SOPHIA GIRLS' COLLEGE,
(AUTONOMOUS)
AJMER

Scheme of Examination
And
SYLLABUS

2018-19 (Batch)

FOR

MASTER OF SCIENCE (CHEMISTRY)

Under
Choice Based Credit System

Semester I to IV

MASTER OF SCIENCE (CHEMISTRY)

Eligibility for admission in First Year of M.Sc. (Chemistry) is (The student can choose the course only when she had chemistry in graduation) with at least 50% marks in B.Sc. With regard to admission on reserved category seats government rules will be applicable.

SCHEME OF EXAMINATION

The number of the paper and the maximum marks for each paper together, with the minimum marks required to pass are shown against each subject separately. It will be necessary for a candidate to pass in the theory as well as the practical part of a subject/paper, wherever prescribed, separately.

Classification of successful candidates shall be as follows:

First Division 60% } of the aggregate marks prescribed in Semesters I to IV taken together

Second Division 50% }

All the rest shall be declared to have passed the examination.

- For passing a candidate shall have to secure at least 40% marks in each course (Theory and Practical separately).
- No division shall be awarded in Semesters I to III.
- Whenever a candidate appears for a due paper examination, she will do so according to the syllabus in force.
- A candidate not appearing in any examination/absent in any paper of term end Semester shall be considered as having DUE in those papers.

End Semester Examination Pattern

Maximum Marks : 70 **Duration : 3 Hrs.**

Section A 10 x 1 =10 marks

Contains 10 Questions of 1 mark each and all are compulsory.
Three questions from each unit and one extra question from any one unit.
3 + 3 + 4 = 10 Questions

Section B 3 x 5 = 15 marks

Contains 3 questions with internal choice (Two questions from each unit).
Each Question carries 5 marks,
A student has to attempt 3 questions, choosing at least one question from each unit.

Section C 3 x 15= 45marks

Contains 3 questions with internal choice (Two questions from each unit).
Each Question carries 15 marks.
A Student has to attempt 3 questions, choosing at least one question from each unit.

End Semester Practical Examination Pattern

Maximum Marks: 70 **Duration : 6 Hrs.**

Note:

1. A Laboratory Exercise File should be prepared by each student for each practical paper and should be submitted during practical examinations.
2. One internal and one external examiner shall conduct two practical exams, in a day, of a batch of 20 students.
3. Duration of practical exam is 6 hours.
4. Practical of 70 marks distribution is as under:
    a. 50 marks for practical examination exercises.
    b. 10 marks for Viva-voce
    c. 10 marks for Laboratory Exercise File.

Scheme for Choice Based Credit System
M.Sc. (Chemistry) Post Graduate 2018-19

SEM.	CORE COURSE (C)	ELECTIVE COURSE		ABILITY ENHANCEMENT COURSE (AEC) (2 CREDITS)
	CORE COURSE (DSCC) / (DSCP) (96)	DISCIPLINE SPECIFIC ELECTIVE (DSE) (24)	GENERIC ELECTIVE (GE) (2)	
I	DSCC – I DSCC – II DSCC – III DSCC – IV DSCL – V	--	--	-
II	DSCC – I DSCC – II DSCC – III DSCC – IV DSCL – V	--	--	-Adv. Communication Skill - Human Rights
III	DSCC – I DSCC – II DSCC – III DSCC – IV DSCL – V	--	-Adv. Tax Management -Adv. Computer Application	-
IV	DSCL – V	DSCC – I (A/B/C) DSCC – II (A/B/C) DSCC – III (A/B/C) DSCC – IV (A/B)		-

- Note: - DSCC has three groups in Semester IV, from which a student can select any one group. All the papers of the selected group are applicable for that student. A student cannot select two papers from two different groups, but in Paper 404 the student can opt either for 404(A) or 404(B).

OUTLINE OF CHOICE BASED CREDIT SYSTEM FOR PG PROGRAMMES:

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course:
   - ***Discipline Specific Core Course (DSCC)***
   - ***Discipline Specific Core Project/ Dissertation (DSCP)***
   - ***Discipline Specific Core Practical (DSCL)***

2. **Elective Course:** Generally a course which can be chosen from a pool of courses:

   2.1 **Discipline Specific Elective (DSE) Course or Project**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective.
   2.2 **Generic Elective (GE) Course**: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

3. **Ability Enhancement Courses (AEC):** The Ability Enhancement (AE) Courses are based upon the content that leads to Knowledge enhancement. These are mandatory for all disciplines. SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

   Ability Enhancement Compulsory Courses (AECC) - (2 Credits) These courses may be chosen from a pool of courses designed to provide value-based or skill-based knowledge and is aimed at providing hands-on-training, competencies, skills, etc. It is a 2 credit course and the total duration will be 30 hours.

Course Structure in Semester – I

Paper Code	Nomenclature	Contact Hours		Credits	Total Marks		Max. Marks	Min. Marks	Duration
		Per Sem	Per Week		CIA	ESE			
CHEM-101	Inorganic Chemistry	90	06	06	30	70	100	40	3 hrs
CHEM-102	Organic Reaction Mechanism-I	90	06	06	30	70	100	40	3 hrs
CHEM-103	Physical Chemistry -I	90	06	06	30	70	100	40	3 hrs
CHEM-104	Programming in Chemistry	90	06	06	30	70	100	40	3 hrs
CHEM-105	Practical	180	12	06	30	70	100	40	6 hrs
						Total	**500**	**200**	

CHEM – 101: Inorganic Chemistry

Max. Marks : 100 **Min. Marks: 40**
Credit : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Predict stereochemistry and bonding in main group compounds
2. Assess the chemical behavior of transition metal complexes.
3. Summarize the reaction mechanism of transition metal complexes.

Unit – I

1. Stereochemistry and bonding in main group compounds:

VSEPR, Irregular Geometry of molecules, Walsh Diagrams of tri atomic molecules, dπ-pπ bonds, Bent's rule and energetics of hybridization, some simple reactions of covalently bonded molecules

2. Metal Clusters:

Higher boranes, carboranes, metalloboranes and metallocarboranes

Unit - II

Fundamentals of Transition Metal Complexes:

Energy profile of reaction, reactivity of metal complexes, inert and labile complexes, kinetic applications of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism ,direct and indirect evidences in favour of conjugate mechanism.

Unit - III

Reaction Mechanism of Transition Metal Complexes:

Anation reaction, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction, Redox reaction, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.

Reference Books:

- F.A.Cotton and Wilkinson*: Advanced Inorganic Chemistry*, John Wiley
- J.E. Huhey, Harpes & Row: *Inorganic Chemistry*, Pearson
- G. Wilkinson, R.D. Gillars and J.A. Mc Cleverty: *Comprehensive Coordination Chemistry eds*., Pergamon
- Basalo Pearson: *Reaction mechanism*, Academic Press.
- D.F. Shriver, P.W. Atkins and C.H. Longford: *Inorganic Chemistry*, ELBS with Oxford University

CHEM – 102 Organic Reaction Mechanism-I

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Predict structure and bonding in common organic molecules and mechanism of organic reactions.
2. Review various aliphatic and aromatic substitution reactions.
3. Explain different types of free radical reactions.

Unit - I

1. **Nature of Bonding in organic molecules**
   Aromaticity in benzenoid and non benzenoid compounds, alternant and non alternant hydrocarbons, Huckel's rule, energy level of π molecular orbital, annulenes, anti aromaticity ,homoaromaticity.
2. **Reaction Mechanism: Structure and Reactivity**
   Types of reactions, types of mechanisms. General methods for the determination of reaction mechanism – product analysis, determination of presence of intermediates, study of catalysis, isotopic labelling, stereochemical evidences, kinetic evidences and isotope effects. Thermodyamic and kinetic requirements for a reaction, kinetic and thermodynamic control.

Unit – II

1. **Aliphatic Nucleophilic substitution**
   The SN^2 SN^1, mixed SN^1 and SN^2 and SET mechanism
2. **Aromatic Nucleophilic Substitution**
   The $ArSN^1$, $ArSN^2$, benzyne and SRN1 mechanism. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser and Smiles rearrangements.
3. **Aliphatic Electrophilic Substitution**
   Bimolecular mechanism-SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.
4. **Aromatic Electrophilic Substitution**
   The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring system. quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-koch reaction.

Unit – III

Free Radical Reactions

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvent on reactivity.
Allylic halogenations(NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction. Free radical rearrangement, Hunsdiecker reaction.

Reference Books :

- Jerry March : *Advanced Organic Chemistry*, John Wiley and Sons.
- F.A. Carey and R.J. Sundberg: *Advanced Organic Chemistry*, Plenum
- Peter Sykes: *A Guide Book to Reaction Mechanism in Organic Chemistry*, Orient Longman.
- C.K. Ingold: *Structure and Mechanism in Organic Chemistry*, Cornell University Press.
- T.R. Morrison and R.N. Boyd: *Organic Chemistry*, Prentice-Hall
- H.O. Housee: *Modern Organic Reactions*, Benjamin
- R.O.C. Norman and J.M. Coxon: *Principles of Organic Synthesis*, Blackie Academic & Professional.

CHEM – 103 Physical Chemistry – I

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Predict aspects of Quantum Chemistry
2. Summarize various concepts of thermodynamics and phase rule.
3. Assess the kinetics of various chemical reactions.

Unit I

1. **Quantum Chemistry :**
   Schrodinger equation to some model systems viz., harmonic oscillator, the rigid rotor, the hydrogen atom. Applications of variation method and perturbation theory to the Helium atom.
2. **Molecular Orbital Theory**
   Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc.

Unit II

Thermodynamics

Concept of fugacity and determination of fugacity. Non-ideal systems, Excess functions for non-ideal solutions, Activity, Activity coefficient and their determinations, Debye Huckel theory for activity coefficient for electrolytic solution; ionic strength. Application of phase rule to three component system – acetic acid + chloroform + water.

Unit III

Chemical Dynamics

Collision theory of reaction rates, steric factor, activated complex theory, ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, methods of determining mechanism, isotope effects. Dynamic chain (hydrogen-bromine reactions, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine reaction), acid base catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, flash photolysis, dynamics of unimolecular reactions (Lindemann Theory,Hinshelwood Modifications).

Reference Books :

- P.W.Atkins : *Physical Chemistry*, Oxford University Press.
- A.K. Chandra: *Introduction to Quantum Chemistry*, Tata McGraw Hill.
- Ira N. Levine: *Quantum Chemistry*, Prentice Hall.
- K.J.Laidler: *Chemical Kinetics*, MacGraw-Hill
- J. Rajaram and J.Kuriacose: *Kinetics and Mechanism of Chemical transformations*, McMillan.
- V.Moroi: *Micelles, Theoretical and Applied Aspects*, Plenum
- G.M.Barrow: *Physical Chemistry*, Tata McGraw Hill.
- Puri ,Sharma, Pathania: *Principles of Physical Chemistry*, Vishal publication

CHEM – 104 Programming in Chemistry

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcome:

On successful completion of the course, the students will be able to-

1. Understand basic concepts of programming language
2. Choose the loops and decision making statements to solve the problem
3. Implement different operations on array and pointers and Able to make functions and structure.
4. Understand how to use programming language in basic chemistry practicals.

Unit I

Introduction to Computer: Definition, Block Diagram, Hardware. Software & its types.Introduction to Language & its Types, Compilation and Execution. 'C' Language: Character Set, Tokens- Keywords, Variables, Constants, Operators, Expressions.

DataTypes, Type Conversion (implicit & explicit), Input Output Instructions (printf, scanf, getch, getchar, gets, putch, putchar, puts). Arithmetic Instructions: Hierarchy, Priority and Associativity of Operators.

Unit II

Control Instructions:

Decision Control (Statements and blocks- if, if-else, conditional operator) nesting.

Loop Control (Statements and blocks- while, for, do-while, Nesting Loops),

Case Control- (Statements and blocks- switch-case,), break, continue, goto statements.
Arrays:- Concept of Arrays, One dimensional array &Two dimensional array, Storage strategy, Array Initialization, Memory Map of One Dimensional &Two dimensional Array, Operations on Arrays, Sorting – Selection Sort, Bubble Sort

Unit III

Functions (Structure and Block):- Declaration, Calling (Call by value, Call by reference), Definition of functions, Recursion, Storage Class (auto, static, register, extern), Scope rules (Local, Global).
Pointers:- Pointers and addresses, Pointers as Function arguments, Address Arithmetic.
Structures: Basics, StructuresVariables,Arrays of Structures Variables, Pointers Structure Variable.
Reference Books:

- Yashavant P Kanetkar: *Let Us 'C'*, BPB Publications
- Balaguruswami: *Programming in Ansi 'C'*, TMH.
- Kernighan & Ritchie, *'C' Programmiung Language,* PHI
- Dietel&Dietel: *'C' How to Program*, PHI

CHEM – 105 Practical

Max. Marks : 100 **Min. Marks: 40**
Credit : 6 **Duration : 6 Hrs**

Learning Outcomes:
On successful completion of the course the student will be able to-

- Understand the practical applications of various aspects of chemistry

1. **Inorganic Preparations (Any five of the following preparations)**
   A. Tris(thiourea)copper (II)sulphate.
   B. Cis –Potassium Diaquatrioxalatochromate(III).
   C. SodiumDiamminetetrathiocynatochromate(III).
   D. Tris(acetylacetonato)manganese(II).
   E. Potassium Trioxalatoferrate(III).
   F. Purssian Blue.
   G. Hexamminecobalt(III)
   H. Hexanitro-N-cobaltate(III).
   I. Vanadyl acetylacetonate
   J. Dichloridobis(pyridine)cobalt(II).
   K. Hexamminenickle(II) chloride.
   L. Bis(dimethylglyoximato)nickel (II).
   M. Tetramminecopper(II) sulphate.
2. **Organic Chemistry**
   A. Qualitative Analysis
   Separation, purification and identification of compounds of binary mixture (two solids).
   B. Quantitative Analysis (any three)
   a) Estimation of amines/phenols using bromide solution or acetylation method.
   b) Determination of Iodine value of an oil sample.
   c) Determination of Acid Value of an oil sample.
   d) Determination of Saponification value of an oil sample.
3. **Physical Chemistry**
   (Students are required to perform at least five experiments from the following experiments.)
   A. Determination of the effect of (a) change of temperature (b) change of concentration of reactants and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reactions. 2.Determination of strength of acid in gm/l conductmetrically using following combinations (i)SA-WB (ii)WA-SB (iii)WA-WB (iv)SA-SB {S-Strong, W-Weak, A-Acid, B-Base }
   B. Determination of the velocity constant, order of the reaction and energy of activation of saponification of ethyl acetate by sodium hydroxide conductometrically
   C. Determination of the velocity constant, order of the reaction and energy of activation of saponification of ethyl acetate by sodium hydroxide conductometrically

Instrumentation

a. Determination of solubility and solubility product of sparingly soluble salts (e.g. $PbSO_4$, $BaSO_4$) conductomerically.
b. Determination of the strength of strong and weak acids in a given mixture conductometrically.
c. To construct the phase diagram for three component system(e.g., chloroform-acetic acid-water).
d. Determination of the dissociation constant of acetic acid in DMSO,DMF acetone and dioxane by titrating it with KOH.
e. Determination of the dissociation constant of monobasic/dibasic acid

Reference Books (Laboratory Courses)

- J. Bassett, R.C. Denney, GH. Jeffery and J. Mendham: *Vogel's Textbook of Quantitative Analysis*, revised, ElBS.
- W.L. Jolly: *Synthesis and Characterization of Inorganic Compounds*, Prentice Hall.
- D.Past, C.Johnson and M. Miller: *Experiments and Techniques in Organic Chemistry,* Prentice Hall.
- K.L. Williamson: *Macroscale and Miicroscale Organic Experiments*, D.C. Health.
- H. Mideleton: *Systematic Qualitative Organic Analysis*, Adward Arnold.
- H. Clark: *Handbook of Organic Analysis-Qualitative and Quantitative*, Adward Arnold.
- A.R. Tatchell: *Vogel's Textbook of Practical Organic Chemistry*, John Wiley.
- A.M. James and F.E. Prichard: *Practical Physical Chemistry,* Longman.
- B.P. Levitt: *Findley's Practical Physical Chemistry*, Longman.
- R.C. Das and B. Behera: *Experiments in Physical Chemistry*, Tata McGraw Hill.

SCHEME OF PRACTICAL EXAMINATION-

Max. Marks- 70

1. Inorganic Preparations 10
2. Organic Chemistry
   a. Qualitative Analysis 15
   b. Quantitative anlaysis 10
3. Physical Chemistry 15
4. Viva 10
5. Record 10

Course Structure in Semester – II

Paper Code	Nomenclature	Contact Hours		Credits	Total Marks		Max. Marks	Min. Marks	Duration
		Per Sem	Per Week		CIA	ESE			
CHEM-201	Coordination Chemistry	90	06	06	30	70	100	40	3 hrs
CHEM-202	Organic Reaction Mechanism-II and Stereochemistry	90	06	06	30	70	100	40	3 hrs
CHEM-203	Physical Chemistry -II	90	06	06	30	70	100	40	3 hrs
CHEM-204	Group Theory and Spectroscopy	90	06	06	30	70	100	40	3 hrs
CHEM-205	Practical	180	12	06	30	70	100	40	6 hrs
AEC-201 ***(Ability Enhancement Course)***	1. Adv. Communication Skills **OR** 2. Human Rights	2		2	15	35	50	20	2 ½ hrs
					Total		550	220	

CHEM – 201: COORDINATION CHEMISTRY

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Analyse the aspects of metal-ligand equilibria in solution and metal-ligand bonding.
2. Summarize various concepts of electronic spectra and magnetic properties of transition metal complexes.
3. Review various metal π-complexes.

Unit – I

Metal-Ligand Equilibria in Solution Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.

Metal Ligand Bonding Limitation of crystal field theory, molecular orbital theory- σ and π−bonding in octahedral, tetrahedral and square planar complexes.

Unit - II

Electronic Spectra and Magnetic Properties of Transition Metal Complexes:

Spectroscopic ground state, Selection rules for electronic spectra – Laporte and Spin selection rule, relaxation in rules, luminescence, Orgel diagrams for transition metal complexes (d_1-d_9 States). Charge transfer spectra, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

Unit - III

Metal π-Complexes:

Metal carbonyls, structure and bonding. Vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand.

Reference Books:

- F.A.Cotton and Wilkinson: *Advanced Inorganic Chemistry*, John Wiley
- J.E. Huhey: *Inorganic Chemistry*, Harpes & Row.
- N.N. Greenwood and A. Earnshow: *Chemistry of the Elements*, Pergamon.
- A.B.P. Lever: *Inorganic Electronic Spectroscopy*, Elsevier.
- R.L. Carlin*: Magnetochemistry*, Springer Verlag.
- G. Wilkinson, R.D. Gillars and J.A. McCleverty: *Comprehensive Coordination Chemistry* eds., Pergamon.
- Basalo Pearson: *Reaction mechanism*, Academic Press.

CHEM – 202 Organic Reaction Mechanism-II and Stereochemistry

Max. Marks : 100 **Min. Marks: 40**
Credit : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Explain the mechanism of various types of condensation and elimination reactions.
2. Analyse the stereochemistry of organic compounds.
3. Review the various aspects of pericyclic reactions.

Unit - I

Addition to Carbon-Hetero Multiple Bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reaction involving enolates-Aldol, Knoevenagel. Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.Hydrolysis of esters and amides.

Elimination reactions

The E2,E1 and E1CB mechanism and their spectrum , Orientation of the double bond , reactivity effect of substrate structure , attacking base, leaving group and the medium, Mechanism and orientation in Pyrolytic elimination.

Unit – II

Stereochemistry

Elements of symmetry, Chirality, molecules with more than one chiral center, threo and erythroisomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms,groups and faces,stereospecific and stereroselective synthesis .Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Conformational analysis of cycloalkanes and decalins, steric strain due to unavoidable crowding.

Unit – III

Pericyclic Reactions

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene,1,3,5-hexatriene and allyl system. Classification of pericyclic reaction. Woodward-Hoffmann correlation diagrams. FMO and PMO approach Electrocyclic reactions- conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloadditions-antarafacial and suprafacial additions, 4n, 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloaddition and cheleotropic reactions. Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3-and 5,5-sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements, Ene reaction.

Reference Books :

- Jerry March: *Advanced Organic Chemistry*, John Wiley and Sons.
- F.A. Carey and R.J. Sundberg: *Advance Organic Chemistry*, Plenum.
- Peter Sykes: *A guide Book to Mechanism in Organic Chemistry,* , Longman
- C.K. Ingold: *Structure and Mechanism in Organic Chemistry*, Cornell University Press.
- T.R. Morrison and R.N. Boyd: *Organic Chemistry*, Prentice-Hall
- H.O. Housee: *Modern Organic Reactions*, Benjamin.
- R.O.C. Norman and J.M. Coxon: *Principles of Organic Synthesis*, Blackie Academic & Profesional.
- S.M. Mukherji: *Pericyclic Reactions*, Macmillan, India.
- S.M. Mukherji and S.P. Singh: *Reaction Mechanism in Organic Chemistry*, Macmillan.
- D. Nasipuri: *Stereochemistry of Organic Compounds*, New Age International.
- P.S. Kalsi: *Sterochemistry of Organic Compounds*, New Age Int.

CHEM – 203 Physical Chemistry-II

Max. Marks : 100 **Min. Marks: 40**
Credit : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Explain electrochemistry.
2. Summarize the concepts of adsorption and micelles.
3. Assess the chemistry of macromolecules.

Unit I

Electrochemistry

Electrochemistry of solutions, Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Bjerrum model. Semiconductor interfaces-theory of double layer at semiconductor, structure of double layer interfaces. Effect of light at semiconductor solution interface. Overpotentials, exchange current density, derivation of Butler-Volmer equation, Tafel Plot. Polarography theory, Ilkovic equation; half wave potential and its significance. Corrosion – Types, mechanism and inhibition.

Unit II

Surface Chemistry

1. **Adsorption** Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation without derivation), mechanism of surface catalytic reactions.
2. **Micelles** Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization, solubilization, micro emulsion, reverse micelles.

Unit III

Macromolecules:

Polymer- definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerisation , mechanism of polymerisation. Molecular mass , number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering methods) , sedimentation, chain configuration of macro molecules, calculation of average dimensions of various chain structures.

Reference Books :

- P.W.Atkins : *Physical Chemistry*, Oxford University Press.
- R McWeeny: Coulson's Valance, ELBS
- K.J.Laidler: *Chemical Kinetics*, MacGraw-Hill
- J. Rajaram and J.Kuriacose: *Kinetics and Mechanism of Chemical transformations*, McMillan.
- V.Moroi: *Micelles, Theoretical and Applied Aspects*, Plenum
- G.M.Barrow: *Physical Chemistry*, Tata McGraw Hill.
- Puri ,Sharma, Pathania: *Principles of Physical chemistry*, Vishal publication.
- J.O.M. Bockris and A.K.N. Reddy: *Modern Electrochemistry* Vol.I and Vol.II, Plenum
- V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar: *Introduction to Polymer Science*, Wiley Easterm.

CHEM – 204 Group Theory and Spectroscopy

Max. Marks : 100 **Min. Marks: 40**
Credit : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Interpret the symmetry and group theory in chemical science.
2. Analyse the molecular and photoelectron spectroscopy.
3. Assess the electron spin resonance spectroscopy.

Unit I

1. **Symmetry and Group Theory in Chemistry** Symmetry elements and symmetry operation, definitions of group, sub-group, relation between orders of a finite group and its subgroup Conjugacy relation and classes. Point symmetry group. Group Multiplication table(C_2, C_{2h},C_{2v},C_{3v})

2. **Raman Spectroscopy:** Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle.Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS)

Unit II

1. **Molecular spectroscopy :**Energy levels, molecular orbitals, vibrational transitions, vibration progression and geometry of the excited states, Franck-Condon Principle, electronic spectra of polyatomic molecules, Emission spectra, radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.
2. **Photoelectron Spectroscopy** Basic principles, photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple molecules. ESCA. Chemical information from ESCA. Auger electron spectroscopy-basic idea. Photoacoustic Spectroscopy: Basic principle of photoacoustic spectroscopy (PAS), PAS-gases and condensed systems, chemical and surface applications.

Unit III

Electron Spin Resonance Spectroscopy Basic principles, zero field splitting and Kramer's degeneracy, "g" value, factors affecting the "g" value, Hyperfine splitting, Hyperfine coupling constant, Isotropic and anisotropic hyperfine coupling constants, application to study of free radicals, determination of oxidation state of metal and to transition metal complexes (having one unpaired electron) including biological systems .

Reference Books:

- J.M. John: *Modern Spectroscopy*, Wiley.
- H. Windawi and F.L. No: *Applied Electron Spectroscopy for chemical Analysis Ed*., Wiley Interscience.
- R.V. Parish: *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry,* Ellis Harwood.
- R.S. Drago: *Physical Methods in Chemistry*, Saunders College.
- F.A. Cotton: *Chemical Application of Group Theory,*
- R. Chang: *Introduction to Molecular Spectroscopy,* McGraw Hill.
- R. Chang: *Basic Principles of Spectroscopy*, McGraw Hill
- H.H. Jaffe and M. Orchin: *Theory and Applications of UV Spectroscopy*, IBH-Oxford.
- P.K. Ghosh: *Introduction of Photoelectron Spectroscopy,* John Wiley.
- A Carrington and A.D. Carrington and A.D. Maclachalan: *Introduction to Magnetic Resonance,* Harper & Raw.

CHEM –205 Practical

Max. Marks : 100 **Min. Marks: 40**
Credit : 6 **Duration : 6 Hrs**

Learning Outcomes:

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

- Understand the practical applications of various aspects of chemistry

1. Inorganic Chemistry

Separation and determination of two metal ions Cu-Ni, Ni-Mg, Cu-Fe,Cu-Ba etc. involving volumetric and gravimetric methods.

2. Organic Chemistry

a) Organic Synthesis(any five)

i. Acetylation: Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.
ii. Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
iii. Aldol condensation: Dibenzal acetone from benzaldehyde.
iv. Sandmeyer reaction: p-chlorotoluene from p-toluidine.
v. Cannizzaro reaction: 4-chlorobenzaldehyde as substrate.
vi. Friede1 Crafts Reaction: β-Benzoy1propionic acid from succinic anhydride and benzene.
vii. Aromatic electrophilic substitutions: Synthesis of p-nitroaniline and p-bromoaniline

b) **Quantitative Analysis (any two)**

i. Determination of DO of a water sample.

ii. Determination of COD of a water sample.
iii. Determination of BOD of a water sample

1. **Physical Chemistry**

(Students are required to perform at least five experiments from the following experiments.)

a. Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone system).
b. To study the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixture (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.
c. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.
d. Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.
e. Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodine ion is oxidized by persulphate ion).
f. Determination of strengths of halides in a mixture potentiometrically.
g. Determination of the strengths of strong and weak acids in a given mixture using a potentiometer/pH meter.
h. Determination of the formation constant of silver-ammonia complex and stoichiometry of the complex potentiometrically.
i. Acid-base titration in a non-aqueous media using a pH meter.
j. Determination of activity and activity coefficient of electrolytes.
k. Determination of partition coefficient of I_2 between water and CCl_4.
l. Determination of equivalent conductance of a strong electrolyte such as KCl,AgNO3 etc. at several concentrations and hence verify the Onsagar's Equation.
m. To construct the phase diagram for three component system(e.g., chloroform-acetic acid-water).

Reference Books:

- J. Bassett, R.C. Denney, GH. Jeffery and J. Mendham, *Vogel's Textbook of Quantitative Analysis*, revised, ElBS.
- W.L. Jolly, *Synthesis and Characterization of Inorganic Compounds*, Prentice Hall.
- D.Past, C.Johnson and M. Miller, *Experiments and Techniques in Organic Chemistry,* Prentice Hall.
- K.L. Williamson, *Macroscale and Miicroscale Organic Experiments*, D.C. Health.
- H. Mideleton, *Systematic Qualitative Organic Analysis*, Adward Arnold.
- H. Clark, *Handbook of Organic Analysis-Qualitative and Quantitative*, Adward Arnold.
- A.R. Tatchell *Vogel's Textbook of Practical Organic Chemistry*, John Wiley.
- A.M. James and F.E. Prichard, *Practical Physical Chemistry,* Longman.
- B.P. Levitt, *Findley's Practical Physical Chemistry*, Longman.
- R.C. Das and B. Behera, *Experiments in Physical Chemistry*, Tata McGraw Hill.

SCHEME OF PRACTICAL EXAMINATION-

Max. Marks- 70

1. InorganicChemistry	15
2. Organic Chemistry	
a. Qualitative Analysis	10
b. Quantitative anlaysis	10
3. Physical Chemistry	15
4. Viva	10
Record	10

Course Structure in Semester – III

Paper Code	Nomenclature	Contact Hours		Credits	Total Marks		Max. Marks	Min. Marks	Duration
		Per Sem	Per Week		CIA	ESE			
CHEM-301	Spectroscopy	90	06	06	30	70	100	40	3 hrs
CHEM-302	Photochemistry and Solid State Chemistry	90	06	06	30	70	100	40	3 hrs
CHEM-303	Green and Environmental Chemistry	90	06	06	30	70	100	40	3 hrs
CHEM-304	Bioinorganic chemistry	90	06	06	30	70	100	40	3 hrs
CHEM-305	Practical	180	12	06	30	70	100	40	6 hrs
						Total	500	200	

CHEM – 301: SPECTROSCOPY

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Analyse ^{13}C - NMR spectroscopy.
2. Elaborate the mass spectroscopy.
3. Determine the structure of different organic compounds with the help of spectroscopic data.

Unit – I

^{13}C NMR Spectroscopy

Difficulties and solution for recording ^{13}C - NMR spectra, recording of ^{13}C- NMR spectra- scale, solvent, solvent signals and their positions, multiplicity, ^{13}C -^{1}H coupling constant- proton coupled and decoupled, ^{13}C spectra- broad band decoupling, off resonance technique. Chemical shifts in ^{13}C spectra- chemical shift calculations for alkanes, alkenes, alkynes and aromatic compounds. Nuclear Overhauser Effect, ^{13}C-DEPT Spectra- differentiation in primary, secondary and tertiary carbons by Dept-45, Dept-90, Dept-135 Spectra.

Unit - II

Mass Spectroscopy

Introduction, ion production- EI, CI, FD and FAB, factors affecting fragmentation, ion analysis abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Mc Lafferty rearrangement, Nitrogen rule, High Resolution Mass Spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Unit - III

Applications of spectroscopy

UV-Visible, IR, ^{1}H- NMR, ^{13}C- NMR, MASS-interpretation of common organic compounds.

Reference Books :

- K. Nakamoto: *Infrared and Raman Spectra*: *Inorganic and Coordination Compounds,* Wiley.
- A.P.B Leaver: *Inorganic Electronic Spectroscopy,* Elsevier.
- R.V.Parish: *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry*, Ellis Horwood.
- R.M. Silverstein, G.C. Bassler and T.C, Morrill: *Spectrometric identification of Organic Compounds*, John Wiley.
- R.J. Abraham, J. Fisher and P. Loftus: *Introduction to NMR Spectroscopy*, Wiley.
- J.R. Dyer: *Application of Spectroscopy of organic Compounds*, Prentice Hall.
- D.H. Williams, I Fleming: *Spectroscopic Methods in Organic Chemistry*, TataMcGraw Hill.

CHEM – 302 PHOTOCHEMISTRY AND SOLID STATE CHEMISTRY

Max. Marks: 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Explain the solid state chemistry.
2. Analyze photochemical reactions.
3. Elaborate the photochemistry of various organic compounds.

Unit - I

1. **Electronic Properties and Band Theory**
   Metals, insulators and semiconductors, electronic structure of solids- band theory. Band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junction.
2. **Super conductors-**
   Definition types and BCS theory
   Optical properties- photoconduction- photoelectric effects.
   Magnetic Properties- Classification of materials-magnetic domains, hysteresis.

Unit – II

1. **Photochemical Reactions**
   Interaction of electromagnetic radiation with matter, type of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.
2. **Determination of Reaction Mechanism**
   Classification, rate constants and life Duration of reactive energy state- determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Type of photochemical reactions- photodissociation, gas-phase photolysis.
3. **Photochemistry of Alkenes**.
   Intermolecular reactions of the olefinic bond-geometrical isomerism cyclisation reaction, rearrangement of 1,4-and 1,5-dienes.

Unit – III

1. **Photochemistry of Carbonyl Compounds**
   Intramolecular reactions of the carbonyl compounds- saturated, cyclic and acyclic, α,β-unsaturated, cyclohexadienones, Intermolecular cycloaddition reaction-dimerisation and oxetane formation.
2. **Photochemistry of Aromatic Compounds**
   Isomerisations, additions and substitutions.
3. **Miscellaneous Photochemical Reactions**
   Photo-Fries reactions of anilides. Photo-Fries rearrangement. Barton reaction. Singlet molecular oxygen reactions. Photochemical formation of smog. Photo Degradation of polymers.

Reference Books :

- E.A.V. Ebsworth, D.W.H. Rakin and S. Cradock: *Structural Methods in Inorganic Chemistry*, EIBS.
- F.A Cotton, S.J. Lippard: *Progress in Inorganic Chemistry*,Wiley.
- K.K Rohtagi- Mukherji: *Fundamentals of Photochemistry*, Wiley-Eastern.
- A. Gilbert and J.Baggott: *Essentials of Molecular Photochemistry*, Blackwell Scientific Publication.
- A Cox and T.Chap: *Introductory Photochemistry*, Mc-Graw Hill.
- A. Gilbert, D. Bryce Smith: *Photochemistry*, Royal Society of Chemistry.
- J. Coxon and B. Halton: *Organic Photochemistry*, Cambridge University Press.

CHEM – 303 GREEN AND ENVIRONMENTAL CHEMISTRY

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Elaborate the principle and concept of green chemistry.
2. Illustrate application of greener alternative approaches.
3. Analyse the various aspects of pollution.

Unit I

Introduction, Principle and concept of green chemistry: Introduction and need of green chemistry, green chemistry in day to day life, Basic principles of green chemistry, concept of atom economy, designing green synthesis using these principles.

Unit II

Application of greener alternative approaches

Different approaches to green synthesis : Use of green reagents-dimethyl carbonate, polymer supported reagents- (per acids and chromic acids), green solvents, Synthetic organic transformations under microwave- Fries reaarangement, Diels-Alder reaction, decarboxylation, Saponification of esters, alkylation of reactive methylene compounds, heterocyclic synthesis : 3-alkyl coumarins, flavones, 3-aryl-2H-1,4- benzoxazines.

Unit III

Analysis of pollution: Sampling procedures and monitoring of water pollutants, determination of total dissolved solids, conductivity , acidity, alkalinity, hardness, chloride, Free (Residual) chlorine, sulphate, fluoride, phosphate, phenols, pesticides and surfactants, determination of DO, BOD, COD and microorganism. Water quality parameters, standards and laws.

Reference Books :

- S.E. Mannahan: *Environmental Chemistry*, Lewis Publishers.
- Sharma & Kaur: *Environmental Chemistry*, Krishna Publishers.
- A.K. De: *Environmental Chemistry*, Wiley Eastern.
- S.M. Khopkar: *Environmental Pollution Analysis*, Wiley Eastern.
- F.J. Welcher: *Standard Method of Chemical Analysis Vol.III*, Van Nostrand Reinhold Co.
- Colin Baird, Michael Cann: *Environmental Chemistry*, W.H. Freeman.
- Ed.Paul T. Anastas, Lauren G. Heine & Tracy C. Williamson: *Green Chemical Syntheses and Processes*, ACS Symposium Series.
- Ed Rashmi Sanghi, M. M. Srivastava: *Green Chemistry: Environment Friendly Alternatives*, Narosa Publishing House, New Delhi.
- Ed Paul T. Anastas & Tracy C. Williamson: *Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes*, Oxford University Press
- Paul T. Anastas, John Warner: *Green Chemistry: Theory and Practice*, Oxford University Press
- V.K. Ahluwalia, M. Kidwai: *New Trends in Green Chemistry*, Kluwer Academic Publishers.

CHEM – 304 BIOINORGANIC CHEMISTRY

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Review of bioenergetics and nitrogen fixation.
2. Illustrate metalloenzymes and metals in medicine.
3. Analyse haemoglobin and myoglobin in oxygen transport mechanism.

Unit-I

1. Role of bulk and trace metals ions in biological processes with special reference to Ca, Mg, Mn, Fe, Co, Na and K. Na^+/K^+ Pump.
2. **Bioenergetics**
   Standard free energy change in biochemical reactions, exergonic, endergonic, Hydrolysis of ATP, synthesis of ATP from ADP.

3. **Nitrogen fixation:**
   Biological nitrogen fixation and its mechanism, nitrogenase, chemical nitrogen fixation and other nitrogenase model systems.

Unit-II

1. **Metalloenzymes and their role in biological systems**
   Zinc enzymes- carboxypeptidase A and carbonic anhydrase. Iron enzyme- oxygenases, cytochrome P-450, catalase and peroxidase. Copper enzyme- superoxide dismutase. Molybdenum enzyme- xanthine oxidase. Vitamin B_{12}.
2. **Metals In Medicine**
   Metals deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs based on Pt.

Unit-III

Oxyen transport and oxygen uptake proteins. Haemoglobin (Hb) and Myoglobin (Mb) in oxygen transport mechanism. Structural feature of Heme group in Hb and Mb. Functions of Hb and Mb. Characteristics of oxygen binding interactions with Hb and Mb.

Reference Books :

- Berttini, H.B. Gray, S.J. Valentine: *Bioinorganic Biochemistry*, University Science Books.
- S.J. Lippard and J.M. Berg: *Principles of Bioinorganic Chemistry*, University Science Books.
- G.L. Eichhorn: *Inorganic Biochemistry* vols I and II. ed., Elsevier.
- Progress in Inorganic Chemistry, Vols 18 and 38 ed. J.J. Lippard, Wiley.
- R.R. Chirchton: *Biological Inorganic Chemistry*, Elsevier

CHEM –305 Practical

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 6 Hrs**

Learning Outcomes:

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

- Understand the practical applications of various aspects of chemistry

A. INORGANIC PREPARATIONS (At least seven preparations)

1. Prepare sodium amide
2. Prepare calcium oxalate
3. Prepare magnesium oxalate
4. Prepare sodium tetrathionate $Na_2S_4O_6$
5. Prepare vanadyl acetylacetonate Vo $(acac)_2$
6. Prepare Fe $(acac)_2$
7. Prepare $R_2Sn(acac)_2$
8. Prepare $Cr(acac)_2$
9. Prepare Cu $(acac)_2$ H2O
10. Prepare $Al(acac)_3$
11. Prepare tris (acetyl acetanato) manganese(II)
12. Prepare Fe (II) chloride
13. Prepare ferrocene
14. Prepare copper glycine complex.

B. ORGANIC CHEMISTRY (At least seven mixtures)

Qualitative Analysis

Separation and identification of the compound of mixture of three organic compounds (three solids and/or two solids and liquid) by Water, $NaHCO_3$, NaOH. Prepare derivatives, wherever possible.

C. PHYSICAL (Perform at least Five experiments)

1. Determine the partial molar volume of solute and solvent in a binary mixture
2. Study the effect of addition of an electrolyte on the solubility of an organic acid.

3. Determine the composition of binary mixture containing $K_2Cr_2O_7$ and $KMnO_4$ using spectrophotometer.
4. Determine the heat of neutralization of hydrochloric acid by sodium hydroxide.
5. Determine the heat neutralization of two acids eg HCl and CH_3COOH and hence their relative strengths.
6. Study the adsorption of iodine form alcoholic solution on charcoal
7. Study the adsorption of certain dyes such as methyl violet, picric acid or malachite green on charcoal.
8. Find the specific rotation and molecular rotation of cane sugar polarimetrically and also find the concentration of the unknown solution (concentration lies 1% and 5%). Calculate intrinsic rotation for cane sugar.
9. Study the influence of added impurity on rotation of a solute.
10. Investigate the inversion of cane sugar in the presence of an acid say HCl at 30 degree Celsius
11. Calculate the molecular weight of a high molecular weight polymer by means of viscosity measurements.
12. Study the complex formation and find the formula of silver amine complex by partition method.
13. Determine the solubility product of calcium hydroxide using common ion effect of sodium hydroxide or of any other strong alkali.
14. Determine the rate constant of a reaction between acetone and iodine in presence of mineral acid and a catalyst and to show that this reaction is of zero order with respect to iodine.
15. Estimate the amino acid using ninhydrin method
16. Study the kinetics of reaction between glycolic acid and ceric ammonium sulphate.
17. Determine the effect of concentration of salt on the reaction between glycolic acid and ceric ammonium sapphire.
18. Verify Beer's law for the solubility and determine the concentration of the given unknown aqueous solution of $KMnO_4$
19. Determine the solubility of various salts like NaCl, KCl, KNO_3. $NaNO_3$ at the different temperature and draw solubility curve.

Reference Books (Laboratory Courses)

- J. Bassett, R.C. Denney: GH. Jeffery and J. Mendham, *Vogel's Textbook of Quantitative Analysis*, revised, ElBS.
- W.L. Jolly: *Synthesis and Characterization of Inorganic Compounds*, Prentice Hall.
- D.Past, C.Johnson and M. Miller: *Experiments and Techniques in Organic Chemistry,* Prentice Hall.
- K.L. Williamson: *Macroscale and Miicroscale Organic Experiments*, D.C. Health.
- H. Mideleton: *Systematic Qualitative Organic Analysis*, Adward Arnold.
- H. Clark: *Handbook of Organic Analysis-Qualitative and Quantitative*, Adward Arnold.
- A.R. Tatchell: *Vogel's Textbook of Practical Organic Chemistry*, John Wiley.
- A.M. James and F.E. Prichard: *Practical Physical Chemistry,* Longman.
- B.P. Levitt: *Findley's Practical Physical Chemistry*, Longman.
- R.C. Das and B. Behera: *Experiments in Physical Chemistry*, Tata McGraw Hill.

SCHEME OF PRACTICAL EXAMINATION-

Max. Marks- 70

1.	Inorganic Chemistry	15
2.	Organic Chemistry	20
3.	Physical Chemistry	15
4.	Viva	10
5.	Record	10

Course Structure in Semester – IV

Course Structure- M.Sc Chemistry Semester – IV

Paper Code	Nomenclature	Contact Hours Per Week	Credits	Total Marks		Max. Marks	Min. Pass Marks	Duration
				CIA	ESE			
Group A - Inorganic chemistry								
CHEM-401	Organometallic Chemistry	06	06	30	70	100	40	3 hrs
CHEM-402	Supramolecular Chemistry	06	06	30	70	100	40	3 hrs
CHEM-403	Inorganic Polymers	06	06	30	70	100	40	3 hrs
Group B - Organic Chemistry								
CHEM-401	Organometallics and Disconnections	06	06	30	70	100	40	3 hrs
CHEM-402	Heterocyclic Chemistry	06	06	30	70	100	40	3 hrs
CHEM-403	Natural Products	06	06	30	70	100	40	3 hrs
Group C - Physical Chemistry								
CHEM-401	Chemical Dynamics	06	06	30	70	100	40	3 hrs
CHEM-402	Electrochemistry **- I**	06	06	30	70	100	40	3 hrs
CHEM-403	Electrochemistry – II	06	06	30	70	100	40	3 hrs
CHEM-404	**A.** Dissertation **OR** **B.** Analytical Chemistry	06	06	30	70	100	40	3 hrs
CHEM-405	Practicals	12	06	30	70	100	40	6 hrs
GE-401 ***(Generic Elective)***	1. Adv. Tax Management **OR** 2. Human Rights	2	2	15	35	50	20	2 ½ hrs

GROUP A – INORGANIC CHEMISTRY

CHEM – 401(A): ORGANOMETALLIC CHEMISTRY

Max. Marks: 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Summarize the basic concepts of organo transition metal complexes.
2. Elaborate the chemistry of organo transition metal complexes.
3. Illustrate application of organometallic compounds in homogenous catalysis.

Unit – I

An Introduction to Organometallic Compounds

Introduction, Classification and Nomenclature of Organometallic Compounds, Bonding: Stable electron Configuration, Electron Count Preference, Electron Counting and Oxidation states, Reaction of Organometallic Compounds- Ligand Subsituition, Oxidative addition and Reductive elimination, σ bond

metathesis, 1, 1- Migratory insertion, 1, 2- insertions and β hydride elimination and Cyclometallations. Concept of Isolability and Isolobal analogies.

Unit - II

Organometallic compounds of Transition metals

Preperation, Properties, Nature of Bonding and Structural features of σ bonded Transition metal complexes and Complexes with unsaturated organic molecules alkenes, alkynes, allyl and diene,

Unit - III

Application of Organometallic Compounds as homogenous Catalysts

1. Hydrogenation of Alkene
2. Hydroformylation
3. Wacker process
4. Alkene Metathesis
5. Pd catalysed C-C Bond forming reactions
6. Methanol Carbonylation- ethanoic acid synthesis

Reference Books:

- J.P. Collman, L.S. Hegdus, J.R. Norton and R.G. Finke: *Principles and Application of Organotransition Metal Chemistry,* University Science Books.
- A.J. Pearson: *Metallo-Organic Chemistry*, Wiley.
- R.C. Mehrotra and A. Singh: *Organometallic Chemistry*, New Age International.
- D.F. Shriver, P.W. Atkins and C.H. Longford: *Inorganic Chemistry*, ELBS with Oxford University
- Ajai Kumar: *Organometallic and Bioinorganic Chemistry*,Aaryush Education

CHEM – 402(A): SUPRAMOLECULAR CHEMISTRY

Max. Marks: 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Analyse different aspects of supra molecular chemistry.
2. Assess supramolecular reactivity and catalysis.
3. Elaborate about various supramolecular devices.

Unit – I

1. **Introduction-** Definition and development of Supramolecular Chemistry, Classification of Supramolecular Host- Guest Compounds, receptors, Coordination and the lock and key analogy, Nature of Supramolecular Interactions- Ion-Ion Interactions, Ion-dipole Interactions, Dipole- Dipole interaction, Hydrogen bonding, Cation-π interaction, Anion-π interactions, π-π interactions, vander wall forces and Crystal Close packing, Closed shell Interactions
2. **Molecular recognition:** Introduction to recognition, information and complementarity, Principle of molecular receptor designs, Spherical recognition, Tetrahedral recognition, Recognition of ammonium ions and neutral molecules, multiple recognition by coreceptor molecules.

Unit – II

1. **Supra molecular reactivity and catalysis**-Introduction, Catalysis by cation , anion and metalloreceptor molecules, catalysis with Cyclophane type receptors, Co catalysis- synthetic reaction catalysis, Bimolecular and abiotic catalysis.
2. **Transport processes and carrier design**- carrier mediated transport, cation, anion transport process, coupled transport process, electron coupled, proton coupled and light coupled transport.
3. **Supramolecular assemblies-** Introduction, Supramolecular solid materials, molecular recognition at surfaces, molecular and supramolecular morphogenesis.

Unit – III

1. **Supra molecular photochemistry**- Light conversion and energy transfer devices, photosensitive molecular receptors, photinduced electron transfer in photoactive devices, photoinduced reactions in supramolecular devices, Non linear optical properties of supramolecular species, Supramolecular effects in photochemical hole burning.

2. Molecular and Supra molecular electronic and ionic devices, switching devices and signals.

Reference Books:

- J.M.Lehn: *Supramolecular Chemistry*, VCH.
- Dr. AK Goswami, Dr. Rekha Dashora: *Supramolecular and Bioinorganic Chemistry*, Pragati Prakashan
- J.W. Steed,J.L. Atwood: *Supramolecular Chemistry,* John wiley and Sons
- P.S. Kalsi, J.P. Kalsi: *Bio-organic, Bio-inorganic and Supramolecular Chemistry*, New age International
- Ajay Kumar Bhagi, G.R. Chatwal: *Bioinorganic and Supramolecular Chemistry*, Himalaya Publishing House.

CHEM – 403(A) INORGANIC POLYMERS

Max. Marks: 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

- Elaborate basic concepts and synthesis of Inorganic polymers.
- Analyse the Chemical nature of polymers.
- Summarize the Properties of Inorganic Polymers.

Unit-I

1. **Basic Concepts**
   Definition, Classification by Connectivities, Classification by Dimensionality, the Metal/Backbone Classification of Metal-Containing Polymers.
2. **Inorganic Polymer Synthesis**
   Step Growth synthesis, Chain Polymerization, ring opening polymerization, Reductive coupling and other Redox Polymerisation reactions.

Unit-II

1. **Inorganic Polymer Characterization**
   Average Molecular Masses and Degrees of Polymerization, Methods of Characterizing Average Molecular Masses- Gel Permeation Chromatography, Viscosity, Universal Calibration, Colligative Properties (Vapor Pressure Lowering, Boiling Point Elevation, Melting Point Lowering, and Osmotic Pressure), End-Group Analysis, Mass Spectroscopy, Ultracentrifugation.
2. **Analysis and. testing of polymers**
   Chemical analysis of polymers, spectroscopic methods. X-ray diffraction study, microscopy. thermal analysis and physical testing-tensile strength. Fatigue, impact, tear resistance. hardness and abrasion resistance.

Unit-III

1. **Polymers based on Boron –** Borides, Carborane Polymers, Borazine, Boron Nitride
2. **Polymers based on Silicon-**
   Silicones- Preparation and properties of Silicones, Silicone Fluids, Silicone Rubbers, Silicone Resins, Modification of Silicones
   Polysilanes and related polymers- Structure, Synthesis, Physical and electronic properties of polysilanes, Chemical modification of Polysilanes, Other Silicon Containing Polymers

Reference Books:

- F.W. Billmeyer Jr: *Text book of Polymer Science*, Wiley.
- V.R. Gowarikar, N.V. Viswanathan and J. Srcedhar: *Polymer Science*, Wiley- Eastern.
- Ronald D. Archer: *Inorganic and Organometallic Polymers*, Wiley-VCH
- M.F. Lappert, G.J. Leigh: *Developments in Inorganic Polymer Chemistry*, ACS Publications
- G.R. Chatwal*: Inorganic Polymers*, Himalaya Publishing House.
- James E. Mark, Harry R. Allcock, Robert West: *Inorganic Polymers*, Oxford University Press
- Barbara Stuart: *Polymer Analysis*, Wiley

GROUP B – ORGANIC CHEMISTRY

CHEM – 401 (B) ORGANOMETALLICS AND DISCONNECTIONS

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

- Analyse organometallic reagents of transition metals.
- Elaborate disconnection approach.
- Implement the application of disconnection approach in the synthesis of complex organic compounds.

Unit I

1. **Organometallic Reagents**
   Principles, preparations, properties and applications of the following in organic synthesis with mechanistic details.
   Transition Metal organic compounds
   Cu, Pd, Ni, Fe, Co, Rh, Cr and Ti Compounds.
2. **Protecting Groups**
   Principle of Protection of alcohol, amine, carbonyl and carboxyl group.

Unit-II

1. **One Group C-C Disconnections**
   Alcohols and carbonyl compounds, regioselectivity. Alkene Synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.
2. **Two Group C-C Disconnections**
   Diels-Alder reactions 1,3-difunctionalised compounds. - unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalized compounds . Micheal addition and Robinson annelation.

Unit-III

Synthesis of Some Complex Molecules

Application of disconnection approach in the synthesis of following compounds : Camphor, Longifoline, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A.

Reference Books:

1. H.O House: *Modern Synthetic Reactions*, Benjamin Cummings Pub. Co.
2. W. Carruthers: *Some modern methods of Organic Synthesis,* Cambridge Univ. Press.
3. J. March: *Advanced organic Chemistry, Reactions Mechanisms and Structure,* John Wiley.
4. R.O.C. Norman and J.M. Coxon: *Principles of Organic Synthesis,* Blackie Academic & Professional.
5. F.A. Carey and R.J. Sundberg: *Advanced Organic Chemistry Part B*, Pleanum Press.
6. S. Warren: *Designing Organic Synthesi*s, Wiley.

CHEM 402 (B) – HETEROCYCLIC CHEMISTRY

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Interpret aromatic and non- aromatic heterocycles.
2. Elaborate the synthesis of various types of heterocyclic compounds.
3. Illustrate benzo fused five-membered and six-membered heterocycles.

Unit-I

1. **Nomenclature of Heterocycles**
   Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles.
2. **Aromatic Heterocycles**
   General chemical behavior of aromatic hetrocycles, classification (structural type), criteria of aromaticity (Bond lengths, ring current and chemical shifts in ^{1}H NMR-spectra, empirical resonance energy, delocalization energy and Dewar resonance energy, dimagnetic susceptibility exaltations.) Heteroaromatic reactivity and tautomerism in aromatic heterocycles.
3. **Non Aromatic Hetrocycles**

Strain-bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction.

Stereo-electronic effects-anomeric and related effects. Attractive interactions-hydrogen bonding and intramolecular nucleophilic- electrophilic interactions.

Unit-II

1. **Heterocyclic Synthesis**
   Principles of heterocyclic synthesis involving cyclization reaction and cycloaddition reactions.
2. **Small Ring Heterocycles**
   Three - membered and four - membered heterocyles - synthesis and reactions of aziridines, oxiranes, azetidines, oxetanes.
3. **Heterocyclic Systems containing P-** Heterocyclic ring containing phosphorus: Introduction, nomenclature, synthesis and characteristics of 5-and 6 membered ring systems-phosphorinanes, phospholanes and phospholes.
4. **Six Membered Heterocycles with one Heteroatom**
   Synthesis and reaction of quinolizinium and benzopyrilium salts, coumarins and chromones.

Unit-III

1. **Benzo Fused Five-membered Heterocyles**
   Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes. Meso-Ionic heterocycles.
2. **Six-Membered heterocycles with Two or More Heteroatoms**
   Synthesis and reactions of tetrazines and thiazines.

Reference Books:

- R.R. Gupta, M.K. Kumar and V. Gupta: *Heterocyclic Chemistry Vol. 1-3*, Springer Verlag.
- T. Eicher and S. Hauptmann: *The Chemistry of Heterocycles*, Thieme.
- T.L. Gilchrist: *Heterocyclic Chemistry*, Longman Scientific Technical
- J.A. Joule, K. Mills and G.F. Smith: Heterocyclic Chemistry, Chapman and Hall.
- G.R. Newkome and W.W Paudler: *Contemporary Heterocyclic Chemistry*, wiley- Inter Science.
- R.M. Acheson: *An introduction to the heterocyclic Compounds*, John Wiley.
- A.R. Karizky and C.W. Reeds: *Comprehensive Heterocyclic Chemistry*, eds. Pergamon Press.
- IL. Finar: *Organic Chemistry*, Vol. 2, ELBS.

CHEM 403 (B) – NATURAL PRODUCTS

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Explain the synthesis of various types of terpenoids, carotenoids and alkaloids.
2. Illustrate the prostaglandins, pyrethroids, rotenones and steroids.
3. Analyse plant pigments and porphyrins.

Unit-I

1. **Terpenoids and Carotenoids**
   Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.
   Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol, α -Terpineol, Menthol, Farnesol, Santonin, Phytol, Abietic acid and β -Carotene.
2. **Alkaloids**
   Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants.
   Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, Nicotine, Atropine, Quinine and Morphine

Unit-II

1. **Prostaglandins**

Occurrence, Nomenclature, Classification, biogenesis and physiological effects. Synthesis of PGE_2 and $PGF_{2\alpha}$

2. **Pyrethroids and Rotenones**
   Synthesis and reactions of Pyrethroids and Rotenones.

3. **Steroids-** Occurrence, nomenclature and basic skeleton, Diel's hydrocarbon and stereochemistry, isolation, structure determiantion and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone, Aldosterone. Biosynthesis of Steroids.

Unit-III

1. **Plant Pigment**
   Occurrence, nomenclature and general methods of structure determination, isolation and synthesis of Quercetin, Myricetin, Diadzein, Butein, Cyanidin, Hirsutidin.
   Biosynthesis of flavonoids; Acetate pathway and Shikimic acid pathway.
2. **Porphyrins-** Structure and synthesis of Haemoglobin and Chlorophyll.

Reference Books:

- Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harbome: *Natural Products: Chemistry and Biological Significance*, J Longman, Essex.
- IL. Finar: *Organic Chemistry*, Vol2. ELBS.
- S. coffey, *Rodd's Chemistry of Carbon Compounds*, ED, Elsevier.
- Kurt Hostettmann, M.P. Gupta and A. Marston Harwood: *Chemistry, Biological and Pharmacological Properties of Medical Plants from the Americas*, Academic Publishers.
- B.A. Bohm: *Introduction to Flavonoids*, Harwood Academic Publishers.
- Atta-ur-rahman and M.I. Choudhary: *New Trends in Natural Products Chemistry*, Harwood Academic Publishers.

GROUP C- PHYSICAL CHEMISTRY

CHEM – 401 (C) CHEMICAL DYNAMICS

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Analyse various inorganic substitution reactions.
2. Illustrate radiation chemistry and photochemistry.
3. Review the kinetics of gas surface reactions.

Unit I

1. **Inorganic Substitution Reactions**

Type of substitution reactions, Langford and Gray classification of substitution mechanisms, Acid Hydrolysis of aquation reaction of petaammine cobalt(III) complexes, Base hydrolysis of chloropentaamminecobalt (III) complex.

Unit-II

1. **Radiation Chemistry** Introduction, sources of high energy raditation, dose, primary and secondary process, radiolysis of water, reaction of hydrogen atoms and hydroxide radicals, radiation chemical yield.
2. **Photochemistry** Unimolecular photophysical processess and their rate laws, kinetics and mechanism of photochemical hydrogen-Bromine reaction, Kinetics of collisional quenching and Stern-Volmer equation, Semi conductor photocatalysis-formation of hole.
   Excited state electron transfer reaction of $[Ru(bpy)_3]^{2+}$

Unit-III

1. **Kinetics of gas surface reactions**
   Adsorption isotherms: Langmuir adsorption isotherm, Adsorption without dissociation, adsorption with dissociation, competitive adsorption; Mechanisms of surface reactions; Kinetics of unimolecular surface reactions: Inhibition,

Kinetics of bimolecular surface reactions : reaction between two adsorbed species; reactions between a gas molecule and an adsorbed molecule; reaction between two adsorbed gases without much displacement. Kinetics and mechanism of oxidation of carbon monoxide by oxygen on a platinum surface.

2. **Enzymes kinetics**
   Kinetic and mechanism of one enzymes - two substrate systems.
   Kinetics mechanism of inhibition of enzyme catalysis.

Reference Books:

- A.G. Sykes: *Kinetics of Inorganic reactions*, Pergamon.
- Keith J. Laidler: *Chemical Kinetics*, New york 1987
- Donald A Mcqurrie and john D. Simo: *Physical Chemistry,* A Molecular approach viva Books New Dehli. 2013.
- J.E. Huheey E.A. Keiter, O.K Medhi: *Inorganic Chemistry*, Pearson.
- S.K. Upadhyay: *Chemical Kinetics and Reaction Mechanism*, Anamya, Delhi, 2006.
- J. Rajaram and J.C. Kuriacose: *Kinetics and Mechanism of Chemical trnsformations,* Mcmillan India and National Book Trust, Delhi, 1993.
- K.K. Rohatgi-Mukherjee: *Fundamentals of Photochemistry*, New Age, Delhi, 1986
- R. Lumry and R.W. Raymond: *Electron transfer Reactions*, Inter science.
- N.L. Bender: *Mechanism of Homogeneous Catalysis from protein to protein*, Wiley.
- A.G. Sykes: *Kinetics of Inorganic reactions*, Pergamon.
- S.W. Benson: *Mechanism of Inorganic Reactions,* Academic Press.
- Basolo and Pearson, *Inorganic Reaction Mechanism*, Wiley.
- H. Taube: *Electron Transfer Reaction*, Oxford Press.

CHEM – 402 (C) ELECTROCHEMISTRY-I

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Explain the conversion and storage of electrochemical energy.
2. Analyse electrochemical energy source.
3. Assess corrosion and stability of metals.

Unit I

Conversion and storage of Electrochemical Energy:

Present status of energy consumption: Pollution problem. History of fuel cells. Direct energy conversion by electrochemical means. Maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the Carnot efficiency factor in electrochemical energy convertors. Power outputs. Electrochemical Generators (Fuel Cells) Hydrogen oxygen cells, hydrogen Air cell, Hydrocarbon air cell, alkaline fuel cell, phosphoric fuel cell, direct NaOH fuel cell, Applications of fuel cells

Unit-II

Electrochemical Energy Storage:

Properties of Electrochemical energy stores; measure of battery performance. Charging and discharging of a battery. Storage density, Energy density
Classical Batteries (i) Lead-Acid (ii) Nickel-Cadmium. (iii) Zinc-Manganese dioxide.
Modern batteries: (1) Zinc-Air (ii) Nickel-Hydride, (iii) Lithium Battery.
Future electricity stores: storage in (i) Hydrogen, (ii) Alkali metals (iii) Non aqueous solutions.

Unit-III

Corrosion and Stability of Metals:

Civilization and surface mechanism of the corrosion of the metals, thermodynamics and the stability of metals, Potential pH (or pourbaux) Diagrams. Uses and abuses, Corrosion current and corrosion potential-Evans diagrams.
Measurement of corrosion rate: (i) Weight loss Method (ii) Electro chemical Method.

Inhibiting corrosion: Cathodic and anodic protection (i) Inhibition by addition of substrates to the electrolyte environment (ii) by charging the corroding method from external source, anodic protection, organic inhibitors. The fuller story green inhibitors.

Passivation:

Structure of passivation films. Mechanism of Passivation, Spontaneous Passivation: Nature's method for stabilizing surfaces.

Reference Books:

- J'OM Bochris and A.K.N. Reddy, *Modern Electrochemistry vol. I, IIA Vol. IIB*, Plenum Publication, New York.
- L. Meites: *Polarographic Techniques*, Interscience.
- A.M. Bond: *Modern Polarographic Methods* by, Marcell Dekker.
- K. Zutshi: *Polarography and allied technique*, New Age Publication New Delhi.
- Badil H. Vessor & Galen W. Wiley, "*Electroanalytical Chemistry*", Insterscience.
- S.K. Rangrajan, *Topic in Pure and Applied Chemistry. Ed*. SAEST Publication.

CHEM – 403 (C) ELECTROCHEMISTRY-II

Max. Marks : 100 **Min. Marks: 40**

Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Summarize kinetics of various reversible amd irreversible electrode processes.
2. Illustrate aspects of biochemistry and electro catalysis.
3. Explain potential sweep and bulk electrolysis method.

Unit I

1. **Kinetics of Electrode Process:**
   Essential of electrode reaction. Current density, Overpotential, Butler Volmer equation, Standard rate constant. Transfer coefficient, exchange current,
2. **Irreversible Electrode Processes**: Criteria of irreversible information from irreversible wave. Methods of determining kinetic parameters for quasi-reversible and irreversible waves: Koutecky's method. Meits Israel methods, Gelling's method.

Unit-II

1. **Bioelectrochemistry**: Bio-electrodes, membrane, potentials, simplistic theory, modern theory. Electrical conductance in biological organism. Electronic, protonic electrochemical mechanism of nervous systems, enzymes as electrodes.
2. **Electro catalysis**: Chemical catalysis and Electrochemical catalysis with special reference to purostates, porphyrin oxides of rare earths, Electro catalysis in simple redox reactions, in reaction involved adsorbed species, Influence of various parameters

Unit-III

1. **Potential Sweep Method:**
   Linear sweep voltammetry, Cyclic voltammetry, theory and applications, Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode technique, comparison with controlled potential methods Chronopotentiometry, theory and applications.
2. **Bulk Electrolysis Methods**
   Controlled potential coulometry, Controlled coulometry, Electro organic synthesis and its importance, application, stripping analysis, anodic and cathodic modes, pre electrolysis and stripping steps, application of stripping analysis.

Reference books:

- J'Om Bockris and A.K.N. Reddy: *Modern Electrochemistry* vol. I,IIA Vol. IIB, Plenum Publication, New York.
- L. Meites: *Polarographic. Techniques*, Interscience.
- K. Zutshi: *Polarography and allied technique*, New Age Publication New Delhi.
- Badil H. Vessor & Galen W.: "*Electroanalytical Chemistry"* Wiley Insterscience.
- S.K. Rangrajan: *Topic in Pure and Applied Chemistry. Ed*., SAEST Publication, Kararikudi (India).

CHEM – 404 (A) DISSERTATION

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

- Create, analyse and critically evaluate different methods in the field of study area in order to identify the issues that must be addressed within the framework of the specific thesis

Data Collection and report writing : 70
Presentation and viva : 30

CHEM – 404 (B) ANALYTICAL CHEMISTRY

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 3 Hrs**

Learning Outcomes:

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

1. Implement statistical methods of analysis to various problems and extraction techniques
2. Apply various methods of thermal analysis
3. Separate various mixtures with the help of different chromatographic techniques

Unit-I

1. Data analysis and statistics

Types and sources of errors, Accuracy and precision, Significant figures; Mean ,Median and Standard Deviation, Rejection of results, Q-Test, Tests of significance, Comparison of the means of two samples, Analysis of Variance, Replicate determinations, Correlation, Regression, Uses of Statistics.

2. Solvent Extraction

Partition: The theory of Extraction, Mechanism of solvent extraction, Extraction involving ion association complexes, Synergistic extraction, Solvent extraction by macromolecules, Techniques for solvent extraction, Applications, Solid phase extraction (SPE), Solid phase micro extraction (SPME).

Unit-II

Thermal methods of analysis

1. **Thermogravimetric analysis** –Introduction, instrumentation, TG –curves, factors affecting TGA, application of TGA
2. **Differential thermal analysis**- Differential scanning calorimetry, instrumentation, Factors affecting DTA and DSC curves.
3. **Thermometric titrations**

   Introduction, instrumentation, Application of thermometric titrations.

Unit-III

Chromatographic Techniques

Introduction and classification of chromatographic techniques - Paper chromatography, Column Chromatography, Thin Layer Chromatography, Gas Chromatography- Introduction, instrumentation and applications.

Reference Books:

- G.H. Jeffery, J.Bassett, J.Mendham, R.C. Denney, V*ogel's Textbook of Quantitative Chemical Analysis*: John Wiley and Sons
- H. Kaur, *Methods for Instrumental Analysis*: Pragati Prakashan
- Gurdeep Chatwal, Sham Anand, *Instrumental methods of Chemical Analysis*: Himalaya Publishing House
- S.M. Khopkar, *Basic Concepts of Analytical Chemistry*: Wiley Eastern Limited

CHEM –405 Practical

Max. Marks : 100 **Min. Marks: 40**
Credits : 6 **Duration : 6 Hrs**

A. **INORGANIC**

a) Spectrophotometric Determination (Any Three)

1. Manganese/Chromium/Vanadium in steel sample.
2. Nickel/molybdenum/tungsten/vanadium/uranium by extractive spectrophotometric method.
3. Fluoride/nitrite/phosphate.
4. Iron-phenanthroline complex; Job's method of continuous variations.
5. Zirconium-Alizarin Red-S Complex; Mole-ratio method.
6. Copper-ethylene diamine complex; Slope-ratio method.

OR

b) Flame Photometric Determinations (Any Three).

1. Sodium and potassium when present together.
2. Lithium/Calcium/barium/strontium
3. Cadmium and magnesium in tap water.
4. Sulphate,
5. Phosphate
6. Silver.

OR

c) Chromatographic Separations (Any Three)

1. Cadmium and Zinc.
2. Zinc and Magnesium
3. Nickel and Cadmium
4. Thin-layer Chromatography-separation of nickel, manganese, cobalt and zinc. Determination of Rf values.
5. Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper Chromatography and determination of Rf values.
6. Separation and identification of Pb and Cd by Paper Chromatography and determination of Rf values.

B. ORGANIC

a) Organic synthesis

Multi-step Synthesis of Organic Compounds (any four)

The exercise should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques.

1. Photochemical reaction
   Benzophenone benzpinacol benzpinacolone
2. Beckmann rearrangement: benzanilide from benzene
   Benzene Benzphenone Benzophenone oxime benzanilide
3. Benzoin benzil benzilic acid
4. Preparation of Quinoline from aniline; Preparation of 2-phenylindole from phenylhydrazine.
5. Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S(+) ethyl-3-hydroxybutanoate and determine its optical purity.
6. Biosynthesis of ethanol from sucrose.
7. Synthesis using microwave-Alkylation of diethylmalonate with benzyl chloride.
8. Synthesis using phase transfer catalyst.

OR

Extraction of organic compound from natural source

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins.)
3. Isolation of lactose from milk (Purity of sugar should be checked by TLC and PC and Rf (value reported.).
4. Isolation of nicotine dipicrate from tobacco.
5. Isolation of cinchonine from cinchona bark.
6. Isolation of piperine from black pepper.
7. Isolation of lycopene from tomatoes.
8. Isolation of -carotene from carrots.

9. Isolation of oleic acid from olive oil (involving the perparation of complex with urea and separation of linoleic acid.
10. Isolation of eugenol from cloves.
11. Isolation of (+) limonine from citrus rinds.

b) Spectroscopy

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR).

OR

Spectrometric (UV/VIS) estimations (Any Three):

1. Aminoacids
2. Proteins
3. Carbohydrates
4. Cholesterol
5. Ascorbic acid
6. Aspirin
7. Caffeine

C. PHYSICAL

1. Determination of pKa of indicator (e.g. methyl red).
2. Determination of stoichiometry and stability constant of inorganic (e.g.ferric salicyclic acid) organic (e.g. amine and iodine) complexes.
3. Characterisation of complexes by electronic and IR spectral data.
4. Estimation of Pb^{2+} and Cd^{2+} /Zn^{2+} by polarography.
5. To obtain solubility curve for a ternary system of liquids, water-acetic acid, acidchloroform system.
6. To estimate oxalic acid by carrying out suitable conductometric titration in the following solutions.
   a) A solution of pure Oxalic acid.
   b) A solution of Oxalic acid and HCI.
   c) A solution of Oxalic acid and CH_3 COOH
7. Study the kinetics of reaction between potassium persulphate and potassium iodide and determine the rate constant for different reaction mixtures.

Reference Books:

- J. Kerek Woollins: *Inorganic Experiments*, VCH
- A Sqafran, R.M. Pike and M.M. Singh, *Microscale Inorganic Chemistry*, Wiley.
- G.Marr and B. W. Rockelt, Ban Nostrand : *Practical Inorganic Chemistry*, London ; New York : Van Nostrand Reinhold
- M.P. Doyle and W.S. Mugall: *Experimental Organic Chemistry*, Wiley
- P.J. Hill, *Small Scale Organic Preparations*, E Arnold
- J.J. Fisch and R.B. king: *Organometallic Synthesis*, Academic.
- D.P. Shoemaker, C.W. Garland and J.W. Niber: *Experimental Physical Chemistry*, McGraw Hill, Interscience.
- B.P. Levitt: *Finalay's Practical Physical Chemistry*, revised, longman.
- J.C. Ghosh: *Experiments in Physical Chemistry*, Bharti Bhavan.
- J.B. Yadav: *Advanced Practical Physical Chemistry*, Goel Publishing House.

SCHEME OF PRACTICAL EXAMINATION

Inorganic (Chromatography or Flame Photometry or Spectrophotometry)-		15 marks
Organic	Synthesis or Extraction	10 marks
	Spectroscopic or spectrometric estimations	10 marks
Physical		15 marks

Viva	10 marks
Record	10 marks
Seminar	30 marks