### Gulbarga University

**Department of Studies and Research in Chemistry**

Course Outline and Revised Syllabus for Master of Science (M. Sc.) in **CHEMISTRY**

Under CBCS and CAGP (Effective from the academic year 2017-2018)

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<p>| <strong>Second</strong> | <strong>Hard Core</strong> |                                        |               |    |       |    |    |    |         |
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|            | HCT2.2        | Organic Chemistry-II                   | 80            | 20 | 100   | 4  | 0  | 0  | 4       |
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|            | SCT2.1        | Analytical Chemistry-II                | 80            | 20 | 100   | 4  | 0  | 0  | 4       |
|            | SCT2.2        | Applied Physical Chemistry-II          | 80            | 20 | 100   | 4  | 0  | 0  | 4       |
| <strong>Open Elective (Any One)</strong> |        |                                       |               |    |       |    |    |    |         |
|            | OET2.1        | Essential of Analytical Chemistry      | 80            | 20 | 100   | 5  | 1  | 0  | 6       |
|            | OET2.2        | Essential of Physical Chemistry        | 80            | 20 | 100   | 5  | 1  | 0  | 6       |
| <strong>Practical</strong> |        |                                       |               |    |       |    |    |    |         |
|            | HCP2.1        | Inorganic Chemistry Practical –II      | 40            | 10 | 50    | 0  | 0  | 4  | 2       |
|            | HCP2.2        | Organic Chemistry Practical –II        | 40            | 10 | 50    | 0  | 0  | 4  | 2       |
| <strong>Soft Core (Any One)</strong> |        |                                       |               |    |       |    |    |    |         |
|            | SCP2.1        | Analytical Chemistry Practical –II     | 40            | 10 | 50    | 0  | 0  | 4  | 2       |
|            | SCP2.2        | Applied Physical Chemistry Practical   | 40            | 10 | 50    | 0  | 0  | 4  | 2       |
| <strong>Total For Second Semester</strong> |        |                                       | 440           | 110| 550   |    |    |    | 24      |</p>
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L = Lecture; T = Tutorials; P = Practical; 4 Credits of Theory = 3 hrs. teaching , 1hr. tutorials per week. 2 Credits of Practical = 4 hours Practicals per week; Scheme of Practical Evaluation: Expts-30 Marks, Viva-voce-5 Marks, Record-5 Marks = 40 Marks and IA 10 marks = 50 marks. **Major Project:** Evaluation-90 Marks , Viva-voce-30 Marks and IA 30 Marks = 150 Marks.
CHEMISTRY (CBCS Scheme)
Semester – I
HCT 1.1: Inorganic Chemistry – I

[64 Hour]

UNIT – I
Ionic bonding: Properties of ionic compounds, lattice energy, Born-Land’s equation, Born-Haber cycle and its applications, Kapustinskii equation, Solvation energy, dissolution of ionic compounds in polar solvents and their energetics. The predictive power of thermochemical calculations of ionic compounds, covalent character in ionic compounds. Radius ratio and structure of ionic compounds and efficiency of packing of crystal lattices.

Covalent bonding: Valance bond theory, orbital overlap, molecular orbital theory, symmetry and overlap, molecular orbital diagrams of diatomic molecules (homo- and hetero- nuclear), triatomic molecules, linear (CO₂, N₂O) and angular (NO₂), Walsh diagrams, Bent rules, some reactions of covalently bonded molecules, Resonance, hybridization, VSEPR theory, molecular geometries.

Metallic bonding: Characterization of metallic states, VB approach, band theory, conductors, insulators, semiconductors, defects in solids.

[16 Hours]

UNIT – II
Metal π-Complexes: Preparation, structure, bonding and important reactions of metal carbonyls, metal nitrosyls, dinitrogen and dioxygen complexes.

Metal Atom Clusters:
Low valency and high valancy clusters; low nuclearity (tri and tetra atomic) carbonyl clusters (LNCCs) and high nuclearity carbonyl clusters (HNCCs); Isoelectronic and Isolobal relationships; structural patterns of high nuclearity carbonyl clusters; Electron count schemes of HNCCs – Wade’s rules; the capping rule; HNCCs of Fe, Ru and Os group, Co, Rh and Ir group, Ni Pd and Pt group; Octahedral metal halide and chalcogenide clusters; Chevrel phases; Compounds with metal-metal multiple bonds-Edge sharing,Face sharing biocathedra; tetragonal prismatic and trigonal antiprismatic structures; Quadruple bond; One dimensional solids.

[16 Hours]

UNIT – III
Stereochemistry of Coordination Compounds: Coordination geometry, types of isomerism (geometrical & optical). Review of bonding theories; Molecular orbital theory/Ligand field theory (octahedral, tetrahedral and square planar complexes), MO theory applied to complexes with π-bonding. Evidences for metal-ligand orbital overlap, spectrochemical series and Jahn-Teller distortion in coordination compounds.

Temperature independent paramagnetism-Intermolecular effects (anomalous magnetic behaviour) [16 Hours]

UNIT – IV

**Acid-base titrations in non-aqueous solvents:** Role of solvent in Acid-base titrations, solvent systems, differentiating ability of a solvent, some selected solvents, titrants and standards, titration curves, effect of water, determining the equivalence point, typical applications-determination of carboxylic acids, phenols and amines.

[16 Hours]

**Books Recommended:**
2. Chemistry of the Elements - N.N.Greenwood and A. Eamshaw, Pergamon
3. Concise Inorganic Chemistry - J.D. LEE, ELBS
8. Inorganic Qualitative Analysis - A.I.Vogel ELBS
10. Inorganic Quantitative methods - Alexeev Mir publications
12. An Introduction to Inorganic Chemistry – Purcell and Kotz-Holt-Saunders

**HCP 1.1: Inorganic Chemistry Practical-I**

[64 Hours]
1. Semimicro qualitative inorganic analysis of a mixture. Mixture containing three cations and three anions including one less common cations such Mo, Ti, Zr, Ce, V and Li and one interfering anion.
2. Analysis of sodium carbonate and sodium bicarbonate in baking soda by acid-base titration.
3. Determination of acid content of vinegar.
5. Books Recommended:
   1. Chemical Semi micro analysis- V.N.Alexeyev Mir Publishers (Mascow)
   2. Vogel’s Qualitative Inorganic analysis, Revised by G.Suchla Longaman group Ltd.

HCT 1.2: Organic Chemistry-I

[64 Hours]

UNIT-I
Bonding in organic molecules and Aromaticity:
Localized chemical bonding: Hybridization index, bonding in cyclopropane, Bond distances, Bond angles, Bond energies, Calculation of heats of reactions and Bond order. Delocalized chemical bonding, Conjugation, Cross conjugation, Hyper conjugation, Resonance, Tautomerism, Valence tautomerism and bonding in fullerenes.
Bonding weaker than covalent: Hydrogen bonding and addition compounds.
Aromaticity: Aromaticity and Huckel’s rule-HMO theory, Benzenoid and Non benzenoid aromatic compounds. Tropones, Tropolones, Pyrillium cation, Ferrocene. Alternant and nonalternant hydrocarbons. Aromaticity of charged rings (3 to 8 membered), non aromatic, antiaromatic and homo aromatic systems, methods for their determination: X-ray, UV and NMR techniques. Annulenes and Hetero annulenes [10-18].

[16 Hours]

UNIT-II
Reaction Mechanism:
Classification of Organic Reactions – meaning and importance of reaction mechanism. Methods of determination of reaction mechanisms.
Kinetic Methods: Order and Molecularity.
Non-Kinetic Methods: Product identification, Cross over experiments, Study of intermediates, Isotopic labeling, Kinetic Isotope effects, Stereochemical studies. Mechanisms of aliphatic nucleophilic substitutions, $S_N^2$, $S_N^1$ and $S_N^i$, $S_{N^i}$ pathways. Rearrangements in $S_N^1$ reactions. Structure, Stability and reactions of the following reactive intermediates: Carbocations (Classical and non-classical), Carbanions, Free radicals, Carbenes, Arynes, Nitrenes, Ylides and Enamines

[16 Hours]
UNIT-III

**Stereochemistry and Conformational analysis:**
Introduction, Configurational notations of simple molecules, DL and RS configurational notations.
Geometrical Isomerism: E-Z Nomenclature, Configuration of Geometrical Isomers, Syn and Anti isomers.
Conformational Analysis: Elementary account of conformational equilibria of ethane, butane and Curtin-Hammett principles. Conformational analysis of cyclohexane. Cis and Trans Decalins. 1,2 and 1,3 substituted cyclohexanes

[16 Hours]

UNIT- IV

**Molecular rearrangements:**
Classification and general mechanistic pattern for electrophilic, free radical and nucleophilic rearrangements.
Mechanism of the following rearrangement reactions:

- **C-C migration:** Wagner-Meerawein, Arndt Eistert Synthesis, Pinacol-Pinacolone, Dienone-Phenol, Benzil-Benzilic acid, Favorkii, Neber, Sommelet-Hauser, Stevens, Smiles, Shapiro, Fritch-Butenberg-Wiechell rearrangements.
- **C-N migration:** Benzidine, Hofmann, Curtius, Lossen and Beckmann rearrangements. **C-O migration:** Baeyer-Villiger rearrangements, Dakin’s reaction.
- **O-C migration:** Baker-Venkataraman, Fries and Witting rearrangements.

[16 Hours]

**Books Recommended:**


**HCP 1.2: Organic Chemistry Practical-I**

*PART - I: Preparation of following Organic compounds:*

1. Benzoic acid and Benzyl alcohol from Benzaldehyde (Cannizarro reaction).
2. P-Chlorobenzoic acid from p-toluidine.
3. Aniline from Benzene.
4. m-Nitroaniline from Nitrobenzene.
5. m-Nitro benzoic acid from Ethyl benzoate.
6. P-Bromoaniline from Acetanilide.
7. p-Nitroaniline from Acetanilide.
8. Microscale experiments involving organic preparations.

*PART – II: Quantitative Estimation of the following Organic compounds:*

1. Acid
2. Acid + Amide.
3. Acid + Ester.
5.

**Books Recommended:**


**HCT 1.3: Physical Chemistry-I**

*UNIT - I*

Quantum Chemistry:
A brief review of black body radiation, Photoelectric effect, Compton effect, de-Broglie’s hypothesis, Heisenberg’s uncertainty principle., Concept of operator - Addition, Subtraction, Multiplication of operators, Commutative, Linear, Del, Hermitian operators and their properties , Hamiltonian operators, Eigenvalue and Eigen function. Postulates of
quantum mechanics Schrödinger wave equation - wave function and its interpretation, Pauli Exclusion Principle, elementary application to a particle in one dimensional box, particle in a ring and hydrogen atom. One dimensional harmonic oscillator. Conditions for orthogonality and normalization of wave functions, Kronecker's delta.

[16 Hours]

UNIT - II
Electro and Supramolecular Chemistry:
Activity and Activity co-efficient, mean activity co-efficient, Debye-Huckle limiting law (qualitative aspect only) and assumptions. Ionic strength, thickness of ionic atmosphere. Concept of acids and bases, buffer action and capacity. Buffer solutions. Henderson Hassalback equation and its application in preparation of buffer. Importance of buffer in biological system.

Supramolecular Chemistry
Definition of supramolecular chemistry. Nature of binding interactions in supramolecular structures ion-ion, ion-dipole, dipole-dipole, H-bonding, van der Waals interactions role of H-bonding and other weak interactions Self-assembly molecules: catenanes and rotaxanes

[16 Hours]

UNIT - III
Polymer Chemistry:
Definition of glass transition and melting point and their relationships.
Polymers for biomedical applications: super adsorbent polymers for-contact lens, dental fixtures, artificial heart, kidney and blood.

[16 Hours]

UNIT - IV
Chemical Kinetics and Thermodynamics:
Reviews on laws of thermodynamics. Maxwell’s relation. Fugacity and its variation with temperature.

[16 Hours]
Books Recommended:
1. Molecular Quantum Chemistry P.W Atkins
6. Quantum Chemistry by Ira N. Levine, Prentiss Hall of India, New Delhi, India.
8. Electrochemistry by S. Glasstone.
14. Polymer chemistry by Flory.
15. Polymer chemistry by A. Tager.
16. Introduction to polymer chemistry Billmayer(Jr).
17. J.-M. Lehn; Supramolecular Chemistry-Concepts and Perspectives (Wiley-VCH, 1995
18. P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry (Oxford University Press, 1999

HCP 1.3: Physical Chemistry Practical - I

[64 Hours]

PART-I
1. Determination of rate constant and energy of activation of a first order reaction.
2. Comparison of acid strengths.
3. Determining adsorption isotherm.
4. Determination of Molecular weight of polymer by viscometer.

PART-II
1. Determination of dissociation of constant of a monobasic acid potentiometrically.
2. Determination of percentage composition of a given acid mixture conductometrically.
3. Determine the equivalent conductance of a strong electrolyte at several dilutions and hence verify the Onsagar’s equation.
4. Determination of amount of CuSO₄ present in the given solution using Spectrophotometer.
5. Conductometric titration of a weak acid with weak base and a strong acid with weak base.
Note: the number of practical may be modified depending upon the facilities and requirements

Books Recommended:
1. Fridley’s practical physical chemistry by B. P. Levitt.
2. Advanced practical physical chemistry by G. B. Yadhav.
3. Experiments in practical physical chemistry by Shomaker.
5. Senior physical chemistry practical’s by Khosla et. al.
6. Experiments in physical chemistry by Daniel alberty and Williams’s et.al.

SCT 1.1: Analytical Chemistry

[64 Hours]

UNIT-I


Need for quality assurance: Good laboratory practices (GLP), ISO guide 25 (EN-45000), significance and importance of six sigma concepts in maintaining the quality. Quality control, quality assurance and accreditation system

[16 Hours]
UNIT - II

**Ion Exchange methods:** Introduction, Definitions, principle, cation exchangers, anion exchangers and their synthesis, regeneration, ion exchange columns used in chromatographic separation, selection of suitable systems, ion exchange capacity, ion exchange technique: Batch method, column method and applications.

**Solvent extraction:** General discussion, principle, factors affecting solvent extraction, quantitative treatment of solvent extraction, synergistic extraction, ion association complex, extraction regents and some practical considerations: choice of the solvent, extraction, stripping, completion of the analysis, automation of solvent extraction and applications.

**Gas chromatography (GC):** Principle, comparison of GSC and GLC, instrumentation, columns-packed and tubular, study of detectors-thermal conductivity, flame ionization, electron capture and mass spectrometry, factors affecting separation, applications, GC-MS and its applications.

**High pressure liquid chromatography (HPLC):** Apparatus, pumps, column packing, characteristics of liquid chromatography detectors-UV, IR, refractometer and fluorescence detectors, advantages and applications, HPTLC and its applications.

[16 Hours]

UNIT - III

**Drug analysis:** Introduction, source of drugs, difference between drug and medicine, dangerous drugs, Narcotics, classification of drugs, drug screening using gas chromatography. **Assay of drugs:** analysis of (i) Local anesthetics - Procaine hydrochloride; (ii) Sedative – Hypnotics – Phenobarbital, (iii) Antianxiety agents – Diazepam; (iv) Anticonvulsants – Phenytoin; (v) Antipsychotic agents – Chlorpromazine; (vi) Narcotic analgesics – Morphine sulphate (vii) Diuretic agents – Hydrochlorothiazide; (viii) CNS stimulant – Fenfluramine hydrochloride. **Drug analysis:** TLC of drugs, analysis of drugs by UV spectrophotometry.


[16 Hours]
UNIT-IV

Electroanalytical techniques:

Potentiometry: Basic principles, different types of electrodes-reference electrodes, glass electrodes, membrane electrodes (ion selective electrodes) and their applications.

Conductometry: Theory, measurements of conductivity, conductometric titrations and its applications.

Coulometry: Basic principles, constant current and control potential Coulometry and its applications.


[16 Hours]

Books Recommended:
10. Separation Methods by M. N. Sastri, Himalaya Publisher.
12. An Introduction to Chromatography: Theory and Practical, V. K Srivastav and K. K. Srivastav
SCP 1.1: Analytical Chemistry Practical-I [64 Hours]

1. Determine the amount of Molybdenum by solvent extraction using KSCN as reagent using spectrophotometry
2. Determine the amount of Iron by solvent extraction using 8-hydroxy quinoline as reagent using spectrophotometry
3. Determination of sulfa drugs potentiometrically by using NaNO₂
4. Determination of halide by potentiometrically.
5. Determination of sulphate by conductometrically.
6. Determination of halide by conductometrically.
7. Determination of Vitamin-C by titrimetry method
8. Estimation of glucose by external indicator method.
9. Determination of lactose present in milk
10. Estimation of aspirin, Paracetamole and caffeine in drug formulation
11. Determination of Mg and Al in antacid tablets by EDTA titration.

SCT 1.2: Pharmaceutical Chemistry [64 Hours]

UNIT-I

Cell Structure and Functions;

Pharmaceutical Microbiology:
Isolation, cultivation, identification and classification of microorganisms, microorganism diseases, microbial ecology related to manufacturing process, disinfection, sterilization, preservation, microbial spoilage of formulated products, detection of microorganisms in raw materials and manufacturing items.

UNIT-II

Drug Design– A Rational Approach:
Introduction, concept of lead compound-crude drugs and analogues, factors governing drug design, rational approach to drug design, tailoring of drug. A brief introduction to quantitative structure activity relationship (QSAR), prodrug, combinatorial chemistry and computer aided drug design (CADD). Molecular modelling, Molecular mechanics, Molecular dynamics, Modelling of known and unknown receptors.

UNIT-III

Drug Metabolism: Absorption, Distribution, Elimination, Dissolution of drugs and factors affecting these properties. Passage of drugs across biological membrane, Construction of diffusion equation for complex systems, Factors influencing drug
metabolism and drug availability. Phase-I reaction – active and inactive metabolites and Phase-II reaction (Discuss Phase-I & Phase-II reactions by taking examples from various categories of drug molecules).

**Pharmacokinetics:** Pharmacokinetics of one compartment and two compartment models, some applications of pharmacokinetics. Principle of multidosing, dose adjustment and bioavailability. Drug interactions-illustrate with examples.

[16 Hours]

**UNIT-IV**

**Industrial Pharmacy:**
Manufacturing, Quality control, Standard presentation, Labelling, Packing and Storage of formulations belonging to categories of Solid (Tablets and Capsules), Liquids (Syrup, Emulsions, Suspensions), Parental dosage forms, Acts and schedules in Pharmacy.

Introduction to Industrial Processing, Extraction: Methods of extraction, Continuous extraction. Distillation: Theory of distillation, azeotropic distillation, steam distillation, extractive distillation. Drying: Classification and types of dryers, factors affecting drying, tray dryer, freezer dryer, fluidized bed dryer, freezer dryer, spray dryer.

[16 Hours]

**Books Recommended:**
3. Drug Design Dr. V. M. Kulkarni and Dr. K. G. Bothara, Nirali prakashan.
10. Industrial Pharmacy-Lachman.
11. Medicinal Chemistry by Hrikishan Singh.

**SCP 1.2: Pharmaceutical Chemistry Practicals**

[64 Hours]

1. **Assays:** Aspirin, Paracetamol, Analgin, Ibuprofen, Chloroquin, Calcium gluconate, Pheneramine maleate, Suphadiazine Ascorbic acid Isonicotinic acid, Benzyl penicillin, Metronidazole, Dapsone.
2. **Preparation of Medicinally Important Compounds OR Intermediates Required for Synthesis of Drugs:**
   a) Benzimidazole from o-phenylene diamine.
   b) PABA from p-nitro benzoic acid
   c) Sulphacetamide from Sulphanilamide
   d) INH from Isonicotinic acid
   e) Benzocaine
f) Coumarin derivatives

3. **Instrumental Methods for Estimation of the Following:**
   a) Creatinine
   b) Uric acid
   c) Chloramphenicol
   d) Cholesterol

**Books Recommended:**
2. Commercial Methods of Analysis by F. D. Snell & B. M. Beftin
4. Indian Pharmacopeia
5. British Pharmacopeia
Semester-II
HCT 2.1: Inorganic Chemistry – II

[64 Hours]

UNIT – I
Chemistry of Non-Transition Elements
Polymorphism of Phosphorous and Sulfur, Synthesis, Properties and Structures of Boranes.; Carboranes and Metallocarboranes; Sulfur-nitrogen ring compounds; Peroxy acids of nitrogen, phosphorous, sulfur and halogens; Chemistry of noble gas compounds (Xenon fluorides).

[16 Hours]

UNIT – II
Electronic Spectra of Transition Metal Complexes: Free ion terms and energy levels; configurations, Terms, States and Microstates; calculation of microstates for \( p^2 \) and \( d^2 \) configurations; L-S (Russel and Saunders) coupling schemes, J-J coupling scheme, derivation of terms for \( p^2 \) and \( d^2 \) configurations; Hole formulation, energy ordering of terms (Hund’s Rules); Selections rules—Laporte orbital selection rule, spin selection rule; splitting of energy level and spectroscopic states; Orgel diagrams of \( d^1 \) to \( d^9 \) metal complexes; interpretation of electronic spectra of aqua complexes of Ti (III), V (III), Cr (III), Mn (II), Fe (II), Fe (III), Co (II), Ni (II) and Cu (II); calculation of Racah parameters (B and C) for \( d^8 \) metal complexes; Tanabe-Sugano diagrams for \( d^2 \) and \( d^6 \) octahedral complexes; Charge transfer spectra of metal complexes.

[16 Hours]

UNIT – III
Reaction Mechanism of Transition Metal Complexes:
Energy profile of a reaction, reactivity of metal complexes, introduction substitution reactions- Inert and labile complexes. Kinetic consequences of reaction pathways – Dissociation, association and Interchange; Experimental evidence in octahedral substitution – Dissociation, association mechanism, the conjugate base mechanism; Substitution reactions in square planar complexes – evidence for associative reactions, explanations of the trans effect. Recemisation and isomerisation; Redox reactions, Electron transfer reactions - mechanism of one electron, two electrons, complimentary and non-complimentary reactions, outer sphere and inner sphere type of reactions.

[16 Hours]

UNIT – IV
Organometallic Chemistry:
Nomenclature, general properties of organometallic compounds, \( d^n \) electronic configuration of transition metals – 16 and 18 electron rules; Metal alkyls, aryls, olefin, metallocenes and metal carbenes synthesis, structure and bonding in organometallic compounds. Reactions of organometallic complexes-substitution reactions, oxidative addition and reductive elimination reactions; insertion and elimination reactions. organometallic compounds in organic synthesis and applications.

Homogeneous catalysis: Introduction, Types of catalyst, alkene hydrogenation (Wilkinson’s catalyst); Hydroformylation; Water-Gas shift reaction; Monosanto acetic
process; The Wacker process; Synthetic gasoline, Ziegler-Natta catalysis and activation of C-H bond.

**Books Recommended:**

1. Chemistry of Elements – N.N.Greenwood and Earnshaw - Pergamon
2. Concise Inorganic Chemistry - J.D. LEE, ELBS
9. Inorganic Qualitative Analysis- A.I.Vogel ELBS
11. Inorganic Quantitative methods- Alexeev Mir publications
13. An Introduction to Inorganic Chemistry – Purcell and Kotz-Holt-Saunders
17. Organometallic Chemistry A Unified Approach - R.C.Mehrotra, A. Singh, New age international publishers
18. Organometallic compounds - Dr. Indrajeet kumar, pragathi prakashan

**HCP 2.1: Inorganic Chemistry Practical-II**

**Quantitative Analysis:**
Separation and determination of two metal ions involving volumetric and gravimetric methods from the following  

i) Fe + Ni  
ii) Cu + Fe  

**Preparation and quantitative analysis of inorganic complexes:**

i) Cis and trans–potassium dioxalatoaquachromium(III) complex [analysis of oxalate and chromium] present in the above complex.  
ii) Hexaminecobalt(III)chloride [analysis of cobalt]  
iii) Chloropentammine cobalt(III) chloride  
iv) Tris (acetylacetonate) copper (II) sulphate  
v) Mercuric tetrathicynato cobalate (II).  
vii) Estimation of Ni$^{2+}$ as Ni-DMG.
Books Recommended:


HCT 2.2: Organic Chemistry– II

[64 Hours]

UNIT-1
Reaction Mechanism:
Aliphatic Electrophilic Substitutions: Bimolecular pathways. $\text{SE}_2^2$, $\text{SE}_1^1$ and $\text{SE}_i^i$ mechanisms. Reactions involving double bond shifts.
Aromatic Nucleophilic Substitutions: SNAr, SN1 and Aryne pathways. Meisenheimer complexes, Various Nucleophilic displacement.
Addition Reactions: Electrophilic addition across alkenes and dienes.
Substitution Reactions: Mannich Reactions, Chloromethyalation and Vilsmeier-Haack reaction. Elimination reactions: $E_2$, $E_1$, $E_1C_B$ pathways, Stereochemistry, Hydrolysis of Esters, Mechanism: $BAc_2$ and $AAC_2$.

[16 Hours]

UNIT-II
Advanced Stereochemistry:
Prochirality: Homotopic, Enantiotopic and Diastereotopic atoms, groups and faces. Optical activity due to molecular dissymmetry: Allenes, Spiranes, Biphenyles, Atropisomerism, Molecular Crowding.
Stereoselective synthesis: Classification, terminology, Cram’s rule (open chain, cyclic and chelet and dipolar models), Prologs rule and principle of stereoselectivity. Strategy of stereoselective synthesis. Acyclic stereoselection. Enantioselective synthesis, diastereoselection in cyclic compounds. Stereoselective Catalytic hydrogenation and alkylation. Stereoselective formation of double bond, stereoseelective cyclisation of polyenes. [16 Hours]

UNIT-III
Chemistry of Heterocycles:
Nomenclature, Structure, Reactivity, Synthesis and Chemical reactions of Indole, Benzofuran, Benzothiophene, Quinoline, Isoquinoline, Pyrazole, Imidazole, Benzimidazole, $\alpha$-Pyrone, $\gamma$-Pyrone, Coumarins, Chromones and Flavones. [16 Hours]
UNIT-IV
Medicinal Chemistry
Drug Design– A Rational Approach:
Introduction, concept of lead compound-crude drugs and analogues, factors governing drug design, rational approach to drug design, tailoring of drug. A brief introduction to quantitative structure activity relationship (QSAR).

Drug Metabolism: Absorption, Distribution, Elimination, Dissolution of drugs and factors affecting these properties. Passage of drugs across biological membrane, Construction of diffusion equation for complex systems, Factors influencing drug metabolism and drug availability. Phase-I reaction – active and inactive metabolites and Phase-II reaction (Discuss PhaseI & Phase-II reactions by taking examples from various categories of drug molecules).
Synthesis and mode of action of each class of following drugs.
Sulfa Drugs: Sulfadiazines and Sulfisoxazoles.
Antibiotics: Penicillins and Semisynthetic penicillins

[16 Hours]

Books Recommended:
HCP 2.2: Organic Chemistry Practical-II  [64 Hours]

Qualitative analysis:
Separation of a binary mixture, systematic analysis and identification of compounds.

Books Recommended:

SCT 2.1: Analytical Chemistry-II  [64 Hours]

UNIT - I
Body fluids: Composition and detection of abnormal level of certain constituents leading to diagnosis, sample collection and preservation of physiological fluids, analytical methods for the constituents of physiological fluids (blood, urine).
Blood: Estimation of glucose, cholesterol, urea, haemoglobin and bilirubin.
Urine: Urea, uric acid, creatinine, calcium, phosphate, sodium, potassium and chloride.

[16 Hours]

UNIT -II

Assay of Enzymes, Vitamins and Hormones: Biological significance, analysis and assay of enzymes (pepsin, tyrosinase), vitamins (thiamine, ascorbic acid, vitamin A) and hormones (progesterone, oxytocin, insulin), chemical, instrumental and biological assay to be discussed wherever necessary.
Forensic analysis: General discussion of poisons with special references to mode of action of cyanide, organophosphates and snake venom. Estimation of poisonous materials - lead, mercury and arsenic in biological materials.
Analysis of dairy products: Composition of milk, butter and Ghee, determination of water, solid ash, fat and lactose content in milk, analysis of fat content in butter and ghee.

[16 Hours]
UNIT-III


**Fuel Analysis:** Definition and classification of fuels, characteristics of fuels, sampling, proximate and ultimate analysis of coal, and determination of calorific value. Liquid fuels: determination flash point, fire point, aniline point, knocking of petrol and diesel octane and cetenenumbers, carbon residue. Gaseous fuels-analysis of coal gas, water gas, producer gas, gobar gas and blast furnace gas. Calorific value, determination of Junker's gas calorimeter. Relative merits of solid, liquid and gaseous fuels.

[16 Hours]

UNIT-IV

**Ultracentrifugation:** Principle, sedimentation constant, sedimentation equilibrium, sedimentation velocity, methodology and applications.

**Electrophoresis:** Overview, types, the basic of electrophoretic separations, migration rates and plate heights, electro osmotic flow, instrumentation, capillary zone electrophoresis, capillary gel electrophoresis, capillary isoelectricphorosis, capillary isoelectric focusing.

**Capillary electrochromatography:** Packed column electrochromatography, micellar electro kinetic electro chromatography, capillary electro chromatography and applications.

**Supercritical fluid chromatography:** Properties of supercritical fluids, instrumentation and operating variables, comparison of supercritical to other types of chromatography, applications.

**Supercritical fluid extraction:** Advantages of supercritical fluid extraction, instrumentation, supercritical fluid choice, off-line and on-line extractions, typical application of supercritical fluid extraction.

[16 Hours]

**Books Recommended:**
6. Analytical chemistry, Alka. L. Gupta, A Pragati edition,
8. Chromatography by B. K. Sharma, Goel publishing house, Meerut.
11. Modern analytical chemistry by David Harvey, McGraw-Hill publishing company limited.
13. Industrial methods of chemical analysis, F. D. sneel (Encylopedia)
18. Text Book of quantitative chemical analysis.A.I. Vogel (ELBS)
21. Separation Chemistry. by R.P.Budhiraj, New age International(P) Limited, Publisher
22. Basic concepts of Analytical Chemistry, S.M. Khopkar, New age International(P) Limited, Publisher

SCP 2.1 : Analytical Chemistry Practical-II

[64 Hours]

1. Estimation of cholesterol in blood
2. Estimation of creatinine in urine sample
3. Estimation of nitrogen in soil sample
4. Determination of calcium and magnesium in soil sample
5. Determination of lactose present in milk
6. Determination of calcium in milk powder.
7. Separation of metal ions of group IV by ascending chromatography.
8. Separation of metal ions of group I by ascending chromatography.
9. Separation of the components in the indicator by TLC/ Paper chromatography.
10. Separation of amino acids by paper chromatography.
Books Recommended:

SCT 2.2: Applied Physical Chemistry-II
[64 Hours]

UNIT-I
Chemical Kinetics:

UNIT-II
Catalysis and Molecular Group Theory:
Adsorption, adsorption isotherms- Langmuir, Freundlich, BET and Gibb’s adsorption isotherms, adsorption with dissociation, competitive adsorption, mechanism of Unimolecular and bimolecular surface reactions.
Homogenous catalysis: Principle of general and specific acid-base catalysis, linear free energy relation and acidity function and Hamet equation, salt effect and base catalysis.
Heterogeneous catalysis: Study of solid surface, employing surface techniques viz. BET and N2 adsorption.
Enzyme catalysis: single substrate mechanism, Michaelis-Menten equation, effect of pH, temperature and inhibition on kinetics of enzyme catalyzed reaction.
Group Theory: Symmetry operators and symmetry elements, products of symmetry operations C2V, C3V, C2h, groups, point groups, group multiplication table, character table, matrix representation of groups, reducible and irreducible representations. Application of group theory to IR and Raman spectra of typical molecules (NH3, H2O and CO2).

[64 Hours]

[16 Hours]
UNIT - III
Material and Nano materials:
Preparative methods: Solid state reaction, role of Chemistry in Materials design, chemical precursor method, co-Precipitation, sol-gel, metathesis, self-propagating high temperature synthesis intercalation / deintercalation reactions; hydrothermal and template synthesis; High pressure synthesis


Materials possessing high strain and energy: simple preparation techniques and properties (velocity of detonation) of organic molecules possessing cage structures. Understanding the energetics and properties of these molecules. Examples of the molecules to be studied include: nitramines (1,3,5-Trinitroperhydro-1,3,5-triazine, 1,3,5,7-Tetranitro-[1,3,5,7]tetrazocane, Hexanitrohexaazaaisowurtzitane, cubanes).

Nanochemistry: classification of nanomaterials as zero, one and two dimensional materials. Synthesis of nanomaterials: chemical (sol gel, low temperature combustion, hydro and solvo thermal methods) and bio (microbial and plant extracts) routes. Synthesis of nanowires and nanorods with reference to carbon nanorods and nanowires (single-walled).

[16 Hours]

UNIT-IV
Atomic spectra and atomic structure:

[16 Hours]

Books Recommended:
1. Physical Chemistry by P. W. Atkins.
2. Introduction to kinetics of chemical chain reactions by Gimblett (TMH).
3. Chemical kinetics by Laidler.
4. X-ray diffraction by Clug and Alexander.
5. Elements of X-ray diffraction by Cullity.
9. Introduction to Atomic spectra by White.
10. Polymer science by Gowrikar.
11. Polymer chemistry by Flory.
13. Physical Chemistry of macromolecules by D. D. Deshpande.

**SCP 2.2: Applied Physical Chemistry Practical-II**

**[64 Hours]**

**PART-I**
1. Determination of limiting equivalent conductance of a weak electrolyte.
2. Determination of Concentration of given solution by spectrophotometer (Cu\(^{2+}\) and NH\(_3\)).
3. Determination of optical rotation and rate constant by polarimeter.
4. Determination of standard electrode potential by potentiometry.
5. Determination of dissociation of constant of dibasic acid potentiometrically.

**PART-II**
1. Determination of rate constant and order of reaction between K\(_2\)S\(_2\)O\(_8\) and KI.
2. Determination of distribution coefficient for benzene, benzoic acid and water system.
3. Construction of phase diagram for three component system.
4. Determine the equilibrium constant for the reaction KI + I\(_2\) = KI\(_3\) by distribution method.
5. Determination of molecular weight of a given solute by Beckmann thermometer.

Note: the number of practical may be modified depending upon the facilities and requirements.

**Books Recommended:**
1. Fridley’s Practical physical chemistry by B. P. Levitt.
2. Advanced practical physical chemistry by G. B. Yadhav.
3. Experiments in practical physical chemistry by Shomaker.
4. Systematic experimental physical chemistry by S.W. Rajbhoj and T K Chondeker.
5. Senior physical chemistry practical’s by Khosla et. al.

**OET 2.1: Essentials of Analytical Chemistry**

**UNIT-I**


**UNIT-II**

**Gravimetric analysis:** General principles, stoichiometry, calculation of results from gravimetric data. Properties of precipitates. Nucleation and crystal growth, factors influencing completion of precipitation. Co-precipitation and post-precipitation, purification and washing of precipitates. Precipitation from homogeneous solution, a few common gravimetric determinations-chloride as silver chloride, sulphate as barium sulphate, aluminium as the oxinate and nickel as dimethyl glyoximate.

**Acid base titrations:** Principles of titrimetric analysis, titration curves for strong acid-strong base, weak acid-strong base and weak base-strong acid titrations, poly protic acids, poly equivalent bases, determining the equivalence point-theory of acid base indicators, colour change range of indicator, selection of proper indicator.

**Applications of acid-base titrations:** Determination of nitrogen, sulphur, ammonium salts, nitrates, and nitrites, carbonates and bicarbonates, and organic functional groups like carboxylic acid, sulphonic acid, amine, ester, hydroxyl, carboxyl groups, air pollutants like SO₂.

**Acid-base titrations in non-aqueous solvents:** Role of solvent in Acid-base titrations, solvent systems, differentiating ability of a solvent, some selected solvents, titrants and standards, titration curves, effect of water, determining the equivalence point, typical applications-determination of carboxylic acids, phenols and amines.

**UNIT-III**

**Precipitation titrations:** Titration curves, feasibility of precipitation titrations, factors affecting shape-titrant and analyte concentration, completeness of the reaction, titrants
and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the Fajan's methods, typical applications.

**Complexometric titrations:** Complex formation reactions, stability of complexes, stepwise formation constants, chelating agents, EDTA-acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves, effect of other complexing agents, factors affecting the shape of titration curves-completeness of reaction, indicators for EDTA titrations-theory of common indicators, titration methods employing EDTA-direct, back and displacement titrations. Indirect determinations, titration of mixtures, selectivity, masking and demasking agents, typical applications of EDTA titrations-hardness of water, magnesium and aluminum in antacids, magnesium, manganese and zinc in a mixture, titrations involving unidentate ligands-titration of chloride with Hg$^{2+}$ and cyanide with Ag$^+$. [16 Hours]

**UNIT-IV**

**Basic Concepts of Chromatography:** General description, definitions, terms and parameters used in chromatography Classification of chromatographic methods. Criteria for selection of a stationary and mobile phase-nature of adsorbents, factors influencing the adsorbents, nature and types of mobile phases.


**Thin layer Chromatography:** Principle, methodology, determination of $R_f$ value and its significance, variables that affect $R_f$ value and applications. [16 Hours]

**Books Recommended:**
10. Separation methods by M. N. Sastri, Himalaya publisher.
11. Modern analytical chemistry, Harvey, Harcourt publishers.
12. An introduction to chromatography, theory and practical, V. K Srivastav and K.K.
OET 2.2: Essentials of Physical Chemistry

[64 Hours]

UNIT - I
Electrochemistry:

UNIT - II
Thermodynamics:

[16 Hours]

UNIT - III
Polymer Chemistry:
Review of polymers, Basic concepts and classification of polymers - Monomer, Repeat units, Linear, Branched, Cross Linked, Straight, Copolymers and Network s and interpenetrating net works(IPN). Degree of polymerization. Molecular weight distribution - Average molecular weight concepts, Number Average, Weight Average, Viscosity Average and Z - Average molecular weights. Determination of molecular weights, Osmotic pressure method, viscosity method, light scattering (Debye and Zimm plots), Ultra centrifugation method, Polydispersity and molecular weight distribution, Practical significance of polymer molecular weight, Glass transition temperature (Tg) and Melting point and relation between them. Commercial importance of polymers. Size of Polymer molecules.

[16 Hours]

UNIT - IV
Chemical Dynamics-1:
**Dynamics in solution:** Ionic reactions, effect of ionic strength. Primary and secondary salt effects. Dynamics of Fast reactions, Relaxation methods, Flow methods (stopped flow and plugged flow), Flash photolysis methods.

**Books Recommended:**
1. Molecular Quantum Chemistry P.W Atkins
6. Quantum Chemistry by Ira N. Levine, Prentiss Hall of India, New Delhi, India.
8. Electrochemistry by S. Glasstone.
14. Polymer chemistry by Flory.
15. Polymer chemistry by A. Tager.
16. Introduction to polymer chemistry Billmayer(Jr)
Semester-III
HCT 3.1: Organic Chemistry-- III (Spectroscopy)

[64 Hours]

UNIT-I
Electronic, Chiroptical and Vibrational Spectroscopy:
Introduction, energy considerations, Beer-Lambert’s law. Theory and classification of
electronic transitions. Terminology, substituent and solvent effects. Woodward-Fieser
rules and their application in structural elucidation of organic compounds.
UV spectral study of alkenes, dienes, polyenes. Carbonyl and aromatic compounds.
Steric effects, isobestic points, model compounds and charge transfer bands.
Vibrational Spectroscopy: Introduction Complementarity of IR and Raman. Fundamental
vibrations, Overtones, group frequencies, factors affecting group frequencies;
Conjugation, Inductive, Resonance, steric effects. Mechanical coupling, Fermi
resonance. Applications of IR In the study of H-bonding, stereoisomerism, tautomerism.
Identification of the following organic compounds by IR; Alkenes,
Alkynes, Aromatic compounds, Aldehydes, Ketones, Alcohols, Thiols, Acids, Acid
chlorides, Amides, Amines, Esters, Halides and Nitro compounds.

[16 Hours]

UNIT – II
Proton Magnetic Resonance Spectroscopy:
Introduction- chemical shift- Mechanism of shielding and deshielding in alkanes,
alkenes , alkyl halides, aromatic compounds, carbonyl compounds and annulenes.
Chemical shifts of different types of organic compounds- Empirical rules.
Spin-spin coupling, geminal and vicinal coupling. Relative intensities, Karplus equation-
curve, equivalence of protons-chemical and magnetic equivalence. Spin system- First
order and second order patterns.
Long range coupling- Spin decoupling, CIDNP, NOE, Lanthanide shift reagents.
Protons attached to elements other than carbon exchange phenomena and temperature
effect.

[16 Hours]

UNIT – III
Multi-Nuclear NMR and correlation spectroscopy:
$^{13}$C-NMR Broad band and off resonance decoupling, methods of detection.
$^{13}$C chemical shifts of different classes of organic compounds- Alkanes, alkyl halides,
alkenes, alcohols, ethers, carbonyl compounds and aromatic compounds.
$^{13}$C-H coupling DEPT. Introductory aspects of $^{15}$N, $^{19}$F, $^{31}$P-NMR. Correlation NMR
spectroscopy.
Theory, pulse sequence. FT methods $^1$H-$^1$H (Cosy) and $^{13}$C-H (Heterocopy) methods.

[16 Hours]

UNIT-IV
Mass Spectrometry and Composite Problems:
Ionization and mass analysis:
Instrumentation, methods of ionization, EI, CI, DI, SI-methods.
Fragmentation: Principle, odd and even electron ions, molecular ion and base peak, nitrogen rule, meta stable ions, Isotopic effect in chloro and bromo compounds.
Stevenson rule.
Fragmentation of:
Mc Lafferty and Mc Lafferty+1 rearrangement, calculation of molecular formula. Composite problems.
Applications of UV-VIS, IR, IR, NMR, and Mass spectral analysis in the structural elucidation of organic compounds.

Books Recommended:
1. Introduction to spectroscopy- By D. L. Paxia, G. M. Lampman and G. S. Kriz.
7. Interpretation of mass spectroscopy- by Mc Lafferty.

HCP 3.1: Synthesis and Spectral Analysis

Synthesis and Spectral Analysis of Synthesised compounds.

Books Recommended:
1. Applications of computers in chemistry- Raman.
HCT 3.2: Physical Chemistry-III

[64 Hours]

UNIT-I
Statistical Thermodynamics and Quantum Statistics: Microstates’ and Microstates, Assemblies of localized and Non-localized systems, Phase space, $\gamma$-Space, $\mu$-Space, and Ensembles.

[16 Hours]

UNIT-II
Approximation Methods-Variation theory and Perturbation theory (zero, first, second order).
MO Theory: MO Theory of Hydrogen molecule and ion, Bonding and Anti-bonding orbitals. Examples of MO of simple HOMO and HETERO nuclear molecules. Notations of few molecular orbitals, correlation diagrams and Non-crossing rules, Simple Huckel theory of linear conjugated systems (HMO) and applications to systems like benzene, ethylene and butadiene molecules.
VB Theory: Secular equation and determinants, Columbic, exchange and overlap integrals. VB theory of $H_2$ molecule. Comparison of VB and MO theories.

[16 Hours]
UNIT-III

Solid State Chemistry: Solid state reactions: General principles and classification of reactions
Methods of Single Crystal Growth: Solution growth; Melt Growth-Bridgeman, Czochralski, Verneuil;
Chemical Vapour Transport; Fused Salt

Characterization:
Thermal analysis: TGA, DTA, DSC

Electrical properties: Band theory of solids; semiconductors - extrinsic and intrinsic, Hall effect; thermoelectric effects (Seebeck); Fermi energy levels and their determination for semiconductors. ferroelectric, pyroelectric and piezoelectric properties; ionic and superionic conductors. Superconductivity: Basics, discovery and high Tc materials

Magnetic properties: dilute and concentrated magnetic systems. Dia, para, ferro, ferri, and antiferro magnetic types; soft and hard magnetic materials; select magnetic materials such as spinels, garnets and perovskites and hexaferrites magnetoresistance and giant magnetoresistance. Understanding.

Optical properties optical, reflectance, photoconductance structure and properties of amorphous materials (glasses) and zeolites

UNIT-IV

Thermodynamics, Non-equilibrium Thermodynamics and Colloids: Solutions: Introduction, partial molar quantities, Gibb’s function of mixing and other thermodynamic mixing functions(Gibbs-Duhmen and Duhmen-Margules equations), chemical potential of liquids and liquid mixtures, Excess function for non-ideal solutions. Non-equilibrium Thermodynamics: Microscopic reversibility, entropy production in irreversible process. Different types of forces and fluxes, stationary states

phenomenological equations. Onsagar’s reciprocity relations, Principle of minimum entropy production, phenomenological in non-linear region.

Colloids: Electro kinetic phenomena of colloids, Classification of Surface active agents, Critical Micellar concentration (CMC), determination of Surface tension by ‘Surface Tension Method’.

Books Recommended:

1. Theoretical Chemistry- Glasstone.
3. Elements of Statistical Thermodynamics- E. K. Nash
4. Statistical Thermodynamics- M.C.Gupta
5. Introduction to Quantum Chemistry- A.K.Chandra
6. Quantum Chemistry- R.K.Prasad
7. Textbook of Quantum Mechanics-P M Mthews & P Venkateshan
10. Solid State Chemistry- A.R.west
13. Thermodynamics by L.M. Koltz & R.M. Rosenberg
14. Thermodynamics by Glasstone

**HCP 3.2: Physical Chemistry Practicals-III**

**[64 Hours]**

**Part-I**
1. Effect of added salt (Uni-Uni and Bi-Bi salts)
2. Determination of rate constant and order of reaction between \( \text{K}_2\text{S}_2\text{O}_8 \) and KI.
3. Determination of equilibrium constant of reaction between KI + \( \text{I}_2 \) = KI\(_3\) by distribution method.
4. Kinetic study of iodination of an acetone.
5. Study of kinetics of inversion of cane sugar by Polarimetry.
6. Phase diagram of three component system.

**Part-II**
1. Titration of p-Toludine against HCl by conductometry.
2. Determination of end point of some typical titrations. (Precipitation & replacement) conductometrically.
3. Potentiometric titration of o-phosphoric acid against alkalies NaOH.
4. Potentiometric titration of halide mixture against AgNO\(_3\).
5. Titration of mixture of HCl, AcOH ,CuSO\(_4\) against conductometrically
6. Determination of equivalent conductance at infinite dilution of a strong electrolyte and verification of Onsgars law.
7. Potentiometric titration of Pb(NO\(_3\))\(_2\) vs EDTA
8. Potentiometric titration of mixture of weak acids, HCOOH, CH\(_\text{3}\)COOH, CICH\(_2\)COOH Vs NaOH Estimation of metal ions solution by polarographic method.

Note: the number of practical may be modified depending upon the facilities and requirements.

**Books Recommended:**
1. Fridley’s Practical Physical Chemistry- B.P.levitt.
2. Advanced Practical Physical Chemistry- G.B.Yadav
3. Experiments Practical Physical Chemistry- Shomaker
5. Senior Physical Chemistry Practical- Kholsa et.al
SCT 3.1: Analytical Chemistry-III

[64 Hours]

UNIT - I


Air Pollution control: Atmospheric cleaning processes, approaches to contaminant control-detection and control at source.

Control devices for particulates: Gravitational settlers, centrifugal collectors, wet collectors, electrostatic precipitation and fabric filtration.

Control devices for gaseous pollutants: Adsorption, absorption, condensation and combustion processes. Automotive emission control-catalytic converters. [16 Hours]

UNIT – II

Water pollution and analysis: Water resources, origin of wastewater, types of water pollutants of their sources and effects, chemical analysis for water pollution control-objectives of analysis, parameters of analysis, sample collection and preservation. Environmental and public health significance and measurement of color, turbidity, total solids, acidity, alkalinity, hardness, chloride, residual chlorine, chlorine demand, sulphate, fluoride, phosphates and different forms of nitrogen in natural and in waste/polluted waters, heavy metal pollution-public health significance of Pb, Cd, Cr, Hg, As, Cu, Zn and Mn, general survey of the instrumental techniques for the analysis of heavy metals in aquatic systems, organic loadings-significance and measurement of DO, BOD, COD, TOD, and TOC, phenols, pesticides, surfactants, tannin and lignin as water pollutants and their determination. [16 Hours]

UNIT-III


Primary treatment: sedimentation, equalization, neutralization.

Secondary treatment: Aerated lagoons, trickling filters, activated sludge process, oxidation ditch, oxidation pond and anaerobic digestion. Sludge treatment and disposal.

Tertiary treatment: evaporation, ion-exchange, adsorption, electrodialysis, electrolytic recovery and reverse osmosis.
**Advanced waste water treatment:** Nutrient removal—nitrogen and phosphorus removal, solid removal. Waste water disposal and reuse. Industrial waste water and its treatment (paper and pulp, sugar and leather industries)

**[16 Hours]**

**UNIT-IV**

**Analysis of Complex Materials:** Composition, Properties and Analysis of:
- **Minerals and Ores:** Hematite, pyrulosite, dolomite, chromate, bauxite and limestone,
- **Metal and Alloys analysis:** Steel, Cu-Ni alloy, solder, bronze, brass and aluminum alloy.
- **Analysis of structural materials:** Cement.

**[16 Hours]**

**Books Recommended:**

17. Laboratory Manual for Environmental Chemistry. Sunita Hooda and Sumanjeet Kaur, S. Chand & Company Ltd.
22. Qualitative inorganic analysis by A. I. Vogel.
24. Chemical methods of analysis. Snell and Snell
27. Analytical Chemistry. Dr. ALKA L. GUPTA apragati edition.


SCP 3.1: Analytical Chemistry Practical-III

[64 Hours]

1. Determination of phosphorous by spectrophotometry.
2. Determination of COD of water.
3. Determination of hardness of water
4. Determination of chloride in a water sample
5. Determination of pH of soil.
6. Determination of Total dissolved salts and conductivity of water.
7. Analysis of solder.
8. Analysis of copper- nickel alloy.
10. Analysis of steel

Books Recommended:
5. Laboratory manual for Environmental chemistry. Sunita Hooda & Sumanjeet Kaur.

SCT 3.2: Inorganic Chemistry-III

UNIT-I
Bio-inorganic Chemistry: Essential and trace metals, chlorophyll and its role in photosynthesis; transport and storage of dioxygen-heme proteins; oxygen uptake--functions of haemoglobin, myoglobin, hemerythrin and hemocyanins, synthetic oxygen carriers. Metal storage and transport, ferritin, transferrin and ceruloplasmin. Electron transfer proteins-cytochromes and iron-sulphur proteins; Biological nitrogen fixation; in vivo and in vitro nitrogen fixation, interactions of transition metal complexes.
Metals in medicine: Anti cancer agents, diabetes, arthritis, radionuclides and related applications.

[16 Hours]

UNIT-II

Photoinorganic Chemistry: Absorption, excitation, photochemical laws, quantum yield, electronically excited states, life times measurements for the times; Energy dissipation by radiative and non-radiative process.

Excited States of Metal Complexes: Excited states of metal complexes: comparison with organic compounds, electronically excited states of metal complexes. Charge-transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.

Ligand Field Photochemistry: Photosubsitution, photooxidation and photoreduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero- zero spectroscopic energy, development of the equations for redox potentials of the excited states. Photo isomerisation and photo recimization reactions

Metal Complex Sensitizers: Metal complex sensitizer, electron relay, metal colloid system, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and coarbon dioxide reduction.

[16 Hours]

UNIT-III

Nuclear and Radio Chemistry: Fundamentals; units of radioactivity; interaction of α, β and γ radiation with matter; Determination of half life period, radioactive decay, kinetics, parent-daughter decay-growth relationships; Detection and measurement of radioactivity; construction and operation of ionization chambers; G.M. counters and scintillators; Induced radioactivity, nuclear fission and fusion.

Nuclear Reactors: Characteristics features, nuclear reactors in actual use; some Indian reactors, applications of reactors--advantages and disadvantages of nuclear reactors, power reactors; Nuclear power stations in India, An introduction to breeder reactors. Applications of nuclear sciences. Nuclear waste management including waste storage and disposal procedures.

[16 Hours]

UNIT-IV


Industrial pollution: Industrial pollution with respect to cement, thermal power plants and metallurgy, disposable and its management.
Chemical Toxicology: Toxic chemicals in the environment; impact of toxic chemicals on enzymes, biochemical effects of As, Cd, Pb, Hg, CO, NOx, SO$_2$, O$_3$, PAN, cyanides, pesticides and carcinogens.

Books Recommended:
1. Fundamentals of Photochemistry - Rohatgi Mukherjee.
3. Industrial Chemistry - B.K. Sharma (Goel Publishers).

SCP 3.2: Applied Inorganic Chemistry Practicals – III

(64 Hours)

1. Analysis of cement
2. Analysis of hematite ore: Estimation of silica by gravimetrically and iron by volumetrically.
3. Analysis of mint alloy: Estimation of copper by volumetrically and nickel by gravimetrically.
4. Separation and estimation of Al and Mg by using 8-hydroxyquinoline reagent
5. Separation and estimation of copper and nickel by using salicylaldoxime reagent
7. Separation and estimation of anions by using cation exchanger.
8. Determination of Ca in limestone by redox, acid-base and complexometric titrations.
9. Analysis of water sample for COD by titrimetry
10. Determination of DO in water sample.
11. Spectrophotometric determination of NO$_2^-$-N in a water sample (Diazo coupling reaction).
12. Water analysis: TDS, conductivity, acidity, alkalinity, hardness, sulphate, chloride and fluorides.

Books Recommended:


OET 3.1: Essentials of Inorganic Chemistry
[64 Hours]

UNIT – I

**Ionic bonding:** Properties of ionic compounds, lattice energy, Born-Land’s equation, Born-Haber cycle and its applications, Kapustinskii equation, Solvation energy, dissolution of ionic compounds in polar solvents and their energetics. The predictive power of thermochemical calculations of ionic compounds, covalent character in ionic compounds. Radius ratio and structure of ionic compounds and efficiency of packing of crystal lattices.

**Covalent bonding:** Valance bond theory, orbital overlap, molecular orbital theory, symmetry and overlap, molecular orbital diagrams of diatomic molecules (homo- and hetero- nuclear), triatomic molecules, linear (CO₂, N₂O) and angular (NO₂), Walsh diagrams, Bent rules, some reactions of covalently bonded molecules, Resonance, hybridization, VSEPR theory, molecular geometries.

[16 Hours]

UNIT – II

**An overview of metals in biology:** Introduction; the element content of living systems; biological chemistry of hydrogen; the economical use of recourses—abundance and availability; biological need and behavior of inorganic elements.

**Sodium and potassium channels and pumps:** Introduction; transport across membranes; potassium and sodium channels; the sodium and potassium pump; active transport driven by Na⁺ gradients, sodium/proton exchangers; other roles of intracellular K⁺.

**Metal assimilation pathways:** Introduction; metal assimilation in bacteria, plants, fungi and in mammals (iron, copper and zinc).

**Storage and homeostasis of metal ions:** Introduction; metal storage and homeostasis in bacteria, plants, fungi and in mammals (iron, copper and zinc).

[16 Hours]

UNIT – III

**Stereochemistry of Coordination Compounds:** Coordination geometry, types of isomerism (geometrical & optical). Review of bonding theories; Molecular orbital theory/Ligand field theory (octahedral, tetrahedral and square planar complexes), MO
theory applied to complexes with \( \pi \)-bonding. Evidences for metal-ligand orbital overlap, spectrochemical series and Jahn-Teller distortion in coordination compounds.

**Magnetism:** Types of magnetism; magnetic susceptibility; spin only moment; orbital contribution to spin only moment.

[16 Hours]

**UNIT – IV**

**Review of Acid-Base Concepts:** Introduction, different definitions, types of reactions, solvent system and leveling effect. Generalized Acid-Base concepts (basicity of metal oxide, hydratide and hydrolysis).

Measurement of Acid-Base strengths, Steric effect (back strain, front strain and Internal strain) Solvation effects with reference to liquid ammonia, anhydrous sulfuric acid, acetic acid and liquid sulfur dioxide. Hard-Soft Acids and Bases; classification, strength of hardness and softness; Irving William series; theoretical basis of hardness and softness.

[16 Hours]

**Books Recommended:**

2. Chemistry of the Elements – N.N.Greenwood and A. Eamshaw, Pergamon
3. Concise Inorganic Chemistry – J.D. LEE, ELBS
8. Inorganic Qualitative Analysis - A.I.Vogel ELBS
10. Inorganic Quantitative methods - Alexeev Mir publications
12. An Introduction to Inorganic Chemistry – Purcell and Kotz-Holt-Saunders
OET 3.2: Essential of Organic Chemistry

[64 Hours]

UNIT-I
Bonding and Aromaticity:
Hybridization, bond length, bond angle, bond energies, bond polarity and dipole moment aromaticity and Huckels rule-HMO theory, Non-benzenoid aromatics, Annulenes (10-18).

[16 Hours]

UNIT-II
Stereochemistry:
Elements of symmetry, symmetry operations E/Z, R/S nomenclature, Fischer, newman Sawhorse and flywedge projection, Enantiomers, Diastereomers and Epimers. Prochirality: Homotopic, enantiotopic, diastereotopic groups and faces

[16 Hours]

UNIT-III
Organic Reactions:
Reactivity, classification of organic reactions, methods of identification kinetics, non kinetic methods. Isotopic labeling techniques, intermediates, cross over products and product proportions in different types of reactions. Named reactions. Classification, Aldol, Dieckmann, Claisen-Schmidt and similar anion addition reactions.

[16 Hours]

UNIT-IV
Heterocycles and Group Transformations:
Structure, synthesis, reactivity of the following heterocycles and their biologically important derivatives. pyrrole, furan, thiophene, pyridine, pyrimidine, Quinoline, isoquinoline & indole. Organic functional group inter conversions involving substitution, addition, eliminations, oxidation, reductions, esterification and hydrolytic reactions.

[16 Hours]

Books Recommended:
Semester - IV

HCT 4.1: Inorganic Chemistry – IV

[64 Hours]

UNIT-I

Inductively coupled plasma-Atomic emission spectroscopy: Limitations of flame emission spectroscopy, principles of plasma spectroscopy, process of atomisation and excitation, plasma as an excitation source, inductively coupled plasma source, ICP-AES instrumentation, applications of plasma spectroscopy, comparison of ICP-AES with AES, comparison of AFS, AAS and ICP-AES.

[16 Hours]

UNIT-II
Radioanalytical Methods:
Radioactive tracers, principles and applications. Isotopic dilution analysis – direct and inverse; special analytical applications and radiometric titrations.
Neutron activation analysis: Principle, instrumentation, applications and limitations.
Radiochromatography and radio immunoassay- principle and applications.

Thermal methods: Thermogravimetry- instrumentation, factors affecting thermogram, applications.
Differential thermal analysis (DTA) - theories, apparatus, and applications.
Differential scanning calorimetry (DSC) – Introduction, instrumentation and applications. Thermometric titrations and applications.

[16 Hours]

UNIT-III
Applications of Mossbauer techniques to the studies of (i) Bonding and Structure of Fe\(^{\text{+2}}\) and Fe\(^{\text{+3}}\) compounds (ii) Detection of oxidation states.

NQR Spectroscopy: Consequence of nuclear spin larger than \(\frac{1}{2}\), prolate and oblate nucleus, nuclear quadrupolar charge distribution-theory and instrumentation, relationship between electric field gradients and molecular structure, applications and interaction of eQq data. Effect of crystal lattice on the magnitude of eQq. Structural information from NQR spectra.

[16 Hours]
UNIT-IV
ESR spin – orbit coupling and significance of g tensors application to first row transition metal complexes.

Photoelectron Spectroscopy: Basic principles, photo-electric effect, ionization process, Koopman’s theorem. Photoelectron spectra of simple molecules, chemical information from ESCA, instrumentation and applications. Auger electron spectroscopy principles, instrumentation and applications.

[16 Hours]

Books Recommended:

8. Instrumental Method of Analysis – Willard, Mserit and Dean.
10. Introduction to Spectroscopy- Pavia, Lampman and Kriz.

HCP 4.1: Inorganic Chemistry Practicals-IV

[64 Hours]

1. Determination of iron using 1, 10- phenanthroline as a reagent by Spectrophotometry.
2. Determination of zirconium using alizarin red s as a reagent by Spectrophotometry.
3. Determine the composition of complex of copper ethylenediamine by spectrophotometry
4. Determination of iron by Potentiometrically by using ceric ammonium sulphate and potassium dichromate.
5. Determination of mixture of halides by Potentiometrically.
Determination of mixture of halides by conductometrically.
Determination of strength of acids by pH metrically.
Flame photometry determination of following metal ions from different samples:
   a) sodium b) potassium c) calcium d) lithium e) sodium and potassium in a mixture.

Books Recommended:

HCT 4.2: Physical Chemistry-IV

UNIT-I
Electrochemistry and Photochemistry:
Ion-solvent interaction, Born model, solvation number and their determination, over voltage, Decomposition potential, Butler-Volmer equation, Taffel equation, Factors important in elucidating electrode reaction and some electrochemical systems of technological importance, Electroplating.

[64 Hours]

UNIT-II
Diffraction Studies:
X-ray diffraction: Crystal systems, crystallographic axes and angles, nomenclature and point groups. Space lattice, Reciprocal lattice, Bravis lattice, Unit cell, Weiss indices, Miller indices, Bragg’s equation, Single crystal rotation methods, Powder methods-analytical procedures for powder diffraction analysis, structure factor. Fourier series, Fourier refinement. Phase problem.
Electron diffraction: Introduction, Scattering intensity versus scattering angle, Wierl’s equation, Radial distribution function, Refinement radial distribution function, Rotation sector method.

[16 Hours]
UNIT-III
Molecular Spectroscopy:
Characterization of electromagnetic radiation, quantization of energy levels, rotational spectroscopy, classification of molecules based on their moment of inertia, rotation of rigid diatomic molecules and non rigid diatomic molecules and rotational energy levels.
Vibrational and rotational spectra of diatomic and polyatomic molecules and its applications to CO, CO$_2$ and H$_2$O molecules. Overtones and combination frequencies PQR branches, Born-Oppenheimer approximation.
Electronic spectra of diatomic molecules, Electron transition in diatomic molecule V` and V`` progressions. Frank-Condon principle, rotational fine structure of electronic vibrations Fortrate diagrams and pre dissociation.

[16 Hours]

UNIT-IV
Polymer Science and Technology:
Determination of molecular weight by end group analysis and GPC method, determination of chain dimension from light scattering technique.
Understanding of thermo mechanical behavior from TMA and DMA techniques. Physical properties v/s applications: plastic, fibers, elastomers, and additives. Swelling of polymers, stress strain behavior, viscoelastic behavior and elastomers.
Conduction polymers: synthesis through chemical oxidation understanding of structure and properties of polyaniline, polypyrrole and polythiophene.

[16 Hours]

Books Recommended:
2. Electrochemistry by Glasstone
3. Heterogeneous catalysis- G.C.Bond
4. The basic applications of heterogeneous catalysis- Michael Bowker.
5. Fundamentals of Molecular Spectroscopy- CN Banwell & Mc Cash
6. Introduction to molecular Spectroscopy- G.M.barow
7. Polymer Chemistry- Billayer
8. Polymer Chemistry- P.J.Flory
9. Physical chemistry of macromolecules by D.D.Deshpande
10. Polymer Science- Gowarikar
11. Physical chemistry- P.W. Atkins
12. Chemical Kinetics- Laidler
HCP 4.2: Physical Chemistry Practical-IV [64 Hours]

Part-I
1. Determination of stability constant of the complex formed between Fe$^{3+}$ and Salicylic acid-5-SSA.
2. Determination of pKa of given indicator.
3. Determination of specific and molar rotation of optically active substances and to find out the intrinsic rotation.
4. Determination of surface tension of liquid by stalagnometer.
5. Determination of molecular weight of given polymer(Polyvinyl alcohol, polystyrene, methyl acrylate etc) using viscometer.
6. Determination of Ka values of given samples by pH-meteric titration.

Part-II
1. Titration of mixture of KCl and KI against AgNO$_3$ by conductometry.
2. Titration of o-phosphoric acid against NaOH by pH meter.
3. Determination of solubility of sparingly soluble salt by Potentiometry.
5. Kinetics of decomposition of benzene diazonium chloride and determination Ea and
6. Thermodynamic parameters
8. Elucidation of structure from the given spectroscopic data.
9. Note: the number of practicals may be modified depending upon the facilities and requirements.

Books Recommended:

1. Fridley’s Practical Physical Chemistry- B.P.levitt.
2. Advanced Practical Physical Chemistry- G.B.Yadav
3. Experiments Practical Physical Chemistry- Shomaker
5. Senior Physical Chemistry Practical- Kholsa et.al
SCT 4.1: Analytical Chemistry-IV

[64 Hours]

UNIT-I

Nephelometry and Turbidometry: Light scattering, principles of nephelometry and turbidometry measurements, instruments, general procedure for operating nephelometer, surface scatter turbidometer, turbidometric titrations, applications.

Polarometry: Introduction polarized light, optical activity, applications of polarimetry in saccharimetry.

Optical Rotator Dispersion and Circular Dichroism: Rotatory dispersion, instrumentation for ORD and CD, Cotton effect, Anamalous ORD curves, Octant rule, applications of Octant rule, applications of ORD and CD. Advantages of CD over ORD, limitations of ORD and CD.

[16 Hours]

UNIT-II

Fluorimetry and Phosphorimetry: Principle (laws governing phosphorescence and fluorescence); Instrumentation, quantitative analysis, application in real sample analysis (e.g. in environment, biology, medicine, rock, minerals, etc.)

Chemiluminescence Methods: Principle, Apparatus, Quantitative Chemiluminescence - Gas phase and liquid phase chemiluminescent analysis and titrations.

[16 Hours]

UNIT-III


[16 Hours]
UNIT -IV

HYPHENATED TECHNIQUES: Need for hyphenation, Interfacing devices and applications of GC - MS, GC - IR, MS-MS, HPLC - MS, ICP -MS, ICP - OES.

[16 Hours]

Books Recommended:

7. The Essentials Forensic Medicine and Toxicology.Dr. K. S. Narayana Reddy.
19. The Quantitative Analysis of Drugs, 3rd edn. D. C. Garratt, science Paperbacks
28. Text Book of quantitative chemical analysis. A.I. Vogel (ELBS)
29. Standard Methods of chemical analysis. Wekin E. J

**SCP 4.1: Analytical Chemistry Practical-IV**

[64 Hrs]

1. Turbidometric determination of sulphate
2. Flame photometric determination of Na\(^+\) & K\(^+\) concentration in tap water.
3. Flame photometric determination of Ca & Mg
4. Identification and determination of Cd\(^{2+}\)/Pb\(^{2+}\)/Zn\(^{2+}\) by polarography
5. Determine the amount of calcium, magnesium and zinc in face powder by using chromatographic methods.
6. Separation of Lead (II) and Mercury (II) by Partition Chromatography
7. Separation of Chlorophyll Pigments by Column Chromatography
8. Demonstration of HPLC/GC interpretation of Behavior by plots
9. Spectrophotometric determination of NO\(_2^-\) N in water sample
10. Determination of As in ant acid control preparation by redox titration

**Books Recommended:**

SCT 4.2: Organic Chemistry – IV (Special Topics In Organic Chemistry)

[64 Hours]

UNIT-I

Photochemistry:

Photochemistry of olefins: Cis–trans isomerisation, (2+2) cycloaddition, De Mayo cycloaddition (2+2) photochemical and rearrangements. Reactions of conjugated olefins and di-II methane rearrangements.

Photochemistry of Ketones: Excited states of ketones, Norrish type I and type II cleavages. Pattero-Buchi reaction, α,β–unsaturated ketones, (2+2) addition, cis-trans isomerization. Rearrangements of cyclohexadienones.


Photochemical oxidation and reduction: Cycloadditions of (singlet) molecular oxygen, oxidative coupling, photoreduction by hydrogen abstraction.

[16 Hours]

UNIT-II

Pericyclic reactions:
Definition of various terms, Pericyclic, electrocyclic, cycloaddition, sigmatropic, chelotropic and ene reaction. Con-rotatory, disrotatory, suprafacial, antarafacial, HOMO, LUMO etc.

Symmetry properties of molecular orbitals of ethylene, butadiene, hexatriene, vinyl radicals, anion, cation, pentadienyl radical, anion and cation. Conservation of orbital symmetry and the photochemical concerted processes. Formulation of selection rule by 1) orbital correlation diagrams 2) HOMO-LUMO method and 3) Huckel-Mobius aromaticity approach (all qualitative method only) for electrocyclic reactions of (butadiene-cyclobutene and hexatriene- cyclohexadiene interconversions)

Cycloadditions (2+2), (2+4) and examples of other higher systems.

Sigmatropic reactions: (1,3), (1,5), and (3,3) sigmatropic reactions, Cope and Claisen rearrangement reactions.(Several suitable examples are to be taken for each class of transformation). Chelotropic and ene reactions. (Several examples in each class)

[16 Hours]

UNIT-III

Organometallics and non-metallic Reagents:
Organo magnesium halides, ogarno lithium reagents, organo copper,organo zinc, organo cadmium, oragno mercury, oragno cilicon, oragno tin, organo palladium compound.

Metal carbonyl complexes of Fe, Co and Ni.Pentacarbonyl iron, octocarbonyl dicobalt, teracarbonyl nickel.Organo phosphorus compounds.

[16 Hours]
UNIT-IV

Green chemistry:


[16 Hours]

Books Recommended:

SCP 4.2: Spectrophotometric Analysis and Polarimetry

[64 Hours]

Spectrophotometry: Quantitative estimation of ascorbic acid, cholesterol, carbohydrates, proteins, aminoacids, caffeine and uric acid.

Polarimetry: Quantitative estimation of sugars, mixture of sugars and determination of specific rotation of sugars.

Books Recommended:
1. Applications of computers in chemistry- Raman.
HCMP 4.3: Major Project

The project work may include inplant training in industries/short term work in the department/ other department or institution/ R & D organization/ review of current literature/ theoretical method computer applications/ experimental work may involve studies on synthesis of novel and known organic compounds, metal complexes and their characterization by physical and chemical methods/ drug analysis/ Biological activity of reported or unreported research work/ water, air and soil analysis/ pollution studies/ estimation of food adulterants.

In case of students working outside the campus the supervisor/ staff member incharge visit the place of work during the period and may be eligible for TA and DA as per university rules.

Books Recommended:
1. Applications of computers in chemistry- Raman.