion, stress and corrosion. Use of Hull cell in plating.

Unit IV: Selected key industrial processes **08L**
Halogenation: Introduction, type of halogenation reactions, halogenating agents, kinetics and mechanism of halogenation, manufacturing of chloroethane, chlorobenzene, chloral.
Nitration: Introduction, type of nitration reaction, nitrating agents, kinetics and mechanism of nitration, manufacturing of nitrobenzene and p-nitroacetanilide.
Sulphonation: Introduction, type of sulphonation reaction, sulphonating agents, mechanism of sulphonation reaction, commercial sulphonation of benzene and alkyl benzene.
Physico chemical principles involved in the manufacture of HNO_3 (Ostwald's method) and NH_3 (Haber's method).

Unit V: Boilers and heat exchangers **04L**
Introduction, classification and applications of boilers and heat exchangers.

Unit VI: Paint chemistry **03L**
Introduction, general classification, composition, characteristics and applications of paints.

Unit VII: Industrial Safety and Conducts **08L**
Meaning of industrial safety, industrial accidents, industrial hazards, MSDS and safety programme.
Process Safety: a) Chemical reaction hazards: Fundamental understanding, various instruments used to understand chemical reaction hazards. b) Fire and Explosion Hazards: Fundamental understanding, various instruments used to understand fire and explosion hazards.

Unit VIII: Effluent treatment and waste management **06L**
Principles and equipments for aerobic, anaerobic treatment, adsorption, filtration, sedimentation, bag filters, electrostatic precipitators, mist eliminators, wet scrubbers, absorbers, solid waste management and reverse osmosis.

PRACTICALS
Course Title: Introduction to Industrial Chemistry
Course Code: CHE-III.E-2
Maximum Marks: 25
Credits: 1
List of experiments: (Any 6)
1. Preparation of 1-nitronaphthalene from naphthalene (Nitration)
2. Preparation of 2,4,6-tribromophenol from phenol (Bromination)
3. Preparation of 4-hydroxybenzenesulphonic acid from phenol (Sulphonation)
4. Electroplating of Ni or Cu
5. Electroless plating of Ni or Cu
6. Effect of pH and salinity on rate of corrosion of iron/steel
7. Formation of thin films of metals or alloys
8. Synthesis of common industrial compounds involving two step reactions: phthalic acid to phthalic anhydride (minimum 4 hours)
9. To prepare crystals of potash alum, $K_2SO_4.Al_2(SO_4)_3.24\ H_2O$, from Aluminium foil
10. Ore analysis: calcium from limestone (minimum 4 hours)
11. To estimate the amount of copper by spectrophotometric method

TEXT BOOK:

1. Sharma, B. K. *Industrial Chemistry* (06 Ed.). Goel Publishing House, Meerut.

REFERENCE BOOKS:

1. Bentley, J. et. al. **2011** *Introduction to paint chemistry and principles of paint technology* (04 Ed.). Springer Nethetlands.
2. Cotton, F. A. et. al. *Basic Inorganic Chemistry* (02 Ed.). Wiley Eastern Ltd.
3. De, A. K. *Environmental Chemistry* Wiley Eastern Limited.
4. Foye, A. O. *Principles of Medicinal Chemistry* Publication Philadephia.
5. Frederick, A. L. **1974** *Modern Electroplating* (03 Ed.). J. Wiley and sons Inc. New York.
6. Iqbal, S. A. et. al. *Chemistry of Air and Air Pollution* Discovery Publishing House, New Delhi.
7. Korolkovas, A. et. al. *Essentials of Medicinal Chemistry* Wiley - Interscience.
8. Lednicer, D. et. al. *Organic Chemistry of Drugs Synthesis* Wiley Interscience.
9. Lee, J. D. *Concise Inorganic Chemistry* (05 Ed.). Wiley Blackwell Science Publications.
10. Naseer, K. **2004** *Electroplating- Basic Principles, Processes and Practice* (01 Ed.). Elsevier.
11. Singh, P. P. et. al. *An Introduction to Synthetic Drugs* Himalaya Publication, Bombay.
12. Terrance, H. I. **1970** *The Chemical Analysis of Electroplating Solutions* Chemical Publishing Co. New York 1970.
13. Tyagi, O. D. et. al. *A Text Book of Environmental Chemistry* Anmol Publications, New Delhi.
14. Wilson, C. O. et. al. *Textbook of Organic Medicinal and Pharmaceutical Chemistry*

Lippincott - Toppan.

Note: Wherever possible, latest edition of the prescribed books are to be used.

ELECTIVE COURSE

THEORY
Course Title: Surface Chemistry and Catalysis
Course Code: CHE- III. E-3
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:

On successful completion of the course, the student will be able to:
CO1 : Understand the behavior of solid surfaces.
CO2 : Differentiate between surface energy and surface tension in case of solids.
CO3 : Classify and interpret various types of adsorption isotherms.
CO4 : Estimate surface area of a solid.
CO5 : Predict the mechanistic behavior of catalytic reactions.
CO6 : Evaluate conditions under which a catalysed reaction changes rate dependence.

Learning outcome:

1. Will have an understanding of chemistry of surfaces and be able to interpret various types of adsorption.
2. Will understand the mechanism and applications of catalytic processes.
3. Will have practical knowledge of synthesis and characterisation of catalysts.

1. Surfaces of solids **08 L**

Introduction, surface mobility of solids-sintering; effect of past history on condition of solid surfaces; Thermodynamics of crystals; Surface tension and surface free energy; equilibrium shape of a crystal; Kelvin equation; Theoretical estimates of surface energies and free energies in various types of crystals and metals; Factors affecting surface energies and surface tensions of actual crystals; experimental methods for determining surface structure, reactions of solid surfaces.

2. Adsorption **17 L**

Introduction, Differences between adsorption, absorption and sorption, Characteristics of adsorption, sorption and occlusion, Adsorption of gases on solids; Physisorption and chemisorptions; Adsorption

isotherms, Types of adsorption isotherms: Freundlich adsorption isotherm, Langmuir adsorption isotherm, The BET equation (Derivation not needed); Determination of surface area: Harkin and Jura method, Benton and White method, The BET method, Point B method, From electrical potential of adsorbed layer, Using rate of dissolution, From heat of wetting; Importance of surface area; Heat of adsorption and its measurement; Adsorption isobars; Adsorption from solution, Gibbs adsorption equation(Derivation not needed), Adsorption by porous solids, Adsorption in mesopores and micropores

3. Catalysis **20 L**

Introduction, Types of catalysis, Characteristics of catalysts; Theory of Homogenous catalysis, Function of a catalyst in terms of Gibbs Free energy of activation; Theory of heterogeneous catalysis, Quantitative treatment of Adsorption theory, Kinetics of heterogeneous reactions, Effect of temperature on heterogeneous reactions, Absolute rate theory in heterogeneous gas reactions; Classification of catalysis, Enzyme catalysis, Characteristics of enzyme catalysis; Factors governing rate of enzyme catalysed reactions; Mechanism and kinetics of enzyme catalysed reactions, Michaelis-Menten equation; Acid-base catalysis, Mechanism and kinetics of acid-base catalysis, catalytic coefficients, Hammett and Bronsted equation(Derivation not needed); Acidity function; some important classes of catalysts

PRACTICALS
Course Title: Surface Chemistry and Catalysis
Course Code: CHE- III. E-3
Maximum Marks: 25
Credits: 1

List of experiments: (Any 8 experiments to be performed)

1. To study the adsorption of acetic acid on charcoal and to verify Freundlich isotherm.
2. To study the adsorption of oxalic acid on charcoal and to verify Langmuir adsorption isotherm.
3. To study acid catalysed inversion of cane sugar by polarimetry.
4. To determine the interfacial tension between two immiscible liquids (chloroform-water) at room temperature.
5. To determine the indicator constant of a given indicator by colourimetric measurements.
6. To synthesize ZnO from zinc nitrate by decomposition method and determine the amount of zinc in ZnO by titrimetry.
7. To synthesize CuO from copper nitrate and determine the amount of copper in CuO using titrimetry.
8. To study the kinetics of iodination of acetone.
9. To study the hydrolysis of methyl acetate and determination of energy of activation in presence of sulphuric acid.
10. To investigate the auto-catalytic reaction between potassium permanganate and oxalic acid.
11. To determine the Scherrer particle size of any three catalysts using their X-ray diffraction data.
12. To calculate band gap of any five catalysts using their UV-DRS data.
13. To determine the Hammett constant of a substituted benzoic acid by pH measurements
14. To study the adsorption of iodine from alcoholic solution using charcoal
15. To investigate the autocatalytic reaction between $KMnO_4$ and oxalic acid

TEXT BOOK:
Raj Gurdeep, Advanced Physical Chemistry, Goel Publishing House

REFERENCE BOOK:
Adamson A. W., Physical Chemistry of Surfaces, Interscience Publishers

PRACTICAL BOOK
Rajbho S.W., Chondhekar T. K., Systematic Experimental Physical Chemistry

ELECTIVE COURSE

THEORY
Corse Title: Bioinorganic Chemistry
Course Code: CHE- III. E-4
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Elucidate the role of metal ions that are involved in different processes like oxygen transport, electron-transfer reactions etc. in biological systems.
CO2 : Apply the concepts of coordination chemistry to metallobiomolecules which are based on iron and copper ions.
CO3 : Evaluate the role of metal centres in the metalloenzymes that are involved in the catalysis of various biological reactions and thus predict the reaction mechanisms.
CO4 : Develop skills to prepare model systems which mimic the role of metal ions in biological systems.
CO5 : Discuss the importance of essential and trace elements in biological processes and evaluate their role in biology.
CO6 : Explain the biologically important compounds like proteins, carbohydrates etc. and to interpret their biological importance.
CO7 : Compare different mechanisms of ion transport across cell membrane and classify different biomolecules which help in the transport of ions and to illustrate PS-I and PS-II approach of photosynthesis.
CO8 : Analyze how metals are used as diagnostic agents and application of Au, Cu, Zn, Pt-complexes as anti-cancer drug and in medicine.

Learning outcome:
On successful completion of the course, the student will be able to:
1. Describe the role of metal ions that are involved in different processes like oxygen transport, electron-transfer reactions etc. in biological systems.
2. Describe the most common metal centres for electron-transfer reaction which are based on copper and iron ions.
3. Summarize the role of metal centres in the enzymes that are involved in the catalysis of various biological reactions.
4. Will be proficient in the basic principles of bioinorganic chemistry and biochemistry.
5. Will develop skills to prepare model systems which mimic the role of metal ions in biological systems.

1. Introduction to Bioinorganic Chemistry 05 L
Essential and trace elements in biological processes; distribution of elements in biosphere; bio-availability and bio-stability; Biologically important compounds: sugars (carbohydrates), fatty acids (lipids), nucleotides (nucleic acids) and amino acids (proteins); Biological importance of water; Metallobiomolecules.

2. Alkali and Alkaline earth metals in biological systems 12 L
Structure and functions of biological membranes; mechanism of ion transport across membranes; sodium pump; Ionophores: valinomycin; Crown ether complexes of Na^+ and K^+; Photosynthesis: chlorophyll a, PS I and PS II; Role of calcium in muscle contraction and blood clotting.

3. Iron and Copper containing compounds in biology 15 L
Heme proteins: hemoglobin, myoglobin and cytochrome c; Non-heme proteins: hemerythrin and hemocyanin; Iron transport and iron storage proteins: Siderophores, transferrin and ferritin; Electron transfer: Iron-Sulphur clusters, cytochromes.

4. Metalloenzymes **07 L**

Copper enzymes: superoxide dismutase, cytochrome oxidase and ceruloplasmin; Zinc enzymes: carbonic anhydrase, carboxy peptidase and interchangeability of zinc and cobalt in enzymes; Molybdenum enzyme: xanthine oxidase; Coenzymes: Vitamin B12 and B12 coenzymes

5. Chemistry of elements in medicine **06 L**

Metals as diagnostic and therapeutic agents: chelation therapy, cancer treatment, anti-arthritis drugs; Platinum complexes as anticancer drugs; Pt-DNA binding; complexes of gold, copper, zinc, mercury, arsenic and antimony as drugs.

PRACTICALS:
Corse Title: Bioinorganic Chemistry
Course Code: CHE- III. E-4
Maximum Marks: 25
Credit: 1

List of experiments:(Any 8 Experiments to be performed)

1. Preparation of acetylacetonato manganese (III) complex(minimum 3 hours)
2. Preparation of trisethylenediamine nickel (II) complex (minimum 3 hours)
3. Preparation of Tris(acetylacetonato) iron (III) (minimum 3 hours)
4. Estimation of Fe from the complex Tris(acetylacetonato) iron(III)
5. Preparation of tris(thiourea)copper(I)sulphate
6. Preparation of optical isomers, cis and trans dichloro(ethylenediamine)cobalt(III)chloride (minimum 3 hours)
7. Preparation of hexamine cobalt (III) chloride(minimum 3 hours)
8. Estimation of cobalt (III) from hexamine cobalt (III) chloride
9. Preparation of bis(dimethylglyoxime)cobalt (I) a Vitamin B12 model system(minimum 3 hours)
10. Determination of hardness of water by EDTA

TEXT BOOK:

Bertini I., Gray H. B., Lippard S. J. and Valentine J.S., Bioinorganic Chemistry, University Science Books

REFERENCE BOOKS

1. Fausto da Siliva J. J. R. and Williams R. J. P., The Biological Chemistry of the Elements, Oxford University Press
2. Fenton D. E., Bio-coordination Chemistry, Oxford Chemistry Printers, Oxford University Press
3. Shriver and Atkins, Inorganic Chemistry, 5th Edition, Oxford University Press

PRACTICAL BOOK:

Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis

SEMESTER IV

CORE COURSE

THEORY
Course Title: Comprehensive Chemistry-II
Course Code: CHE- IV. C- 6
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Identify and classify diverse organic compounds containing C, H and O elements.
CO2 : Predict the chemical reactivities of several organic compounds containing CHO elements.
CO3 : Outline the preparations of several compounds belonging to different classes of organic compounds having CHO elements.
CO4 : Apply the important reactions involved in each class of organic compounds with CHO elements.
CO5 : Design scheme for an analytical process.
CO6 : Use proper techniques of sampling of solids, liquids & gases.
CO7 : Apply statistical treatment to analytical data.

Learning outcome: Students will learn about;
1. Important classes of organic compounds include CHO elements.
2. Preparations involved in different classes of organic compound having CHO elements.
3. Important reaction involved in each class of included compounds.

SECTION I (ORGANIC CHEMISTRY)

1. a. Studies of organic compound containing C, H and O **04 L**
Chemistry of organic compounds containing C, H, O elements; Alcohols, ethers, acids, ester, aldehydes and ketones

b. Ethers
Properties of ethers, Symmetric and asymmetric ethers, crown ethers, Preparations of ethers: Williamson ether synthesis, alkoxymercuration-demercuration, Reaction of ethers with acids (HX).

2. Aldehydes and Ketones **08 L**
Properties of aldehydes and ketones, Geometry and polarity of the carbonyl group, Preparation of aldehydes: Oxidation of alcohols, reduction of acid chlorides, Ozonolysis of alkene; Preparation of ketones: oxidation of alcohols, Friedel-Crafts acylation, Reaction of acid chloride with organocopper compounds; Reactions of aldehydes and ketones: General mechanism of nucleophilic addition at carbonyl group; Oxidation and reduction of aldehyde and ketones; Reaction with amine derivative (imine formation with mechanism); Cannizaro reaction and addition of Grignard reagents; Addition of carbanions (Aldol condensation).

3. Carboxylic Acids **06 L**
Properties of carboxylic acids, Preparation of acids: Oxidation of primary alcohols and alkyl benzenes, hydrolysis of nitriles with mechanism; Reaction of acids: Salt formation, conversion to different functional groups (esters, amides, acid chlorides and anhydrides), reduction of acids.

4. Esters **05 L**
Properties of esters; Preparation of esters: from acids, acid chlorides and anhydrides; Reactions of esters: Conversion to acids (Hydrolysis along with mechanism), conversion to amides, Trans-esterification, reduction to aldehydes and alcohols.

SECTION II (ANALYTICAL CHEMISTRY)

1. The Scope and Nature and of Analytical Chemistry **05 L**

Introduction; quantitative and qualitative analysis; qualitative analysis by classical and instrumental methods; analytical chemistry and analytical process (steps involved in chemical analysis): defining the problem, sampling, separation of desired components, actual analysis, presentation and interpretation of results; factors affecting the choice of analytical method.

1. Sampling Techniques **07 L**

Terms encountered in sampling: Sample, the population or the universe, sampling unit, increment, the gross sample, the sub sample, Analysis sample, bulk ratio, size to weight ratio, random sampling, systematic sampling, multistage sampling, sequential sampling; sampling of gases, liquids and solids; Preservation, storage and preparation of sample solution.

2. Statistical Treatment of Analytical Data **10 L**

Limitations of analytical methods, classification of errors, accuracy and precision; Errors: determinate and indeterminate error, constant and proportionate errors, minimization of errors; Significant figures and rounding off; mean, median, mode, range; standard deviation; histogram and frequency polygon; measures of central tendency and dispersion; Gaussian distribution curve; Confidence limit; Test of significance: F test, Students T; Rejection of the results: Q test, 2.5 d and 4.0 d rule; linear least squares/ method of averages.

PRACTICALS
Course Title: Comprehensive Chemistry-II
Course Code: CHE- IV. C- 6
Maximum Marks: 25
Credit: 1

List of experiments:
ORGANIC CHEMISTRY EXPERIMENTS

1. Qualitative analysis of organic compounds: **(Any 2)**
   Solids (examples: Benzoic acid, Nitro-benzaldehyde, Benzophenone)
   Liquids (Acetone, methylacetate, benzaldehyde)
2. Identification of type and separation of mixture of organic compounds: **(Any 4)**
   Solid-solid (Soluble-insoluble, insoluble-insoluble), solid-liquid (Solid and low boiling liquid), liquid-liquid) (High boiling and low boiling liquid)

ANALYTICAL CHEMISTRY EXPERIMENTS (Any 4)

1. To estimate the NO_2^- in the given solution by $KMnO_4$ method by back titration
2. To determine the amount of HCl in the given solution by pH metric titration
3. To determine the specific rotation of the given solution and to determine the percentage composition of unknown solution using polarimeter
4. To estimate the amount of benzoic acid in the given solution by back titration
5. To estimate the amount of vitamin C in the given solution
6. To estimate the amount of Aspirin present in the given tablet
7. To calibrate the burette and pipette using statistical treatment of data
8. To calibrate the volumetric flask of different volume capacity
9. To determine the hardness of water by EDTA method and to take at least five readings and apply the statistical data treatment to calculate mean, median, range, standard deviation and Q test. (Any six experiments to be performed)

ORGANIC CHEMISTRY
TEXT BOOK:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.

REFERENCE BOOKS:

1. Bruice, P. Y. Organic Chemistry, Pearson India
1. Carey, F. C. and Giuliano, R. M. Organic Chemistry, Tata McGraw-Hill India
2. Finar, I. L. Organic Chemistry, Pearson India

PRACTICAL TEXT BOOK:
Furniss, B. Brian, S., Vogel©s Textbook of Practical Organic Chemistry, Pearson education

ANALYTICAL CHEMISTRY
TEXT BOOK:
Skoog, D. A., West, D. M., Holler F. J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 8th Edition,

REFERENCE BOOKS:
1. Willard, H. H., Merritt, L. L., Dean, J. A., Settle, F. A., Instrumental Methods of Analysis, CBS Publishing, New Delhi, 7th Edition
2. Vogel's Text Book of Quantitative Inorganic Analysis - J. Bassett, R. C. Denney, G. H. Jeffrey, J. Mendham.
3. Christian, G. D., Analytical Chemistry, Analytical Chemistry, John Wiley, 5th Edition

PRACTICAL TEXT BOOK:
Yadav J. B. Advanced Practical Physical Chemistry, Goel Publishing House, 14th Edition

SEMESTER IV

ELECTIVE COURSE

THEORY
Course Title: Pharmaceutical Chemistry
Course Code: CHE- IV. E-5
Maximum Marks: 75
Credits: 3
Theory: 45 lectures

Course Outcomes:
On successful completion of the course, the student will be able to**:**
1. Outline the significance of terminologies and regulation in Pharmaceutical chemistry.
2. Classify pharmacological drugs.
3. Delineate the medicinal chemistry in plants.
4. Define and apply different types of chromatographic techniques in pharmaceutical industry.
5. Understand the working of quality control and quality.
6. Discuss Safety in Pharmaceutical laboratories.

Learning outcomes:
1. Students will learn about important aspects with respect to pharmaceutical Chemistry.
2. Students will develop understanding in structure-activity relationship.
3. Students will learn efficient chemical synthesis involved in important drug.

Unit I: General Introduction **05 L**
Importance of Chemistry in Pharmacy, Definition of terminologies: Pharmacology: Pharmacokinetics, Pharmacodynamics; Pharmacognosy, Dosage forms and Routes of administration, Advantages and disadvantages. Pharmacopoeia

Unit II: Regulation and Authorities **05 L**
Introduction to different regulatory bodies and their role: WHO, Therapeutic Goods Administration(TGA),Medicines and Health care products Regulatory Agency (MHRA), Central Drugs Standard Contol Organisation (CDSCO),UNICEF, USFDA, Food and Drug act 1945, Good Automated Manufacturing Practices (GAMP), State Licensing Authority
Requirement of regulation: 21CFR part 11, Electronic Signature and Password control, ICH, (Different guideline and scope), CGMP & Schedule M

Unit III: Pharmacological classification of Drugs **04 L**

Anti-Infective agents, anti-diabetic agents, anti-cancer agents, anti-pyretic agents, antipsychotic agents, Antacids, Analgesics, CNS Depressants, CNS stimulants, Anti histaminic agents, Diuretics, anti-malarial, antibiotics, adrenergic agents, cholinergic agents, Cardiovascular drugs, Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) (Definition of each class, any two examples with structure)

Unit IV: An introduction to the Medicinal Chemistry of plants **04 L**

Historical background; Type of plant, active ingredient structure and their medicinal properties: Capsicum, Garlic, turmeric.

Unit V: Introduction to Chromatography **06 L**

Column chromatography, Paper Chromatography, HPLC, Gas chromatography

Unit VI: Quality Control **10 L**

Introduction, Quest for Quality, Role of QC, Good Laboratory Practices (GLP), Standards: Reference Standard, Primary standard, Working standard.

Raw Material Testing: Solubility, Acidity /Alkalinity, Chloride, Sulphate, LOD, Sulphated ash, Loss on ignition, Heavy metals, Karl-fischer titration.

Finished Product Testing: Dimension, Weight variation, Hardness, Dissolution, Identification, Assay, Uniformity of content, Stability Testing, Different conditions for stability testing, Dissolution, Related substances

Handling of "Out Of Specifications", 'Out Of Trend', Laboratory Incidences, Root cause analysis, Corrective action and Preventive Action. Facing audits: Roles, Responsibilities and ensuring compliances.

Data integrity and its challenges

Archiving of results – introduction

Unit VII: Quality Assurance **08 L**

Introduction: Role of QA, Standard Operating procedure, Change control, Deviation, Market complaints, Master production record (Batch card) , Audit, Drug Master File (DMF), Complaints & adverse reactions, Labels & printed materials, Documentation & records, Distribution records

Validation: Method Validation, Types of Analytical Procedures to be Validated; Accuracy, Precision (Repeatability, Intermediate Precision, Reproducibility), Specificity, Detection Limit, Quantitation Limit, Linearity, Range, Robustness.

Process validation,

Unit VIII: Safety in Pharmaceutical laboratories **03 L**

Introduction, Risks in a pharmaceutical Laboratory, Personal Protective Equipment (PPE), General preparation for Emergencies, Laboratory Emergencies: Spills and Fires.

PRACTICALS
Course Title: Pharmaceutical Chemistry
Course Code: CHE- IV. E-5
Maximum Marks: 25
Credits: 1

List of experiments:(Any 7-8 practicals may be conducted)

1. Complete Pharmacopoeial analysis of drugs: a) Paracetamol b) Ibuprofen c) Aspirin
2. Synthesis of Benzocaine
3. Synthesis of benzophenone oxime.
4. Synthesis of phenytoin
5. Estimation of acetyl salicylic acid in the given aspirin tablet by titrating against 0.1N alcoholic KOH potentiometrically.
6. UV Absorbance Standard Curve of Salicylic Acid
7. Assay of Nitrazepam potentoimetrically.
8. Estimation of Ascorbic acid in tablets by iodometry.
9. Calibration of UV-visible spectrophotometer
10. Estimation of Penicillin – G.
11. Estimation of Chloramphenicol.

TEXT BOOK:

1. Skoog Douglas A., Leary James J. (1992). *Principles of Instrumental Analysis* (04 ed.). Philadelphia: Saunders College Publishing.
2. Beale John Jr., Block John (2010). *Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry* (12 ed.). Baltimore: Lippincott Williams and Wilkins.

REFERENCES:

1. Indian Pharmacopoeia Commission. (2007). Indian Pharmacopoeia 2007.
2. Prichard Elizabeth, B. V. (2007). *Quality Assurance in Analytical Chemistry.* John Wiley & Sons.
3. Beckett A.H., Stenlake J.B.(2001). *Practical Pharmaceutical Chemistry* (04 ed.). London: The Athlone Press.
4. Christian, G. D. (2004). *Analytical Chemistry* (06 ed.). New Jersey: John-Wiley & Sons, Inc.
5. Prabhu D.V, Raghuraman K, (2014). *Basic Principles of Analytical Chemistry* (05 ed.). Mumbai: Sheth Publishers.
6. Lednicer Daniel, Mitscher Lester (2008). *The Organic Chemistry of Drug Synthesis* (01 ed.). New Jersey: John-Wiley & Sons, Inc.
7. Gennaro, A. R. (1995). *Remington: The Science and Practice of Pharmacy* (19 ed.). London: Mack Publishing Company.
8. Sharma, D. B. (2005). *Instrumental Methodsof Chemical Analysis* (24 ed.). Meerut: Goel Publishing House.
9. Higuchi T., E. B.-H. (1961). *Pharmaceutical Analysis.* New York: Interscience Publishers.

ELECTIVE COURSE

THEORY
Course Title: Polymer and Colloid Science
Course Code: CHE- IV. E-6
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Distinguish between different types of solutions in terms of solute dimensions.
CO2 : Evaluate properties of colloids.
CO3 :.Explain properties of gels and emulsions.
CO4 : Calculate molecular weight of a polymer.
CO5 : Design synthesis of a polymer.
CO6 : Measure molecular weight of a polymer.
CO7 : Understand solid state properties of polymers.

Learning outcome:
1. Will be able to classify colloids.
2. Will be able to calculate molar mass of polymers.
3. Will learn to synthesis some polymers in the laboratory

1. Colloidal Science

a. Introduction: 10 L

Colloidal state; colloidal solution; classification of colloids; lyophobic and lyophilic colloids; true solution, colloidal solution and suspension; preparation of sols; purification of sols; stability of colloids; protective action; Hardy- Schulze Law; gold number

b. Properties of colloids: 07 L

General properties; electrical properties; electrical double layers

c. Emulsions and gels: 06 L

Definition; types of emulsions, preparation; gels: definition; classification, preparation and properties, inhibition; kinetics of coagulation; general applications of colloids on size of colloidal particles

2. Polymer Chemistry:

a. Introduction to Polymer Science **06 L**

Classification of polymers: thermoplastics and thermosetting, classification based on polymerization scheme, polymer structure: copolymers, tacticity, geometric isomerism; molecular weight: molecular weight distribution, molecular weight averages; chemical structure and thermal transitions.

b. Synthesis of high polymers **07 L**

Step growth polymerization: molecular weight in a step growth polymerization, step growth polymerization kinetics; chain growth polymerization: free redical polymerization and copolymerization, ionic polymerization and copolymerization; polymerization technique; bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, solid state- gas phase and plasma polymerization.

c. Solution properties, thermodynamics and molecular weight determination **05 L**

Polymer conformation and chain dimensions; thermodynamics of polymer solution: Flory-Huggins theory, Flory-Krigbaum and Flory-Huggins theory, Equation of state theory; calculation of molecular weight: osmometry, light scattering method, intrinsic viscosity method

d. Solid state properties of polymer **04 L**

Amorphous state: chain enlargements and reputation, the glass transition, secondary relaxation processes; the crystalline state: ordering of polymer chains, crystalline-melting temperature, crystallization kinetics, technique to determine crystallinity.

PRACTICALS

Course Title: Polymer and Colloid Science

Course Code: CHE- IV. E-6

Maximum Marks: 25

Credit: 1

List of experiments:(Any 8 Experiments to be performed)

1. To determine the flocculation value of univalent and divalent electrolyte for ferric hydroxide sol
2. To prepare colloidal solutions of cadmium sulphide and ferric hydroxide
3. To study the coagulation value of As_2S_3 sol with $AlCl_3$
4. To study the mutual coagulation value of ferric hydroxide sol
5. To determine the critical micelle concentration of a soap by surface tension method
6. To determine the viscosity of a given liquid using Ostwald's viscometer (minimum two liquids)
7. To determine the molar mass of a polymer using Ostwald's viscometer
8. To determine the viscosity of mixture A and B and test the validity of Kendalls equation
9. To determine the viscosity of mixture of A and B and determine the composition of the two liquids
10. To study the variation of the viscosity of a given liquid with temperature using Ostwald's viscometer
11. To determine the surface tension of a liquid by drop number method
12. To determine the composition of mixture of two liquids by surface tension method
13. To determine the molecular weight of a given polymer by turbidimetry
14. To separate the amino acids from the mixture by electrophoresis
15. To separate the inorganic cations by paper electrophoresis

TEXT BOOK:

Raj Gurdeep, Advanced Physical Chemistry; Goel Publishing House, Meerut, 27^{th} Edition

REFERENCE BOOKS:

1. Puri B.R., Sharma L.R., Pathania M. S., Principles of Physical Chemistry
2. Fried J. R., Polymer Science and Technology; Prentice Hall of India private limited
3. Bhatnagar M.S., A Text Book of Polymer Science, Volume 1

ELECTIVE COURSE

THEORY
Course Title: Spectroscopic Techniques
Course Code: CHE-IV. E-7
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Outline the Beer's Law, Lambert's law, Beer-Lambert's Law and interpret the deviation from Beer-Lambert's Law; to identify the validity and limitations of Beer-Lambert's Law.
CO2 : Interpret the spectroscopic methods for qualitative and quantitative analysis; discuss the principle instrumentation; compare the Colorimeter and Spectrophotometer and employ UV-Visible Spectrophotometer.
CO3 : Outline the principle on which inductively coupled plasma spectroscopy works and illustrate the instrumentation involved in the technique.
CO4 : Employ inductively coupled plasma spectroscopy technique and identify its limitations.

Learning outcome:
1. Will be able to understand the basic components of instruments and the choice of solvents for spectrometry.
2. Will be able to perform qualitative and quantitative analysis using principles of spectrometry.
3. Will be able to operate an UV-visible spectrophotometer.

1. General Introduction **15 L**
Overview of spectroscopy; meaning of electromagnetic radiation; interaction of electromagnetic radiation with matter; wave properties of electromagnetic radiation; particle properties of electromagnetic radiation; the electromagnetic spectrum; regions of spectrum; atomic and molecular spectra; representation of spectra; photons as a signal source; basic components of spectroscopic instruments; sources of energy; sources of electromagnetic radiation; sources of thermal energy; chemical sources of energy; wavelength selection; wavelength selection using filters; wavelength selection using monochromators; interferometers; detectors; photon transducers; thermal transducers; signal processors; solvents for spectrometry; quantitative calculations; spectrometric errors in measurements

2. UV Visible Spectroscopy: **20 L**
Beer's Law; Lambert's Law; Beer -Lambert's Law; Deviations from Beer -Lambert's Law; validity and limitations of Beer- Lambert's law; principles of instrumentation: Sources, monochromators, cells; types of instruments; photoelectric colorimeters: single and double beam photoelectric colorimeters; single and double beam spectrophotometers; comparison between colorimeter and spectrophotometer; analytical applications of colorimeter and spectrophotometer: $\square_{max}$, quantitative analysis, identification of structural groups in a molecule, study of co-ordination compound; photometric titrations; Theory of electronic (UV) spectroscopy; Electronic transitions in a molecule; Chromophores and auxochromes; Bathochromic, hypsochromic, hyperchromic and hypochromic shifts; solvent effect; effect of temperature; applications of UV and visible spectroscopy: identification of structural groups, cis-trans isomerism, chemical kinetics, qualitative and quantitative analysis; limitations of UV and visible spectroscopy.

3. Atomic Spectroscopy **10 L**
Origins of atomic spectra, production of atoms and ions; Atomic Emission Spectrometry: Introduction, principle, instrumentation, applications, advantages and limitations of flame photometry and Inductively coupled plasma spectroscopy; Atomic Absorption Spectrometry: Introduction, principle, instrumentation, applications, internal standard and standard addition calibration, limitations
Atomic Fluorescence Spectrometry: Introduction, principles, instrumentation and applications.

PRACTICALS
Course Title: Spectroscopic Technique/ Method
Course Code: CHE-IV. E-7
Maximum Marks: 25
Credit: 1

List of experiments:(Any 8 Experiments to be performed)

1. To test the validity of Beer-Lambert Law using spectrophotometer and determine the unknown concentration of a solution
2. To calibrate the UV- Visible spectrophotometer for control of absorbance and limit of stray light
3. Determination of Mn^{2+} ion concentration by periodate method using spectrophotometer
4. Determination of Fe^{3+} ion concentration by salicylic acid method using spectrophotometer
5. To verify the law of additivity of absorbance ($KMnO_4$ and $K_2Cr_2O_7$) at $_{max}$ of $K_2Cr_2O_7$ and determine molar absorptivity
6. To verify the law of additivity of absorbance ($KMnO_4$ and $K_2Cr_2O_7$) at $_{max}$ of $KMnO_4$ and determine molar absorptivity
7. To determine the amount of K_2CrO_4 present in given sample by using UV-Visible spectrophotometer
8. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by continuous variation method
9. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by mole ratio method
10. To determine the phosphate concentration in a soft drink by spectrophotometric method
11. To determine the dissociation constant of methyl red indicator by spectrophotometric method
12. To estimate the amount of nitrite in water sample by spectrophotometric method
13. To estimate the amount of paracetamol in tablet by spectrophotometric method
14. To estimate the amount of aspirin in the given tablet by spectrophotometric method
15. To determine the amount of Cr (VI) in the given solution as dichromate by least square method spectrophotometrically

TEXT BOOK:

Skoog, D. A., West, D. M., Holler F. J., Crouch, S. R., Fundamentals of Analytical Chemistry, 8th Edition

REFERENCE BOOKS:

1. Holler F. J., Skoog, D. A., Crouch, S. R., Principles of Instrumental Analysis, 6th Edition, Thomson Books
2. Willard, H.H., Merritt, L.L., Dean, J. A., Settle, F. A., Instrumental Methods of Analysis, CBS Publishing New Delhi, 7th Edition
3. Christian, G. D., Analytical Chemistry, John Wiley, 5th Edition
4. Ewing, G.W., Instrumental Methods of Chemical Analysis, 5th Edition, Mc-Graw Hill International Edition.
5. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis, 4th Edition, ELBS and Longman

PRACTICAL BOOK:

Yadav, J. B., Advanced Practical Physical Chemistry, 14th Edition, Goel Publishing House

ELECTIVE COURSE

THEORY
Course Title: Chemistry of Natural Products
Course Code: CHE- IV. E-8
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:
1. The main objective of this course is to study the Chemistry of Natural products.
2. This course focuses on different classes of natural products, their importance, properties, biogenesis and chemical synthesis.
3. This course will also focus on the techniques involve in natural product separation and characterisation in brief.

Learning outcome:
1. Students will learn about importance of natural product in day today life.
2. Students will learn different techniques used in isolation and characterisation of natural products.
3. Students will learn important chemical synthesis involved in natural product.

1. Introduction to Natural Product Chemistry 02 L
Introduction to natural products and classifications of natural products

2. Isolation, purification and characterization techniques in natural products Chemistry 15 L
Extraction methods in isolation/purification of natural products; Distillation techniques, Column chromatography for separation of natural products; Chromatographic techniques in natural products characterization: TLC, Mass spectrometry, spectroscopic techniques: IR, UV-Visible (Introduction, basic principle, utilization of techniques in identification of organic compounds).

3. Terpenes 10 L
Occurrence, classification and isolation of terpenes; Menthol, Geraniol- Biogenesis, biosynthesis and chemical synthesis and Structure elucidation

4. Alkaloids 09 L
Occurrence, Classification and isolation of alkaloids; Chemical synthesis and structure elucidation of selected alkaloids: Morphine and Nicotine.

5. Biomolecules of life 09 L
Fats: Occurrence and composition; Hydrolysis of fats; Carbohydrates: Classification, nomenclature and uses; Amino acids: Classification, nomenclature and uses. Structures and classes of peptides and proteins; Nucleic acids: different types of nucleic acids, Nucleosides, nucleotides and structure of DNA.

PRACTICALS
Course Title: Chemistry of Natural Products
Course Code: CHE- IV. E-8
Maximum Marks: 25
Credit: 1

List of experiments:(Any 8 Experiments to be performed)
1. Synthesis of dilantin natural product from benzyl
2. Synthesis of 2-phenyl-3,1-benzoxazin-4-on from anthranilic acid
3. Identification of citric acid in lemon juice as calcium citrate
4. Conversion of calcium citrate to citric acid
5. Synthesis of Benzylideneacetophenone
6. Carotenoid extraction from tomato using a green solvent
7. Carotenoid extraction from carrot using a green solvent

8. To prepare isopentyl acetate from isopentyl alcohol and acetic acid by the Fischer esterification reaction
9. To prepare octyl acetate from octyl alcohol and acetic acid by the Fischer esterification reaction
10. To prepare ethyl butyrate from ethyl alcohol and butyric acid by the Fischer esterification reaction
11. To synthesize salicylic acid from methyl salicylate in wintergreen oil
12. To identify the natural products using Spectroscopic techniques such as Mass spectrometry, IR, UV spectroscopy
13. Synthesis of dihydropyrimidinone
14. Preparation of caffiec acid from 3, 4 dihydroxy benzaldehyde
15. Isolation of caffeine from tea leaves

TEXT BOOKS:

1. Nakanishi K., Natural Product Chemistry, Academic Press

REFERENCE BOOKS:

1. Manitto P., Biosynthesis of Natural Products, Horwood Ltd
2. Finar I. L., Textbook of organic Chemistry, Volume II
3. Finar I. L., Organic Chemistry: Stereochemistry and the Chemistry of Natural Products, ELBS Edition

SEMESTER V

CORE COURSE

THEORY
Course Title: Advanced Chemistry I: Physical and Inorganic Chemistry
Course Code: CHE- V. C-7
Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Understand the interactions of electromagnetic radiation and matter in IR and Raman spectroscopy and their applications.
CO2 : Express applications and harmful effects of nuclear radioisotopes.
CO3 : Demonstrate a sound knowledge of the photochemistry principles and their application.
CO4 : Employ the theories that govern metal ligand bonding.
CO5 : Interpret the types of crystal field splitting and calculate the crystal field stabilization energy.
CO6 : Discuss the types of d-d transitions and its theory.

Learning outcome
1. Will have a working knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. Will help to get better understanding about the basics of Physical and Inorganic Chemistry.
3. Will be able to carry out experiments with required skills.

SECTION I (PHYSICAL CHEMISTRY)

UNIT I: Molecular Spectroscopy **07L**
Definition of spectrum. Electromagnetic radiation, quantization of different forms of energies in molecules : translational, rotational and electronic, Born Oppenheimer approximation, factors affecting line width and intensity.
Infrared spectroscopy
Hook's law, energy levels and transitions: Simple harmonic oscillator, anharmonic oscillator (derivations expected), Calculation of force constant, Stretching and bending vibrations, modes of vibration of diatomic, linear triatomic (CO_2) and non linear triatomic (H_2O) molecules, applications of IR spectroscopy.
Raman spectroscopy - Rayleigh and Raman scattering, Stokes and Antistokes lines. Mutual exclusion principle. Differences between Raman and IR spectroscopy Numerical problems expected

UNIT II: Photochemistry **04L**
Interaction of radiation with matter, difference between thermal and photochemical processes, Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions. Numerical problems expected

UNIT III: Electrochemistry **07L**
EMF of a cell and its measurements, concentration cells: electrode and electrolyte with and without transport, liquid junction potential and its measurement; applications of concentration cell: determination of ionic product of water, transport number of ions, solubility and solubility product.
Numerical problems expected

UNIT IV: Nuclear Chemistry **05L**
Natural Radioactivity: kinetics of radioactive decay, half-life and average life of radioelements (derivations expected),
Measurement of radioactivity: GM counter, Scintillation counter

Artificial radioactivity: Chain reaction and conditions for its control.
Radioisotopes and their applications; radiolabelled reactions, radiocarbon dating, medicinal and agricultural field, hazards of radiation.
Numerical problems expected

SECTION II (INORGANIC CHEMISTRY)

UNIT V: Metal-Ligand Bonding in Transition Metal Complexes 11L

Principles and limitations of Valence bond theory, Crystal field theory (CFT) splitting of d- orbitals in octahedral, tetrahedral and square planar complexes. Crystal Field Stabilization Energy (CFSE), Measurement of 10 Dq for $[Ti(H_2O)_6]^{3+}$ complex, Factors affecting 10 Dq, Spectrochemical series, Effect of crystal field splitting on properties of Octahedral complexes: Magnetic, Spectral.

UNIT VI: Electronic spectra of Transition Metal Complexes: 11L

Introduction, types of electronic transitions: The d-d transitions (d^1/d^9 and d^2/d^8), charge transfer transitions and ligand-ligand transitions, selection rules (Laporte orbital and spin), applications (ligand field strength, colour of complexes, *cis*-, *trans*- isomerism and geometry of complexes).

PRACTICALS
Course Title: Advanced Chemistry I: Physical and Inorganic Chemistry
Course Code: CHE- V. C-7
Marks: 25
Credits: 01

List of experiments:
PHYSICAL EXPERIMENTS: (Any four may be performed)

1. To determine the percent composition of acid mixture (weak acid and salt of weak base and strong acid) by titrating against standard 0.1N NaOH solution conductometrically.
2. To determine the strength of mixture containing weak acid (CH_3COOH) and weak base (NH_4OH) by titrating against standard 0.1N NaOH solution conductometrically.
3. To determine the formal redox potential of Fe^{2+}/Fe^{3+} system using standard 0.1N $K_2Cr_2O_7$ solution potentiometrically.
4. To determine the percent composition and amount of halide ions from their mixture (any two halides) using standard 0.1N $AgNO_3$ solution potentiometrically.
5. To determine the dissociation constant of weak monobasic acid (CH_3COOH) by titrating against standard 0.1N NaOH solution using pH meter.
6. To study the acid hydrolysis of ethyl acetate at two different temperatures and calculate the energy of activation.

INORGANIC CHEMISTRY

1. Preparations of the following complexes. (2hours each)
   a) $[Ni(NH_3)_6]Cl_2$
   b) $[Co(NH_3)_3(NO_2)_3\ Cl_3$
   c) $K_3[Al(C_2O_4)_3].H_2O$
   d) Preparation and estimation of Ti in $[Ti(H_2O)_6]^{3+}$ complex.
2. Estimation of Ni in $[Ni(NH_3)_6]Cl_2$ gravimetrically
3. Estimation of Co in a cobalt complex gravimetrically

REFERENCE BOOKS:

PHYSICAL CHEMISTRY
TEXTBOOK:

1. Bahl B.S, et.al, 2004, "Essentials of Physical Chemistry" S. Chand & Co., New Delhi

ADDITIONAL READING:

1. Arnikar H.J.,1995, "Essentials of Nuclear Chemistry", Wiely-Eastern Ltd., New Delhi
2. Atkins P, et.al, 2006,"Physical Chemistry", Oxford University Press, New Delhi
3. Castellan, G.W,2002, "Physical Chemistry", Narosa Publishing House, New Delhi,
4. Kundu K. et.al,2003, "Physical Chemistry", S. Chand & Co., Ltd., New Delhi

5. Puri B.R et.al,2008,"Principles of Physical Chemistry",Vishal Publishing Company, Jalandhar
6. Raj Gurdeep, 2000 ,"Advanced Physical Chemistry", Goel Publishing House, Meerut
7. Srivastava A.K, et.al, 1989,"Essential of Nuclear Chemistry", S.Chand & Co, New.Delhi

INORGANIC CHEMISTRY
TEXTBOOK:

1. Atkins P, Overton T, Rourke J et.al, *Shriver and Atkins' Inorganic Chemistry*, 5th Edition, Oxford University Press.

ADDITIONAL READING:

1. Cotton F.A and Wilkinson G, *Basic Inorganic Chemistry*,Wiley Eastern Ltd.
2. Huheey J.E, Keiter E.A, Keiter R.L, Medhi O.K, *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Edu.
3. Lee J.D, *Concise Inorganic Chemistry*, Wiley-India

SEMESTER V

ELECTIVE COURSES

THEORY
Course Title: Heterocyclic Chemistry
Course Code: CHE- V. E-9
Maximum Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Identify, name and classify the various heterocyclic compounds.
CO2 : Describe the structure, different reactions and preparations of selected nitrogen and oxygen containing aliphatic heterocycles.
CO3 : Describe the structure, diverse reactions and syntheses of pyrrole, furan, thiophene and pyridine heterocycles.
CO4 : Describe the structure, diverse reactions and synthetic routes with mechanisms of numerous condensed heterocycles.
CO5 : Predict the reactivities of complex heterocyclic compounds containing the structural motif of these simple heterocycles.
CO6 : Apply the synthetic methodologies for the synthesis of complex heterocycles.

Learning outcome:
1. Students will learn about important aspects with respect to heterocyclic chemistry.
2. Students will develop understanding with regards to reactivity of heterocyclic chemistry.
3. Students will learn efficient chemical synthesis involved in heterocyclic compounds.

UNIT I: Introduction to heterocyclic compounds **03L**
Classification and Nomenclature of aliphatic and aromatic heterocycles.

UNIT II: Aliphatic heterocycles **10L**
Structure and reactivity of nitrogen and oxygen containing aliphatic heterocycles. Methods of preparation and reactions of oxiranes, aziridines, tetrahydrofuran, pyrrolidine.

UNIT III: Five and six membered aromatic heterocycles **17L**
Structure and reactivity of five and six membered heterocycles: furan, pyrrole, thiophene and pyridine; comparison of basicity of pyrrole, pyridine & piperidine. Electrophilic substitution reactions of five and six membered heterocycles: General mechanism, mechanism of halogenation, nitration and reaction using acids (HCl, H_2SO_4 and HNO_3). Methods of preparation of furan, pyrrole, thiophene and pyridine. Nucleophilic substitution reactions of aromatic heterocycles.

UNIT IV: Condensed heterocycles **15L**

Structure and reactivity of condensed heterocycles like benzofuran, Indole, benzothiophene, quinoline and isoquinoline. Electrohilic and nucleophilic substitution reactions of condensed heterocyles: General mechanism and with examples. Oxidation and reduction of condensed hetero cylcles. Methods of preparation of benzofuran, Indole, benzothiophene, quinoline and isoquinoline.

PRACTICALS
Course Title: Heterocyclic Chemistry
Course Code: CHE- V. E-9
Marks: 25
Credits: 01

List of experiments: (Any 6)

1. Epoxidation of chalcones (2steps)
2. Synthesis of the Coumarins via Pechmann condensation
3. Synthesisof 3,4- dihydropyrimidin-2(1H)-ones by a one-pot three component cyclocondensation reaction of 1,3 dicarbonyl compound, aldehyde, and urea via Biginelli reaction
4. Synthesis of 1,3,5-trisubstituted pyrazoles (2steps)
5. Synthesis of benzimidazole from o-phenylenediammine and formic acid
6. Synthesis of 2-substituted benzoxazoles from 2-amino phenol and aromatic aldehydes.
7. Synthesis of quinoxaline derivatives
8. Synthesis of flavones via Baker-Venkataraman rearrangement (3steps)
9. Preparation of 2-phenyl indole via fischer indole synthesis

REFERENCES:

TEXT BOOK

1. Joule J. A. and Mills K. **2010.** "*Heterocyclic Chemistry*". Wiley publications

ADDITIONAL READING:

1. Carey, F. C. and Giuliano, R. M. **2000.** "*Organic Chemistry"* Tata McGraw-Hill India.
2. Gilchrist T. **2007.** "*Heterocyclic Chemistry".* Pearson Education India
3. Smith, M. B and March, J . **2012.** " March's Advance organic Chemistry" Wiley publications.

ELECTIVE COURSE

THEORY
Course Title: Nanomaterials and Solid State Chemistry
Course Code: CHE-V. E-10
Maximum Marks: 75
Credits: 3
Theory: 45 Lectures

Course Objectives:

On successful completion of the course, the student will be able to:
CO1 : Recall the history, occurrence and technological development of nanomaterials and classify them.
CO2 : Compare different synthesis techniques of nanoparticles like biological, chemical and physical and design various nanomaterials.
CO3 : Evaluate XRD data, and calculate its parameters; carry out analysis of TG-DTA thermogram; assess morphology and particle size from SEM/TEM images.
CO4 : Express the physical and chemical properties of solids like magnetic, electrical and dielectric which can be interpret the applications of materials in various field like catalysis, ferrofluids, etc.

Learning outcome:

1. Students will have a basic and concise knowledge of nanomaterials.
2. Students will develop skills in nanomaterial synthesis.
3. Will be able to understand characterization techniques in solid state chemistry.

UNIT I: Introduction and properties of nanomaterials **06L**

Fundamentals: terminology and history, classification of nanomaterials, properties of nanomaterials: optical, magnetic, electronic, surface area, catalytic and mechanical.

UNIT II: Synthesis and characterization of nanomaterials **10L**

Synthesis Approach with at least one example of each: Chemical methods (sol-gel, hydrothermal, sonochemical, microwave, precursor). Top down and bottom up, physical methods (mechanical methods, methods based on evaporation, sputter deposition, chemical vapour deposition), biological methods (using microorganism and plant extract).

Characterization techniques: electron microscopic techniques (SEM/TEM), diffraction techniques, spectroscopic (UV-Visible, magnetic measurement), BET surface area.

UNIT III: Applications of nanomaterials **06L**

Energy, automobiles, sports, textile, cosmetics, medicinal, space, defence, engineering and catalytic. Toxicity of nanomaterials

UNIT IV: Solid state chemistry **11L**

Reactions of solids: tarnish reactions, decomposition reaction, solid-solid reactions, addition reactions, double decomposition reaction, electron transfer reaction, solid-gas reactions. Sintering.

Phase transformations in solids: structural change in phase transformation, Martensite transformation, temperature and pressure induced transformations, order-disorder transitions.

UNIT V: Electrical and magnetic properties of solids **12L**

Electrical conductivity, insulators, semiconductor and conductors. Band theory of semiconductors, photo conductivity and ionic conductivity.

Piezoelectric, ferroelectric materials and applications.

Introduction to magnetism, behavior of substance in a magnetic field, magnetic moments, diamagnetism, paramagnetism, experimental determinations of susceptibility, ferromagnetism, antiferromagnetism, ferrimagnetism, magnetizations of a ferromagnetic substance.

PRACTICALS
Course Title: Nanomaterials and Solid State Chemistry
Course Code: CHE-V. E-10
Maximum Marks: 25
Credits: 01

List of Practicals: (Any 8 practicals)

1. Synthesis of silver nanoparticles by chemical method.
2. Synthesis of ZnO nanomaterials.
3. Synthesis of CdS nanomaterials.
4. Synthesis of nanoparticles using plant extract (metal/ metal oxides).
5. To find out particle size using SEM/TEM data.
6. To study the X-ray diffraction pattern of given sample (Phase and particle size).
7. Preparation of zinc oxalate dihydrate and analysis of its TG/DTA pattern.
8. To prepare mixed metal oxide of Zn and Fe using co-precipitation technique.
9. To prepare mixed metal oxide of Zn and Fe using precursor technique.
10. Measurements of electrical and magnetic properties of pure and mixed metal oxides.

REFERENCE BOOKS:

TEXTBOOK:

1. Atkins P. W., Overton T. L., Rourke J. P., Weller M. T. and Armstrong F. A., *Shriver and Atkins Inorganic Chemistry*, Oxford University press.

ADDITONAL READING:

1. Keer H. V., *Principles of Solid State Chemistry*, New Age International Publishers,
2. Kulkarni S. K., *Nanochemistry, Principles and Practices*, Capital publishers.

3. Poole C. P. and Owens F. J., *Introduction to Nanotechnology*, John-Wiley and Sons.
4. Rao M. B. and Reddy K. K., *Introduction to Nanotechnology*, Campus books International.
5. West A. R., *Solid State Chemistry and its Applications*, John-Wiley and Sons.

ELECTIVE COURSE

THEORY
Course Title: Organometallic Chemistry
Course Code: CHE- V. E-11
Maximum Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Illustrate metal-ligand interaction in formation of different metal carbonyls based on valence bond theory.
CO2 : Explain and rationalize the synthesis, structure, bonding, properties of organometallic compounds of main group elements.
CO3 : Apply the EAN concept and Wade's rules to any organometallic system and predict its stability, structure and bonding.
CO4 : Understand the chemical behavior and predict the reaction mechanism of organometallic compounds.
CO5 : Illustrate the catalytic cycles using an organometallic compound as a catalyst for industrial synthesis of some organic compounds.
CO6 : Interpret IR spectra of metal carbonyls and predict their structure.

Learning outcome: Upon completion of the course, the student will be able to:
1. Use the basic principles of chemistry and molecular orbital theory to describe chemical bonding and structure of organometallic compounds and describe the structure and behaviour of organometallic compounds.
2. Explain and predict the chemical behavior and reactivity of organometallic compounds.
3. Describe and explain catalytic processes using an organometallic compound as a catalyst and explain how organometallic compounds are used as catalysts in organic synthesis.

UNIT I: Introduction to organometallic chemistry 08L
Definition, classification of organometallic compounds, Nomenclature, ligands, concept of hapticity of organic ligands, 18 electron rule, EAN concept, electron counting and oxidation states in complexes. General methods of preparation with one example of each (direct combination, reductive carbonylation, thermal and photochemical decomposition) and general properties of organometallic compounds of 3d series.

UNIT II: Metal carbonyls 10L
Classification of metal carbonyls; Mononuclear metal carbonyls: Preparation, properties, structure and bonding of $Ni(CO)_4$, $Fe(CO)_5$, $Cr(CO)_6$ using VBT; Polynuclear metal carbonyls: Preparation, properties, structure and bonding of $Co_2(CO)_8$, $Mn_2(CO)_{10}$, $Fe_2(CO)_9$ and $Fe_3(CO)_{12}$. -acceptor behaviour of CO (MO diagram of CO), synergic effect and use of IR data to explain structure and bonding in metal carbonyls.

UNIT III: Metallocenes 09L
Sandwich compounds, Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation etc.). Structure and aromaticity, comparison of aromaticity and reactivity with benzene. Synthesis and reactivity of cyclopentadienyl compounds, bonding in bis(cyclopentadienyl) complexes, Fluxional behaviour of metallocenes. Metal-metal bonding and metal clusters: structure of clusters, electron counting in clusters, synthesis of clusters.

UNIT IV: Organometallic compounds of Main group elements 09L
Preparation, properties, reactions and structure of alkyls and aryls of Group 1 elements (Li, Na); Group 2 elements (Be, Mg); Group 13 elements (B, Al)

UNIT V: Reactivity of organometallic compounds **09L**

Reactions of organometallic compounds: Ligand substitution, Oxidative addition and reductive elimination, σ-bond metathesis, 1,1-migratory insertion reactions, 1,2-insertions and β-hydride elimination. Catalysis by organometallic compounds: Alkene hydrogenation with Wilkinson's catalyst.

PRACTICALS
Course Title: Organometallic Chemistry
Course Code: CHE- V. E-11
Maximum Marks: 25
Credit: 01

List of experiments:

1. Synthesis of chloro(quinoline)cobaloxime
2. Synthesis of (phenyl)(pyridine)cobaloxime
3. Preparation of chloro(pyridine) *bis* (dimethylglyoximato) cobalt(III)
4. Preparation of bromo (pyridine) bis (dimethylglyoximato) cobalt (III)
5. Structure analysis of metal-carbonyls based on IR data.(4 hrs)
6. Metal complexes with triphenyl phosphine (minimum 4 hrs)
    i. $Co(PPh_3)Cl_2.\ 2H_2O$
    ii. $Ni(PPh_3)Cl_2.2H_2O$

REFERENCE BOOKS:
TEXTBOOK:

1. Atkins P, Overton T, Rourke J et.al, *Shriver and Atkins' Inorganic Chemistry*, 5th Edition, Oxford University Press.

ADDITIONAL READING:

1. Cotton F.A and Wilkinson G, *Basic Inorganic Chemistry*,Wiley Eastern Ltd.
2. Huheey J.E, Keiter E.A, Keiter R.L, Medhi O.K, *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Edu.
3. Lee J.D, *Concise Inorganic Chemistry*, Wiley-India

SEMESTER VI

CORE COURSE

THEORY
Course Title: Advanced Chemistry II: Organic and Analytical Chemistry
Course Code: CHE- VI. C-8
Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Assess conditions for obtaining maximum efficiency of extraction.
CO2 : Classify chromatographic methods.
CO3 : Apply chromatographic method for separation, qualitative and quantitative estimation.
CO4 : Predict the stereochemistry of products for various reactions using the mechanisms involved in the course.
CO5 : Explain the reactivity of organic compounds containing nitro, amino and cyano functional groups.
CO6 : Name and classify the carbohydrates and analyze its chemical reactivities.
CO7 : Name and classify the organosulfur and organophosphorous compounds and analyze its chemical reactivities.
CO8 : Apply the important reactions involved for the synthesis of other similar compounds.

Learning outcome
1. Will learn to write mechanisms with stereochemistry.
2. Will learn principles of separation and its applications.
3. Will have practical knowledge of chromatographic techniques.
4. Will be able to carry out experiments with required skills.

SECTION I (ORGANIC CHEMISTRY)

UNIT I: Mechanism and stereochemistry of addition, substitution and elimination reactions 07L
Mechanism and stereochemistry of (i) Addition of halogens acids (HX) and halogen (X_2) to open chain alkenes. Markownikoff's and anti-Markownikoff's addition. (ii) S_N1, S_N2, S_Ni , substitutions and (iii) E1, E2 and E1cb elimination reactions.

UNIT II: Organic Compounds containing Nitrogen 06L
Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid: preparation and properties. Structure and nomenclature of amines, physical properties. Structural features affecting basicity of amines. Preparation of alkyl and aryl amines by reduction of nitro compounds and nitriles, reductive amination of carbonyl compounds, Gabriel phthalimide reaction and Hofmann rearrangement.

UNIT III: Carbohydrates 06L
Classification and nomenclature. Monosaccharides: General reactions. Configuration of monosaccharides with reference to glucose. d(+)/l(-) and D/L systems of nomenclature. Interconversion of glucose to fructose and glucose to mannose. Cyclic structure of D(+)glucose. Mechanism of mutarotation. Formation of glycosides, ethers and esters. Structure of sucrose and inversion of cane sugar.

UNIT IV: Chemistry of Organosulfur and organophosphorus compounds 04L
Nomenclature and classification of Organosulfur compounds. Methods of preparation and chemical reactions of thiols, disulfides and sulphonic acids. Nomenclature and classification of organophosphorus compounds. Preparation of phosphines. Phosphorous ylides and their general methods of preparation. Wittig reaction and its synthetic applications.

SECTION II (ANALYTICAL CHEMISTRY)

UNIT V: Solvent Extraction **05L**

Principle, efficiency of extraction, percentage extraction, complexing agents in solvent extraction, separation factor, types of extraction, applications of solvent extraction
(Numericals expected)

UNIT VI: Chromatographic techniques **17L**

Principle, classification of chromatographic techniques Theory of chromatographic separation
Column Chromatography: Principle, technique and applications
Paper chromatography: Principle, technique and applications
Thin layer chromatography: Principle, technique and applications
Ion exchange chromatography: Principle, classification of ion exchangers. Factors affecting the distribution of ions between the resin and the solution, ion exchange capacity, applications of ion exchange chromatography
Gas chromatography: Principle, instrumentation, and applications. Comparison of GSC and GLC
HPLC: Principle, instrumentation and applications
Hyphenated techniques: GC-MS and LC-MS
(Numericals expected)

PRACTICALS
Course Title: Advanced Chemistry II: Organic and Analytical Chemistry
Course Code: CHE- VI. C-8
Marks: 25
Credits: 01

List of experiments:
ORGANIC CHEMISTRY EXPERIMENTS:
Organic mixture separation, purification of individual compounds and qualitative analysis of separated compound. **(Any 06)**
Solid-solid, 03 mixtures
Solid-liquid, 02 mixtures
Liquid-liquid, 01 mixtures
Note: 0.5 gm of solid-solid mixture to be analyzed on small scale. 3-4 ml of liquid to be added in mixture.

ANALYTICAL CHEMISTRY EXPERIMENTS: (Any 4 experiments to be performed)
1. To separate metal ions by paper chromatography and determine retardation factor (4 hours)
2. To study separation of organic compounds by TLC (4 hours)
3. To estimate magnesium from Zn^{2+}/Mg^{2+} mixture by using an anion exchanger resin
4. To estimate zinc from Zn^{2+}/Mg^{2+} mixture by using an anion exchanger
5. To determine the equilibrium constant for the reaction $KI + I_2 = KI_3$ (4 hours)
6. To separate a mixture of carboxylic acid and neutral compound by using solvent extraction technique (4 hours)

REFERENCE BOOKS:
ORGANIC CHEMISTRY
TEXT BOOK
1. Morrison, R. T., etal. **2010. "**Organic Chemistry". Pearson Publications, Noida India.

ADDITIONAL READING
1. Bruice, P. Y. **2015**. "Organic Chemistry". Pearson Publications, Noida India.
2. Carey, F. C., etal. **2012.** "Organic Chemistry". Tata McGraw-Hill India.
3. Finar, I. L. **2013**. "Organic Chemistry". Volume 1. Pearson Publications, Noida India.

ANALYTICAL CHEMISTRY
1. Christian, G. D. "Analytical Chemistry". 5th edition. John Wiley publications
2. Skoog D.A., West D. M. and Holler F. J.; Fundamentals of Analytical Chemistry, 4th Saunders College Publishing

SEMESTER VI

ELECTIVE COURSE

THEORY
Course Title: Spectroscopic Methods in Organic Chemistry
Course Code: CHE-VI. E-13
Maximum Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Describe the principles of IR, UV and Mass spectroscopy.
CO2 : Calculate UV maxima of any given organic compound using Woodward-Fieser rules.
CO3 : Predict the presence of various functional groups in a given organic compound using IR spectroscopy.
CO4 : Interpret the mass spectra of various organic compounds.
CO5 : predict the structures of organic compounds based on the given ^{1}H NMR and ^{13}CMR data.
CO6 : interpret the ^{1}H NMR and ^{13}CMR spectra of organic compounds.

Learning outcome:
1. Will be able to do spectral analysis of organic compounds.
2. Will learn theory of important spectroscopic techniques.
3. Will be able to elucidate structures of organic compounds based on spectral data.
4. Will be able to operate an UV-visible spectrometer.

UNIT I: Introduction to spectroscopy 03L
Nature of electromagnetic radiation: wave length, frequency, energy, amplitude, wave number, and their relationship, different units of measurement of wavelength frequency, different regions of electromagnetic radiations, Regions of electromagnetic radiation. Interaction of radiation with matter: absorption, emission, fluorescence and scattering, types and advantages of spectroscopic methods.

UNIT II: UV-Visible Spectroscopy 07L
Ultraviolet (UV) absorption spectroscopy: Absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophores and auxochromes, bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated dienes and enones, Woodward-Fieser rules for calculation of UV maxima of the above two systems.
Numerical problems expected

UNIT III: Infra Red (IR) absorption spectroscopy 09L
Molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, functional group region, finger print region and its use to establish identity, applications to determine purity, to study progress of chemical reactions and hydrogen bonding. Characteristic absorptions bands of various functional groups and interpretation of IR spectra of organic compounds. Structure elucidation by using UV and IR spectral data is expected.

UNIT IV: Proton Magnetic Resonance (^{1}H NMR) spectroscopy 13L
Introduction to NMR Spectroscopy, types of protons: equivalent, non-equivalent, homotopic, enantiotopic and diastereotopic protons, NMR Spectrometer (block diagram), nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, intensity of peaks, interpretation of ^{1}H NMR spectra of simple organic molecules. Structure elucidation of organic compounds using ^{1}H NMR spectral data is expected.

UNIT V: ^{13}C Nuclear Magnetic Resonance 06L
Number of signals, splitting of signals, proton coupled and decoupled spectra, off resonance decoupled spectra. ^{13}C NMR chemical shifts, identification of hybridization of carbons and nature of functionalization. Structure elucidation of organic compounds using ^{13}C NMR spectral data is expected.

UNIT VI: Mass Spectrometry **07L**

Instrumentation, definitions of parent or molecular ion peak and base peak. Isotope effect with respect to alkyl halides. Fragmentation of ketones: -cleavage and Mc-Lafferty rearrangement.

[Structure elucidation of organic compounds using Mass, UV, IR, ^{1}H NMR and ^{13}C NMR spectral data is expected]

PRACTICALS

Course Title: Spectroscopic Methods in Organic Chemistry

Course Code: CHE-VI. E-13

Maximum Marks: 25

Credits: 01

List of experiments: (Any 10)

1. Calculate UV maxima for given organic structure and match it with the given spectra of organic compounds.
2. Match the given set of organic compounds with the given set of spectra. List: Alkane, alkene, alcohol, ether, amine, carboxylic acid, ester and amides.
3. Verify Bathochromic, hypsochromic, hyperchromic and hypochromic shifts in phenol and aniline using UV-Vis spectrometer.
4. Identification of organic compounds based on given IR spectra of organic compounds.
5. On basis of IR spectra, distinguish between the given set of organic compounds. (set of 2 compounds × 3).
6. Identify the compounds based on given Mass Spectra. List: Alkane, alkene, alcohol, ether, amine, carboxylic acid, ester and amides.
7. Give the fragmentation patterns for the given mass spectra of organic compounds.
8. Compare relative abundance of isotopes of halogen containing compound.
9. Determination of organic compound using given set of ^{1}H NMR data.
10. Determination of organic compound using given ^{1}H NMR spectrum.
11. Assigning the chemical shift values to the peaks of given ^{1}H NMR spectrum of organic compounds.
12. Determination of organic compound using given set of ^{13}C NMR data.
13. Assigning the chemical shift values to the peaks of given ^{13}C NMR spectrum of organic compounds.
14. Assigning the chemical shift values to the peaks of given ^{1}H NMR spectrum of organic compounds.
15. Identification of organic compounds based on given spectroscopic information.

REFERENCE BOOKS:

TEXTBOOKS:

1. Silverstein, R. M., et. al. **2015. "***Identification of Organic Compounds*". Wiley publications

REFERENCE:

1. Kalsi, P. S. **2007. "***Spectroscopy of Organic compounds*". New Age International (P) Ltd. New Delhi.
2. Morrison, R. T., et. al. **2010. "***Organic Chemistry*". Pearson Publications, Noida India.
3. Pavia, D. L., et. al. **2008**. "*Introduction to Spectroscopy"*. Cengage Learning.

ELECTIVE COURSE

THEORY
Course Title: Environmental Chemistry
Course Code: CHE-VI. E-14
Maximum Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Delineate how pollutants are transported and accumulated in the environment.
CO2 : Recognize different types of toxic substances and analyze toxicology.
CO3 : Describe water purification and waste treatment processes.
CO4 : Apply knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil.
CO5 : Apply basic chemical concepts to analyze chemical processes involved in different environmental problems.
CO6 : Develop skills in procedures and few instrumental methods applied in analysis of soil and water pollution.

Learning outcomes
The course provides understanding how:
1. pollution affects our environment
2. knowledge of chemistry can be used to solve problems.
3. instrumental techniques can be used for chemical analysis of pollutants.

UNIT I: Introduction **07L**
Atmosphere: Composition, Structure, properties vertical temperature behavior, lapse rate and temperature inversion.

a) **Air pollution**: Introduction, classification of pollutants, sources, control, effect w.r.t. oxides of Nitrogen, Carbon and Sulphur, Photochemical smog, acid rain and Green House effect
b) **Water pollution**: Chemical, physical and biological characteristics of water pollution, specific an d Nonspecific characterization of water. DO, BOD, COD and chlorine demand, typical water treatment and waste water treatment. Importance of buffer and buffer index in waste water treatments.

UNIT II: Sampling of Pollutants **05L**
Sampling of air pollutants**:**

a) Absorption in liquids
b) Adsorption on solids: cold trapping adsorption and collection of particulates.

Sampling of water pollutants: sampling and sample preservation.
Sampling of solids: sample size, equipment and methods of sampling, Auger sampler, tube sampler.

UNIT III: Chemistry of atmosphere and soil **07L**
Reactions in the atmosphere: a) formation in the atmosphere b) reaction of hydroxyl radical with trace gases and as sources of hydroperoxy radical and hydrogen peroxide. The methane cycle.
Macro- and micro-nutrients in soil (N, P,K), chemistry of minerals of soil forming rocks.
Toxic elements in soil including those are in trace quantities.
Pollutants in soil

UNIT IV: Adverse effects of specific pollutants **03L**
Effects of Hg, Pb and nitrites on humans and other living organisms.
Oil Spill: Biological and physical effects.
Acid, mine and drainage: Reactions of FeS_2 (pyrites), Cr, As and F.

06L

UNIT V: Ozone Chemistry

Major atmospheric species involved in ozone formation and destruction.

Some major chemical reactions in the troposphere associated with ozone. Stratospheric ozone: pollutants destroying stratospheric ozone layer. Species destroying ozone layer: a) catalytic NO, b) photo dissociation of CFCs, c) catalytic role of chlorine, and d) combined chain reaction. The ozone holes

UNIT VI: Techniques of water treatment and solid waste management 07L

a) Treatment of water for municipal purpose: important process involved in purification of water.
b) Treatment of water for Industries: removal of hardness of water Clark's method, use of ion exchange resins. Solid waste management
c) Classification of solid wastes, types of waste of origin.
d) Solid waste management method: (i) Utilisation, (ii) Recovery, (iii) Reuse (iv) Recycling of wastes/ residues, (v) Recycling avoidance of solid waste.
e) Use of Remote Sensing in Environmental Management**.**

UNIT VII: Optical and radiochemical techniques 03L

1. Turbidimetry and Nephelolmetry: introduction, basic principle
2. Isotope dilution analysis: principle and applications
3. Neutron activation analysis: principle and applications

UNIT VIII: Application of instrumental techniques in environmental and chemical analysis 07L

1. Air analysis: (a) SO_2, (b) H_2S, c) CO d) CO_2 and (e)NOx
2. Water analysis: a) determination of organic loadings b) determination of toxic metal ions c) C.O.D d) B.O.D and e) D.O.
3. Soil/Sediment analysis:a) Bulk density, b)Specific gravity, c) Moisture content d) Water holding capacity e) Conductivity f) Alkalinity, and g) detection of Sulphate, calcium and iron

PRACTICALS

Course Title: Environmental Chemistry
Course Code: CHE-VI. E-14
Maximum Marks: 25
Credits: 01

List of experiments: (Any 8 may be performed)

1. Determination of sodium in water: ion exchange method
2. Determination of Total solids, Total dissolved solids and total suspended solids and its significance.
3. Determination of chloride content in tap water samples: Mohr's method
4. Determination of acidity and alkalinity in water samples.
5. Determination of total, permanent and temporary hardness of water sample
6. Determination of DO of water sample
7. Determination of polluting elements such as Pb, Hg and As in water.
8. Analysis of Mn in a water sample by visual titrimetry/Spectrophotometry.
9. Analysis of different types of soil- pH, conductivity, alkalinity
10. Determination of nitrite in water : colorimetric method
11. Determination of COD of water samples
12. Determination of BOD of water samples
13. Determination of phosphate: Colorimetric method

REFERENCE BOOKS:

1. Christan G. D., 5th edition ,"Analytical Chemistry ", Wiley publication
2. De, A. K,1995 "Environmental Chemistry", Wiley eastern Ltd.
3. Iqbal,S.A.et.al,1995," Chemistry of Air and Air Pollution", Discovery Publishing House, New Delhi
4. Katyal Jimmy et.al, 1993,"Environmental Pollution", Anmol Publications, New Delhi
5. Manahan, S.E. 1994,"Environmental Chemistry" Lewis Publishers
6. Neil,P. O 2007,"Environmental Chemistry", Blackie Academic & Professional
7. Raghuraman, K.et al,4th edition," Basic Principles of Analytical Chemistry",sheth publishers
8. Schroede, E.D,1997, "Water & waste water treatment", Mc. Graw Hill
9. Skoog et.al, 4th International edition ,"Principles of Analytical Chemistry"
10. Trivedi P.R. et.al, 1st edition"Environmental Water and Soil Analysis",

11. Akashdeep Publishing House, New Delhi
12. Tyagi, O.D. et.al, 1992,"A Text Book Of Environmental Chemistry" Anmol Publications, New Delhi
13. Vanloon G.W. et.al, 2003,"Environmental Chemistry", Oxford University Press

ELECTIVE COURSE

THEORY
Course Title: Selected Topics in Inorganic Chemistry
Course Code: CHE- VI. E-15
Maximum Marks: 75
Credits: 03
Theory: 45 Lectures

Course Objectives:
On successful completion of the course, the student will be able to:
CO1 : Differentiate between thermodynamic stability and kinetic stability and apply it to transition metal complexes.
CO2 : Apply the concepts to determine the reaction mechanism of transition metal complexes.
CO3 : Determine the factors that govern the stability and lability of transition metal complexes.
CO4 : Understand the chemistry and function of some of the technologically useful materials like liquid crystals, superconductors and fullerides.
CO5 : Discuss what are polymers and their properties, to classify the polymers (based on coordination, addition and condensation reaction).
CO6 : Illustrate the preparation, structure and bonding and applications of polymers comprising of B, P, Si and S.
CO7 : Analyze the magnetic properties of the transition metal complexes as well as interpret the effect of temperature on magnetic properties.
CO8 : Explain Guoy's balance for determining the magnetic susceptibility.
CO9 : Identify and apply the symmetry elements in molecules and to evaluate the Point groups and symmetry elements in molecules with appropriate examples.

Learning outcome: Upon completion of the course, the student will be able to:
1. encourage students to analyze and integrate concepts relevant to graduate level Inorganic chemistry.
2. understand the bond formation of compounds with special reference to MOT and CFT.

UNIT I: Inorganic Polymers **08L**
Definition, properties, classification (condensation, addition and coordination), preparation, structure and bonding and applications of polymers containing Boron (borazine), phosphorous (phosphazenes), silicon (silicones), sulfur (S_4N_4, thiazyl halides).

UNIT II: Magnetic Properties of Transition Metal Complexes **07L**
Types of magnetic behaviour, magnetic susceptibility, effect of temperature on magnetic properties, Curie temperature, Neel temperature, Curie-Weiss law. Methods of determining magnetic susceptibility, Guoy's balance, spin only formula, calculation of magnetic moment of transition metal ions, application of magnetic moment data for 3d-metal complexes.

UNIT III: Thermodynamic and Kinetic Aspects of Metal Complexes **12L**
Thermodynamic and kinetic stability of metal complexes, equilibrium constants, formation constants, lability, inert complexes, factors affecting the stability, substitution reactions in tetrahedral and octahedral complexes. Electron transfer reactions- inner sphere mechanism and outer sphere mechanism, Trans effect with respect to square planar complexes.

UNIT IV: Materials Chemistry **10L**

Zeolites: types, structure and applications.
Composite materials: Metal-organic frameworks (MOF's); structure, ligands, applications.
Molecular materials: Fullerides, liquid crystals, molecular magnets.
Superconductors: discovery, critical temperature, Meissner effect, types of superconductors.
Corrosion: response of material to chemical environments, galvanic corrosion and other forms of corrosion. Prevention methods.

UNIT V: Molecular Symmetry **08L**

Symmetry elements and operations: Centre of symmetry, Rotation axis, Mirror plane, rotation-reflection axis, Identity element. Point groups, Identifying symmetry elements and point group in molecules. (examples to be solved)

PRACTICALS
Course Title: Selected Topics in Inorganic chemistry
Course Code: CHE- VI. E-15
Maximum Marks: 25
Credit: 01

List of experiments:

1. Separation and Determination of transition metal ions
    a) Separation of Mg^{2+} and Zn^{2+} by ion exchange and its estimation (4 hrs)
    b) Separation of Cd^{2+} and Zn^{2+} by ion exchange and its estimation (4 hrs)
2. Determination of stability constant of complex ions in solution
    a) Fe(III) – salicylic acid complex (Job's Method)
    b) Fe(II) – 1,10-phenanthroline
3. Determination of instability constant for the reaction between Ag^{+} and NH_3
4. Determination of instability constant for the reaction between Cu^{2+} and en
5. Estimation of Ca in compounds containing calcium.
6. Estimation of Ni in compounds containing nickel.
7. Estimation of Cu in compounds containing copper.
8. Estimation of metal ions in mixed metals compound.

REFERENCE BOOKS:

TEXTBOOKS:

1. Atkins P, Overton T, Rourke J et.al, *Shriver and Atkins Inorganic Chemistry*, Oxford University Press.

ADDITIONAL READING:

1. Lee J.D, *Concise Inorganic Chemistry*, Wiley-India
2. Huheey J.E, Keiter E.A, Keiter R.L, Medhi O.K, *Inorganic Chemistry: Principles of structure and reactivity*, Pearson Edu., 1993
3. Cotton F.A and Wilkinson G, *Basic Inorganic Chemistry*,Wiley Eastern Ltd, 1993
4. Puri B.R, Sharma L.R, Kale K.C, *Principles of Inorganic Chemistry*, Vallabh Publications.