DEPARTMENT OF CHEMISTRY

COURSE SYLLABUS EFFECTIVE FROM

ACADEMIC YEAR: 2022-2023

SEMESTER I

SEMESTER II

SEMESTER III

SEMESTER IV

SEMESTER V

SEMESTER VI

COURSE STRUCTURE:

SEMESTER	CORE COURSES		ELECTIVE COURSES				SKILL ENHANCEMENT COURSES	GEC
I	CHE-I. C-1 General Physical and Inorganic Chemistry	CHE-I. C-2 General Organic and Inorganic Chemistry	---	---	---	---	---	CHE-GEC-1 Basics of 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 and Inorganic Chemistry)	---	CHE-III. E-1 Name Reactions and Synthetic Methodologies	CHE-III. E-2 Introduction to Industrial Chemistry	CHE-III. E-3 Surface Chemistry and Catalysis	CHE-III. E-4 Bioinorganic Chemistry	CHE.SEC-1 Skill Development in Chemistry CHE. SEC-2 Plating and corrosion	
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	CHE. SEC-3 Laboratory Techniques in Organic Chemistry	
V	CHE-V. C-7 Advanced Chemistry – I (Physical and Inorganic Chemistry)	---	CHE-V. E-9 Heterocyclic Chemistry	CHE-V. E-10 Nanomaterials and Solid State Chemistry	CHE-V. E-11 Organometallic Chemistry	CHE-V. E-12 Selected Topics in Physical 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	CHE-VI. E-16 Electro analytical Chemistry	---	

COURSE SYLLABUS:

SEMESTER- I

CORE COURSES

THEORY
Course Code: CHE-I.C-1
Course Title: General Physical and Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

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 requiredskills.

Course Learning Outcomes:

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 and study kinetics of chemical reactions.
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.

SECTION- I (PHYSICAL CHEMISTRY)

Unit I: Mathematical Preparations for Chemists **06 hours**

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.

Unit II: Chemical Kinetics **08 hours**

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).

Unit III: Solid State **08 hours**

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).

Unit IV: Gaseous State **08 hours**

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)

Unit V: Atomic Structure and the Periodic Table **05 hours**

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 nuclearcharge.

Unit VI: Covalent Bonding **10 hours**

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^- 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
Course Code: CHE- I.C-1
Course Title: General Physical and Inorganic Chemistry (Practicals)
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

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. [Multiple solutes may be used]
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.
6. To study the molecular condition of benzoic acid in toluene-water system.
7. To study the kinetics of reaction between bromide ions and HNO_3 using colorimeter.

8. To study the kinetics of Iodine-Clock reaction.
9. To study the oxidation of iodide ions by hydrogen peroxide as an iodine clock reaction.
10. To study the kinetic characteristics of iodination of acetone by colorimetric method.

INORGANIC CHEMISTRY

1. Preparation of standard solutions and to carry out the dilution to 0.05, 0.01, 0.001 M in 50 mL standard volumetricflask.
2. To prepare 100 ppm 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.
4. Preparation of chrome Red
5. Preparationof ferrous ammonium sulphate.

PHYSICAL CHEMISTRY TEXT BOOK:

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

ADDITIONAL READING:

1. Bahl A., Bahl B. S. and Tuli, G. D. *Essentials of Physical Chemistry*, S. Chand and 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.

PRACTICAL BOOK:

Khosla B. D., Garg V. C., Gulati A., *Senior Practical Physical Chemistry*, S. Chand and Co., New Delhi

WEB REFERENCES:

1. http://alpha.chem.umb.edu/chemistry/ch115/Mridula/CHEM%20116/documents/chapter_14auLectureSlides_000.pdf
2. https://www.livescience.com/53304-gases.html
3. https://www.slideshare.net/kumar_vic/solid-state-chemistry-17237117
4. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Properties_of_Gases/Kinetic_Theory_of_Gases/Basics_of_Kinetic_Molecular_Theory

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 and Atkins' InorganicChemistry*, Oxford University Press.

PRACTICAL BOOK:

Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., *Vogel's Text book of Quantitative Chemical Analysis*, Pearson.

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., Kalia, K. C. *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Sharpe and Emilus, Inorganic Chemistry.
6. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, Prentice Hall.

WEB REFERENCES:
1. https://www.thoughtco.com/valence-shell-electron-pair-repulsion-theory-605773
2. https://www.britannica.com/science/covalent-bond
3. https://www.electrical4u.com/schrodinger-wave-equation/
4. http://www.chem4kids.com/files/atom_structure.html
5. https://pubchem.ncbi.nlm.nih.gov/periodic-table/

CORE COURSE

THEORY
Course Code: CHE-I.C-2
Course Title: General Organic and Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
1. Students will learn about the basic concepts in Organic Chemistry like the hybridization 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 IUPACnomenclature.
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.

Course Learning Outcomes:
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 given unknown organic compounds (solid) by carrying out various chemical tests.
CO6: Predict available oxidation states for s- and p-block elements.
CO7: Identify which halides, oxides and hydrides are covalent, which are ionic, and why.
CO8: Apply the knowledge of Normality and Molarity in preparation of different solutions.

SECTION- I (ORGANIC CHEMISTRY)

UNIT I: IUPAC Nomenclature of Organic Compounds 02 hours

Basic rules of IUPAC nomenclature, nomenclature of the compounds- alkanes, cycloalkanes, alkenes, alkynes, halo alkanes, 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.

UNIT II: Structure and Reactivity of Organic Compounds 10 hours

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 organicmolecules.

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

Different arrows used 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.

UNIT III: Stereochemistry 08 hours

Isomerism, types of isomers: constitutional, conformational and configurational isomerism. Chirality, chiral centre, enantiomers and diastereomers (with example of threo and erythrodiastereomers, 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 explained). E/Z nomenclature.

UNIT IV: Study of alkanes, cycloalkanes and alkenes 10 hours

Alkanes and Cycloalkanes**:** Physical properties of alkanes and cycloalkanes, sources of alkanes and cyclo alkanes, 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, regio selectivity in alcohol dehydration: The Zaitsev rule, rearrangement in alcohol dehydration, dehydro halogenation: E1 and E2 mechanisms, reactions of alkenes: hydrogenation, addition of halides and hydrogen halides, regio selectivity of hydrogen halide addition, hydroboration and oxidation reactions, oxymercuration- demercuration reactions, epoxidation of alkenes, ozonolysis of alkenes.

SECTION- II (INORGANIC CHEMISTRY)

UNIT V: Chemistry of s-block elements 05 hours

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

UNIT VI: Chemistry of p-block Elements **10 hours**

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 poly halides.

PRACTICALS

Course Code: CHE-I.C-2

CourseTitle: General Organic and Inorganic Chemistry

Credits: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

ORGANIC CHEMISTRY

1. Purification techniques for organic solid compounds
   Crystallization: a. Benzoic acid from water; b. m-Dinitrobenzene from ethanol
2. Purification techniques for organic solid compounds
   Sublimation: a. Naphthalene b. Anthracene c. Camphor
3. **Organic Synthesis:** Benzoylation of β-naphthol andaniline.
4. **Organic Synthesis:** Bromination of aromatic compounds using $KBrO_3$
5. **Organic Synthesis:** Anthraquinone from anthracene (Oxidation reaction)
4. **Qualitative Analysis (Solids)**

   Acids: Benzoic, salicylic, phthalic
   Phenols: α-Naphthol, β-naphthol
   Bases: p-Toluidine, diphenylamine, o-, m- and p-nitro anilines
   Anilides: Acetanilide, benzanilide
   Hydrocarbons: Naphthalene, anthracene
   Amides: Benzamide, urea
   Haloarenes: p-Dichlorobenzene
   Nitro Compounds: m-Dinitrobenzene, p-nitrotoluene
   Carbohydrates: Glucose, fructose, mannose

   Note: Any five solids to be analysed

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. To determine the alkali content in antacid tablet using standard HCl solution.
4. Volumetric estimation of Calcium from anhydrous Calcium Chloride.
5. To determine the Total Dissolved Solids (TDS) of Magnesium Sulphate.

ORGANIC CHEMISTRY TEXT BOOK:

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.
4. Vogel, A. I.,Tatchell, A.R., Furnis, B.S., Hannaford, A. J. and Smith, P. W. G., *Vogel's Textbook of Practical Organic Chemistry,* Pearson.

WEB REFERENCES:

1. https://www.khanacademy.org/science/organic-chemistry/bond-line-structures-alkanes-cycloalkanes
2. https://www.khanacademy.org/science/organic-chemistry/gen-chem-review
3. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination-reactions
4. https://www.khanacademy.org/science/organic-chemistry/stereochemistry-topic
5. https://www.khanacademy.org/science/organic-chemistry/alkenes-alkynes

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 and Atkins' InorganicChemistry*, Oxford University Press.

PRACTICAL BOOK:

Mendham, J., Barnes, J. D., Denney, R. C., Thomas, M. J., Sivasankar, B., *Vogel's Text book of Quantitative Chemical Analysis,* Pearson.

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., Kalia, K. C., *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Sharpe and Emilus, InorganicChemistry.
6. Housecroft, C. E. and Sharpe, A. G. *Inorganic Chemistry*, Prentice Hall.

WEB REFERENCES:

1. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/complexing-agent
2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Descriptive_Chemistry/Main_Group_Reactions/The_s-Block_Elements_in_Biology
3. https://classnotes.org.in/class11/chemistry/p-block-elements/boron-hydrides/
4. https://www.toppr.com/guides/chemistry/the-p-block-elements/interhalogen-compounds/
5. https://www.sciencedirect.com/topics/materials-science/fullerene

SEMESTER- II

CORE COURSES

THEORY
Course Code: CHE-II.C-3
Course Title: Concepts in Physical and Analytical Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
1. Will have knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or relatedfields.
2. Will be able to understand the principles of titrimetric methods.
3. Attain practical skills in some classical and instrumental techniques.

Course Learning Outcomes:
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 science, stoichiometric calculations and apply for numerical.
CO5: Sketch titration curves and solve numerical.
CO6: Explain theory of precipitation and complex formation titrations.
CO7: Perform non-instrumental and instrumental quantitative analysis.

SECTION- I (PHYSICAL CHEMISTRY)

Unit I: Thermodynamics **10 hours**

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 Thomson effect, 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 thermodynamic data, Temperature dependence of enthalpy, Kirchoff's equation (Numerical expected).

Unit II: Liquid State and Applications **07 hours**

The Inter molecular 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 liquid crystals (Numerical expected).

Unit III: Phase Equilibria **06 hours**

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)

Unit IV: Introduction to Analytical Chemistry and some basic concepts **04 hours**

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

Unit V: Titrimetric methods of analysis **05 hours**

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 (Numericalexpected

Unit VI: Theory and applications of neutralization titrations **05 hours**

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 (Numerical expected).

Unit VII: Titration curves for poly functional acids and poly functional bases **04 hours**

Poly functional acids and poly functional bases, titration curves for poly functional acids, titration curves for poly functional bases, composition of solutions of a poly protic acid as a function of pH (Numerical expected).

Unit VIII: Precipitation and Complex formation titrations **04 hours**

Titration curves, end points for argentometric titrations, applications of standard silver nitrate solutions, Complex formation reactions, titrations with amino poly carboxylic acids (Numerical expected).

PRACTICALS
Course Code: CHE-II.C-3
Course Title: Concepts in Physical and Analytical Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

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.

5. To determine the heat of neutralization of strong acid with strong base.
6. To determine the heat of neutralization of weak acid with weak base.
7. To determine the surface tension of a liquid by drop number method using stalagmometer.
8. To study the effect of surfactant on the surface tension of Toluene.

ANALYTICAL CHEMISTRY

1. To standardize hydrochloric acid against sodium carbonate.
2. To standardize sodium hydroxide against potassium hydrogen phthalate.
3. To determine the hardness in water.
4. To standardize sodium thiosulphate solution against copper.
5. To determine the amount of boric acid in the given solution using conductometry.
6. To determine the amount of lead ions in the given solution using conductometry.
7. To determine the percent composition of sulphuric acid and phosphoric acid in a mixture volumetrically.

PHYSICAL CHEMISTRY TEXT BOOK:

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 and 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.

WEB REFERENCES:

1. https://www.livescience.com/50881-first-law-thermodynamics.html
2. https://www.thoughtco.com/surface-tension-definition-and-experiments-2699204
3. https://www.chem.uci.edu/~lawm/263%206.pdf

ANALYTICAL CHEMISTRY TEXT BOOK:

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

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. and Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.
4. Puri, B. R., Sharma, L. R., Kalia, K. C., *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, Prentice Hall.

WEB REFERENCES:

1. http://ion.chem.usu.edu/~sbialkow/Classes/3600/Overheads/Titration/Volumetric.html
2. https://facultystaff.richmond.edu/~rdominey/301/local/Titrimetry_Methods.pdf

THEORY
Course Code: CHE-II.C-4
Course Title: Concepts in Organic and Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75
Course Objectives:

1. Students will learn 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.

Course Learning Outcomes:

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 and interpret crystal structures.
CO7: Describe lattice energy, Born-Haber's cycle, Fajan's rule and defects in solids.
CO8: Explain trends in periodic properties of d-block elements with respect to their ionic radii, oxidation state, spectral properties, magnetic properties.
CO9: Describe crystalline solids in terms of their structure, ionic radii and coordination there by able to interpret crystal structure.
CO10: Identify the given organic compounds (liquids) by carrying out various chemical tests.

SECTION- I (ORGANIC CHEMISTRY)

Unit I: Study of alkynes **03 hours**

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.

Unit II: Arenes and Aromaticity **08 hours**

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.

Unit III: Study of Alcohols and Alkyl Halides **12 hours**

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)

Unit IV: Chemistry of transition elements **12 hours**

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.

Unit V: Ionic Solids: Structure and Bonding **10 hours**

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

Course Code: CHE-II.C-4

Course Title: Concepts in Organic and Inorganic Chemistry

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

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 andnitrobenzene
2. Organic synthesis: a. p-Bromo acetanilide from aniline
   b. Oxidising agent PCC (Pyridinium Chlorochromate)
   c. Oxime from cyclohexanone
3. Qualitative Analysis: (Liquids)

   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
Note: Minimum five compounds to be analysed covering different functional groups.

INORGANIC CHEMISTRY

Semi-micro qualitative analysis: To analyse 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+}, K^{+}, NH_4^{+}.

Anions: Cl^{-}, Br^{-}, I^{-}, NO_2^{-}, NO_3^{-}, SO_3^{2-}, CO_3^{2}-, SO_4^{2-}, PO_4^{3-}

Note: Minimum five inorganic compound mixtures to be analysed covering different groups of cations.

ORGANIC CHEMISTRY TEXT BOOK:

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. Fina, r I. L., *Organic Chemistry*, Pearson India.

WEB REFRENCES:

1. https://www.khanacademy.org/science/organic-chemistry/alkenes-alkynes
2. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination-reactions
3. https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds
4. https://www.khanacademy.org/science/organic-chemistry/alcohols-ethers-epoxides-sulfides
5. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf
6. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2011.pdf

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., *Concise Inorganic Chemistry*, ELBSPublications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F. *Shriver and Atkins' InorganicChemistry*, Oxford University Press.

PRACTICAL BOOK:

1. Svehla, G. and Sivasankar, B., *Vogel's Qualitative Inorganic Analysis,* Pearson
2. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., *Vogel's Text Book of Quantitative Inorganic Analysis*

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. and Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.
4. Puri, B. R., Sharma, L. R., Kalia, K. C., *Principles of Inorganic Chemistry*, Vishal Publishing Co.
5. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, Prentice Hall.

WEB REFERENCES:

1. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/magnetic-property
2. https://www.toppr.com/guides/chemistry/the-solid-state/imperfections-or-defects-in-a-solid/
3. https://www.quora.com/What-is-fajans-rule-in-chemistry
4. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Crystal_Lattices/Thermodynamics_of_Lattices/Lattice_Energy%3A_The_Born-Haber_cycle
5. https://www.chem.fsu.edu/chemlab/chm1046course/solids.html

SEMESTER III

CORE COURSE

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

Course Objectives:

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 andactinides.
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 acrystal.
5. Will be able to get a deeper understanding of the theory with practical knowledge.

Course Learning Outcomes:

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.
CO8: Perform instrumental analysis
CO9: Perform synthesis and estimation of inorganic complexes

SECTION - I (PHYSICAL CHEMISTRY)

Unit I: Thermodynamics **10 hours**

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 acriterion of spontaneity and equilibrium; Entropy changes 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.

Unit II: Chemical Equilibrium **05 hours**

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.

Unit III: Electrochemistry **08 hours**

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 andl imitations; Migration of ions and Kohlrauschlaw; 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 (Example: Strong acid and strong base).

SECTION - II (INORGANIC CHEMISTRY)

Unit IV: Chemistry of f-block elements **09 hours**

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.

Unit V: Introduction to Coordination Compounds **08 hours**

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

Unit VI: Acids, Bases and Non-aqueous solvents **05 hours**

Arrhenius concept and Bronsted theory; Lewis's 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 Code: CHE-III.C-5
Course Title: Comprehensive Chemistry - I (Physical and Inorganic Chemistry)
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:
PHYSICAL CHEMISTRY

1. To verify Ostwald's dilution law by determining the equivalent conductance of a weak mono basic 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 solubility of benzoic acid in water at different temperatures and to calculate the heat of solution.
7. To determine energy of activation for acid catalysed hydrolysis of methyl acetate.
8. To determine the equivalent conductance of a weak electrolyte (CH_3COOH) at infinite dilution by conductometric method.

INORGANIC CHEMISTRY

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 dissolved oxygen in water sample
7. Gravimetric estimation of Ba as $BaSO_4$
8. Gravimetric estimation of Fe as Fe_2O_3

PHYSICAL CHEMISTRY TEXT BOOK:

Raj G., *Advanced Physical Chemistry*, Goel Publishing House, Meerut, 27th Edition

REFERENCE BOOK:

Puri B. R., Sharma L. R., Pathania M. S., *Principles of Physical Chemistry*, Vishal Publishing Company

WEB REFERENCES:

1. https://www.livescience.com/50941-second-law-thermodynamics.html
2. https://www.chemguide.co.uk/physical/equilibria/lechatelier.html
3. https://sciencenotes.org/electrolytes-strong-weak-and-non-electrolytes/

INORGANIC CHEMISTRY TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

1. https://www.britannica.com/science/coordination-compound
2. https://www.unf.edu/~michael.lufaso/chem4612/chapter9.pdf
3. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Descriptive_Chemistry/Elements_Organized_by_Block/4_f-Block_Elements/The_Lanthanides/aLanthanides%3A_Properties_and_Reactions

ELECTIVE COURSE

THEORY

Course Code: CHE-III.E-1

Course Title: Name Reactions and Synthetic Methodologies

Credits: 3

Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

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.

Course Learning Outcomes:

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 involving electrophilic aromatic substitution reactions

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.

CO8: Apply the theoretical knowledge during practical hours to prepare selected compounds,

UNIT I: Name reactions involving nucleophilic addition to carbonyl compounds 15 hours

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.

UNIT II: Name reactions involving electrophilic aromatic substitutions and rearrangement reactions 15 hours

Introduction to general mechanism involved, reactivity of arenes, product distribution, ipso-substitution and orientation in aromatic compounds with electron donating and electron withdrawing substituents.

Reactions and mechanisms of: Friedel-Crafts alkylation and acylation, Vilsmeier-Haack reaction, Gattermann-Koch reaction, Reimer-Tiemann reaction and Kolbe-Schmitt reaction. Reactions and mechanisms of: Beckmann rearrangement, Curtius rearrangement, Hofmann rearrangement, Pinacol- Pinacolone rearrangement, Wagner-Meerwin rearrangement, Claisenrearrangement.

UNIT III: Oxidation and reduction reactions 15 hours

Oxidation reactions: 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 inhydrocarbons.

Reduction reactions: 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 Code: CHE-III.E-1
Course Title: Name Reactions and Synthetic Methodologies
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

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 acetophenone by grinding
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. Preparation of Iodoform from acetone

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

1. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination-reactions
2. https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds
3. https://www.masterorganicchemistry.com/2017/07/11/electrophilic-aromatic-substitution-introduction/
4. https://www.toppr.com/guides/chemistry/aldehydes-ketones-carboxylic-acids/nucleophilic-addition-reaction/

5. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2011.pdf
6. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf

ELECTIVE COURSE

THEORY
Course Code: CHE-III.E-2
Course Title: Introduction to Industrial Chemistry
Credits: 03
Duration: 45 Hours
Maximum Marks: 75

Course 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.

Course Learning 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 itsprevention.
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.
CO6: Will understand the fundamentals of industrial processes.
CO7: Will learn to treat industrial effluents.
CO8: Will learn electroplating.

Unit I: Fundamentals of Industrial Chemistry and Electroplating 15 hours
Relevance of catalysis in modern industrial processes, Mechanical properties of materials and change with respect to temperature, Metals and alloys- important metals and alloys, Glass- types, composition, manufacture, physical and chemical properties applications, Corrosion- various types of corrosion relevant to chemical industry- Mechanism, Preventive methods. Introduction: definition, fundamental principles- Faraday's laws, mechanism of deposition, surface preparation for electroplating of Zinc and Tin. Testing of electro deposits: for thickness, adhesion, stress and corrosion. Use of Hull cell in plating.

Unit II: Industrial processes, Boilers, Heat exchangers and Paint chemistry 15 hours
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); Introduction, classification and applications of boilers and heat exchangers; Introduction, general classification, composition, characteristics and applications of paints.

Unit III: Industrial Safety, Conducts, Waste management and Effluent treatment 15 hours
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 explosionhazards; 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; Treatment of electronic waste.

PRACTICALS
Course Code: CHE-III.E-2
Course Title: Introduction to Industrial Chemistry
Credits: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Preparation of 1-nitro naphthalene from naphthalene (Nitration).
2. Preparation of 2,4,6-tribromophenol from phenol (Bromination).
3. Preparation of 4-hydroxy benzene sulphonic 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.
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 lime stone.
11. To estimate the amount of copper from copper salt by spectrophotometric method.
12. To determine the rate of corrosion on a zinc plate in acidic medium.
13. To determine the rate of corrosion on an Aluminium plate in basic medium.
14. To determine the effect of temperature on rate of corrosion in acidic medium.
15. To determine the rate of corrosion on different metallic plates (Iron, Aluminium) in various HCl concentrations.

TEXT BOOK:

Sharma, B. K., *Industrial Chemistry*, 6th Edition, Goel Publishing House, Meerut.

REFERENCE BOOKS:

1. Bentley, J. et. al., *Introduction to paint chemistry and principles of paint technology*, 4th Edition, *Springer* Nethetlands.
2. Cotton, F. A. et. al. *Basic Inorganic Chemistry*, 2nd Edition, Wiley Eastern Ltd.
3. De, A. K., *Environmental Chemistry*, Wiley Eastern Ltd.
4. Foye, A. O., *Principles of Medicinal Chemistry*, Publication Philadephia.
5. Frederick, A. L., *Modern Electroplating*, 3rd Edition, 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,* 5th Edition, Wiley Blackwell Science Publications.
10. Naseer, K., *Electroplating- Basic Principles, Processes and Practice*,1st Edition, Elsevier.
11. Singh, P. P. et. al., *An Introduction to Synthetic Drugs,* Himalaya Publication, Bombay.
12. Terrance, H. I., *The Chemical Analysis of Electroplating Solutions,* Chemical Publishing Co. New York.
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.

WEB REFERENCES

1. https://www.sciencedirect.com/science/article/pii/S0010938X19309163
2. https://www.intechopen.com/books/wastewater-treatment-engineering/biological-and-chemical-wastewater-treatment-processes
3. https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/paints-pigments-coatings.html
4. https://oshwiki.eu/wiki/Prevention_of_fires_and_explosions
5. https://www.safeopedia.com/definition/1052/industrial-safety

ELECTIVE COURSE

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

Course Objectives:

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

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CO1: Describe the behavior of solid surfaces.
CO2: Understand the concept of catalysts and catalysis.
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.
CO7: Synthesize and characterize catalysts.

Unit I: Surfaces of Solids and Introduction to Catalysis **15 hours**

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. Introduction to catalysis, Types of catalysis, Characteristics of catalysts, Classification of catalysis, Some important classes of catalysts.

Unit II: Adsorption **15 hours**

Introduction, differences between adsorption, absorption and sorption; characteristics of adsorption, sorption and occlusion; adsorption of gases on solids; Physisorption and chemisorption; Adsorption isotherms; types of adsorption isotherms: Freundlich adsorption isotherm, Langmuir adsorption isotherm; adsorption isobars; 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 from solution; Gibbs adsorption equation (derivation not needed); ddsorption by porous solids; adsorption in meso pores and micro pores.

Unit III: Theories of Catalysis **15 hours**

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; 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.

PRACTICALS
Course Code: CHE-III.E-3
Course Title: Surface Chemistry and Catalysis
Credits: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To study the adsorption of acetic acid on charcoal and to verify Freundlich adsorption 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 using stalagmoeter.
5. To determine the indicator constant of a given indicator by colourimetric measurement.
6. To synthesize ZnO by decomposition method and determine the amount of zinc in ZnO by

complexometric method

7. To synthesize CuO and determine the amount of copper in CuO by complexometric method
8. To study the kinetics of iodination of acetone.
9. To study the hydrolysis of methyl acetate in presence of sulphuric acid and determine the energy of activation.
10. To study the kinetics of the autocatalytic 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 measurement.
14. To study the adsorption of iodine from alcoholic solution using charcoal.
15. To determine the energy of activation for the autocatalytic reaction between $KMnO_4$ and oxalic acid.

TEXT BOOK:

Raj G., Advanced Physical Chemistry, Goel Publishing House

REFERENCE BOOKS:

1. Adamson A. W., Physical Chemistry of Surfaces, Interscience Publishers.
2. Bowker M., The Basis and Applications of Heterogeneous Catalysis, Oxford University Press.
3. Somorjai G. A., Introduction to Surface Chemistry and Catalysis, Wiley, NewYork.

PRACTICAL BOOK:

Rajbhog S. W. and Chondhekar T. K., Systematic Experimental Physical Chemistry

WEB REFERENCES:

1. https://www.britannica.com/science/catalysis/Classification-of-catalysts
2. http://www.chemistrylearning.com/adsorption/
3. https://www.scienceofhealthy.com/enzyme-catalysis/
4. https://www.slideshare.net/lovnishthakur75/what-is-catalysis-its-type-and-its-application
5. https://www.slideshare.net/e_gulfam/sintering-33538445

ELECTIVE COURSE

THEORY
Course Code: CHE-III.E-4
Course Title: Bioinorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To be proficient in the basic principles of bioinorganic chemistry and biochemistry.
2. Understand the role of metal ions that are involved in different processes like oxygen transport, electron-transfer reactions, etc. in biological systems.
3. Summarize the role of metal centres in the metallo enzymes that are involved in the

catalysis of various biological reactions.

4. Will develop practical skills to prepare model systems which mimic the role of metal ions in biological systems.

Course Outcomes:

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 metallo biomolecules which are based on iron and copper ions.

CO3: Evaluate the role of metal centres in the metallo enzymes 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 photo synthesis.

CO8: Analyze how metals are used as diagnostic agents and application of Au, Cu, Zn, Pt-complexes as anti-cancer drug and in medicine.

CO9: Synthesize and analyze complexes.

Unit I: Introduction to Bioinorganic Chemistry **15 hours**

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; 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.

Unit II: Iron containing compounds in biology **15 hours**

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.

Unit III: Metallo enzymes and chemistry of metals in medicine **15 hours**

Copper enzymes: superoxide dismutase, cytochrome oxidase and ceruloplasmin; Zinc enzymes: carbonic anhydrase, carboxy peptidase and inter changeability of zinc and cobalt in enzymes; Iron and Molybdenum enzymes: xanthine oxidase, nitrogenase; Coenzymes: Vitamin B_{12} and B_{12} coenzymes; 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
Course Code: CHE-III.E-4
Course Title: Bioinorganic Chemistry (Practicals)
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Preparation of acetylacetonato manganese (III) complex.
2. Preparation of trisethylenediamine nickel (II) complex.
3. Preparation of Tris(acetylacetonato) iron (III).
4. Preparation of tris(thiourea) copper(I) sulphate.
5. Preparation of optical isomers, cis and trans dichloro(ethylenediamine) cobalt (III) chloride.
6. Preparation of hexamine cobalt (III) chloride.
7. Estimation of cobalt (III) from hexamine cobalt (III) chloride.
8. Preparation of bis(dimethylglyoxime)cobalt (I) a Vitamin B12 model system.
9. Preparation of Potassium trioxalatoferrate (III).
10. Estimation of Fe from the complex Tris(acetylacetonato) iron (III).
11. Estimation of oxalate from Potassium trioxalatoferrate (III).
12. Preparation of pentathiourea dicuprous nitrate.
13. Estimation of copper from pentathiourea dicuprous nitrate.
14. Estimation of nickel from trisethylenediamine nickel (II) complex.

TEXT BOOK:

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

REFERENCE BOOKS:

1. Fausto da Silva 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
4. Cotton F. A. and Wilkinson G, *Basic Inorganic Chemistry*, Wiley Eastern Ltd.

PRACTICAL BOOK:

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

WEB REFERENCES:

1. https://www.nature.com/subjects/bioinorganic-chemistry
2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Book%3A_Inorganic_Chemistry_(Saito)/8%3A_Reaction_and_Physical_Properties/8.2%3A_Bioinorganic_chemistry
3. https://nptel.ac.in/courses/104104109/
4. https://www.internetchemistry.com/chemistry/bioinorganic-chemistry.php
5. https://www.sciencedirect.com/journal/bioinorganic-chemistry

SKILL ENHANCEMENT COURSE

Course Code: CHE.SEC-1
Course Title: Skill Development in Chemistry (Theory and Practicals)
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. To understand the chemistry of fats, oils and the process involved in preparing soaps, detergents and disinfecting agents and provide necessary skills for the preparation.
2. To study the composition and chemical parameters of commonly consumed beverages like soft drinks and packed fruit juices, the process involved in their preservation and their long term effects on human health.
3. To study the various food additives like food colours, taste enhancers, preservatives, etc. and their effects on food and health. Food adulteration of commonly used kitchen ingredients like wheat, rice, dal, milk, butter, etc. and the tests involved to detect the adulterants will be studied.

Course Outcomes:

On successful completion of the course the students will be able to:

CO1: Determine the saponification value, iodine value and acid values of oils and test the adulterants in food items.

CO2: Apply the skills for the preparation of white phenyl and liquid soap.

CO3: Apply the knowledge for the safe disposal of white phenyl.

CO4: Understand chemistry of soaps, synthetic detergents, alkyl and aryl sulphonates and floor cleaners.

CO5: Determine the pH of soft drinks and other beverages.

CO6: Understand chemistry of food additives and adulterants and apply the knowledge for detecting and testing foods items for adulterants.

Unit I: Fats and Oils, Soaps, Detergents and Disinfecting agents, Beverages, Food Additives and Adulterant **15 hours**

Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides. Hydrogenation of unsaturated oils. Saponification value, iodine value and acid value of oils. Soaps, synthetic detergents, alkyl and aryl sulphonates, floor cleaners- preparation, storage and disposal of white phenyl. Soft drinks, soda, fruit juices and alcoholic beverages (Types and content of alcohol). Composition of soft drinks, and its excessive use leading to urinary bladder stones. Preservation in tetra pack. Nitrogen preservation and packing of fruit juices. Food additives: Artificial sweeteners-saccharin, cyclomate, asparatame; food Flavours-esters, aldehydes and heterocyclic compounds. Food colours: Restricted use, spurious colours. Emulsifying agents, preservatives and leavening agents- baking powder, Yeast. Taste enhancers-MSG, vinegar. Food Adulteration: Contamination of wheat, rice, dal, milk, butter, etc. with clay, sand, stone, water and toxic chemicals. Food poisons: natural poisons (alkaloids, nephrotoxins), pesticides (DDT, BHC, Follidol), Heavy metal (Hg, Pb, Cd) contamination of sea food.

PRACTICALS **45 hours**

LIST OF EXPERIMENTS

1. Preparation of house hold /floor cleaner. **12 hours**
2. Preparation of detergent powder/soap/liquid soap. **13 hours**
3. Determination of Iodine number and saponification value of oils. **06 hours**
4. To analyze the pH of different soft drinks using pH meter **06 hours**
5. Test for adulterants in food items (turmeric powder, chilli powder, vanaspati in ghee, starch in milk, etc.) **08 hours**

REFERENCES BOOKS:

1. Battershall, J. P. *Food Adulteration and its detection*, ebook.
2. Belitz, H. D. etal., *Food Chemistry*. 4th Edition, Springer.
3. Branen, A. L. etal., *Food Additives*. 2nd Edition, Marcel Dekker, Inc.,
4. Fennema, O. R., *Food Chemistry*, Marcel Decker Inc., NewYork.
5. Madan, R. L., *Chemistry for Degree Students: T. Y. B. Sc. Students*, 2nd Edition, S. Chand Publications.

WEB REFERENCES:

1. https://www.wikihow.com/Formulate-White-Phenyle
2. https://www.youtube.com/watch?v=33NysscBs1k
3. https://www.wisegeek.com/what-are-the-most-common-hand-sanitizer-ingredients.htm
4. https://www.sciencedirect.com/topics/food-science/food-adulteration
5. https://fssai.gov.in/
6. https://www.who.int/news-room/fact-sheets/detail/food-additives

SEMESTER IV

CORE COURSE

THEORY
Course Code: CHE-IV.C-6
Course Title: Comprehensive Chemistry-II (Organic and Analytical Chemistry)
Credits: 3
Theory: 45 Hours
Maximum Marks: 75

Course Objectives:
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.
4. Steps involved in an analytical procedure.
5. Sampling of solids, liquids and gases.
6. Statistical treatment of analytical data.

Course Learning Outcomes:
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 reactivity 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 and gases.
CO7: Apply statistical treatment to analytical data.
CO8: Perform analytical procedures.

SECTION I (ORGANIC CHEMISTRY)

UNIT I: Ethers **04 hours**

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

UNIT II: Aldehydes and Ketones **08 hours**

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 organo copper 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).

UNIT III: Carboxylic Acids **06 hours**

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. Acid anhydrides: Preparation and reactions.

UNIT IV: Ester **05 hours**

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)

UNIT V: The Scope and Nature of Analytical Chemistry **05 hours**

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.

UNIT VI: Sampling Techniques **07 hours**

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.

UNIT VII: Statistical Treatment of Analytical Data **10 hours**

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 Code: CHE- IV. C-6
Course Title: Comprehensive Chemistry-II
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:
ORGANIC CHEMISTRY EXPERIMENTS

1. Identification of type and separation of mixture of organic compounds:
   Solid-solid (Soluble-insoluble, insoluble-insoluble), solid-liquid (Solid and low boiling liquid), liquid- liquid (High boiling and low boiling liquid).
2. Estimation of Ester.
3. Estimation of Amide.
4. Estimation of Acetone.
5. Estimation of Aniline.

Note: Maximum four Separation of mixture can be done.

ANALYTICAL CHEMISTRY EXPERIMENTS

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 iron present in the ferric alum by titrimetric method.
6. To calibrate the burette and pipette using statistical treatment of data.
7. To calibrate the volumetric flask of different volume capacity.
8. 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.

ORGANIC CHEMISTRY TEXT BOOK:

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

PRACTICAL TEXT BOOK:

Furniss, B. Brian, S., *Vogel's Textbook of Practical Organic Chemistry*, Pearson education

WEB REFERENCES:

1. https://www.khanacademy.org/science/organic-chemistry/alcohols-ethers-epoxides-sulfides
2. https://www.khanacademy.org/science/organic-chemistry/aldehydes-ketones
3. https://www.khanacademy.org/science/organic-chemistry/carboxylic-acids-derivatives

ANALYTICAL CHEMISTRY TEXT BOOK:

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

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. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis.
3. Christian, G. D., Analytical Chemistry, John Wiley.

PRACTICAL TEXT BOOK:

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

WEB REFERENCES:

1. https://www.slideshare.net/umar121/errors-in-chemical-analysis
2. https://www.britannica.com/science/sample-preparation/Sampling-solids-liquids-and-gases

ELECTIVE COURSE

THEORY

Course Code: CHE-IV.E-5

Course Title: Pharmaceutical Chemistry

Credits: 3

Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. The main objective of this course is to study the Chemistry involved in pharmaceutical industries.
2. This course gives blend of chemical and pharmaceutical principles necessary for understanding structure–activity relationships and molecular mechanisms of drug action.
3. This course also includes synthesis of some important drugs.

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Outline the significance of terminologies and regulation in pharmaceutical chemistry.
CO2: Discuss Safety in Pharmaceutical laboratories.
CO3: Classify pharmacological drugs.
CO4: Apply practical knowledge for the synthesis of some pharmaceutical drugs.
CO5: Understand the medicinal chemistry in plants.

Unit I: Introduction to pharmaceutical Chemistry and drug design strategies 15 hours

Importance of Chemistry in Pharmacy, Definition of terminologies: Pharmacology: Pharmacokinetics, Pharmacodynamics; Pharmacognosy, Dosage forms and Routes of administration, Advantages and disadvantages. Pharmacopoeia. Risks in a pharmaceutical Laboratory, Personal Protective Equipment (PPE), General preparation for Emergencies, Laboratory Emergencies: Spills and Fires.

Drug designing; General pathways of drug metabolism: Oxidative reactions, reductive reactions, hydrolytic reactions, Phase II or conjugation reactions.

Unit II: Anti-infective agents and Cardiovascular agents 15 hours

Antifungal agents: Haloprogin and Flucytosine. (Definition, structures, Mechanism of action and uses); Antibacterial agents: Ciprofloxacin and Furazolidone (Definition, structures and uses); Anti protozoal agents: Metronidazole (Definition, structure and uses); Antihelmintics: Thiabendazole (Definition, structure and uses); Antibacterial agents: Linezolid (Definition, structure and uses); Synthesis of Flucytosine.

Cardiovascular agents: Antianginal Agents and Vasodilators: Nitroglycerin, Nifedipine (Definition, structures and uses); Antiarrhythmic Drugs: Quinidine sulfate (Definition, structure and uses); Antihypertensive Agents: Prazosin (Definition, structure and uses); Synthesis of Nifedipine by Hantsch synthesis.

Unit III: Central nervous system stimulant and depressants and introduction to the Medicinal Chemistry of plants 15 hours

Analeptics: Pentylenetetrazole (Definition, structure and uses); Central sympathomimetic agents (psychomotor stimulants): Pentylenetetrazole (Definition, structure and uses); Antidepressants: Desipramine Hydrochloride and Clomipramine Hydrochloride (Definition, structure and uses); Anxiolytic: Paroxetine (Definition, structure and uses); Sedative and hypnotic agents: Propofol, Methaquolone (Definition, structure and uses); Synthesis of clomipramine.

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

PRACTICALS
Course Code: CHE-IV.E-5
Course Title: Pharmaceutical Chemistry
Credits: 1
Duration: 30 hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Synthesis of Aspirin.
2. Synthesis of Benzocaine.
3. Synthesis of Paracetamol.
4. Synthesis of Acetaminophen.
5. Synthesis of benzophenone oxime.
6. Synthesis of phenytoin.
7. Synthesis of benzimidazole.
8. Estimation of acetyl salicylic acid in the given aspirin tablet by titrating against 0.1 N alcoholic KOH potentiometrically.
9. Determination of purity of paracetamol spectrophotometrically.
10. Determination of optical rotation of pharmaceutical compounds.
11. UV Absorbance Standard Curve of Salicylic Acid.
12. Assay by titration of the following: Ibuprofen, aspirin.
13. Hydroxyzine dihydrochloride (HDH) determination by titrimetry.
14. Assay of Nitrazepam potentiometrically.
15. Quantitative estimation of aspirin in tablets using metformin hydrochloride.

TEXT BOOK:

1. Beale J. Jr., Block J., Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, Baltimore: Lippincott Williams and Wilkins.

REFERENCES BOOKS:

1. Indian Pharmacopoeia.
2. D. Lednicer, *The Organic Chemistry of Drug Synthesis*, New Jersey: John-Wiley & Sons, Inc.
3. Gennaro, A. R., *Remington: The Science and Practice of Pharmacy*, London: Mack Publishing Company.
4. Williams, D. A., Foye, W. O., Lemke, T. A., *Foye's Principles of Medicinal Chemistry*, Lippincott Williams & Wilkins.

WEB REFERENCES:

1. http://www.chemistryexplained.com/Ny-Pi/Pharmaceutical-Chemistry.html
2. https://www.thoughtco.com/important-lab-safety-rules-608156
3. https://www.labmanager.com/lab-health-and-safety/2017/12/science-laboratory-safety-rules-guidelines#.XiUvXcgzaM8 9. http://www.lawplainandsimple.com/legal-guides/article/health-and-safety-in-the-pharmaceutical-industry
4. https://benthamscience.com/journals/anti-infective-agents
5. https://www.sciencedirect.com/topics/medicine-and-dentistry/cardiovascular-agent
6. https://benthamscience.com/journals/medicinal-chemistry
7. https://pharmafactz.com/introduction-to-medicinal-chemistry
8. https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl

TEXT BOOKS:

1. Skoog D. A., Leary J. J., Principles of Instrumental Analysis, Philadelphia: Saunders College Publishing.
2. Beale J. Jr., Block J., Wilson and Gisvold's Textbook of Organic Medicinal and

Pharmaceutical Chemistry, Baltimore: Lippincott Williams and Wilkins.

REFERENCES BOOKS:

1. Indian Pharmacopoeia Commission, Indian Pharmacopoeia 2007.
2. Prichard Elizabeth, B. V., Quality Assurance in Analytical Chemistry. John Wiley and Sons.
3. Beckett A.H., StenlakeJ.B., Practical Pharmaceutical Chemistry, London: The Athlone Press.
4. Christian, G. D.; Analytical Chemistry, 6th Edition, New Jersey: John-Wiley and Sons, Inc.
5. Prabhu D.V, Raghuraman K., Basic Principles of Analytical Chemistry, Shet Publishers.
6. Lednicer D., Mitscher L., The Organic Chemistry of Drug Synthesis, New Jersey: John-Wiley and Sons, Inc.
7. Gennaro, A. R., Remington: The Science and Practice of Pharmacy, London: Mack Publishing Company.
8. Sharma, B. K., Instrumental Methods of Chemical Analysis, Meerut: Goel Publishing House.
9. Higuchi T., E. B.-H., Pharmaceutical Analysis. New York: Interscience Publishers.

WEB REFERENCES:

1. http://www.chemistryexplained.com/Ny-Pi/Pharmaceutical-Chemistry.html
2. https://www.pharmatutor.org/articles/significance-of-pharmaceutical-regulatory-bodies-a-review
3. https://www.pharmatutor.org/articles/pharmaceutical-regulatory-agencies-and-organizations-around-world-scope-challenges-in-drug-development
4. https://luxury.rehabs.com/drug-abuse/classifications/
5. https://www.europeanpharmaceuticalreview.com/article/868/pharmaceutical-analysis-in-quality-control/
6. https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
7. https://www.pharmatutor.org/articles/chromatography-introduction
8. https://www.labmanager.com/lab-health-and-safety/2017/12/science-laboratory-safety-rules-guidelines#.XiUvXcgzaM8
9. http://www.lawplainandsimple.com/legal-guides/article/health-and-safety-in-the-pharmaceutical-industry

ELECTIVE COURSE

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

Course Objectives:

1. Will be able to classify colloids.
2. Will be able to calculate molar mass of polymers.
3. Will learn to determine the molar mass of polymers in the laboratory.

Course Learning Outcomes:

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

CO1: Understand the term colloidal state of matter.

CO2: Evaluate properties of colloids.

CO3: Explain properties of gels and emulsions.

CO4: Calculate the molecular mass of polymer.

CO5: Understand solid state properties of polymers.

CO6: Design the synthesis of a polymer.

CO7: Synthesize and characterize colloids and determine molecular weight of polymer.

CO8: Distinguish between different types of solutions in terms of solute dimensions.

UNIT I: Colloidal Science **15 hours**

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; general properties; electrical properties; electrical double layers; kinetics of coagulation; inhibition; general applications of colloids on size of colloidal particles.

UNIT II: Emulsions, Gels and Introduction to Polymer Science **15 hours**

Emulsions- definition, types, preparation; gels- definition; classification, preparation and properties; 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; calculation of molecular weight: osmometry, light scattering method, intrinsic viscosity method.

UNIT III: Polymer Chemistry **15 hours**

Step growth polymerization- kinetics, molecular weight; chain growth polymerization- free radical polymerization and copolymerization, ionic polymerization and copolymerization; polymerization technique; bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, solid state-gas phase and plasma polymerization; polymer conformation and chain dimensions; thermodynamics of polymer solution- Flory-Krigbaum and Flory-Huggins theory; equation of state theory; 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 Code: CHE- IV. E-6

Course Title: Polymer and Colloid Science

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To prepare colloidal solutions of cadmium sulphide and ferric hydroxide.
2. To determine the flocculation value of a univalent and a divalent electrolyte for ferric hydroxide sol.

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 molar mass of a polymer using Ostwald's viscometer.
6. To study the variation of the viscosity of a given liquid with temperature using Ostwald's viscometer.
7. To determine the composition of a binary liquid mixture using viscometer.
8. To determine the viscosity of liquid mixture and test the validity of Kendall'sequation.
9. To compare the cleansing powers of two samples of detergents.
10. To determine the composition of a binary liquid mixture using stalagmometer.
11. To determine critical micelle concentration of a soap by surface tension method using stalagmometer.
12. To determine the molecular weight of a given polymer by turbidimetric method.
13. To separate the amino acids from the mixture by electrophoresis method.
14. To separate the inorganic cations by paper electrophoresis method.
15. To determine the amount of chloride ion by adsorption indicator method.

TEXT BOOK:

Raj G., *Advanced Physical Chemistry*; Goel Publishing House, Meerut.

REFERENCE BOOKS:

1. Puri B. R., Sharma L.R., Pathania M. S., *Principles of Physical Chemistry*, Vishal Publishing Co.
2. Fried J. R., *Polymer Science and Technology*; Prentice Hall of India private limited
3. Bhatnagar M. S., *A Text Book of Polymer Science*, Volume1

WEB REFERENCES:

1. https://www.toppr.com/guides/chemistry/surface-chemistry/classification-of-colloids/
2. https://www.slideshare.net/azamushahiullahprottoy/applications-of-colloid
3. https://www.livescience.com/60682-polymers.html
4. https://www.sciencenewsforstudents.org/article/explainer-what-are-polymers
5. https://www.toppr.com/guides/chemistry/surface-chemistry/properties-of-colloidal solutions/

ELECTIVE COURSE

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

Course Objectives:

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

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.

Course Learning Outcomes:

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

CO1: Outline the Beer's Law, Lambert's law and interprets 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; compare the colorimeter and spectrophotometer and employ the UV-Visible Spectrophotometer.

CO3: Outline the principle on which inductively coupled plasma spectroscopy works and illustrate the instrumentation involved in the technique.

CO4: Apply inductively coupled plasma spectroscopy technique and understand its limitations.

CO5: Perform qualitative and quantitative analysis based on absorbance measurements

UNIT I: General Introduction **15 hours**

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.

UNIT II: UV-Visible Spectroscopy **15 hours**

Beer's Law; Lambert's Law; Beer-Lambert's Law; validity and limitations of Beer-Lambert's law; Deviations from Beer-Lambert's Law; Instrumentation principles: Sources, monochromators, cells; types of instruments; photoelectric colorimeters- single and double beam; spectrophotometers- single and double beam; comparison between colorimeter and spectrophotometer; analytical applications of colorimeter and spectrophotometer: λ_{max}, quantitative analysis, identification of structural groups in a molecule, study of co-ordination compound; photometric titrations.

UNIT III: Electronic and Atomic Spectroscopy **15 hours**

Electronic (UV) spectroscopy- Theory; 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; Atomic Spectroscopy- 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 Code: CHE-IV.E-7

Course Title: Spectroscopic Techniques
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

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 estimate the amount of nitrite in water sample by spectrophotometric method.
6. To determine the amount of K_2CrO_4 present in given sample by using UV-Visible spectrophotometer.
7. To estimate the amount of paracetamol in tablet by spectrophotometric method.
8. To estimate the amount of aspirin in the given tablet by spectrophotometric method.
9. To verify the law of additivity of absorbance ($KMnO_4$ and $K_2Cr_2O_7$) at λ_{max} of $K_2Cr_2O_7$ and determine molar absorptivity.
10. To determine the phosphate concentration in a soft drink by spectrophotometric method.
11. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by continuous variation method.
12. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by mole ratio method.
13. To determine the dissociation constant of methyl red indicator by spectrophotometric method.
14. To determine the amount of Cr (VI) in the given solution as dichromate by least square method spectrophotometrically.
15. To derermine the amount of nitrobenzene from the organic sample by spectrophotometric method.

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.

WEB REFERENCES:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Spectrpy/UV-Vis/spectrum.htm
2. https://chemdictionary.org/beer-lambert-law/
3. https://www.indiastudychannel.com/resources/146681-Principle-working-and-applications-of-UV-spectroscopy.aspx
4. https://www.slideshare.net/manishpharma/application-of-uv-spectroscopy
5. http://liskeard.cornwall.sch.uk/images/Liskeard-Sixth-Form/Atomic-Absorption-Spectrometry.pdf

ELECTIVE COURSE

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

Course Objectives:

1. Students will learn about importance of natural product in day todaylife.
2. Students will learn different techniques used in isolation and characterisation of natural products.
3. Students will learn important chemical synthesis involved in naturalproduct.

Course Learning Outcomes:

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

CO1: Identify, name and classify different natural products.

CO2: Describe the occurrence, isolation, biogenesis, biosynthesis, chemical synthesis and structure elucidation of selected terpenes.

CO3: Describe methods for the isolation, purification and characterization techniques in natural products Chemistry.

CO4: Describe the occurrence, classification, isolation, chemical synthesis and structure elucidation of selected alkaloids.

CO5: Describe the occurrence, composition, classification, nomenclature, uses and some reactions of various biomolecules like fats, carbohydrates, amino acids and nucleic acids.

CO6: Apply practical knowledge for the isolation and synthesis of natural products.

UNIT I: Introduction to Natural Product Chemistry, Isolation, purification and characterization techniques in natural products Chemistry 15 hours

Introduction to natural products and classifications of natural products, Occurrence, classification and isolation of terpenes; 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).

UNIT II: Alkaloids and Biomolecules of life 15 hours

Occurrence, Classification and isolation of alkaloids; Chemical synthesis and structure elucidation of selected alkaloids: Nicotine, Atropine, Papaverine; Fats: Occurrence and composition; Hydrolysis of fats; Carbohydrates: Classification, nomenclature anduses; 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.

UNIT III: Terpenes **15 hours**

Occurrence, Classification and isolation of Terpenes; Chemical synthesis and structure elucidation of selected Terpenes: Citral, α-terpeneol, Camphor, Zinziberene.

PRACTICALS

Course Code: CHE-IV.E-8

Course Title: Chemistry of Natural Products

Credit: 1

Duration: 30 hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

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 Benzylidene acetophenone.
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 winter green oil.
12. To identify the natural products using spectroscopic techniques such as Mass spectrometry, IR, UV spectroscopy.
13. Synthesis of dihydropyrimidinone.
14. Preparation of caffeic acid from 3, 4 dihydroxybenzaldehyde.
15. Isolation of caffeine from tea leaves.

TEXT BOOK:

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.

WEB REFERENCES:

1. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/ch105-chapter-6-hydrocarbons/
2. https://www.jsps.go.jp/english/e-plaza/e-sdialogue/03_data/Dr_Lemin.pdf
3. https://www.ukessays.com/essays/chemistry/natural-product-chemistry.php
4. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/lipids.htm#terpen
5. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/proteins.htm#aacd1
6. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/carbhyd.htm#carb1
7. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/nucacids.htm#nacd1
8. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/30%3A_Natural_Products_and_Biosynthesis

SKILL ENHANCEMENT COURSE

THEORY
Course Code: CHE. SEC-2
Course Title: Plating and corrosion (Theory and Practicals)
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. Will learn principles of electroplating and its applications in various processes.
2. Will obtain a comprehensive and detail understanding of the principles of electroless plating.
3. Will be able to distinguish between various types of corrosion and calculate rate of corrosion.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand principles of electroplating.
CO2: Design bath for electroplating.
CO3: Formulate ideal conditions for electroless plating.
CO4: Perform electroless plating.
CO5: Identify types of corrosion.
CO6: Calculate rate of corrosion.

Unit I: Electro plating, Electroless plating and Corrosion studies 15 hours

Electroplating processes: Rack plating, mass plating, continuous plating, in-line plating; Applications of plating; Requirements of metal finishing: Quality test for plated materials and cost effectiveness, ecology and environment; Materials that can be electroplated; Electrolytes for deposition of metal coatings; Electrolytic metal deposition: Direct current electrodeposition, pulse plating processes, laser induced metal deposition; Electroless metal deposition: Deposition of metal layers, deposition of alloys, deposition of composite coatings, coating thickness distribution; Electroless plating of nickel, electroless plating of copper; Thermodynamics of corrosion, electrochemical cells and galvanic corrosion, Pourbaix diagrams; kinetics of corrosion; concentration polarization and diffusion, passivity, crevice corrosion and pitting, mechanically assisted corrosion, corrosion inhibitors.

PRACTICALS 45 hours

LIST OF EXPERIMENTS:

1. To study electroplating of copper. 06 hours
2. To study electroplating of nickel. 06 hours
3. To study electroplating of chromium. 06 hours
4. To study electroless plating of copper. 06 hours
5. To study electroless plating of nickel. 06 hours
6. To study corrosion of copper inacid solution. 04 hours
7. To calculate rate of corrosion of copper in acid solution. 04 hours
8. To study corrosion of iron in salt solution. 04 hours
9. To study corrosion of aluminium and zinc. 03 hours

TEXT BOOKS:

1. Kanani N., *Electroplating: Basic Principles*, Processes and Practice, Elsevier.
2. McCafferty E., *Introduction to Corrosion Science*, Springer-Verlag New York Inc.
3. Mallory G. D. and Hajdu J. B., *Electroless Plating: Fundamentals and applications*, Elsevier.

WEB REFERENCES:

1. https://sciencestruck.com/zinc-electroplating-process
2. http://www.iom3.org/sites/default/files/Development%20and%20Application%20of%20%20Corrosion %20Control%20Methods.pdf
3. https://www.twi-global.com/technical-knowledge/faqs/what-is-corrosion
4. https://nptel.ac.in/content/storage2/courses/113108051/module1/lecture1.pdf
5. https://inversesolutionsinc.com/different-types-of-plating-and-their-effect-on-the-end-product/

SKILL ENHANCEMENT COURSE

THEORY

Course Code: CHE. SEC-3

Course Title: Laboratory Techniques in Organic Chemistry (Theory and Practicals)

Credits: 4

Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

1. Develop skill that are required in a Research Laboratory set up.
2. To make the students aware of the hazards in Organic Chemistry Laboratory and precautions.
3. To learn how to write a laboraory note book.
4. To learn how to use a hand book and other references.
5. To develop experimental skills required in Organic Chemistry Laboratory.

Course Learning Outcomes:

On successful completion of the course the students will be able to:

CO1: Students will be able to work in Research and Development industry, Chemical Laboratories etc.
CO2: Take responsibility for their safety and the safety of their colleagues
CO3: Set up reaction and distillation assemblies.

Unit I: Skill Enhancement Course in Laboratory Techniques in organic Chemistry **15 hours**

General introduction: Synthesis, isolation, purification and characterization. Safety in the laboratory, Laboratory note book. Handbook: CRC handbook, Merck index, Aldrich catalogue. Glassware: Joints, adapters, round bottom flask, columns and condensers, greasing of joints, cleaning and drying of glassware. Drying agents: Drying agents and using a drying agent. Handling of solid and liquid products. Recrystallization: Theory and practice, practice of solvent extraction and washing. Distillation: Clamping and distillation setup, boiling chip, steam distillation. Heating and cooling methods: Steam bath, Bunsen burner, Heating mantel, oil bath, proportional heaters and stepless controllers. Assembling reaction apparatus for: Refluxing, anhydrous reactions, Inert reaction condition, addition of reagents during a reaction, removal of noxious vapours. Preparation of TLC and staining techniques. Drying of solvents.

PRACTICALS **45 hours**

LIST OF EXPERIMENTS

1. Drying of Acetone. **07 hours**
2. Distillation of Ethyl acetate and Petether. **08 hours**
3. Cleaning glass ware and drying. **04 hours**
4. Separation of colourless compound by thin layer Chromatography (Anthracene, Acetophenone, Benzophenone). **04 hours**
5. Recrystallization of organic compounds having low and high solubility and melting point determination. **04 hours**
6. Reaction involving inert atmosphere/anhydrous condition: Grignard Reaction: Synthesis, reaction monitoring, purification and characterization of Product OR Preparation of Fremys Salt and oxidation of phenol to quinone and purification. **08 hours**
7. Preparation of PDC **02 hours**
8. Oxidation of cinnamyl alcohol using PDC: Synthesis, reaction monitoring, purification by column chromatography and characterization of product. **08 hours**

TEXT BOOKS:

Vogel, A. I.;Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J. Smith, P. W. G., *Textbook of Practical Organic Chemistry*, 5th Edition, Prentice Hall.

REFERENCES BOOKS:

1. MANN, F. G.; SAUNDERS, B. C.**,** *Practical Organic Chemistry*, 2nd Edition, Longman Inc., New York.
2. GATTERMANN, L., *The Practical Methods of Organic Chemistry*, 2nd Edition, Macmillan and Co., Ltd.

WEB REFERENCES:

1. https://www.linfield.edu/assets/files/chem/Courses/CHEM%20321/2014-labtechniques-chem321-53f4eb52cbe42.pdf
2. https://open.umn.edu/opentextbooks/textbooks/organic-chemistry-laboratory-techniques

3. https://doi.org/10.1021/acs.jchemed.5b00528
4. http://do.chem.uni.wroc.pl/system/files/Organic%20chemistry%20-%20laboratory%20methods_201617_0.pdf

SEMESTER V

CORE COURSE

THEORY
Course Code: CHE-V. C-7
Course Title: Advanced Chemistry -I (Physical and Inorganic Chemistry)
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

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.

Course Learning Outcomes:

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.
CO7: Perform instrumental methods of analysis.
CO8: Synthesize and analyze complexes.

SECTION I (PHYSICAL CHEMISTRY)

UNIT I: Molecular Spectroscopy **07 hours**

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.

UNITII: Photochemistry **04 hours**

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.

UNITIII: Electrochemistry **07 hours**

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 **05 hours**

Natural Radioactivity: kinetics of radioactive decay, half-life and average life of radioelements (derivations expected), Measurement of radioactivity: GM counter, Scintillation counterArtificial 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 TransitionMetalComplexes **11 hours**

Principles and limitations of Valence bond theory, Crystal field theory (CFT) splitting of d-orbitals inoctahedral, 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 **11 hours**

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 Code: CHE-V.C-7
Course Title: Advanced Chemistry I: Physical and Inorganic Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:
PHYSICAL CHEMISTRY

1. To determine the percent composition of acid mixture (strong acid and weak acid) by titrating against strong base conductometrically.
2. To determine the strength of mixture containing weak acid (CH_3COOH) and salt of strong acid and weak base (NH_4Cl) by titrating against strong base 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 0.1 N $AgNO_3$ solution potentiometrically.
5. To determine the dissociation constant of weak monobasic acid (CH_3COOH) by titrating against standard 0.1 N NaOH solution using pH meter.

6. To study the acid hydrolysis of ethyl acetate at two different temperatures and calculate the energy of activation.
7. To determine solubility product of silver halide potentiometrically.
8. To investigate the reaction between H_2O_2 and HI

INORGANIC CHEMISTRY

Preparation of the complexes:

1. $[Ni(NH_3)_6]Cl_2$
2. $[Co(NH_3)_3(NO_2)_3Cl_3$
3. $K_3[Fe(C_2O_4)_3]. 3H_2O$
4. Estimation of Al from the $K_3[Al(C_2O_4)_3]. H_2O$ complex.
5. Preparation of zinc oxalate and estimation of zinc from the complex.
6. To estimate the amount of barium as $BaSO_4$ in a solution of Barium chloride containing ferric chloride and free HCl.
7. To estimate aluminium by back titration using zinc sulphate.

PHYSICAL CHEMISTRY TEXT BOOK:

Bahl B. S., et.al., Essentials *of Physical Chemistry*, S. Chand and Co., New Delhi.

ADDITIONAL READING:

1. Arnikar H. J., *Essentials of Nuclear Chemistry*, Wiley-Eastern Ltd., New Delhi.
2. Atkins P, et. al., *Physical Chemistry*, Oxford University Press, New Delhi.
3. Castellan G. W., *Physical Chemistry*, Narosa Publishing House, New Delhi.
4. Kundu K. et.al., *Physical Chemistry*, S. Chand and Co., Ltd., New Delhi.
5. Puri B.R., et.al, *Principles of Physical Chemistry*, Vishal Publishing Company, Jalandhar.
6. Raj G., *Advanced Physical Chemistry*, Goel Publishing House, Meerut.

WEB REFERENCES:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/photchem.htm
2. https://www.nde-ed.org/EducationResources/HighSchool/Radiography/detectionmeasurement.htm
3. https://ocw.mit.edu/courses/chemistry/5-35-introduction-to-experimental-chemistry-fall-2012/labs/MIT5_35F12_Mod1_Background.pdf

INORGANIC CHEMISTRY TEXT BOOK:

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

WEB REFERENCES:

1. http://cdn.intechopen.com/pdfs/38537/InTech-Electronic_absorption_spectra_of_3d_transition_metal_complexes.pdf
2. https://employees.csbsju.edu/cschaller/Principles%20Chem/New_Folder/TMligands.htm3. https://link.springer.com/chapter/10.1007/978-3-662-25191-1_8

ELECTIVE COURSE

THEORY
Course Code: CHE-V. E-9
Course Title: Heterocyclic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
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.

Course Learning Outcomes:
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 such as oxiranes, aziridines, tetrahydrofuran and pyrrolidine.
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 such as benzofuran, indole, benzothiophene, quinoline and isoquinoline.
CO5: Predict the reactivity of complex heterocyclic compounds containing the structural motif of these simple heterocycles.
CO6: Apply the synthetic methodologies for the synthesis of complex heterocycles.
CO7: Apply practical knowledge for the synthesis of other heterocycles.

UNIT I: Introduction to heterocyclic compounds and Aliphatic heterocycles 15 hours
Classification and Nomenclature of aliphatic and aromatic heterocycles. Structure and reactivity of nitrogen and oxygen containing aliphatic heterocycles. Any two methods of preparation and reactions of oxiranes, aziridines, tetrahydrofuran, pyrrolidine.

UNIT II: Five and six membered aromatic heterocycles 15 hours
Structure and reactivity of five and six membered heterocycles: furan, pyrrole, thiophene and pyridine; comparison of basicity of pyrrole, pyridine and 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). Any two methods of preparation of furan, pyrrole, thiophene and pyridine. Nucleophilic substitution reactions of aromatic heterocycles.

UNIT III: Condensed heterocycles 15 hours
Structure and reactivity of condensed heterocycles like benzofuran, indole, benzothiophene, quinoline and isoquinoline. Electrohilic and nucleophilic substitution reactions of condensed heterocycles: General mechanism and with examples. Oxidation and reduction of condensed heterocycles. Any two methods of preparation of benzofuran, Indole, benzothiophene,

quinoline and isoquinoline.

PRACTICALS
Course Code: CHE-V. E-9
Course Title: Heterocyclic Chemistry
Credits: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Epoxidation of chalcones (2 steps).
2. Synthesis of the Coumarins via Pechmann condensation.
3. Synthesisof 3,4- dihydropyrimidin-2(1H)-ones by a one-pot three component cyclo condensation reaction of 1,3 dicarbonyl compound, aldehyde, and urea via Biginelli reaction.
4. Synthesis of 1,3,5-tri substituted pyrazoles (2 steps).
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 (3 steps).
9. Preparation of 2-phenyl indole via Fischer indole synthesis.
10. Synthesis of Quinoline.
11. Synthesis of Isoquinoline.
12. One pot synthesis of flavones.
13. Synthesis of flavanone.
14. Synthesis of bisindolylmethane.
15. Synthesis of 3,4-dihydrocoumarin.

TEXT BOOK:

Joule, J. A. and Mills, K., *Heterocyclic Chemistry*, Wiley publications.

ADDITIONAL READING:

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

WEB REFERENCES:

1. https://www.britannica.com/science/heterocyclic-compound
2. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/heterocy.htm
3. http://www.3rd1000.com/chem301/chem302a.htm
4. http://www.chem.gla.ac.uk/staff/stephenc/teaching/HeterocycleLectures2011_2C12.pdf
5. .http://www.chtf.stuba.sk/~szolcsanyi/education/files/Chemia%20heterocyklickych%20zlucenin/Hetero cyclic%20Reviews%20and%20Summaries/Short%20Course%20on%20Heterocyclic%20Chemistry_Katritzky.pdf
6. http://www.chem.gla.ac.uk/staff/stephenc/teaching/HeterocycleLectures2011_2C12.pdf
7. https://www.studocu.com/en/document/glasgow-caledonian-university/organic-chemistry-2/lecture-notes/heterocyclic-compounds-lecture-notes/2771041/view

ELECTIVE COURSE

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

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

Course Learning Outcomes:
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 interpret the applications of materials in various field like catalysis, ferrofluids, etc.
CO5: Synthesize and characterize the nanomaterials.

UNIT I: Introduction, synthesis, properties, characterization of nanomaterials 15 hours
Fundamentals: terminology and history, classification of nanomaterials, properties of nanomaterials- mechanical, optical, magnetic, electronic, catalytic and surface area; synthetic 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- diffraction techniques, electron microscopic techniques (SEM/TEM), magnetic measurement, UV-Visible spectroscopic, BET surface area.

UNIT II: Applications of nanomaterials and Solid State Reactions 15 hours
Energy, automobiles, sports, textile, cosmetics, medicinal, space, defense, engineering and catalytic applications; toxicity of nanomaterials; 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 III: Electrical and magnetic properties of solids 15 hours
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, ferromagnetism, antiferromagnetism, ferrimagnetism, magnetizations of a ferromagnetic substance; experimental determinations of susceptibility; Superconductors: Theory of Superconductivity, discovery, critical temperature, Meissner effect, types of superconductors.

PRACTICALS
Course Code: CHE-V. E-10
Course Title: Nanomaterials and Solid State Chemistry
Credits: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Synthesis of Silver nanoparticles by chemical method.
2. Synthesis of ZnO nanoparticles by chemical method.
3. Synthesis of CdS nanoparticles by chemical method.
4. Synthesis of Nickel oxide nanoparticles by sol-gel method.
5. Synthesis of Silver nanoparticles using plant extract
6. Synthesis of Copper/Gold nanoparticles by chemical method.
7. To determine the particle size of metal oxides using SEM/TEM data.
8. To study the X-ray diffraction pattern of given sample (Phase and particle size).
9. Preparation of zinc oxalate dihydrate and analysis of its TG/DTA pattern.
10. To prepare mixed metal oxide of Zn and Fe using co-precipitation technique.
11. To prepare mixed metal oxide of Zn and Fe using precursor technique.
12. Measurements of electrical and magnetic properties of pure and mixed metal oxides.
13. To determine the crystallinity of any three metal oxides using their X-ray diffraction data.
14. To calculate the lattice parameter of any three-metal oxide/ mixed metal oxides using their X-ray diffraction data.
15. To study the EDS pattern of Metal Oxide/ Mixed Matal Oxide.

TEXTBOOK:

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, Capitalpublishers.
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.

WEB REFERENCES:

1. https://www.toppr.com/guides/physics/electric-charges-and-fields/conductors-and-insulators/
2. https://www.livescience.com/38059-magnetism.html
3. https://www.understandingnano.com/nanomaterials.html
4. https://www.sciencedirect.com/topics/chemistry/solid-state chemistry
5. https://link.springer.com/article/10.1007/s11837-013-0826-6
6. https://www.slideshare.net/Krishanyadav28/synthesis-of-nanomaterials

ELECTIVE COURSE
THEORY
Course Code: CHE-V.E-11
Course Title: Organometallic Chemistry
Credits: 03
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Understand the basic principles of chemistry and molecular orbital theory with respect to chemical bonding.
2. To predict the structure and stability of organometallic cluster compounds based on the electron count and explain 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.
4. Develop practical skills in the preparation of organometallic compounds and their precursors.

Course Learning Outcomes:

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: Carry out synthesis of organometallic compounds and Interpret IR spectra of metal carbonyls and predict their structure.

UNIT I: Introduction to organometallic chemistry and metal carbonyls 15 hours

Definition, classification of organometallic compounds, Nomenclature, ligands, concept of hapticity of organic ligands, 18 electron rule, EAN concept, electron counting and oxidation states incomplexes.

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 II: Metallocenes and Reactivity oforganometallic compounds 15 hours

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 ofclusters.

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.

UNIT III: Organometallic compounds of Main group elements 15 hours

Preparation, properties, reactions, uses and structure of alkyls and aryls of Group 1 elements (Li, Na); Group 2 elements (Be, Mg); Group 13 elements (B, Al) Group 14 (Sn, Pb). Alkyl and aryl compounds of Ti, Zn and Hg.

PRACTICALS

Course Code: CHE-V. E-11

Course Title: Organometallic Chemistry

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Synthesis of chloro cobaloximes [Co $(Dmg)_2LCl$] {L*= quinoline, indole, benzimidazole, NH_3, aquo}
2. Synthesis of $[Co(dmg)_2(qui)Cl]$
3. Synthesis of $[Co(dmg)_2(Im)Cl]$
4. Synthesis of (phenyl)(pyridine) cobaloxime
5. Preparation of alkyl(aquo) cobaloxime
6. Preparation of aquo bromobis(dimethylglyoximato) cobalt (III)
7. Preparation of chlorobis(dimethylglyoximato) triethanolaminecobalt (III)
8. Preparation of chlorobis(dimethylglyoximato)(1,10 phenanthroline) cobalt (III)
9. Structure analysis of metal-carbonyls based on IR data
10. Synthesis of Co $(PPh_3)_2Cl_2.2H_2O$
11. Synthesis of Ni $(PPh_3)_2Cl_2.2H_2O$
12. Synthesis of Ni $(NCS)_2(PPh_3)_2$

* NOTE: Four synthesis to be carred out using different ligands as per the list given in brace bracket.

TEXT BOOK:

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 Structureand Reactivity*, PearsonEdu.
3. Lee J. D., *Concise Inorganic Chemistry*, Wiley-India

WEB REFERENCES:

1. https://www.nature.com/subjects/organometallic-chemistry
2. https://nptel.ac.in/content/storage2/courses/104108062/module2.pdf
3. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Book%3A_Introduction_to_Organometallic_Chemistry_(Ghosh_and_Balakrishna)/8%3A_Carbonyls_and_Phosphine_Complexes/8.1%3A_Metal_Carbonyls
4. https://www.intechopen.com/books/recent-progress-in-organometallic-chemistry/radical-mechanisms-in-the-metallocenes
5. https://www.uni-due.de/ak_schulz/roocind.php

ELECTIVE COURSE

THEORY
Course Code: CHE-VI.E-12
Course Title: Selected Topics in Physical Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To understand quantum mechanics.
2. To understand fundamentals and applications of Electrochemistry.
3. To understand types of electrodes and electrode processes.

Course Learning outcome:

CO1: Will be able to understand Schrödinger wave equation and its importance.
CO2: Will be able to understand electrochemical cells and their applications.
CO3: Will be able to set up electrochemical cells and use them for applications.

UNIT I: Quantum Mechanics **15 hours**

Black body radiation, Plank's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects, Compton Effect, de Broglie hypothesis, Heisenberg's uncertainty principle, sinusoidal wave equation, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in one dimensional box; Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers, hydrogen like wave function, radial wave functions, angular wave functions.

UNIT II: Quantum Chemistry and Electrochemistry **15 hours**

Molecular orbital theory, Formation of M.O from A.O, construction of M.O's by LCAO-H^{2+} ion, calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics, Hybrid orbitals sp, sp^2, sp^3; Calculation of coefficients of A. O's used in the hybrid orbitals sp, sp^2, sp^3; introduction to valence bond model of H_2; comparison of M. O. and V. B. models.

Electrolytic and galvanic cells, reversible and irreversible cells, conventional representation of electrochemical cells, types of reversible electrodes, gas-metal ion, metal-metal ion, metal-insoluble salt-anion, redox electrodes; electrode reaction, Nernst equation, derivation of cell E. M. F. and single electrode potential, reference electrodes, standard hydrogen electrode, calomel

electrodes, standard electrodes potential, sign convention, electrochemical series, and its applications.

UNIT III: Electrochemistry **15 hours**

EMF of a cell and its measurements, computation of cell EMF, calculations of thermodynamic quantities of cell reactions (ΔG, ΔH and K); Polarization, elimination of polarization, decomposition potential, measurement of decomposition potential, factor affecting decomposition potential; over voltage, types of over voltage, measurement of over voltage, factor affecting overvoltage; Corrosion: types, theories, and methods; Energy sources- acid and alkaline battery; Ni-Cd cell, fuel cells, solar cells; Secondary batteries; Definition of pH, pOH, pK_a and pK_b; buffer solution, types, buffer action, buffer capacity, mechanics of buffer action, Henderson- Hazelbulch equation; Hydrolysis of salts (Numerical).

PRACTICALS
Course Code: CHE-V. E-12
Course Title: Selected Topics in Physical Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To determine the standard oxidation potential of Zn/Zn^{2+} at three different concentrations.
2. To determine the standard oxidation potential of Cu/Cu^{2+} at three different concentrations.
3. To determine the dissociation constant of weak dibasic acid ($H_2C_2O_4$) by potentiometric titration.
4. To determine the dissociation constant of tribasic acid (H_3PO_4) by potentiometric titration.
5. To determine the activity coefficient of silver ion using concentration cell.
6. To determine the equilibrium constant for the reaction: $[Ag(NH_3)_2]^+ = Ag^+ + 2\ NH_3$.
7. To determine solubility of silver bromide by potentiometric method.
8. To determine the mean ionic activity coefficients of HCl solutions at different concentrations.
9. To determine the amount of strong acid (HCl) and weak acid (CH_3COOH) present in the mixture by potentiometric method.
10. To determine the amount of ferrous ion, present in the given solution using $KMnO_4$ by potentiometric method.
11. To study the effect of ionic strength on the mean ionic activity coefficient of silver ions in $AgNO_3$ solution.
12. To prepare different buffer solutions using Henderson- Hazelbulch equation and confirm the pH of prepared solutions using pH meter.
13. To study the effect of concentration on the cell EMF: $Cu_{(s)}|Cu^{2+}_{(aq)}||Ag^{1+}_{(aq)}|Ag_{(s)}$ at room temperature.
14. To determine the pH values of various mixture of sodium acetate and acetic acid in aqueous solution and hence determine the dissociation constant of the acid.
15. To construct standard Daniell cell and determine the EMF of a cell at three different temperature.

REFERENCE BOOKS

1. Gurdeep Raj, Advanced Physical Chemistry, Goel Publishing House, Meerut.
2. Puri, Sharma, Pathania, Principles of Physical Chemistry by Vishal Publishing Company, Oxford University Press.
3. Donald A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
4. Donald A. McQuarrie, Quantum Chemistry, Viva Books Private Limited.

SEMESTER VI

CORE COURSE

THEORY
Course Code: CHE-VI. C-8
Course Title: Advanced Chemistry - II (Organic and Analytical Chemistry)
Credits: 3
Theory: 45 Hours
Maximum Marks: 75

Course Objectives:

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.

Course Learning Outcomes:

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, classify the carbohydrates and analyze their chemical reactivity.

CO7: Name, classify organo sulphur and organo phosphorous compounds and analyze their chemical reactivity.

CO8: Perform qualitative and quantitative analysis based on theory.

SECTION I (ORGANIC CHEMISTRY)

UNIT I: Mechanism and stereochemistry of addition, substitution and elimination reactions **07 hours**

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 E1 cb eliminationreactions.

UNIT II: Organic Compounds containing Nitrogen **06 hours**

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 **06 hours**

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 Organosulphur and Organophosphorus compounds 04 hours

Nomenclature and classification of Organosulphur compounds. Methods of preparation and chemical reactions of thiols, disulphides 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 07 hours

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

UNIT VI: Chromatographic techniques 15 hours

Principle, classification of chromatographic techniques; Theory of chromatographic separation thin layer chromatography: Principle, technique and applications; Paper chromatography: Principle, technique and applications; Column 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 (Numerical expected).

PRACTICALS
Course Code: CHE-VI. C-8
Course Title: Advanced Chemistry II: Organic and Analytical Chemistry
Credit: 1
Duration: 30 Hours
Maximu, Marks: 25

LIST OF EXPERIMENTS:
ORGANIC CHEMISTRY

1. Organic mixture separation, purification of individual compounds and qualitative analysis of separated compound.
   Solid-solid, Solid-liquid, Liquid-liquid
   Note: 0.5 g solid-solid mixture to be analyzed on small scale. 3-4 mL liquid to be added in mixture.
2. Preparation of 2-bromo styrene.
3. Reduction of nitrobenzene to aniline.
4. Estimation of Glucose.
5. Acetyl derivative of Salicylic acid.
   Note: Any four to be performed.

ANALYTICAL CHEMISTRY

1. To separate metal ions by paper chromatography and determine the retardation factor
2. To study separation of organic compounds by TLC
3. To estimate nickel from Zn^{2+}/Ni^{2+} mixture by ion exchange chromatography
4. To estimate zinc from Zn^{2+}/Ni^{2+} mixture by ion exchange chromatography
5. To determine the equilibrium constant for the reaction $KI + I_2 = KI_3$
6. To separate a mixture of carboxylic acid and neutral compound by using solvent extraction technique
7. To estimate amount of potassium ions in the given solution by cation ion exchange chromatography.
8. To separate the mixture of o-and p-nitroanilines column chromatography.

ORGANIC CHEMISTRY TEXT BOOK:

Morrison R. T., et. al., *Organic Chemistry*, Pearson Publications, Noida- India.

ADDITIONAL READING:

1. Bruice P. Y., *Organic Chemistry*, Pearson Publications, Noida- India.
2. Carey F. C., et. al., *Organic Chemistry*, Tata McGraw-Hill India.
3. Finar I. L., *Organic Chemistry*, Volume 1. Pearson Publications, Noida- India.

WEB REFERENCES:

1. https://www.khanacademy.org/science/organic-chemistry/stereochemistry-topic
2. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination-reactions
3. https://www.khanacademy.org/science/organic-chemistry/amines-topic
4. https://www.saddleback.edu/faculty/jzoval/mypptlectures/ch12_carbohydrates/lecture_notes_ch12_carbohydrates_current.pdf

ANALYTICAL CHEMISTRY TEXT BOOK:

1. Christian, G. D., *Analytical Chemistry*, 5th Edition, John Wileypublications
2. Skoog D.A., West D. M., Holler F. J., *Fundamentals of Analytical Chemistry*, 2nd edition, Saunders College Publishing

PRACTICAL BOOK:

Khosla B. D., Garg V. C., Gulati A., *Senior Practical Physical Chemistry*, S. Chand and Co., New Delhi

WEB REFERENCES:

1. http://www.ccamp.res.in/sites/default/files/Basics%20of%20Chromatography_KR_C-CAMP.pdf
2. https://www.biochemden.com/ion-exchange-chromatography/
3. http://gonuke.org/wp-content/acad/Solventextraction.pdf

ELECTIVE COURSE

THEORY
Course Code: CHE VI. E-13
Course Title: Spectroscopic Methods in Organic Chemistry
Credits: 3
Duration: 45 Hours

Maximum Marks: 75

Course Objectives:

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.

Course Learning Outcomes:

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

CO1: Describe the principles of IR, UV and Mass spectrometry.

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.

UNIT I: UV-Visible Spectroscopy and IR-Spectroscopy 15 hours

UV Spectroscopy: 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 expected.

IR Spectroscopy: 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 absorption bands of various functional groups and interpretation of IR spectra of organic compounds.

UNIT II: Proton Magnetic Resonance (^{1}H NMR) and ^{13}C Nuclear Magnetic Resonance Spectroscopy 15 hours

^{1}H NMR: 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.

^{13}C NMR Spectroscopy: 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 III: Mass Spectrometry and spectral problems 15 hours

Mass Spectrometry: Instrumentation, definitions of parent or molecular ion peak and base peak. Isotope effect with respect to alkyl halides. Fragmentation of alkanes, alkenes, aromatic

hydrocarbons, alkyl halides, alcohols, aldehydes, ketones: α -cleavage and Mc-Laffertyrearrangement.
Structure elucidation of organic compounds using Mass, UV, IR, ^{1}H NMR and ^{13}C NMR spectral data is expected.

PRACTICALS
Course Code: CHE-VI. E-13
Course Title: Spectroscopic Methods in Organic Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:
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. Distinguish between given set of organic compounds on basis of their IR spectra (3 sets of 2 compounds).
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.

TEXT BOOK:
Silverstein, R. M., et. al., *Identification of Organic Compounds*, Wiley Publications

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

WEB REFERENCES:
1. https://www.khanacademy.org/science/organic-chemistry/spectroscopy-jay

2. http://web.mit.edu/5.33/www/lec/spec1.pdf
3. http://www.uni-salzburg.at/fileadmin/oracle_file_imports/359201.PDF
4. https://nptel.ac.in/content/storage2/courses/104106075/Week6/MODULE%2025.pdf
5. https://nptel.ac.in/content/storage2/courses/104106075/Week4/MODULE%2017.pdf
6. https://www.brown.edu/academics/chemistry/sites/academics-chemistry/files/NMR_Introductory_Lecture.pdf

ELECTIVE COURSE

THEORY
Course Code: CHE-VI. E-14
Course Title: Environmental Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
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.

Course Learning Outcomes:
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.

UNIT I: Introduction **15 hours**

Atmosphere: Composition, Structure, properties vertical temperature behavior, lapse rate and temperature inversion. Air pollution: Introduction, classification of pollutants, sources, control, effect with respect to oxides ofNitrogen, Carbon and Sulphur, Photochemical smog, acid rain and Green House effect. Water pollution: Chemical, physical and biological characteristics of water pollution, specific and 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 treatment. 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: i) catalytic NO, ii) photo dissociation, of CFCs, iii) catalytic role of chlorine, and iv) combined chain reaction. The ozone holes.

UNIT II: Chemistry of Atmosphere, Soil and Pollutants **15 hours**

Chemistry of Atmosphere and soil: Reactions in the atmosphere: i) formation in the atmosphere ii) reaction of hydroxyl radical with trace gases and as sources of hydroperoxy radical and hydrogen peroxide. The methane cycles. Macro- and micro-nutrients in soil (N, P, K), chemistry of minerals of soil forming rocks. Sampling of Pollutants: Sampling of air pollutants: Absorption in liquids, 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. Adverse effects of specific pollutants: 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. Toxic elements in soil including those are in trace quantities.

UNIT III: Application of instrumental techniques in environmental analysis and Solid waste management 15 hours

Air analysis: a) SO_2, b) H_2S, c) CO d) CO_2 and e) NOx. 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. 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. Optical and radiochemical techniques: Introduction, basic principle and applications of Turbidimetry, Nephelolmetry, Isotope dilution analysis and Neutron activation analysis. Techniques of water treatment: a) Treatment of water for municipal purpose: Important processes involved in purification of water. b) Treatment of water for Industries: Removal of hardness of water by Clark's method and use of ion exchange resins. Solid waste origin and management: a) Origin and Classification of solid waste types b) Solid waste management method: i) Utilisation, ii) Recovery, iii) Reuse iv) Recycling of wastes residues, v) Recycling avoidance of solid waste, Use of Remote Sensing in Environmental Management

PRACTICALS
Course Code: CHE-VI. E-14
Course Title: Environmental Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

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'smethod.
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 spectrophotometry.
9. Analysis of different types of soil- pH, conductivity, alkalinity.
10. Determination of nitrite in water by colorimetric method.
11. Determination of COD of water samples.
12. Determination of BOD of water samples.

13. Determination of phosphate: Colorimetric method.
14. Determination of free acidity in ammonium sulphate fertilizer.
15. Determination of alkalinity of a given mixture of OH^- and $CO3^{2-}$ using phenolphthalein and methyl orange indicator.

REFERENCE BOOKS:

1. Christan G. D., 5th Edition, Analytical Chemistry, Wiley publication.
2. De, A. K., Environmental Chemistry, Wiley Eastern Ltd. House, New Delhi.
3. Katyal Jimmy et.al., Environmental Pollution", Anmol Publications, New Delhi.
4. Manahan, S.E., Environmental Chemistry, Lewis Publishers.
5. Neil, P. O., Environmental Chemistry, Blackie Academic and Professional.
6. Raghuraman, K.et al, 4th Edition, Basic Principles of Analytical Chemistry, Sheth Publishers.
7. Schroede, E. D., Water and waste water treatment, McGraw Hill.Skoog et.al, Principles of
8. Analytical Chemistry, 4th Edition, Saunders college Publishers Trivedi P. R. et.al, Environmental Water and Soil Analysis, 1st Edition, Akashdeep Publishing house, New Delhi
9. Tyagi, O. D. et.al, A Text Book of Environmental Chemistry, Anmol Publications, New Delhi
10. Vanloon G. W. et.al, Environmental Chemistry, Oxford University Press

WEB REFERENCES:

1. https://www.clearias.com/composition-structure-earth-atmosphere/
2. https://www.nrdc.org/stories/air-pollution-everything-you-need-know
3. https://www.nrdc.org/stories/water-pollution-everything-you-need-know
4. https://biologyreader.com/ozone-depletion.html
5. https://www.conserve-energy-future.com/sources-effects-methods-of-solid-waste-management.php

ELECTIVE COURSE

THEORY
Course Code: CHE- VI. E-15
Course Title: Selected Topics in Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Understand and integrate concepts relevant to graduate level Inorganic Chemistry.
2. Acquire knowledge about the bond formation of compounds with special reference to MOT and CFT.
3. Determine the stability and instability of complexes using spectrophotometry.
4. Develop practical skills to carry out separation of metal ions by ion exchange method and analyze them using titrimetry or gravimetry.

Course Learning Outcomes:

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.
CO10: Carry out separation and estimation of ions from compounds.

UNIT I: Magnetic Properties of Metal Complexes and Molecular Symmetry 15 hours

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.
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).

UNIT II: Thermodynamic and Kinetic Aspects of Metal Complexes 15 hours

Thermodynamic and kinetic stability of metal complexes, equilibrium constants, formation constants, labile and inert complexes, factors affecting the stability, substitution reactions in tetrahedral and octahedral complexes, Factors affecting the rate of substitution reactions. Electron transfer reactions- inner sphere mechanism and outer sphere mechanism. Trans effect with respect to square planar complexes.

UNIT III: Inorganic Materials Chemistry 15 hours

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, thiazylhalides).
Zeolites: Types, structure and applications.
Composite materials: Metal-organic frameworks (MOF's); structure, ligands, applications.
Molecular materials: Fullerides, liquid crystals, molecular magnets.
Corrosion: Response of material to chemical environments, galvanic corrosion and other forms of corrosion, Prevention methods.

PRACTICALS
Course Code: CHE- VI. E-15
Course Title: Selected Topics in Inorganic Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Separation and determination of transition metal ions: Separation of Mg^{2+} and Zn^{2+} by ion exchange and its estimation.
2. Separation and determination of transition metal ions: Separation of Cd^{2+} and Zn^{2+} by ion exchange and its estimation.
3. Determination of stability constant of complex ions in solution, Fe(III)- salicylic acid complex (Job's Method).
4. Determination of stability constant of complex ions in solution, Fe(II)-1,10-phenanthroline.
5. Determination of instability constant for the reaction between Cu^{2+} and NH_3.
6. Determination of instability constant for the reaction between Cu^{2+} and en.
7. Estimation of Ni from Nickel Chloride volumetrically.
8. Estimation of Cu from Copper Chloride volumetrically.
9. Estimation of metal ions in mixed metal compound by titrimetric method.
10. Preparation of Malachite.
11. Preparation of Chrome Yellow.
12. Preparation of Prussian blue.
13. To estimate amount of ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions in the given solution containing ferric chloride and ferrous sulphate by using potassium dichromate solution.
14. Estimation of Co from Cobalt Chloride volumetrically.

TEXT BOOKS:

Atkins P., 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.
3. Cotton F. A. and Wilkinson G., *Basic Inorganic Chemistry*, Wiley Eastern Ltd.
4. Puri B. R., Sharma L.R., Kalia K. C., *Principles of Inorganic Chemistry*, Vishal Publishing Co.

WEB REFERENCES:

1. http://asdn.net/asdn/chemistry/zeolites.php
2. https://www.nanowerk.com/mof-metal-organic-framework.php
3. https://www.materialstoday.com/carbon/news/alkali-fullerides-reveal-more-superconductivity-se/
4. https://galvanizeit.org/corrosion/corrosion-process/types-of-corrosion
5. https://saylordotorg.github.io/text_general-chemistry-principles-patterns-and-applications-v1.0/s15-08-liquid-crystals.html
6. http://mathworld.wolfram.com/SymmetryOperation.html

ELECTIVE COURSE

Course Code: CHE-VI.E-16
Course Title: Electroanalytical Chemistry
Credits: 3
Maximum Marks: 75
Duration: 45 Hours

Course Objectives:

1. To provide students the basic understanding about the principles of electro analytical chemistry
2. To incorporate the electrochemical measurements and understanding the cell construction

Course Learning Outcomes:

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

CO1: Understand the basic concepts of potentiometry and different electrodes

CO2: Understand physical and chemical properties of a material which can be studied by commonly used electroanalytical techniques

CO3: Differentiate and compare different voltamograms

CO4: Apply theoretical concepts to analyse various compounds quantitatively

UNIT I: Potentiometry and Ion-selective potentiometry 15 Hours

Electrochemical cell; reversible and irreversible cells; EMF series; standard electrode potential; Nernst equation; calculation of cell potential; introduction to potentiometer; types of electrodes: metallic electrodes- electrodes of first and second kind; reference electrodes- hydrogen gas electrode, calomel electrode and silver/silver chloride; different types of potentiometric titrations: acid-base titration, precipitation titration, redox titration; different method for determination of equivalent point; applications of potentiometric titrations; Membrane electrodes- classifications and properties; principle, design; theory of ion selective electrodes; membrane potential; selectivity; crystalline liquid membrane and enzyme electrodes; crystalline liquid membrane, enzyme membrane and glass membrane electrodes; solid-state sensors; membrane gas-sensor.

UNIT II: Polarography and Amperometry 15 Hours

Introduction; basic principle; deposition potential; dissolution potential, polarization of electrode; polarography instrumentation, electrodes in polarography; advantages and limitations of dropping mercury electrode; polarographic wave, half wave equation with derivation; Ilkovic equation; supporting electrolytes; interference of oxygen; half wave maxima; applications of polarography- organic and inorganic; numerical; amperometry- introduction to amperometric titrations, instrumentation; titration procedure; indicator electrodes, reference electrodes; advantages and disadvantages of amperometric titrations; applications.

UNIT III: Coulometry, Voltammetry and Conductometric Titrations 15 Hours

Coulometry- introduction, theory, current measuring devices- hydrogen-oxygen coulometer, silver coulometer, iodine coulometer; coulometry at controlled potential; coulometry at constant current; variation in coulometric techniques; coulometric applications; Voltammetry- introduction, fundamental, excitation signals, instrumentation of voltammetry; working electrodes and modified electrodes; voltammagram; hydrodynamic voltammetry, applications- oxygen sensor and enzyme-based sensor; cyclic voltammetry, pulse voltammetry; differential pulse voltammetry and square wave voltammetry, applications of voltammetry; Conductometric Titrations- types of conductometric titrations, applications.

TEXTBOOK:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler; 7th Edition,

Sounders College Publishing

REFERENCES BOOKS:

1. Principles of Instrumental Analysis, F. J. Holler, D. A. Skoog, S. R. Crouch; 6th Edition, Thomson Books
2. Analytical Chemistry: Principles, J. H. Kennedy; 2nd Edition, Saunders College Publishing
3. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle; 7th Edition, CBS Publishing, New Delhi
4. Instrumental Methods of Chemical Analysis, G. W. Ewing; 5th Edition, McGraw-Hill
5. Instrumental Methods of Chemical Analysis, B. K. Sharma; Goel Publishing House

WEB REFERENCES:

1. https://derangedphysiology.com/main/core-topics-intensive-care/arterial-blood-gas-interpretation/Chapter%205.0.2/ion-selective-electrode-membranes
2. http://www.federica.unina.it/agraria/analytical-chemistry/potentiometry/
3. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Analytical_Sciences_Digital_Library/JASDL/Courseware/Analytical_Electrochemistry%3A_Potentiometry
4. https://nvlpubs.nist.gov/nistpubs/jres/34/jresv34n2p97_A1b.pdf
5. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Analytical_Sciences_Digital_Library/Active_Learning/In_Class_Activities/Electrochemical_Methods_of_Analysis/02_Text/7%3A_Electrochemical_Analytical_Me
6. http://rxpharmaworld.blogspot.com/2016/12/coulometry.html

PRACTICALS

Course Code: CHE-VI. E-16

Course Title: Electroanalytical Chemistry

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To determine the amount of HCl in the given solution using quinhydrone electrode by potentiometric method.
2. To determine the dissociation constant of Cu-ammonia complex by potentiometric method.
3. To determine the hydrolysis constant of sodium acetate by pH-metric method.
4. To determine the dissociation constant of dibasic acid by pH-metric method.
5. To determine potentiometrically, the standard free energy change and equilibrium constant for the reaction: $Cu_{(s)} + 2\ Ag^{1+}_{(aq)} \leftrightharpoons Cu^{2+}_{(aq)} + 2\ Ag_{(s)}$
6. To determine the hydrolysis constant of aniline hydrochloride by pH metric method.
7. To determine the acid- base dissociation constant and isoelectric point of amino acid by potentiometric method.
8. To determine the dissociation constant of weak organic acid by potentiometric method.
9. To determine the electrode potential of calomel electrode by potentiometric method.
10. To determine the electrode potential of Silver-Silver chloride electrode by potentiometric method.
11. To study the effect of temperature on EMF of a cell, $Pb_{(s)}|Pb^{2+}_{(aq)}||Cu^{2+}_{(aq)}|Cu_{(s)}$, at room temperature, below room temperature and higher temperature.

12. To construct the calibration curve for the quinhydrode electrode and hence determine the standard oxidation potential of quinhydrode electrode.
13. To estimate the amount of dibasic acid present in given solution against standard NaOH solution by conductometric method.
14. To estimate the amount of monobasic (HCl) and dibasic acid (Oxalic acid) present in the mixture solution against NaOH by conductometric method.
15. To estimate the amount of H_2SO_4, CH_3COOH and $CuSO_4$ present in the mixture against NaOH by conductometric method.

PRACTICAL TEXT BOOK:

1. Rajboj S. W.; Chondekar T. K.; Systematic Experimental Physical Chemistry, Anjali Publication
2. Khosla, B. D.; Garg, V. C. and Gulati, A.; Senior Practical Physical Chemistry, R. Chand and Co., New Delhi.
3. Garland, C. W., Nibler, J. W. and Shoemaker, D. P.; Experiments in Physical Chemistry, 8th Edition; McGraw-Hill, New York.
4. Halpern, A. M. and McBane, G. C., Experimental Physical Chemistry; 3rd Edition; W. H. Freeman and Co., New York.

GENERIC ELECTIVE COURSE (GEC)

Course Code: CHE-GEC-1
Course Title: Basics in Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

UNIT I: Introduction to Chemistry **15 Hours**

Introduction, Classification: Organic, Inorganic, Physical and Analytical, Reactants, products, catalysts (with two examples)

Physical: States of matter: solids, liquids, and gases

Organic: Nomenclature and classification of some basic organic compounds (Hydrocarbons: Alkanes, alkenes and alkynes, alcohols, amines, and carboxylic acids with examples), and selected applications. Purification techniques of solids (recrystallization, sublimation) and liquids (distillation)

Inorganic: Atomic structure and type of bonds: ionic, covalent, metallic, acids and bases, metals, non-metals, noble gases.

Analytical: Knowledge of basic chemistry instruments, preparation of solutions, standardization, normality, molarity, and molality

UNIT II: Laboratory Apparatus, Equipments and Safety **15 Hours**

Common apparatus: test tubes, evaporating dish, condenser, round bottom flaks, crucible, watch glass, glass rod, filtration flask, Buchner funnel

Measuring devices: Measuring cylinders, beakers, conical flasks, burette, pipette, standard volumetric flasks, Transfer devices: Dropper, glass funnel, tongs, forceps

Support devices: Piestem triangle, tripod stand, wire gauze, universal clamp, asbestos pad, rubber bulb Heating devices: Bunsen burner, water bath, sand bath Equipments: Analytical balance, oven, fuming chamber; Importance, safety rules, personal protective equipments (PPE): Lab coat, goggle, mask, gloves and shoes; Safety in handling chemicals and safe behaviour; Safety equipment's: Eye wash fountain, safety shower, fire extinguisher, emergency exits; Hazardous chemicals and its symbols: Corrosive, flammable, toxic and carcinogenic; Chemical waste disposal: Aqueous (toxic and non-toxic), organic, glass wastes First aid measures: Eyes, skin, inhalation and ingestion.

UNIT III: Pollution and Green Chemistry **15 Hours**

Types of pollution: Air, Water, Noise: Sources, harmful effects, hazards associated with flora and fauna, measures to control, upcoming methods for air/water pollution treatment Acid rain: causes and harmful effect with an example of effect on Taj mahal, Corrosion Rusting of iron, its causes and prevention, Impact of Toxic chemicals in environment, Pollutants and their statutory limits; 12 principles of green chemistry with one example, Global warming, Greenhouse gases, Greenhouse effect, Hydrochemistry: Reaction of water with atmospheric gases, Renewable and non-renewable sources of energy (examples) and its conservation.

PRACTICALS
Course Code: CHE-GEC-1
Course Title: Basics in Chemistry
Credits 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Purification techniques of solid: Recrystallization, Sublimation
2. Purification techniques of liquids: Distillation
3. Stoichiometric calculation for preparation of solutions
4. Preparations of solution in terms of normality, molarity, ppm, percent
5. Standardisation of solution: Acid and base
6. Total hardness of water
7. Determination of alkanity of water
8. Determination of acidity of water
9. Demonstration experiments on conductometer and pH meter
10. Identification of Chemical type of organic compounds

TEXT BOOKS:

1. Gurdeep, R. *Advanced Physical Chemistry*, 27th Edition; Goel Publishing House, Meerut
2. Morrison, R. T. et. al. *Organic Chemistry* Pearsons publications, Noida India.
3. Shriver, D. F. et. al. *Inorganic Chemistry*, 5th Edition, Oxford University Press
4. Skoog, D. A., et. al. *Fundamentals of Analytical Chemistry*, 8th Edition

REFERENCE BOOKS:

1. Ahluwalia, V. K.; Green *Chemistry: Environmentally Benign Reactions*, Ane Books India, New Delhi.
2. Cooper, M. M.; *Cooperative chemistry laboratory manual*, International Editions McGraw-Hill Companies
3. Furniss, B. et. al. *Vogel's Textbook of Practical Organic Chemistry*, Pearson education
5. Iqbal, S. A. et. al. *Chemistry of Air and Air Pollution* Discovery Publishing House, New Delhi
6. Matlack, A. S. et. al.; *Introduction to Green Chemistry*, CRC Press, New York
7. Puri, B. R. et. al. *Principles of Physical Chemistry*
8. Tyagi, O. D. et. al. *A Text Book of Environmental Chemistry* Anmol Publications, New Delhi

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