University of Rajasthan
Jaipur

SYLLABUS

M.Sc.

(CHEMISTRY)

2015-2016 (I & II SEMESTER)

2016-2017 (III & IV SEMESTER)

Asstt. Registrar (Acad-I)
University of Rajasthan
JAIPUR

Eligibility

Same as notified on website by Admission Committee.

Scheme of Examination:

(1) Each theory paper EoSE shall carry 100 marks. The EoSE will be of 3 hours duration. Part 'A' of theory paper shall contain 10 short Answer Questions of total 20 marks, based on knowledge, understanding and applications of the topics/texts covered in the syllabus. Each question will carry two mark for correct answer.

(2) Part "B" of paper will consist of Four questions with internal choice (except in cases where a different scheme is specifically specified in the syllabus) of 20 mark each. The limit of answer will be five pages.

(3) Each Laboratory EoSE will be of six hour durations and involve laboratory experiments / exercises, and viva-voce examination with weightage in ratio of 75:25.

(4) The Practical examination will be conducted by board of examiners consisting of one internal (to be appointed by the Head of Department) & one external examiner (to be appointed by the University).

Course Structure:

The details of the courses with code, title and the credits assigned are as given below.

Abbreviations Used

Course Category

CCC: Compulsory Core Course
ECC: Elective Core Course
OEC: Open Elective Course
SC: Supportive Course
SSC: Self Study Core Course
SEM: Seminar
PRJ: Project Work
RP: Research Publication

Contact Hours

L: Lecture
T: Tutorial
P: Practical or Other
S: Self Study

Relative Weights

IA: Internal Assessment (Attendance/Classroom Participation/Quiz/Home Assignment etc.)
ST: Sessional Test
EoSE: End of Semester Examination

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First Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per Week			EOSE Duration (Hrs)	
					L	T	P	Thy	P
1.	CHY 101	Inorganic Chemistry	CCC	4	3	1	0	3	0
2.	CHY 102	Organic Chemistry	CCC	4	3	1	0	3	0
3.	CHY 103	Physical Chemistry	CCC	4	3	1	0	3	0
4.	CHY 104	Mathematics / Biology for Chemistry	CCC	4	3	1	0	3	0
5.	CHY 105	Spectroscopy-I	CCC	4	3	1	0	3	0
6.	CHY 106	Bio-Inorganic Chemistry	CCC	4	3	1	0	3	0
7	CHY 111	Practical A- Inorganic Chemistry	CCC	4	0	0	6	0	6
8.	CHY 112	Practical B - Organic Chemistry	CCC	4	0	0	6	0	6
9.	CHY 113	Practical C - Physical Chemistry	CCC	4	0	0	6	0	6

Second Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per Week			EOSE Duration (Hrs)	
					L	T	P	Thy	P
1.	CHY 201	Inorganic Chemistry	CCC	4	3	1	0	3	0
2.	CHY 202	Organic Chemistry	CCC	4	3	1	0	3	0
3.	CHY 203	Physical Chemistry	CCC	4	3	1	0	3	0
4.	CHY 204	Spectroscopy-II	CCC	4	3	1	0	3	0
5.	CHY 205	Bio-Organic Chemistry	CCC	4	3	1	0	3	0
6.	CHY 206	Environmental Chemistry	CCC	4	3	1	0	3	0
7.	CHY 211	Practical A - Inorganic Chemistry	CCC	4	0	0	6	0	6
8.	CHY 212	Practical B - Organic Chemistry	CCC	4	0	0	6	0	6
9.	CHY 213	Practical C - Physical Chemistry	CCC	4	0	0	6	0	6

Third Semester

S.No	Subject Code	Course Title	Course Category	Credit	Contact Hours Per Week			EOSE Duration (Hrs)	
					L	T	P	Thy	P
1.	CHY 301	Solid States and Nanomaterials	CCC	4	3	1	0	3	0
2.	CHY 302	Green Chemistry	CCC	4	3	1	0	3	0
3.	CHY 303	Bio-Physical Chemistry	CCC	4	3	1	0	3	0
4.		Core Elective – 1	ECC	4	3	1	0	3	0
5.		Core Elective – 2	ECC	4	3	1	0	3	0
6.		Core Elective – 3	ECC	4	3	1	0	3	0
7.	CHY 311	Practical A - Inorganic Chemistry	CCC	4	0	0	6	0	6
8.	CHY 312	Practical B - Organic Chemistry	CCC	4	0	0	6	0	6
9.	CHY 313	Practical C - Physical Chemistry	CCC	4	0	0	6	0	6

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Fourth Semester

S.N.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per Week			EOSE Duration (Hrs)	
					L	T	P	Thy	P
1.		Core Elective – 4	ECC	4	3	1	0	3	0
2.		Core Elective – 5	ECC	4	3	1	0	3	0
3.		Core Elective – 6	ECC	4	3	1	0	3	0
4.	CHY 421	Seminar	SEM	4	0	0	6	0	4
5.	CHY 422	Project work in University or Institution or Industry (15 week)	PRJ	20	0	0	30	0	4

ELECTIVE CORE COURSES

Specialization Clusters

A. Inorganic Chemistry

B. Organic Chemistry

C. Physical Chemistry

Elective Course Code	Course Category	Paper Title	Pre requisite	Semester
CHY A01	ECC	Photoinorganic Chemistry		III
CHY A02	ECC	Organotransition Metal Chemistry		III
CHY A03	ECC	Supramolecular Chemistry		III
CHY A04	ECC	Inorganic Polymers	CHY A01	IV
CHY A05	ECC	Advanced Bioinorganic Chemistry	CHY A02	IV
CHY A06	ECC	Mineral Based Industrial Chemistry	CHY A03	IV
CHY B01	ECC	Natural Products		III
CHY B02	ECC	Organic Synthesis-I		III
CHY B03	ECC	Heterocyclic Chemistry-I		III
CHY B04	ECC	Medicinal Chemistry	CHY B01	IV
CHY B05	ECC	Organic Synthesis-II	CHY B02	IV
CHY B06	ECC	Heterocyclic Chemistry-II	CHY B03	IV
CHY C01	ECC	Electroanalytical Techniques		III
CHY C02	ECC	Electrochemistry-I		III
CHY C03	ECC	Chemical Kinetics-I		III
CHY C04	ECC	Chemical Analysis	CHY C01	IV
CHY C05	ECC	Electrochemistry-II	CHY C02	IV
CHY C06	ECC	Chemical Kinetics-II	CHY C03	IV

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SEMESTER – I

CHY 101: INORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT - I

Stereochemistry and Bonding in Main Group Compounds:
Limitations of VSEPR Theory, Walsh diagram - triatomic (AH_2 type) and tetra-atomic (AH_3) molecules, $d\pi$-$p\pi$ bond, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules

UNIT – II

Metal Ligand bonding:
Limitations of crystal field theory, molecular orbital theory and introduction to ligand field theory: octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

UNIT - III

Chemistry of Lanthanides, Actinides and Super heavy elements:
Chemistry of lanthanides and actinides, stable oxidation states, lanthanide and actinide contraction, absorption spectra of lanthanides and actinides and their magnetic properties, separation of lanthanides and actinides, uses of lanthanides and their compounds, chemistry of super heavy elements.

UNIT - IV

Inorganic Reaction Mechanisms
Mechanisms of substitution reactions of tetrahedral, square planar, trigonal bipyramidal, square pyramidal and octahedral complexes, potential energy diagrams, transition states and intermediates, isotope effects, Berry's pseudo rotation mechanism, factors affecting the reactivity of square planar complexes, Swain-Scott equation, Trans effect and its applications to synthesis of complexes.

SUGGESTED BOOKS AND REFERENCES

1. Inorganic Chemistry, Principles of structure and Reactivity, 4th Edition; James E. Huheey: Elleu A. Keiter: Richard L. Keiter.
2. Advanced Inorganic Chemistry; F.A. Cotton and G. Wilkinson.
3. Theoretical Inorganic Chemistry; Day and Selbin.
4. Concepts and Models in Inorganic Chemistry; Doughlas McDaniel.
5. Chemistry of Lanthanides; T. Healler, Chapman and Hall.
6. Chemistry of the Elements; N.N. Greenwood and A. Earnshow, Pergamon, 1984.
7. Inorganic Electronic Spectroscopy; A.B.P. Lever, Elsevier, 1968.
8. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon, 1987; Vol. 2.

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CHY 102: ORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT- I

Reaction Mechanism: Structure and Reactivity
A review of types of mechanisms and reactions, methods of determining reaction mechanism, thermodynamic and kinetic requirements for reaction, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett Principle, Isotope effects. Effects of structure on reactivity, resonance and field effects, steric effects. Quantitative treatment of the effect of structure on reactivity. The Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation.

Aromaticity: Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons. Huckel's rule, energy level of π-molecular orbitals, annulenes, anti-aromaticity, homo-aromaticity, PMO approach, energetic and magnetic concept.

UNIT - II

Aliphatic Nucleophilic Substitution
The S_N1, S_N2, mixed S_N1-S_N2 and SET mechanisms. The S_Ni mechanism. The neighbouring group mechanism - neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system. Application of NMR spectroscopy in the detection of carbocations. Nucleophilic substitution at the allylic, aliphatic trigonal and a vinylic carbon.
Reactivity - effect of substrate structure, attacking nucleophile, leaving group and reaction medium. Ambident nucleophile, regioselectivity.

Aromatic Nucleophilic Substitution
The S_NAr, S_N1, benzyne and $S_{RN}1$ mechanisms. Reactivity - effect of substrate structure, leaving group and attacking nucleophile. The von Richte, Sommelet-Hauser and Smiles rearrangements.

UNIT - III

Aliphatic Electrophilic Substitution
Bimolecular mechanisms - S_E2 and S_Ei. The S_E1 mechanism - electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and solvent polarity on reactivity.

Aromatic Electrophilic Substitution
The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

Free Radical Reactions

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Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity of aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents 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.

UNIT - IV

Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

Addition to Carbon-Heteroatom 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 and application of condensation reactions involving enolates - Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

Elimination Reactions

The E2, El and ElcB mechanisms. Steric orientation of the double bond. Reactivity, effect of substrate structure, the attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic eliminations.

SUGGESTED BOOKS AND REFERENCES

1. Advanced Organic Chemistry: Reactions Mechanisms and Structure by Jerry March, McGraw Hill.
2. Mechanism and Structure in Organic Chemistry – E. S. Gould (Holt, Rinehart and Winston).
3. Advanced Organic Chemistry Part-A. F.A. Carey and R.J. Sundberg, 5th Ed. Springer (2007).
4. Physical Organic Chemistry – J. Hine.
5. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes. Longman
6. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers. Oxford University Press (2001)
7. Structure and Mechanism in Organic Chemistry. C.K. Ingold. Cornell University Press.
8. Organic Chemistry. R.T. Morrison and R N. Boyd. Prentice-Hall.
9. Modern Organic Reactions. H O House, Benjamin.
10. Principles of Organic Synthesis. R O C Norman and J.M. Coxon. Blackie Academic & Professional.
11. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.

CHY 103: PHYSICAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT - I

Quantum Chemistry

Introduction to Exact Quantum Mechanical Results : The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

Approximate Methods : The variation theorem, linear variation principle, Perturbation theory (First order and nondegenerate). Applications of variation method and perturbation theory to Helium atom.

UNIT - II

Quantum Chemistry

Angular Momentum : Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigen values of angular momentum, operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

Molecular Orbital Theory : Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc, Introduction to extended Huckel theory.

UNIT - III

Surface Chemistry

Adsorption : Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon)

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 -phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

UNIT - IV

Electrochemistry

Electrochemistry of solutions, Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum model. Thermodynamics of electrified interface equations. Derivation of electro capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces, Guoy-Chapman, Stern, Graham Devanatham-Mottwatts, Tobin, Bockris, Devanathan models, Overpotentials, exchange current density, derivation of Butler Volmer equation, Tafel plot.
Polarography theory, Ilkovic equation; half wave potential and its significance.

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SUGGESTED BOOKS AND REFERENCES

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Atkins' Physical Chemistry, Atkins & de Paula, Oxford Univ. Press.
3. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
4. Quantum Chemistry by Ira N. Levine, Prentice Hall.
5. Quantum Chemistry; R.K. Prasad, New Age International.
6. Micelles, Theortical and Applied Aspects; V. Morai, Plenum Press.
7. Modern Electrochemistry Vol. I, II & III; J.O'M. Bockris and A.K.N. Reddy, Plenum Press. New York.
8. Physical Chemistry by Puri, Sharma and Pathania, Vishal Publications.

CHY 104: MATHEMATICS FOR CHEMISTS

(For students without Mathematics in B.Sc.)

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks. .

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT - I

Matrix Algebra

Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric Skew-symmetric, Hermitian, skew-Hermitian, unit, diagonal, unitary etc.) and their properties. Matrix equations: Homogenous, nonhomogenous, linear equations and conditions for the solution, linear dependence and independence. Introduction to vector spaces, matrix eigenvalues and eigenvectors, diagonalization, determinants (examples from Huckel theory)

UNIT - II

Differential calculus

Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (example related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc).

UNIT -III

Integral calculus

Basic rules for integration, integration by parts, partial fraction and substitution. Reduction formulae, applications of Integral calculus.

Functions of several variables, partial differentiation, co-ordinate transformations (e.g. Cartesian to spherical polar).

UNIT - IV

Elementary Differential equations and Vectors

Elementary Differential equations: First-order and first degree differential equations, homogenous exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry etc. second order differential equations and their solutions.

Vectors: Vectors, dot, cross and triple products etc. gradient, divergence and curl. Vector calculus.

SUGGESTED BOOKS AND REFERENCES

1. The Chemistry Mathematics Book, E. Steiner, Oxford University Press.
2. Mathematics for Chemistry, Doggett and Suicliffe, Longman.
3. Mathematical Preparation for Physical Chemistry, F. Daniels, McGraw Hill.
4. Chemical Mathematics, D.M. Hirest, Longman.
5. Applied Mathematics for Physical Chemistry, J.R. Barante, Prentice Hall.
6. Basic Mathematics for Chemist, Tebbutt, Wiley.

CHY 104: BIOLOGY FOR CHEMISTS

(For students without Biology in B.Sc.)

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT -I

Cell Structure and Functions

Structure prokaryotic and eukaryotic cells, intracellular organelles and their functions, comparison of plants and animal cells. Overview of metabolic process - catabolism and anabolism. ATP- the biological energy currency. Origin of life unique properties of carbon chemical evolution and rise of living systems, Introduction to biomolecules, building blocks of bio-macromolecules.

UNIT -II

Carbohydrates

Conformation of monosaccharides. Structure and functions of important derivatives of monosaccharides like, glycosides, deoxysugars, myoinositol, amino sugars, N-acetylmuramic acid, sialic acid, disaccharides and polysaccharides. Structural polysaccharides - cellulose and chitin. Storage polysaccharides - starch and glycogen. Structure and functions of glucosaminoglycans or mucopolysaccharides. Carbohydrates of glycoproteins and glycolipids. Role of sugars in biological recognition. Blood group substances, Ascorbic acid.

Carbohydrates metabolism - Kreb's cycle, glycolysis, glucogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway.

UNIT -III

Lipids

Fatty acids, essential fatty acids, structure and functions of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins. Lipoproteins - composition and function, role in atherosclerosis.

Properties of Lipids aggregates - micelles, bilayers liposomes and their possible biological functions. Biological membranes. Fluid mosaic model of membrane structure.

Lipid metabolism - β-oxidation of fatty acids.

UNIT -IV

Proteins and Nucleic acid

Structure of proteins - α-helix, β-sheets, super secondary structure. Triple helix structure of collagen. Tertiary structure of Protein-folding and domain structure. Quaternary structure of proteins.

Nucleic Acids

Purine and pyrimidine bases of nucleic acids, base pairing via hydrogen bonding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acid (DNA), double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The chemical basis for heredity, an overview of replication of DNA, transcription, translation and genetic code, chemical synthesis of mono and tri nucleosides.

SUGGESTED BOOKS AND REFERENCES

1. Principles of Biochemistry, A.L. Lehninger, Worth Publishers.
2. Biochemistry, L. Stryer, W.H. Freeman.
3. Biochemistry, J. David Rawan, Neil Peterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry, E.E. Conn and P.K. Stumpf, John Wiley.

CHY 105: SPECTROSCOPY – I

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT - I

Introduction: Interaction of light with matter, mechanism of absorption and emission of radiation.

Microwave Spectroscopy: Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor; stark effect, nuclear and electron spin interaction and effect of external field applications.

Vibrational Spectroscopy: Vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation

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spectroscopy. P.Q.R. branches, breakdown of Oppenheimer approximation; vibrations of polyatomic molecules; selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal ligand vibrations.

Raman Spectroscopy: Origin, rotational and vibrational Raman Spectra of diatomic molecules.

UNIT - II

Electronic Spectroscopy

Atomic Spectroscopy: Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

Molecular Spectroscopy: Energy levels, molecular orbitals, vibronic transitions, vibrational progressions 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.

Photoelectron Spectroscopy: Photo-electric effect, ionization process, Koopman's theorem, photoelectron spectra of simple molecules, ESCA, chemical information from ESCA; Auger electron spectroscopy-basic idea.

UNIT-III

Nuclear Magnetic Resonance Spectroscopy

Basic Principle : Spin quantum number, interaction between Spin and a Magnetic Field, Larmor Precession, Relaxation Times; Continuous Wave NMR Spectroscopy, Fourier Transform NMR Spectroscopy.

Introduction to Chemical Shift, Spin-spin Coupling, Coupling Constant. Nuclei other than hydrogen: Nuclei with Spin ½ (^{13}C, ^{19}F, ^{31}P, ^{117}Sn, ^{119}Sn, etc.), Nuclei with Spin Greater than ½ (^{14}N, ^{11}B). Quadrupole Effect. Coupling between two or more than two types of NMR active nucleus in a compound (e.g. $CHFCl_2$, HPFCl, HOP(O)FH, $HP(O)F_2$, BH_4).

Factors affecting chemical shift in inorganic compounds - geometry, electronegativity, charge, oxidation state, coordination number.

UNIT-IV

Electron Spin Resonance

Basic principles, zero field splitting and Kramer's degeneracy, Isotropic and anisotropic Hyperfine coupling, spin-orbit coupling and significance of g-tensors, factors affecting the 'g' value, application to transition metal complexes; spin Hamiltonian, spin densities and McConnell relationship, applications - spin polarization for atoms and transition metal ions.

Mossbauer Spectroscopy

Basic principles, spectral parameters and spectrum display, applications of the techniques to the studies of (i) bonding and structures of Fe^{2+} and Fe^{3+} compounds including those of intermediate spin; (ii) Sn^{2+} and Sn^{4+} compounds, nature of M-L bond, coordination number, structure; and (iii) detection of oxidation state and in equivalent MB atoms.

SUGGESTED BOOKS AND REFERENCES

1. Fundamentals of Molecular Spectroscopy, Banewell and McCash
2. Modern Spectroscopy, J.M. Hollas, John Wiley.

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3. Applied Electron Spectroscopy for Chemical Analysis D. H. Windawi and F.L. Ho, Wiley Interscience.
4. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Chemical Applications of Group Theory, F.A. Cotton.
6. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill.
7. Electronic Absorption Spectroscopy and related Techniques, D N Sathyanarayana
8. Basic Principles of Spectroscopy, R. Chang, Mc Graw Hill.
9. Theory and Application of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
10. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.
11. Introduction to Magnetic Resonance. A Carrington and A.D. Maclachalan, Harper & Row.
12. NMR Spectroscopy in Inorganic Chemistry, J. A. Iggo, Oxford University Press: Oxford, 1999, pp 1-21; 31-35.
13. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.

CHY 106 - BIOINORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT - I

Metals in Life Processes
Role of metal ions in biological systems, essential and non-essential elements - macro minerals and essential trace elements - synergism and antagonism among essential trace elements, active transport of Na, K, Mg and Ca ions across the biological membrane, elements of bioenergetics with special reference to elements of high energy phosphate bond.

UNIT - II

Electron Carriers and Photosynthesis
Electron transfer in biology: Structure and functions of electron transfer proteins. Cytochromes and respiratory chain, iron-sulphur proteins, rubredoxin and ferridoxins. Synthetic models for Fe_4S_4 cluster only.
Photosynthetic pigments: Photochemistry of chlorophyll molecules, mechanism of photosynthesis, Calvin cycle and Quantum efficiency. Function of photosystem-I and photosystem-II. Cyclic and non-cyclic phototphosphorylation.

UNIT - III

Transport and Storage of Dioxygen
Haem proteins and oxygen uptake. Structure and function of haemoglobin, myoglobin. Structural model for dioxygen binding co-operativity, Perutz mechanism and Bohr effect; non-haem oxygen carriers in some lower animals, haemocyanin and haemerythrin. Model synthetic complexes of iron, cobalt and copper.

UNIT - IV

Nitrogen Fixation

Nitrogen in biosphere, nitrogen cycle, nitrification role microorganism, nitrogen fixation in soils. Biological nitrogen fixation and its mechanism, nitrogenase, Chemical nitrogen fixation and other nitrogenase model systems.

SUGGESTED BOOKS AND REFERENCES

1. Principles of Bioinogranic Chemistry, S. J. Lippard and J. M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, University Science Books.
3. Bio-organic, Bio-inorganic and Supramolecular Chemistry, P. S. Kalsi and J. P. Kalsi. New Age International, 2010
4. Inorganic Biochemistry, vol. I and II, ed. G.L. Eichhorn, Elsevier.
5. Progress in Inorganic Chemistry, vols, 18 and 38, ed, J.J. Lippard, Wiley.

CHY 111: PRACTICAL A - INORGANIC CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

Ex. 1 Qualitative analysis of mixture consisting of eight radicals (four cationic / four anionic) including interfering anionic radical. **48**

Ex. 2 Preparation of the following selected inorganic compounds and their studies by IR spectra, Mössbauer, ESR and Magnetic susceptibility measurements: **27**

a. $[VO(acac)_2]$
b. $[Mn(acac)_3]$
c. Prussian Blue, Turnbull's Blue
d. Sodium tetrathionate $Na_2S_4O_6$
e. $CuCl_2.2DMSO$

Handling of air and moisture sensitive compounds involving vacuum lines.

Ex. 3 Viva **15**
Ex. 4 Record **10**

CHY 112: PRACTICAL B - ORGANIC CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

Ex. 1 Qualitative Analysis:

Separation, purification and identification of compounds of binary mixture [(one liquid and one solid) or (two solids)] using TLC and column chromatography, chemical tests, IR spectra to be used for functional group identification. **75**

Ex. 2 Viva **15**
Ex. 3 Record **10**

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CHY 113: PRACTICAL C – PHYSICAL CHEMISTRY

DURATION: 6 Hrs MAX. MARKS: 100

Ex. 1 Major (*One exercise*) as given in the syllabus	**45**
Ex. 2 Minor (*One exercise*) as given in the syllabus	**30**

I. Error Analysis and Statistical Data Analysis:
Errors, types of errors, minimization of errors, distribution curves, precision, accuracy and combination, statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F& Q test; linear regression analysis, curve fitting calibration of volumetric apparatus burette, pipette and standard flask.

II. Adsorption:
To study surface tension concentration relationship for solution (Gibbs equation)

III. Conductometry :

i. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometerically.
ii. Determination of solubility and solubility product of sparingly soluble salts (e.g. $PbSO_4$, $BaSO_4$) conductometrically.
iii. Determination of the strength of strong and weak acids in a given mixture conductometrically.
iv. 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 mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.
v. Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.

IV. Phase Equilibrium:

i. Determination of congruent composition and temperature of a binary system (e.g., diphenylamine-benzophenone system).
ii. Determination of glass transition temperature of a given salt (e.g., $CaCl_2$) conductometrically.
iii. To construct the phase diagram for three component system (e.g., chloroform-acetic acid-water).

Ex. 3 Viva	**15**
Ex. 4 Record	**10**

SEMESTER –II

CHY 201: INORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation, definition of group, subgroup, conjugacy relation and classes. Point symmetry group. Schonfilies symbols, representations of groups by matrices (representation for the C_{nh}, C_{nv}, etc., group to be worked out explicity). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their uses; spectroscopic derivation of character table for C_{2v} and C_{3v} point group. Symmetry aspects of molecular vibrations of H_2O molecule.

UNIT-II

Molecular Rearrangement Processes

Electron transfer reactions (outer and inner sphere), HOMO and LUMO of oxidant and reductant, chemical activation. Precursor complex formation and rearrangement, nature of bridge ligands, fission of successor complexes, Two-electron transfers, Synthesis of coordination compounds using electron transfer reactions, mixed valence complexes and internal electron transfer.

UNIT-III

Electronic Spectra of Transition Metal Complexes

Spectroscopic ground states, correlation. Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, Racah parameters (B) and nephelauxetic ratio (β) parameters, charge transfer spectra.

UNIT-IV

Optical Rotatory Dispersion (ORD), Circular Dichroism (CD) and Magnetic Properties of Transition Metal Complexes

Spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical conformation, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

SUGGESTED BOOKS AND REFERENCES

1. Inorganic Chemistry, Principles of Structure and Reactivity, 4th Edition by James E. Huheey, Elleu A. Keiter, Richard L. Keiter.
2. Advanced Inorganic Chemistry by F.A. Cotton and G. Wilkinson.
3. Theoretical Inorganic Chemistry by Day and Selbin.
4. Concepts and Models in Inorganic Chemistry by Doughlas Mc Daniel.
5. Introductory Quantum Chemistry by A.K. Chandra (Tata McGraw Hill)
6. Chemical Applications of Group Theory by F.A. Cotton.

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CHY 202: ORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT I

Stereochemistry
Optical activity and chirality, elements of symmetry, specification of configuration - molecules with more than one chiral center. D/L, R/S and E/Z nomenclature. Enantiotopic and diastereotopic atoms, groups, and faces. Regioselectivity, stereospecificity and stereoselectivity.
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, decalins, effect of conformation on reactivity. Asymmetric synthesis, enatioselective and diastereoselective synthesis. Cram's, Prelog's and Horeau's rules. Circular birefringence, CD, ORD, Octant rule, Cotton effect. The axial haloketone rule. Determination of configuration (absolute and relative) and conformation.

UNIT II

Reagents and methods in Organic Synthesis
Principle, preparation, properties and applications of the following in organic synthesis with mechanistic details: Phase transfer catalysts, Crown ethers and cryptands, Merrifield resin, DCC (Dicyclohexylcarbodiimide), Wilkinson's catalyst, Tributyltin hydride, Selenium dioxide, DDQ (2,3-Dichloro-5,6-dicyano-1,4-benzoquinone), 1,3-Dithiane, Thallium nitrate. Peterson reaction, Suzuki coupling, Negishi coupling, Heck reaction.

UNIT III

Molecular Rearrangements
Mechanistic aspects, nature of the migration, migratory aptitudes, memory effects. A detailed study of the following rearrangements: Dienone-Phenol rearrangement, Benzil-benzilic acid rearrangement, Favorskii rearrangement, Neber rearrangement, Beckmann rearrangement, Hoffmann rearrangement, Curtius rearrangement, Lossen rearrangement, Wolff rearrangement, Baeyer-Villiger rearrangement, Wittig rearrangement, Fritsch-Buttenberg-Wiechell rearrangement, Stevens rearrangement, Chapman rearrangement, Wallach rearrangement.

UNIT IV

Pericyclic Reactions
Molecular orbital symmetry, Frontier orbitals of ethylene, conjugated dienes and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann rules, correlation diagrams. FMO approach and PMO method. Electrocyclic reactions: conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloadditions: antarafacial and suprafacial additions. 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3-dipolar cycloadditions and chelotropic reactions.
Sigmatropic rearrangements: suprafacial and antarafacial shifts of C-H and C-C bonds. 3,3- and 5,5-sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

SUGGESTED BOOKS AND REFERENCES

1. Stereochemistry of Carbon Compounds by E. L. Eliel
2. Stereochemistry of Organic Compounds by Nasipuri.
3. Stereochemistry Conformation and Mechanism by PS Kalsi.
4. Organic Chemistry by J. Clayden, N. Greeves, S. Warren and P. Wothers. Oxford University Press (2001).
5. Advanced Organic Chemistry: Reactions Mechanisms and Structure by Jerry March, McGraw Hill.
6. Mechanism and Structure in Organic Chemistry by E. S. Gould (Holt, Rinehart and Winston).
7. Advanced Organic Chemistry Part-A, by FA Carey and RJ Sundberg, 5th Ed. Springer (2007).
8. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes. Longman
9. Structure and Mechanism in Organic Chemistry, C.K. Ingold. Cornell University Press.
10. Organic Chemistry by R.T. Morrison and R.N. Boyd, Prentice-Hall.
11. Modern Organic Reactions. H.O. House, Benjamin.
12. Principles of Organic Synthesis. R O C Norman and J.M. Coxon. Blackie Academic & Professional.
13. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.
14. Conservation of Orbital Symmetry, R. B. Woodward and R. Hoffmann; Verlag Chemie: Weinheim (1970).
15. Pericyclic Reactions by Ian Fleming (Oxford Chemistry).
16. Pericyclic Reactions- A Textbook by S Sankararaman , 2005 Wiley-VCH, Weinheim ISBN: 3-527-31439-3 .

CHY 203: PHYSICAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Classical Thermodynamics

Brief resume of concept of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities. Concept and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient and its determination. Debye-Huckel theory for activity coefficient of electrolytic solutions; Application of phase rule to three component systems; second order phase transitions.

UNIT-II

Statistical Thermodynamics

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). Partition functions-translation, rotational, vibrational and electronic partition functions. Calculation of thermodynamic properties in terms of partition functions. Application of partition functions.

Heat capacity behavior of solids - chemical equilibria and equilibrium constant in terms of partition functions. Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics distribution Law and application to helium.

UNIT-III

Chemical Kinetics - I

Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects : steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.

Dynamic chain reactions (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical reactions (hydrogen-bromine and hydrogen-chlorine).

UNIT-IV

Chemical Kinetics - II

Kinetics and mechanism of polymerization. Kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method, dynamics of unimolecular reactions (Lindemann Hinshelwood and Rice-Ramsperger-Kassel-Marcus (RRKM) theories of unimolecular reactions).

SUGGESTED BOOKS AND REFERENCES

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Chemical Kinetics, K.J. Laidler, McGraw-Hill.
3. Kinetics and Mechanism of Chemical Transformation, J. Rajaraman and J. Kuriacose, McMillan Publication.
4. Thermodynanics, Kinetic theory and Statistical Thermodyamics by T.M. Maridasan, Narosa Publication.
5. Thermodynamics by Mishra & R.P. Rastogi; S. Chand Publication.

CHY 204 – SPECTROSCOPY II

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT I

Ultraviolet and Visible Spectroscopy
Various electronic transitions (185-800 nm) Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Woodward-Fieser rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds. Steric effect in biphenyls.

Infrared Spectroscopy
Characteristic vibrational frequencies of aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance.

UNIT II

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

UNIT III

Proton Magnetic Resonance Spectroscopy
Chemically nonequivalent protons, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides and mercapto). Chemical exchange, effect of deuteration. Complex spin-spin interaction between two, three, four and five nuclei (first order spectra). Stereochemistry, hindered rotation. Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra - nuclear magnetic double resonance, NMR shift reagents, solvent effects. Fourier transform technique, nuclear overhauser effect (NOE).

UNIT IV

Carbon-13 NMR Spectroscopy
General consideration, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two dimension NMR spectroscopy - COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

Applications of Spectroscopy - Problems based on UV, IR, NMR spectroscopy and Mass spectrometry for structural elucidation of organic compounds.

SUGGESTED BOOKS AND REFERENCES

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein. G.C. Hassler and T.C. Morrill, John Wiley.
2. Fundamentals of Spectroscopy by Banwell and McCash
3. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Lofitus, Wiley.
4. Application of Spectroscopy of Organic Compounds, J.R Dyer, Prentice Hall.
5. Spectroscopic Methods in Organic Chemistry D.H. Williams, I. Fleming, Tata McGraw-Hill.
6. Organic Spectroscopy, William Kemp, Macmillan

CHY 205: BIOORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note : 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Enzymes

Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificjty and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michael's-Menten and Lineweaverburk plots, reversible and irreversible inhibition.

UNIT-II

Mechanism of Enzyme Action

Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chemotrypsin, ribonuclease, lysozyme and carboxypeptidase.

Reactions Catalysed by Enzymes

Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in Isomerisations reactions, β-Cleavage and condensation, some isomerziation and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

UNIT-III

Co-enzyme Chemistry

Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD^+, $NADP^+$, FMN, FAD, lipoic acid, vitaminB12. Mechanisms of reactions catalyzed by the above cofactors.

Enzyme Models

Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality biometric chemistry, crown ether, cryptates, cyclodextrins,

cyclodextrin-based enzyme models, clixarenes, ionospheres, micelles synthetic enzymes or synzymes.

UNIT-IV

Biotechnological Applications of Enzymes

Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity, application of immobilized enzymes, use of enzymes in food and drink industry-brewing and cheese-making, syrups from crown starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

SUGGESTED BOOKS AND REFERENCES

1. Bioorganic Chemistry: A chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer Verlag.
2. Understanding Enzymes, Trevor Palmer, Prentice hall.
3. Enzyme Chemistry: Impact and Applications, Ed. Collin J Suckling, Chemistry.
4. Enzyme Mechanisms, Ed. M.I. Page and A. Williams, Royal Society of Chemistry.
5. Bioorganic and Supramolecular Chemistry, P. S. Kalsi and J. P. Kalsi, New Age International Publication (2010).

CHY 206: ENVIRONMENTAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Atmospheric Chemistry

Atmospheric layers, Vertical temperature profile, heat/radiation budget of the earth atmosphere systems. Properties of troposphere, thermodynamic derivation of lapse rate. Temperature inversion. Calculation of Global mean temperature of the atmosphere. Pressure variation in atmosphere and scale height. Biogeochemical cycles of carbon, nitrogen, sulphur, phosphorus oxygen. Residence times. Sources of trace atmospheric constituents: nitrogen oxides, sulphur dioxide and other sulphur compounds, carbon oxides, chlorofluorocarbons and other halogen compounds, methane and other hydrocarbons.

Tropospheric Photochemistry

Mechanism of photochemical decomposition of NO_2 and formation of ozone. Formation of oxygen atoms, hydroxyl, hydroperoxy and organic radicals and hydrogen peroxide. Reactions of hydroxyl radicals with methane and other organic compounds. Reactions of OH radicals with SO_2 and NO_2. Formation of Nitrate radical and its reactions. Photochemical smog, meteorological conditions and chemistry of its formation.

UNIT-II

Air Pollution: Air pollutants and their classifications. Aerosols - sources, size distribution and effect on visibility, climate and health.

Acid Rain: Definition, Acid rain precursors and their aqueous and gas phase atmospheric oxidation reactions, damaging effects on aquatic life, plants, buildings and health. Monitoring of SO_2 and NO_x, acid rain control strategies.

Stratospheric Ozone Depletion: Mechanism of ozone formation, Mechanism of catalytic ozone depletion, discovery of Antarctic ozone hole. Instrumental methods for detection of ozone depletion gases.

Green House Effect: Terrestrial and solar radiation spectra, major green house gases and their sources and global warming potentials. Climate change and consequences.

Urban Air Pollution: Exhaust emissions, damaging effects of carbon monoxide, monitoring of CO, control strategies.

UNIT-III

Aquatic Chemistry and Water Pollution

Redox chemistry in natural waters. Dissolved oxygen, biological oxygen demand, chemical oxygen demand, determination of DO, BOD and COD. Aerobic and anaerobic reactions of organic sulphur and nitrogen compounds in water, acid-base chemistry of fresh water and sea water. Aluminium, nitrate and fluoride in water, petrification, sources of water pollution, treatment of waste and sewage, purification of drinking water, techniques of purification and disinfection.

UNIT-IV

Environmental Toxicology

Toxic Heavy Metals: Mercury, lead, arsenic and cadmium, causes of toxicity, bioaccumulation, sources of heavy metals, chemical speciation of Hg, Pb, As and Cd, biochemical and damaging effects.

Toxic Organic Compounds: Pesticides, classification, properties and uses of organochlorine and ionospheres pesticides, detection and damaging effects.

Polychlorinated Biphenyls: Properties, use and environmental continuation and effects.

Polynuclear Aromatic Hydrocarbons: Source, structures and as pollutants.

Soil and Environmental Disasters: Soil composition, micro and macronutrients, soil pollution by fertilizers, plastic and metals. Methods of re-mediation of soil. Bhopal gas tragedy, Chernobyl, Three mile island, Minimtata disease, Sevoso (Italy), London smog.

SUGGESTED BOOKS AND REFERENCES

1. Environmental Chemistry, Colin Baird, W.H. Freeman Co. New York, 1998.
2. Chemistry of Atmospheres. R.P. Wayne, Oxford.
3. Environment Chemistry, A.K. De, Wiley Eastern, 2004.
4. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
5. Introduction to Atmospheric Chemistry, P.V. Hobbs, Cambridge.

CHY 211: Practical A – INORGANIC CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

NOTE – During practical examinations any two exercises (major and minor) to be given out of the prescribed exercises

Ex. 1 Qualitative analysis of mixture consisting of eight radicals (cationic / anionic forms) including:

a. Interfering anionic radical
b. Insolubles: oxides, sulphates and halides
c. Less common metal ions: Ti, Mo, Tl, W, Zr, Ce, Th, V, U **48**

Ex. 2 Preparation of the following selected inorganic compounds and their studies by IR spectra, Mössbauer, ESR and Magnetic susceptibility measurements: **27**

a. N,N-bis(salicylaldehyde)ethylenediamine, Salen H_2, Co(Salen)
b. Copper glycine complex – *cis*- and *trans*-bis(glycinato) Copper (II)

Handling of air and moisture sensitive compounds under vacuum.

OR

Chromatographic separation and identification by paper chromatography and determination of Rf values:

a. Cadmium and Copper
b. Zinc and Magnesium

Ex. 3 Viva **15**
Ex. 4 Record **10**

CHY 212: Practical B – ORGANIC CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

Ex.1 Organic Synthesis (*any one*) **45**

1. Aniline → 2,4,6-Tribromoaniline → 1,3,5-Tribromobenzene
2. Aniline → Diazoaminobenzene → *p*-Aminoazobenzene
3. Nitrobenzene → *m*-Dinitrobenzene → *m*-Nitroanilne
4. Phthalic anhydride → Fluorescein → Eosin
5. Phthalic anhydride → Phthalimide → Anthranilic acid
6. Acetanilide → *p*-Bromoacetanilide → *p*-Bromoaniline
7. Acetanilide → p-Nitroacetanilide → p-Nitroaniline

The product may be characterized by m.pt / spectral techniques.

Ex.2 Quantitative Analysis (*any one*) **30**

1. Determination of number of hydroxyl groups in an organic compound by acetylation method.
2. Estimation of amines/phenols using bromate-bromide solution or acetylation method.
3. Estimation of Sulphur by Messenger or Fusion method.
4. Determination of Iodine number and Saponification value of an oil sample.

Ex. 3 Viva **15**
Ex. 4 Record **10**

CHY 213: Practical C – PHYSICAL CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

Ex. 1 Major (*One exercise*) as given in the syllabus **45**
Ex. 2 Minor (*One exercise*) as given in the syllabus **30**

I. Chemical Kinetics:

i. Determination of the effect of (a) Change of temperature (b) Change of concentration of reactant and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester / ionic reactions.
ii. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.
iii. Determination of the rate constant for the oxidation of iodide ions by peroxide studying the kinetics as an iodine clock reaction
iv. Flowing clock reaction (Ref: Experiments in Physical Chemistry by Snowmaker).
v. Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodide ion is oxidized by persulphate ion).
vi. Oscillatory reaction.

II. Solutions:

i. Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.
ii. Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

III. Potentiometry / pH metry:

i. Determination of strengths of halides in a mixture potentiometrically.
ii. Determination of the valency of mercurous ions potentiometrically.
iii. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
iv. Determination of temperature dependence of EMF of a cell.
v. Determination of the formation constant of silver-ammonia complex and stoichiometry of the complex potentiometrically.

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vi. Acid-base titration in a non-aqueous media using a pH meter.
vii. Determination of activity and activity coefficient of electrolytes.
viii. Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by monobasic/dibasic acid by Albert-Serjeant method.
ix. Determination of thermodynamic constants, ΔG, ΔS, and ΔH for the reaction by e.m.f. method.
$Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H$

IV. Polarimetry:

(i) Determination of rate constant for hydrolysis / inversion of sugar using a polarimeter.
(ii) Enzyme kinetics-inversion of sucrose.

Ex. 3	**Viva**	**15**
Ex. 4	**Record**	**10**

SEMESTER – III

CHY 301: SOLID STATES AND NANO-MATERIALS

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Solid State Chemistry

Introduction to the solid state, defects of solids, classification of imperfections, Electronic defects, atomic defects, Lattice imperfections, thermodynamics of Schottky defect and Frenkel defect. Electrical, optical, magnetic and thermal properties of inorganic materials. Solid State Reactions: general principles, types; sintering; nucleation; Factors influencing the reactivity of solids; co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

UNIT-II

Superconductors

Superconductors with special emphasis on the synthesis and structure of high temperature superconductors; solid state LASERS (Ruby, YAG and tunable lasers): Inorganic phosphor materials; synthesis and advantages of optical fibers over conducting fibers, diffusion in solids, catalysis and zone refining of metals.

UNIT-III

Diffraction Methods

X-ray Diffraction: Bragg condition, Miller indices, Laue Method, Bragg method, Debye Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern, Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem; description of the procedure for an X-ray structure analysis, absolute configuration of molecules.

Electron Diffraction: Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, low energy electron diffraction and structure of surfaces.

UNIT-IV

Nanomaterials

Preparation of nanomaterials and their characteristic differences over bulk materials; dynamic light scattering, atomic force microscopy and characterization of nanomaterials; imaging techniques: electron microscopy (Scanning Electron Microscopy, Tanning Electron Microscopy). Applications of nanomaterials.

SUGGESTED BOOKS AND REFERENCES

1. H. V. Keer, Principles of the Solid State; Wiley Eastern Ltd.: New Delhi (1993).
2. Anthony. R. West, Solid State Chemistry and its Applications; 2nd Edn, John Wiley and Sons (2014).
3. N. B. Hannay, Treatise on Solid State Chemistry; Plenum (1976).
4. A. K. Cheetham and P. Day, Eds. Solid State Chemistry Techniques; Clarendon Press, Oxford (1987)
5. John Wulff, The structure and properties of materials, John Wiley & Sons; Trans-ed edition (1966)
6. L. V. Azaroff, J. J. Brophy, Electronic processes in materials, McGraw Hill (1967).
7. D. K. Chakrabarty, Solid State Chemistry, New Wiley Eastern (2009).
8. M. C. Day and J. Selbin, Theoretical Inorganic Chemistry, Reinhold Publishing Co., New York (1962).
9. Arthur W. Adamson and Alice P. Gast, Physical Chemistry of Surfaces, Wiley-Interscience; 6th Edn. (1997).
10. G. Timp, Ed. Nanotechnology; Springer-Verlag: NY (1999).
11. B. D. Fahlman, Materials Chemistry, Springer (2007).

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CHY 302: GREEN CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT – I

Introduction, Principle and Concepts of Green Chemistry

Need for green chemistry; Inception and evolution of green chemistry; Twelve principles of green chemistry with their explanations and examples; Designing a green synthesis using these principles; Green chemistry in day to day life.

UNIT – II

Non-traditional greener alternative approaches

Different approaches to green synthesis: (a) Uses of green reagents in organic synthesis - Dimethyl carbonate, polymer supported reagents - per acids and chromic acid; (b) Green catalysts, role of catalysis in sustainable development, homogeneous and heterogeneous catalysts; Introduction, advantages and applications of - (i) Nanocatalysts, (ii) Phase transfer catalysts, (iii) Biocatalysts, (iv) Organocatalysts, in organic synthesis.

UNIT – III

Applications of non-conventional energy sources

Introduction of microwave induced synthesis: Microwave activation- equipment, time and energy benefits, limitations; Organic transformations under microwaves - Fries rearrangement, Diels-Alder reaction, decarboxylation, saponification of ester, alkylation of reactive methylene compounds; Heterocyclic synthesis- β-Lactams, pyrrole, quinoline.

Introduction of ultrasound assisted green synthesis: Instrumentation, physical aspects, applications in organic transformations.

Electrochemical synthesis: Introduction, synthesis of sebacic acid and adiponitrile.

UNIT – IV

Environmentally Benign Solutions to Organic Solvents

Ionic liquids as green solvents: Introduction, properties and types of ionic liquids. Synthetic applications - Diels-Alder reaction, epoxidation and Heck reaction.

Aqueous phase reactions: Enhancement of selectivity, efficiency. Synthetic applications - 1,3-Dipolar Cycloadditions, Carbon-Carbon bond-forming processes and bromination reactions.

Fluorous solvents in green chemistry: Scope, definition and their synthetic applicability.

Role of supercritical carbon dioxide in green chemistry.

Ethyl lactate as a renewable green solvent: Properties and applications.

SUGGESTED BOOKS AND REFERENCES:

1. Organic synthesis in water; P. A. G. Blackie (Springer).
2. Green Chemistry, theory and practice; P. T. Anastas , J. C. Warner (Oxford University Press).
3. Green Chemistry: An introductory text; M. Lancaster (Royal Society of Chemistry).

4. Nanocatalysis: Synthesis and applications; V. Polshettiwar, T. Asefa, G. Hutchings (Wiley).
5. Introduction to Green Chemistry; M.A. Ryan , M. Tinnesand (American Chemical Society).
6. Handbook of Green Chemistry ; P.T. Anastas (John Wiley and Sons).
7. New Trends in Green Chemistry; V. K. Ahluwalia, M. Kidwai (Springer)

CHY 303: BIOPHYSICAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours ; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Biosensors
Definition, Biosensor system, bio-receptors, surface attachment of biological elements. Electro-chemical transducers, placement of biosensors.
Applications: Glucose monitoring, food analysis, DNA biosensors, microbial biosensors, commercialized biosensors, identification of blood glucose (diabetes) and pregnancy test by colorimetric and electrochemical strip.

UNIT-II

Bioelectrocatalysis and Nanochemistry
Catalysis, electrocatalysis, bioelectrolysis, definition, enzymes as biological catalysts, immobilization, methods of immobilization.
Nanomaterials, bionanomaterials, development of nanomaterials. Synthesis of nanomaterials by physical, chemical and electrochemical methods. Characterization of nanomaterials, chemical sensing and electrochemical properties. Applications of nanomaterials in medicines, elimination of pollutants, food, fabric, automobiles and ceramics industries.

UNIT-III

Cell Membrane and Transport of Ions
Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamic treatment of membrane transport. Nerve conduction. Domman membrane equilibrium. Active transport mechanisms. Autoanalyzers. Radio isotopes: units, specifications, dilution factor, percentage incorporation and measurements.

UNIT-IV

Biopolymers
Basics of polymers, classification, types of biopolymers, chain configuration and confirmations, biopolymer interactions, optical and electrochemical properties, thermodynamics of biopolymer solutions, size and shape of biopolymers, determination of molecular weight of biopolymers by light scattering, sedimentation methods, osmotic, viscosity methods. Kinetics of polymerization, biodegradable polymers, conducting polymers.
Biological half life, effective half life, stable isotopes, radioactive tracer and dilution analysis.

SUGGESTED BOOKS AND REFERENCES

1. "Biosensors - fundamentals and applications" Turner, Anthony, Wilson and George Karube, ISAO (ed.) Oxford, U.K. : Oxford Univ. Press page 770 (1987). ISBN 0198547242
2. Chemical Sensors, Biosensors: fundamentals and applications. Banica, Florinel-Gabril, Chickester U.K. : John Wiley & Sons page 576 (2012) ISBN 9781118354230.
3. Nanocrystals : Synthesis, properties and applications(ed.), C.N.R. Rao, P. John Thomas and G.U. Kulkarni Springer (2007).
4. Principles of nanoscience and nanotechnology. M.A. Shah and Tokeer Ahmad. Narosa Publishing (2011). ISBN -978-81-8487-072-5.
5. Electrochemistry: Principles, Methods and Applications. Brett & Brett. Oxford Univ. Press, (2009). ISBN 019855388
6. Principles of Biochemistry, A. L. Lehninger, Worth Publishers.
7. Biochemistry, L. Stryer, W.H. Freeman.
8. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, H. Dugas and C. Penny, Springer–Verlag.
9. Polymer Science and Technology (Indian Edition) by Joel. R. Fried, PHI Learning Pvt. Ltd. New Delhi, (2009). ISBN 978-81-203-2770-2.

ELECTIVE PAPERS

CHY A01: PHOTOINORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours ; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Properties of Excited States

Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics - calculation of rates of radiative processes. Bimolecular deactivation - quenching.

UNIT-II

Excited States of Metal Complexes

Excited states of metal complexes, electronically excited states of metal complexes, charge transfer spectra, charge transfer excitations.

UNIT-III

Ligand Field Photochemistry

Photosubstitution, photooxidation and photoreduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero spectroscopic energy, development of the equations for redox potentials of the excited states.

UNIT-IV

Redox Reactions by Excited Metal Complexes

Redox reactions of metal complexes in excited states, excited electron transfer, examples using $[Ru(bpy)_3]^{2+}$ complex and $[Fe(bpy)_3]^{3+}$ complex. Role of spin-orbit coupling, life-times of excited states in these complexes.

Metal Complex Sensitizers: Electron relay, semiconductor supported metal oxide systems, water-photolysis, nitrogen fixation and carbon dioxide reduction.

SUGGESTED BOOKS AND REFERENCES:

1. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.
2. Inorganic Photochemistry, J. Chem. Educ. vol. 60, no. 10, 1983.
3. Progress in Inorganic Chemistry, vol. 30, S.J. Lippard (ed.). Wiley.
4. Coordination Chem. Revs., vol. 15, p 321, 1975; vol. 39, p 121, 1981; vol. 97, p 313, 1990.
5. Photochemistry of Coordination Compounds, V. Balzari and V. Carassiti, Academic Press.
6. Elements in Inorganic Photochemistry, G.J. Ferraudi, Wiley.

CHY-A02: ORGANOTRANSITION METAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Synthesis, Properties, Structure and Bonding of:

(Giving some specific examples)

(i) η^1- bonded alkyl complexes
(ii) η^1- carbene and carbyne complexes
(iii) η^2- alkene and alkyne complexes
(iv) η^3- allyl complexes
(v) η^4- dienyl complexes
(vi) η^5- dienyl complexes

UNIT-II

Metal nitrosyls, cyanides and isocyanides

Synthesis, reactions, structure and bonding in metal nitrosyls: nitrosyl complexes, metal cyanides and isocyanides: cyanogens, cyanates and its analogue. Sulfur, selenium and tellurium ion. Diisocyanides, reactions of isocyanide complexes and their uses.

UNIT-III

Synthetic and Catalytic Aspects of Organotransition Metal Chemistry:

(i) Transition metal organometallics in organic synthesis

(ii) Homogenous catalysis by transition metal organometallics
- (a) Hydrogenation of alkenes
- (b) Hydrosilylation of alkenes
- (c) Metathesis of alkenes
- (d) Oligomerization and polymerization of alkenes and alkynes
- (e) Hydroformylation of alkenes
- (f) Acetic acid synthesis and other carbonylation reactions
- (g) Oxidation of alkenes

UNIT-IV

Catalysis

(a) Heterogenous Catalysis by Organotransition Metal Compounds

(b) Fisher Tropsch synthesis: Methanation reactions, Synthesis of methanol, gasoline production, function of ZSM-5 Zeolite in stabilization of carbine molecule, application of reaction to industry.

(c) Water gas shift reaction: Role of ZnO/Cr_2O_3 in the reaction, Acetic acid synthesis from water gas shift, Role of Co catalyst.

(d) Fluxional organometallic compounds: Rate of rearrangement, Simple examples of non rigid molecules in different coordination geometries, classification, future developments.

SUGGESTED BOOKS AND REFERENCES

1. Principles and Applications of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of Transition Metals, R.H. Crabtree, John Willey.
3. Metalloorganic Chemistry, A.J. Pearson, Wiley.
4. Organometallic Chemistry, R. C. Mehrotra and A. Singh, New Age International.
5. Reaction of Transition Metal Complexes, J.P. Candlin, K. Aayler and D.T Thomson, American Elsevier
6. Organometallic Compounds, Vol. II, M. L. H. Green, Methuen.

CHY A03: SUPRAMOLECULAR CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Introduction

Definition and development of supramolecular chemistry, classification of supramolecular host-guest compounds. Nature of supramolecular interactions: ion-ion interactions, ion-dipole interactions, dipole-dipole interactions. Cation binding hosts, binding of anions, binding of neutral molecules, binding of organic molecules.

UNIT-II

Molecular Recognition

Receptors, design and synthesis of co receptors and multiple recognition. Hydrogen bonds, strong, weak and very weak H-bonds, utilization of H-bonds to create supramolecular structures, use of H-bonds in crystal engineering and molecular recognition.

UNIT-III

Supramolecular Reactivity and Catalysis

Supramolecular metallocatalysis, biomolecular and abiotic catalysis. Transport processes and carrier design, cation carriers, anion carriers, couples transport processes.

UNIT-IV

Devices and Chemistry

Supramolecular devices, supramolecular photochemistry, molecular and supramolecular photonic devices, photosensitive molecular receptors. Supramolecular chemistry of Fullerene, Fullerene as guests, Fullerene as hosts, Fullerene as superconducting intercalation compounds.

SUGGESTED BOOKS AND REFERENCES

1. Supramolecular Chemistry, J.M. Lehn, VCH
2. Supramolecular Chemistry, J.W. Steed and J.L. Atwood, WILEY
3. Bio-organic, Bio-inorganic and Supramolecular Chemistry, P.S.Kalsi and J.P.Kalsi, New Age International, 2010.

CHY B01: NATURAL PRODUCT

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks - 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT- I

Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule, stereochemistry, synthesis and biosynthesis of the following representative molecules: Citral, Geraniol, α-Terpineol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-Carotene.

UNIT-II

Alkaloids

Definition, nomenclature, occurrence, isolation, classification based on structure, general methods of structure elucidation, degradation, physiological action and role of alkaloids in plants. Structure, stereochemistry and synthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine and Morphine. Biosynthesis of Morphine and Nicotine.

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UNIT - III

Steroids

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrogen and Progesterone. Biosynthesis of cholesterol.

Plant Hormones

Introduction, occurrence, isolation and physiological effects of Auxins, Gibberellins (Synthesis of GA_3), Cytokinins and Abscisic acid.

Insect Hormones

Introduction to BH, JH and MH. Chemistry of JH, structure elucidation and synthesis, structural analogs. JH mimics structures. Chemistry of Juvabione.

UNIT-IV

Natural Pigments

Occurrence, nomenclature and general methods of structure determination. Isolation, structure determination and synthesis of Luteolin, Quercetin, Myrcetin, Quercetin-3-glucoside, Diadzein, Butin, Butein, Cyanidin chloride, Cyanidin-7-arabinoside.

Porphyrins: Structure, reactions and synthesis of haemoglobin and chlorophyll.

SUGGESTED BOOKS AND REFERENCES

1. Natural Products, Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harbome, Longman.
2. Organic Chemistry: Vol. 2. I. L. Finar, ELBS.
3. Stereoselective Synthesis; A Practical Approach, M. Norgradi, VCH.
4. Chemistry of Natural Products: S.V. Bhat, B.A. Nagasampagi and M. Sivakumar, Narosa Publishing House.
5. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston. Harwood Academic Publishers.
6. Introduction to Flavonoids, B.A. Bohm. Harwood Academic Publishers.
7. New Trends in Natural Products Chemistry, Ata-ur-Rahman and M.L. Choudhary, Harwood Academic Publishers.

CHY B02: ORGANIC SYNTHESIS – I

Theory and Tutorial: 4 hours per week (4 credits)

Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT - I

Enolate Chemistry: Formation of enolates, kinetic and thermodynamic control. Reactions of enolate anions with electrophiles: O vs C alkylation. Enolate condensation reactions: Synthetic applications of inter- and intramolecular Aldol condensations, Claisen, Dieckmann, Knovenagel, Stobbe condensations, Mukaiyama Aldol reaction. Boron enolates. Nozaki-Hiyama-Kishi coupling.

Stereoselective enolate reactions: diastereoselection, Zimmermann-Traxler model, Evans model, Noyori open-chain model. Michael addition and related reactions - Michael addition, Baylis-Hillmann reaction, Robinson annulations. α-Halogenation, Reformatski reaction, Favorski rearrangement. McMurry coupling reaction.

UNIT - II

Metal and non-metal mediated oxidation: Mechanism, selectivity, stereochemistry and applications of Oppenauer oxidations, aromatization, dehydrogenation, cleavage of C=C bond, ozonolysis, epoxidation using peracids, Baeyer-Villeger oxidation. Oxidations using $FeCl_3$, DDQ, NBS, lead tetraacetate, selenium dioxide, Ag, Cr and Mn reagents, periodic acid and osmium tetraoxide. DMSO-based oxidations. Oxidation of S, Se and N containing compounds.

Hydroboration: Introduction, preparation of alkyl- and alkenylboranes. Synthetic transformations: protonolysis, hydrohalogenation, coupling, isomerisation and displacement reactions. Asymmetric hydroboration. Preparation of amines and sulfides *via* hydroboration.

UNIT - III

Metal and non-metal mediated reduction: Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations (using Pd, Pt and Ni catalysts), Clemmensen reduction, Wolff-Kishner reduction, Meerwin-Ponndorf-Verley, dissolving metal reductions, metal hydride reductions ($NaBH_4$, $LiAlH_4$, DIBAL). Stereoselectivity in hydride reductions, Wilkinson's catalysis. Boron in reduction. Hydrosilylation. Photoreduction.

UNIT - IV

Supramolecular Chemistry: Concepts, definition and development, classification, receptors, clatherate and macrocyclic effects, thermodynamic and kinetic selectivity, nature of supramolecular interactions, supramolecular guest-host design.

Cation-binding hosts: Crown ethers, cryptands and spherands - Synthesis and properties.

Binding of anions: Biological anion receptors and organometallic receptors.

Templates and self-assembly: Introduction, catenanes and rotaxanes, helicates; synthetic considerations and properties.

Liquid crystals: Nature and structure, design of liquid crystalline materials and polymers.

SUGGESTED BOOKS AND REFERENCES

1. Advanced organic chemistry, Part B, Carey A and Sundberg R.J., Plenum Press.
2. Advanced organic chemistry: Reactions, mechanism and stereochemistry, J March, John Wiley.
3. Theoretical organic chemistry, Parkanyi C., Elsevier
4. Strategic applications of named reactions in organic synthesis, Kurti L, Czako B, Academic Press, 2005.
5. Organic synthesis, Smith M.B., McGraw Hill, 2002.
6. Classics in total synthesis, Nicolaou E.J., ChemieVerlag, 1996.
7. The logic of chemical synthesis, Corey E.J. and Cheng X.M., John Wiley & Sons, 1989.
8. Reagents in Organic chemistry, Fieser and Fieser.
9. Handbook of reagents in organic synthesis, P Wipf, John Wiley & Sons.
10. Protecting group in Organic synthesis, Greene T, Wuts P.G.M., John Wiley & Sons, 1989.
11. Modern methods of Organic synthesis, Carruther W., Cambridge University Press.
12. Organic synthesis: The science behind art, Smith W.A., Bochkor A.F., Caple, R., RSC, 1998.
13. Supramolecular Chemistry - An Introduction, Vogtle F and Alfter F, J. Wiley & Sons: Chichester, 1993.
14. Supramolecular Chemistry - Concepts and Perspectives, J-M Lehn, Wiley-VCH, 1995.

CHY B03 - HETEROCYCLIC CHEMISTRY - I

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Nomenclature of Heterocycles

Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused, spiro and bridged heterocycles.

Aromatic Heterocycles

General chemical behaviour of aromatic heterocycles, 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, diamagnetic susceptibility exaltations). Heteroaromatic reactivity.

UNIT-II

Non-aromatic Heterocycles

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

UNIT - III

Small Ring Heterocycles

Three-membered and Four-membered Heterocycles: Synthesis and reactions of aziridines, oxiranes, thiiranes, oxaziridines, azetidines, oxetanes, thietanes and azetedinones.

UNIT-IV

Five-membered Heterocycles with Two Heteroatoms

Synthesis and reactions of 1,2- & 1,3-diazoles, oxazoles, thiazoles and azaphospholes.

Benzo-fused five-membered Heterocycles

Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans, benzothiophenes and benzimidazoles.

SUGGESTED BOOKS AND REFERENCES

1. Heterocyclic Chemistry Vol. 1,2. R.R. Gupta, M. Kumar and V. Gupta. Springer India.
2. The Chemistry of Heterocycles. T Eicher and S. Hauptmann. Thieme.
3. Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F Smith. Chapman and Hall.
4. Heterocyclic Chemistry, T.L. Gilchrist, Longman Scientific Technical.
5. Contemporary Heterocyclic Chemistry. G.R. Newkome and W. W. Paudler. Wiley-Inter Science.
6. An Introduction to the Heterocyclic Compounds. R.M. Acheson. John Wiley.
7. Comprehensive Heterocyclic Chemistry, A.R. Katrizky & C W Rees (eds). Pergamon Press.

CHY C01: ELECTROANALYTICAL TECHNIQUES

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT – I

Errors Precision and Accuracy
Definition of terms in mean and median, Precision-Standard deviation, relative standard deviation, accuracy-absolute error, relative error. Types of error in experimental data determinate (systematic), indeterminate (or random) and gross. Sources of error and the effects upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data-indeterminate errors. The uses of statistics.

Chromatography and Applications
Thin layer chromatography (TLC), Adsorption (column) chromatography, High-performance liquid chromatography (HPLC) and Gas chromatography.

UNIT – II

Conductometry
Important laws, definitions, relations, effect of dilution on conductivity, measurement of conductivity, types of conductometric titrations, its applications and limitations.

Potentiometry
Principle, instrumentation, types of potentiometric titrations and its applications, pH measurements, determination of pH, ion selective electrodes, instrumentation and applications.

UNIT – III

Coulometry
Introductions, principle, experimental details of coulometry at constant current and constant potential, titrational applications.

UNIT – IV

Atomic Absorption Spectroscopy
Introduction, principle, Grotrian diagram, instrumentation, applications, detection limit, sensitivity and disadvantages.

SUGGESTED BOOKS AND REFERENCES

1. Principles of instrumental analysis, D.A. Skoog and J.L. Loary. W.B. Saunders, CBS.
2. Principles of Instrumental Analysis, D.A. Skoog and W.B. Saunders, CBS.
3. Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.

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CHY C02 : ELECTROCHEMISTRY - I

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT – I

Electro-chemical Energy Storage
Properties of Electrochemical energy storers: measure of battery performance, charging and discharging of batteries, storage density, energy density.
Classical Batteries : (i) Lead Acid (ii) Nickel-Cadmium (iii) Zinc-Manganese dioxide.
Modern Batteries : (i) Zinc- Air (ii) Nickel- Metal hydride (iii) Lithium Battery.
Future electricity storers : Storage in (i) Hydrogen (ii) alkali metals, (iii) Non-aqueous solutions.

UNIT – II

Bioelectrochemistry
Membrane potential, simplistic and modern theory, Electrical conductance in biological organisms, electrochemical mechanism of nervous systems, enzymes as electrodes, Biosensors, Bioelectrocatalysis.

UNIT – III

Corrosion and Passivity
Electrochemical mechanism of corrosion of metals, thermodynamics and stability of metals, potential - pH (or Pourbaix) Diaphragms, uses and abuses, corrosion current and corrosion potential - Evans diagrams.
Measurement of corrosion rate: weight loss method & electrochemical method. Inhibition of Corrosion (i) by addition of substrates to the electrolyte environment (ii) By charging 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.

UNIT – IV

Kinetics of Electrode Process
Essentials of electrode reaction, current density, overpotential, Tafel equation, Butler Volmer equation. Standard rate constant (K^0) and Transfer coefficient (α), exchange current density. criteria of irreversibility information from irreversible wave. Koutecky's method, Meits Israel and Gelling's method for determining kinetic parameters for quasireversible and irreversible waves.

SUGGESTED BOOKS AND REFERENCES

1. Modern, Electrochemistry, Vol. I, II A, Vol. II B, J'O.M Bockris and A.K.N. Reddy, Plenum Publication, New York.
2. Polarographic Techniques by L. Meites, Intersciences. New York
3. Modern Polarographic Methods by A. M. Bond and Marcel Dekker.
4. Polarography and allied techniques by K. Zutshi, New Age International Publication, New Delhi.

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CHY C03 : CHEMICAL KINETICS

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT – I

Oscillatory Reactions
Autocatalysis and oscillatory reactions, Oscillatory reactions from the new point of thermodynamics. Kinetics and mechanism of Belousov-Zhabotinski (B-Z) reaction.
Enzymes and Inhibitors
Enzyme catalyzed models of 1:2 type enzyme-substrate systems.
Kinetics of one enzyme-Two substrate systems and their experimental characteristics. Enzyme inhibitors and their experimental characteristics. Kinetics of enzyme inhibited reactions.

UNIT – II

Dynamics of Gas-Surface Reactions
Adsorption/desorption kinetics and transition state thoery, Dissociative adsorption and precursor state. Mechanism of Langmuir's adsoprtion of the oxidation of carbon monoxide to carbon dioxide. True and apparent activation energies. Industrial importance of heterogeneous catalysis.

UNIT – III

Transition State
A brief aspect of statistical mechanics and transition state theory, application in calculation of the second order rate constant for reactions with collision for (i) atom + atom (2) atom + molecule (3) molecule (for both linear and non-linear molecules) + molecule reactions. Static solvent effects and thermodynamic formulations. Adiabatic electron transfer reactions, energy surfaces.

UNIT – IV

Metal-ion Catalysis: Kinetics and Mechanism of following Reactions
(i) When reaction rate is independent of one of the reactants in presence of metal ion catalyst.
(ii) When reaction rate is retarded by one of the products in presence of metal ion catalyst.
(iii) When metal ion catalysis indicates an intermediate species.
(iv) Cyclodextrines are acting as catalyst mode of catalysis. Analysis of one full case study of β-cyclodextrine, catalysed reaction, Hydroformylation reaction.

SUGGESTED BOOKS AND REFERENCES

1. Progress in Inorganic Chemistry, Vol. 30, 1967.
2. R. Lumry and R.W. Raymond, Electron Transfer Reactions, Interscience.
3. N.L. Bender, Mechanism of Homogeneous catalysis from protein to protein, Wiley.
4. A.G. Sykes, Kinetics of Inorganic reactions, Pergamon.
5. S.W. Benson, Mechanism of Inorganic Reactions, Academic Press.
6. Physical chemistry Vol. 2, Ed. Prof. Ya Grasimov, Mir Publisher.
7. Basolo and Pearson, Inorganic Reaction Mechanism, Wiley
8. H. Taube, Electron Transfer Reactions, Oxford Press.

SEMESTER - III - PRACTICALS

CHY 311 : Practical A – INORGANIC CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

NOTE – During practical examinations two exercises to be given out of the prescribed exercises.

Ex.1 Quantitative analysis: separation and determination of two metal ions involving Volumetric and Gravimetric methods:

a. Copper – Nickel
b. Nickel – Zinc 48

Ex.2 Spectrophotometric determination of Iron-phenanthroline complex: Job's method of continuous variations.

OR

Determination of ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions in the given solution.

OR

Determination of Ca^{2+} and Mg^{2+} ions in a given solution and estimation of total hardness of water. 27

Ex. 3 Viva 15
Ex. 4 Record 10

SUGGESTED BOOKS AND REFERENCES FOR INORGANIC PRACTICALS

1. Vogel's Textbook of Quantitative Analysis, revised, J Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.
2. Synthesis and Characterization of Inorganic Compounds, W.L.Jolly. Prentice Hall.
3. Inorganic Experiments, J. Derek Woolings, VCH.
4. Microscale Inorganic Chemistry, Z. Szafran , R.M., Pike and M.M. Singh, Wiley.
5. Practical Inorganic Chemistry, G. Marr and B.W. Rockett, Van Nostrad.

CHY 312: Practical B – ORGANIC CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

Ex. 1 Qualitative Analysis **45**

Separation, purification and identification of organic compounds in three component mixture (three solids or two solids and one liquid), using TLC for checking the purity of separated compounds, containing mono and polyfunctional compounds by chemical analysis, IR, ^{1}H-NMR and mass spectral data.

Ex. 2 Multi-step Synthesis **30**

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

i) Photochemical reaction :
(Benzophenone → Benzpinacol → Benzpinacolone)

ii) Beckman Rearrangement : Benzanilide from benzene
(Benzene → Benzophenone → Benzophenone oxime → Benzanilide)

iii) Benzilic acid rearrangement : Benzilic acid from benzoin
(Benzoin → Benzil → Benzilic acid).

iv) Synthesis of heterocyclic compounds
a) Skraup synthesis: Preparation of quinoline from aniline
b) Fisher Indole synthesis: Preparation of 2-phenylindole from phenylhydrazine.

v) Diazocoupling : Phthalic anhydride → Phthalamide → anthranilic acid → methyl red.

vi) Synthesis using microwave : Alkylation of diethyl malonate with benzyl chloride.

vii) Synthesis using phase transfer catalyst : Alkylation of diethyl malonate or ethyl acetoacetate with an alkyl halide.

Paper Chromatography

Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Spectroscopy

Identification of organic compounds by the analysis of their spectral data (UV, IR, ^{1}H-NMR, ^{13}C-NMR and Mass)

Ex. 3 Viva **15**

Ex. 4 Record **10**

CHY 313: Practical C – PHYSICAL CHEMISTRY

DURATION: 6 Hrs **MAX. MARKS: 100**

Ex. 1 Major (One exercise) as given in the syllabus **45**

Ex. 2 Minor (One exercise) as given in the syllabus **30**

Thermodynamics:

i. Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture.

ii. Determination of the temperature dependence of the solubility of a compound in two solvents having similar intramolecular interactions (benzoic acid in water and in DMSO-water mixture) and calculate the partial molar heat of solution.

Spectroscopy:

i. Determination of pKa of an indicator (e.g. methyl red) in (a) aqueous and (b) micellar media.

ii. Determination of stoichiometry and stability constant of Ferric isothiocyanate complex ion in solution.

iii. Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.

Voltammetry:

i. Identification and estimation of metal ions such as (Cd^{2+}, Zn^{2+} and Ni^{2+}) voltammetrically.
ii. To plot a cyclic voltamogram (CV) of a reversible system for $[Fe(CN)_6]^{-3}$ and $[Fe(CN)_6]^{-4}$ systems and calculate no. of electrons involved in the process.
iii. To plot a voltamogram (CV/LSV) of an organic compound (such as nitroanilines) and calculate no. of electrons involved in the process.

Chemical Kinetics:

i. Determination of rate constant and formation constant of intermediate complex in the reaction of Ce(IV) and Hypophosphorous acid at ambient temperature.
ii. Determination of energy and enthalpy of activation in the reaction of $KMnO_4$ and benzyl alcohol in acid medium.
iii. Determination of energy of activation and entropy of activation from a single kinetic run.
iv. Kinetics of an enzyme catalyzed reaction.

Ex. 3 Viva **15**
Ex. 4 Record **10**

SEMESTER –IV

CHY A04 : INORGANIC POLYMERS

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours ; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

A general survey and scope of inorganic polymers special characteristics, classification, homo and hetero atomic polymers. Polydispersion - average molecular weight concept. Number, weight and viscosity average molecular weights.

UNIT-II

Structure, Properties and Applications of:

a. Polymers based on Boron - Borazines, Boranes and Carboranes.
b. Polymers based on Silicon - Silicones, Polymetalloxanes and Polymetallosiloxanes, Silazenes.

UNIT-III

Structure, Properties and Applications of:

a. Polymers based on Phosphorous - Phosphazenes, Polyphosphates.
b. Polymers based on Sulphur - Tetrasulphur tetranitride and related compounds.

UNIT-IV

Silicates and Aluminosilicates:

a. Classification, structure, properties and applications of naturally occurring silicates.
b. Synthesis and applications of aluminosilicates and zeolites with emphasis of catalysis.

SUGGESTED BOOKS AND REFERENCES

1. Inorganic Chemistry, J.E. Huheey, Harper Row.
2. Developments in Inorganic Polymer Chemistry, M.F. Lappert and G.J. Leigh.
3. Inorganic Polymers, N.H. Ray.
4. Inorganic Polymers, Graham and Stone.
5. Inorganic Rings and Cages, D.A. Armitage.
6. Textbook of Polymers Science, F.W. Billmeyer Jr. Wiley.
7. Contemporary Polymer Chemistry, H.R. Al cock and F.W. Lambe, Prentice Hall.
8. Structural Inorganic Chemistry, A. F. Wells, Oxford University Press.
9. Zeolites Molecular Sieves-Structure, Chemistry and Use, D.W. Breck, John Wiley & Sons.
10. Textbook of Polymer Science, F.W. Billimeyer Jr. Wiley.

CHY A05 : ADVANCED BIOINORGANIC CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours ; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Metalloenzymes:

Structure and functions of the following enzymes: carbonicanhydrase, carboxypeptidase, alchoholdehydrogenase, catalalse and peroxidase, cytochrome P-450, super oxide dismutase and xanthin oxidase, coenzyme, vitamin B_{12}.

UNIT-II

Metal Storage and Transport:

Iron storage and transport for mammalia systems, transferrin, ferritin, Transport of iron in microorganism, siderophores, types of siderophores - The catecholate siderophores (eg: enterobactin) and hydroxamate siderophores (eg: ferrichrome), Mechanism involved in binding of Iron(III) siderophores complexes to receptors and the release of Iron into the Cytoplasm. Other storage & transport systems: ceruloplasmin and serum albumin for copper, metalothioneins and phytochepatins.

UNIT-III

DNA and RNA

Metal complexes of polynucleotides, nucleosides and nucleic acids (DNA and RNA), Template temperature, stability of DNA.

UNIT-IV

Metal Deficiency and Diseases:

Iron, zinc and copper deficiency – metal ion toxicity – copper over load and Wilson's disease – iron toxicity – toxicity of arsenic, cadmium, mercury and lead, metal complexes in medicine – chelation therapy – BAL, penicillamine, polyamino carboxyclic acids and desferrioxamine – gold compounds and rheumatoid arthritis – platinum complexes as anticancer, drugs – metal complexes in radio diagnosis and magnetic resonance imaging.

SUGGESTED BOOKS AND REFERENCES

1. Principles of Bioinorganic Chemistry, S. J Lippard & J. M. Berg, University Science Books.
2. Progress in Inorganic Chemistry, S. J. Lippard,. Vols. 18 and 38, Wiley-Interscience.
3. Bioinorganic Chemistry, I. Bertini, H.B. Gray. S.J. Lippard and J. S. Valentine, University Science Books.
4. Inorganic Biochemistry Vols I and II Ed. G.L. Eichhorn Elsevier.

CHY A06 : MINERAL BASED INDUSTRIAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper -3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT – I

Industrial Chemistry

Ferrous and non-ferrous metal industries - quality control methods, general principles applied in studying an industry; manufacture of iron, steel and special steels; metallurgy of iron, aluminium, copper, gold and silver; recycling and pollution control.

UNIT –II

Cement

Classification of cement, manufacture of portland cement, setting and hardening of cement, chemical constitution of portland cement and their characteristics, special cements and their uses.

UNIT III

Ceramics

Classification of ceramics, basic raw materials, manufacture and applications, components imparting colours, comparison of pottery porcelain and china ware. Glass-raw materials, manufacture and applications: special glass, optical, borosilicate, flint and coloured glasses.

UNIT IV

Poisons

Industrial poisons and their classification- solid, liquid and gaseous poisons, their identification-physiological activity and control; Solids: Pb, As, Hg, asbestos, textile fibres; Liquids: organic solvents, Gases: oxides of S, N and H_2S; cyanides, aldehydes, ketones and hydrocarbons.

SUGGESTED BOOKS AND REFERENCES

1. Morris Boris Jacobs, The Analytical Chemistry of Industrial Poisons, Hazards and Solvents, Interscience Publishers, Inc., New York City, 1949.
2. L. L. Shreir, Corrosion, Volume-I, Metal Environment Reactions; Newnes Butterworths, London.
3. Fontana and Greene, Corrosion Engineering; McGraw Hill Publication, 1986.
4. E. Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK, 1990.
5. R.M. Felder, R.W. Rousseau, Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
6. George Austin, Shreve's Chemical Process Industries, McGraw-Hill Book Company, 1985.
7. R. M. E. Diamant, Applied Chemistry for Engineer, Pitman Publishing, 3rd Edition, 1972.
8. Alan Heaton, An Introduction to Industrial Chemistry, Springer-Science Business Media Dordrecht, 1996.
9. Harold H. Trimm, William Hunter III, Harold Henry Trimm, Industrial Chemistry: New Applications, Processes and Systems, Apple Academic Press, Inc., 2011.
10. R.N. Sherve, "Chemical process industries", McGraw-Hill, Kugakuisha Ltd., Tokyo, 1984.
11. Riegels Hand Book of Industrial Chemistry, 9th edition, edited by James A. Kent, New York, Van Nostrand Reinhold, 1992
12. J. A. Kent, Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
13. Mark Anthony Benvenuto, Industrial Chemistry, de Gruyter GmbH, 2013.
14. S. S. Dara, S. S. Umare, A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi, 2013.
15. A. K. De, Environmental Chemistry: New Age International Pvt, Ltd, New Delhi.
16. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
17. Vogel's Text book of Quantitative Chemical Analysis, G.H. Jeffery, J. Basset, J. Mendham and R. C. Denney, English Language Book Society/ Longman.
18. Study Material in vocational subject, Industrial Chemistry (UGC Sponsored).
19. F.A. Settle, Handbook of instrumental techniques for Analytical chemistry, Prentice Hall.
20. K. Kodama, Quantitative Inorganic Analysis, Interscience Publishers, New York.

CHY B04 : MEDICINAL CHEMISTRY

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100

Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Drug Design: Development of new drugs, procedures followed in drug design, concepts of prodrugs and soft drugs, structure-activity relationship (SAR and QSAR). Factors affecting bioactivity - resonance, inductive effect, isosterism, bio-isosterism, spatial consideration. Theories of drug activity. Elementary treatment of drug receptor interactions.

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JAIPUR

Pharmacokinetics: Introduction to drug absorption disposition, elimination using Pharmacokinetics, Important pharmacokinetics parameters in defining drug disposition and in therapeutics, use of pharmacokinetics in drug development process.

Pharmacodynamics: Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, membrane active drugs, drug metabolism, xenobiotics, biotransformation significance of drug metabolism in medicinal chemistry

UNIT-II

Antineoplastic agents: Introduction to cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Carcinolytic antibiotics and mitotic inhibitors. Synthesis of cyclophosphamide, melphalan, uracil, mustards. Recent development in cancer chemotherapy.

Local Antiinfective drugs: Introduction and general mode of action. Synthesis of furazolidone, nalidixic acid, ciprofloxacin, norfloxacin, dapsone, isoniazid, ethambutal, fluconazole, econazole. Antimalarials: chloroquin and primaquin.

UNIT-III

Cardiovascular Drugs: Introduction, Cardiovascular disease, drug inhibitors of peripheral sympathetic function. Synthesis of amyl nitrate, sorbitrate, deltiazem, quinidine, verapamill, methyldopa, atinolol, oxyprenolol.

Psychoactive drugs: Introduction, Neurotransmitters, CNS depressants, general anaesthetics, mode of action of hypnotics, sedatives, antianxiety drugs.

UNIT-IV

Antibiotics: Antibiotics inhibiting protein synthesis, β-lactam rings. Synthesis of Penicillin-G, Ampicillin, Amoxycillin, Chloramphenicol, Cephalosporin, Tetracyclin and Streptomycin.

Analgesics and Antipyretics: Classification, Nonnarcotic analgesic. Synthesis of Mefenamic acid, Diclofenac.

SUGGESTED BOOKS AND REFERENCES

1. Burger. *Medicinal Chemistry and Drug Discovery*, Vol-1, Ed. M. E. Wolff, John Wiley (1994).
2. Goodman & Gilman. *Pharmacological basis of Therapeutics*, McGraw-Hill (2005).
3. S.S. Pandeya & J.R Dimmock. *Introduction to drug design*, New Age International (2000).
4. D. Lednicer. *Strategies for organic drug Synthesis and Design*, John Wiley (1998).
5. Graham & Patrick. *Introduction to medicinal Chemistry* (3rd edn.) OUP (2005).

CHY B05 : ORGANIC SYNTHESIS – II

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Disconnection Approach: An introduction to synthons and synthetic equivalents. Disconnection approach, functional group inter-conversions, importance of the order of events in organic synthesis. One group C-X and two group C-X disconnections. Chemoselectivity, reversal of polarity, cyclisation reaction.

Protecting Groups: Principle of protection of alcohol, amine, carbonyl and carboxyl groups. Simple practice excercises.

UNIT –II

Stereogenic Centres and Planning of Synthesis : Stereogenic skeletal bond forming reactions, asymmetric synthesis, synthesis of a racemate and resolution, incorporation of chiral building blocks.

One Group C-C disconnections: One group C-C disconnection involving alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes, aliphatic nitro compounds in organic synthesis.

UNIT-III

Two group C-C disconnection: Diels-Alder reaction; 1,3-difunctionalised compounds; α,β-unsaturated carbonyl compounds; control in carbonyl condensation; 1,5-difunctionalised compounds, Michael addition and Robinson annelation.
Two group disconnections: 1,2-difunctionalised compounds, Radical reaction in synthesis, 1,4-difunctionalised compounds, 1,6-difunctionalised compounds.
Reconnections: Synthesis of 1,2- and 1,4-difunctionalised compounds by C=C cleavage.

UNIT IV

Ring Synthesis: Introduction to ring synthesis of saturated heterocycles. General strategy and stereoselectivity. 3-Membered rings from cyclisations and insertion reactions. Rerarrangements in synthesis. 4-Membered rings from photocycloadditions and use of ketenes.
5-Membered rings from 1,4-dicarbonyl compounds and six membered rings from 1,6-dicarbonyl compounds.
Pericyclic rearrangements and special methods. 6-membered rings: carbonyl condensations, Diels-Alder reactions and reduction of aromatic compounds.

SUGGESTED BOOKS AND REFERENCES

1. Organic synthesis, Smith M.B. McGraw Hill, 2002.
2. Organic synthesis: The disconnection approach. Warren S., John Wiley & Sons, 2004.
3. Designing Organic Synthesis: The synthon approach, Warren S., Wiley, 1978 (Reprinted 2002).

4. Organic Synthesis – Concepts, Methods and Starting Materials, J Fuhrhop and G. Li. Wiley-VCH, 2003.
5. Modern Methods of Organic Synthesis, Carruther W., Cambridge University Press, 2004.
6. Modern Synthetic Reactions, H.O. House, W.A. Benjamin, 1972.

CHY B06 : HETEROCYCLIC CHEMISTRY– II

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syliabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT – I

Five-membered Heterocycles with more than two Heteroatoms: Synthesis and reactions of triazoles, tetrazoles, oxadiazoles, thiadiazoles and diazaphospholes.
Meso-ionic Heterocycles: General classification, chemistry of some important meso-ionic heterocycles of type A and B and their applications.

UNIT –II

Six-Membered Heterocycles with one Heteroatom: Synthesis and reactions of pyrylium salts, pyrones, coumarins, chromones and phosphorine (phosphabenzene).

Six-Membered Heterocycles with two or more Heteroatoms: Synthesis and reactions of diazines, triazines, tetrazines and azaphosphorine.

UNIT –III

Oxazines, Benzoxazines; synthesis and reactions.
Thiazines, 1,4-benzothiazines and phenothiazines; synthesis and reactions.
Diazepines, 1,4- or 1,5-benzodiazepines; synthesis and reactions.
Thiazepines, 1,4- or 1,5-benzothiazepines; synthesis and reactions.

UNIT-IV

Large membered heterocycles
Eight-membered : 1-Azocine, Diazocine, synthesis and reactions.
Nine-membered : 1-Azonine, 2-Oxonine, synthesis and reactions.
Ten or large membered rings, synthesis and reactions.

SUGGESTED BOOKS AND REFERENCES

1. Heterocyclic Chemistry Vol 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag.
2. The Chemistry of Heterocycles, T. Eicher and S Hauptmann, Thieme.
3. Heterocyclic chemistry J.A. Joule, K. Mills and G.F. Smith, Chapman and Hall.
4. Heterocyclic Chemisty, T.L. Gilchrist, Longman Scientific Technical.
5. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.
6. Comprehensive Heterocyclic Chemistry, A.R. Katrizky and C.W. Rees, eds. Pergamon Press.

CHY C04 : CHEMICAL ANALYSIS

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Water Analysis
Sources of water pollution domestic, industrial, agricultural soil and radioactive wastes as sources of pollution. Objectives of analysis - parameter for analysis color, turbidity, total solids, conductivity, acidity, alkalinity, hardness, chloride, sulphate, fluroide, silica, phosphates and different forms of nitrogen.
Heavy metal pollution - public health significance of cadmium, chromium, copper, lead, zinc, mangnese, mercury and arsenic. General survey of instrumental technique for the analysis of heavy metals in aqueous systems. (Measurement of DO, BOD and COD).
Pesticides as water pollutants and analysis. Water pollution laws and standards.

UNIT-II

Food Analysis
Moisture, ash, crude protein, fat, crude fiber, carbohydrates, calcium, potassium, sodium and phosphate. Food adulteration-common adulterants in food, contamination of food stuffs. Microscopic examination of foods for adulterants. Pesticide analysis in food products. Extraction and purification of sample: HPLC, Gas chromatography for organophosphates. Thin-layer chromatography for identification of chlorinated pesticides in food products.

UNIT-III

Soil and Fuel Analysis
Analysis of soil: moisture, pH, total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts.
Fuel analysis: liquid and gas. Ultimate and proximate analysis, heating values - grading of coal. Liquid fuels flash point, aniline point, octane number and carbon residue. Gaseous fuels - producer gas and water gas, calorific value.

UNIT-IV

Body Fluids and Drug Analysis
Composition of blood collection and preservation of samples. Serum electrolytes, blood glucose, blood urea nitrogen, uric acid albumin, globulins acid and alkaline phosphatases, Immunoassay: Principle of radio immunoassay (RIA) and applications. The blood gas analysis, trace elements in the body.
Narcotics and dangerous drugs, classification of drugs. Screening by gas and thin layer chromatography and spectrophotometric measurements.

SUGGESTED BOOKS AND REFERENCES

1. Analytical Chemistry, G.D. Christian, J. Wiley.
2. Fundamentals of analytical Chemistry, D.A. Skoog, D.M. West and F.J. Hooler, W.B. Saunders.
3. Analytical Chemistry – Principles, J.H. Kennedy, W.B. Saunders.

. Analytical Chemistry - Principles and Techniques. L.G. Hargis, Prentice Hall.
5. Quantitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
6. Environmental Solution, S.M. Khopkar, Wiley Eastern.
7. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.

CHY C05 : ELECTROCHEMISTRY–II

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.

2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.

3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Fuel Cells
Electrochemical Generators (Fuel Cells): Hydrogen oxygen cells. Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, Phosphoric acid fuel cell, direct NaOH fuel cells. Applications of fuel cells.

UNIT-II

Electrocatalysis
Chemical catalysis and Electrocatalysis, cathodic and anodic electro catalysis; electrocatalysis of mixed oxides of titanium dopped with rare earth oxides (Ebonex); Electrolysis in simple redox reactions, Electrocatalysis of carbon nanotubes and bimetallic (alloys), nano- structured materials.

UNIT-III

Voltammetry
General Principle and applications, linear sweep voltammetry (LSV), cyclic voltammetry (CV), square wave voltammetry, stripping voltammetry, cathodic adsorptive stripping voltammetry (CAdSV), anodic adsorptive stripping voltammetry (AAdSV), applications of stripping analysis.

UNIT-IV

Electro-organic Synthesis
Types of electro organic reactions, constant current and constant potential electrolysis, cell design, effect of variable, nature of medium, nature of electrode materials, over-voltage, effect of redox couple, application to sewage waste water treatment, electro-chemical incineration of human waste in combined space. Electro-organic synthesis of novel drugs.

SUGGESTED BOOKS AND REFERENCES

1. Electrochemical methods by Allen J. Bard and Larry R. Faulkner, John Wiley.
2. Electrochemistry by Carl H. Hamann, Andrew Hamett and Wolf Vielstich.
3. Modern Polarographic Methods by A.M. Bond and Marcel Dekker.
4. Electroanalytical chemistry by Basil H. Vessor & Galen W., Wiley Interscience.
5. Topics in pure and applied chemistry Ed. S.K. Rangrajan, SAEST Publications, Karaikudi, (India).
6. Techniques of Electro-organic synthesis Part I, II and III by N.L.Weinberg, John Wiley.

Organic Electrochemistry by M.M. Baizer and Marcel Dekker.
8. Principles and applications of Electrochemistry by D.R. Crow (Stanley Thrones (Pub) Ltd.
9. Electrochemical Incineration of human wastes in confined spaces: by D. K. Sharma, Academic Press (Germany).

CHY C06 : CHEMICAL KINETICS – II

Theory and Tutorial: 4 hours per week (4 credits)
Examination: Theory Paper - 3 Hours; Max. Marks- 100
Note: 1. Candidate has to attempt five questions in all. All questions carry equal marks.
2. Question no. 1 covering whole syllabus will consist of 10 short answer questions carrying 2 marks each.
3. Question No. 2 to 5, each of 20 marks, will be framed by taking one question from each unit. There will be an internal choice within the unit.

UNIT-I

Micelles Catalysis and Inhibition: Micelles and their classification, Kinetics and mechanism of micelle catalyzed reactions (I^{st} order and second order). Various type of micelle catalyzed reactions. Micelle inhibited reactions.

Kinetics and Mechanism of Substitution Reaction: Classification of ligand substitution mechanism, anation and base catalysed. Kinetics of anation reactions. Aquation and acid catalyzed Kinetics of aquation reactions (octahedral complexes).

UNIT - II

Radiation Chemistry
Radiation chemistry and Photochemistry. Radiation chemistry of water and aqueous solutions. Hydrogen atom and hydroxyl radical-oxidizing and reducing conditions. Kinetics and mechanism of photochemical and photosensitized reactions (one example in each case).
Stern-Volmer equation and its application. Hole-concept in the presence of semi-conductor photocatalysts. Kinetics and mechanism of electron transfer reaction in the presence of visible light. Kinetics of exchange reactions (mathematical analysis).

UNIT - III

Induced Phenomenon
Metal ion catalyzed reactions, induced reactions, kinetics of induced reactions and their characteristics. Induction factor and its mechanistic significance. Mechanism of -
(i) Fe(II) induced oxidation of iodide by Cr(VI).
(ii) As(III) induced oxidation of Mn(II) by chromate in acid solutions.
(iii) Kinetics and mechanism of induced reactions in metal complexes (octahedral complexes of cobalt(III) only).

UNIT - IV

Electron Transfer Reactions in Metal Complexes
Kinetics and mechanism of 1:1, 1:2 and 1:3 metal-substrate complexes as intermediates, Inner-sphere and outer-sphere reactions, Henry Taube's classical reaction, its kinetics and mechanism, experimental analysis by chromatographic and spectroscopic techniques.

Patte[illegible]f reaction via adjacent and remote attacks, linkage isomerism. Mechanism of inner sphere and outer sphere mode of electron transfer reactions.
Marcus-Cross relation in outer-sphere reactions (no mathematical derivation) in following reactions-

$$Fe(CN)_6^{4-} + Fe(CN)_6^{3-} = Fe(CN)_6^{3-} + Fe(CN)_6^{4-}$$
$$Ce(IV) + Fe(CN)_6^{4-} = Ce(III) + Fe(CN)_6^{3-}$$

Bridged outer-sphere electron transfer mechanism.

SUGGESTED BOOKS AND REFERENCES

1. Progress in inorganic chemistry, Vol. 30, 1967.
2. Electron Transfer Reactions, R. Lumry and R.W. Raynolds, Interscience.
3. Mechanism of Homogeneous catalysis from protein to protein, N. L. Bender, Wiley.
4. Kinetics of Inorganic Reactions, A.G. Sykes, Pergamon.
5. Physical Chemistry Vol. 2, ed. Prof. Ya Grasimov, Mir Publisher.
6. Mechanism of Inorganic Reactions, S.W. Benson, Academic Press.
7. Inorganic Reaction Mechanism, Basolo and Pearson, Wiley.
8. Electron Transfer Reactions, H. Taube, Oxford Press.

CHY 421 : SEMINAR

Ex. 1 Seminar presentation by the students.