Dr. Hari Singh Gour Vishwavidyalaya, Sagar

M.Sc., CHEMISTRY

SCHEME OF EXAMINATION

Semester-I

Chemistry Semester I			
	Course Code	Course name	Credits
1	CHE-CC-121	Inorganic Chemistry	4
2	CHE-CC-122	Organic Chemistry	4
3	CHE-CC-123	Physical Chemistry	4
4	CHE-CC-124	Spectroscopy and Group Theory	3
5	CHE-EC-125 A	Mathematics for Chemists	2
	CHE-EC-125 B	Biology for Chemists	
6	CHE-CC-126	Laboratory Course -Inorganic Chemistry	2
7	CHE-CC-127	Laboratory Course - Organic Chemistry	2
8	CHE-CC-128	Laboratory Course -Physical Chemistry	2

Distribution of Marks :

Mid Sem. Exam 20 marks	Internal Assessment 20 marks			Total 40 Marks	End Sem Marks	Total Marks
20	Attendance	Assessment	Total	40	60	100
	5	15	20			

M.Sc. Chemistry, Semester I
CHE-CC-121
Inorganic Chemistry

Credits :4 60 Hrs

UNIT I	**Stereochemistry and Bonding in Main Group Compounds** VSEPR Theory, Walsh diagrams (tri- and penta- atomic molecules), dπ-pπ bonds. Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules. Applications of Group Theory on Inorganic molecules.	12
UNIT II	(a) Chemistry of chalcogens, polychalcogenides, sulfur-nitrogen compounds; Selected examples of single, double, and triple bonded Si compounds; Multiple bonding in heavier main-group elements: structure and reactivity. (b) Metal-organic frameworks. Definition, nomenclature and classification of metal-organic frameworks (MOF´s). Synthesis, physico-chemical properties and catalytic applications.	12
UNIT III	**Metal-Ligand Equilibria in Solution** Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.	12
UNIT IV	**Metal - Ligand Bonding** Limitation of Crystal field theory, Ligand Field Theory, Basic aspects of Angular Overlap model; Origin of MO's; molecular orbital theory, octahedral, tetrahedral and square planer complexes, σ and π bonding and MOT. Jahn-Teller effect.	12
UNIT V	**Metal π-Complexes** Metal carbonyls, metal nitrosyls, structure and bonding, Vibrational spectra of metal carbonyls for bonding and structural elucidation & important reactions of metal carbonyls; bonding, structure and important reactions of transition metal nitrosyl; dinitrogen and di oxygen complexes; tertiary phosphine as ligand, metal olefin complexes – structure and bonding (difference between M-σ and M-π bonding), Concept of isolobality and stereochemical nonrigidity.	12

M.Sc. Chemistry Semester I
CHE-CC-122
Organic Chemistry

Credits :4 60 Hrs

UNIT I . **Nature of Bonding in Organic Molecules** 12

Delocalized chemical bonding, conjugation, resonance, hyper-conjugation, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of π-molecular orbitals, annulenes, anti-aromaticity, ψ -aromaticity, homo-aromaticity, PMO approach, Bonds weaker than covelent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins.

UNIT II. **Reaction Mechanism; Structure and Reactivity:** 12

Types of mechanism, types of reactions. Thermodynamic and kinetic requirements, kinetic and thermodynamic control. Hammond's postulate. Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Hard and soft acids and bases.

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes.

Effect of structure on reactivity - resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship. Substituent and reaction constants. Taft equation.

UNIT III. **Aliphatic Nucleophilic Substitution:** 12

The SN_2, SN_1, mixed SN_1 and SN_2 and SET mechanisms.

The neighbouring group-mechanism: neighbouring group participations by π and σ bonds, anchimeric assistance, Classical and nonclassical carbocations, norbornyl system, common carbocation rearrangements.

The SN_1 mechanism:

Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity: The effects of substrate structure, Attacking nucleophile, Leaving group and Reaction medium; Phase transfer catalysis

UNIT IV. **Addition to Carbon-Hetero Multiple Bonds** 12

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

UNIT V. **Free Radical Reactions** 12

Types of free radical reactions and their detection. Free radical substitution mechanism, mechanism at aromatic substrates. Reactivity in the attacking radicals. The effect of solvents on reactivity.

Allylic halogenations (NBS) oxidation of aldehydes to carboxylic acids, auto-oxidation, Radical coupling, arylation of aromatic compounds by diazonium salts. Sand Meyer reaction. Free radical rearrangement. Hunsdiecker reaction.

M.Sc. Chemistry, Semester – I
CHE-CC-123
Physical Chemistry

Credits :4 60 Hrs

UNIT I **Quantum Chemistry :** 12

A 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.

B Approximate Methods : The variation theorem, linear variation principle. Perturbation theory (first order and non-degenerate). Applications of variation method and perturbation theory to the Helium atom

C.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 II **Thermodynamics :** A. Classical Thermodynamics 12

Brief resume of concepts 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 significance. Determination of these quantities. Concept of fugacity and determination of fugacity

B. Non-ideal systems: Excess functions for non ideal solutions. Activity and activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.

UNIT III **Chemical Dynamics** : 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. 12

UNIT IV **Surface Chemistry:** Adsorption : Surface tension, capillary action, pressure difference across curved surface (Laplace euqation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation) surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces. 12

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. ; Micelles

UNIT V **Electrochemistry :** Electrochemistry of solution. Debye-Huckel. Onsagar treatment and its extension, ion solvent interactions. Dye-Huckel- Jerum mode. 12

Guoy-Chapman, Stern, Graham Devanathan- Mottwatts. Tobin, Bockris, Devanathan models.

Over potentials, exchange current density, derivation of butler-Volmer equation, Tafel plot.

Quantum aspects of charge transfer at electrodes-solution interfaces, quantization charge transfer.

Electrochemical Sensors and their determination by electrochemical analyzer. Supercapacitors: Electrical double layer and Pseudocapacitors, Specific capacitance, energy density and Power density. Glassy Carbon Electrode, Gold and Silver electrode.

M.Sc. Chemistry, Semester - I
CHE-CC 124
Group Theory and Spectroscopy

Credits : 3 45 Hrs

UNIT I **Symmetry and Group Theory** 9

Symmetry elements and Symmetry operations, definitions of group, subgroups, relationship between orders of finite group and its subgroup. Schonflies symbols, representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, etc groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use in spectroscopy.

UNIT II **Unifying principles :** 4

Interaction of electromagnetic radiation with matter – absorption, dispersion, emission, polarization, Quantization, reflection, refraction and scattering and transmission (ADEPQRST). Width, Intensity, Shape and Energy (WISE) of the spectral bands : Uncertainty relation and natural band width, transition probability, transition moment, results of time dependent perturbation theory, selection rules , (electronic, rotational, vibrational, spin), Born Oppenheimer approximation , derivation, rotational, vibrational, spin and electronic levels.

Atomic Spectroscopy : 3

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

UNIT III **Molecular Spectroscopy :** 8

Absorption characteristics of organic molecules: electronic transitions and energy levels, molecular orbitals, Frank Condon principle, electronic spectra of polyatomic molecules, emission spectra, radiative and non radiative decay, internal conversion,vibronic transitions, vibrational progression and geometry of the excited states, ultraviolet bands for ⍰⍰ and ⍰⍰ bond carbonyl compounds, unsaturated carbonyl compounds, dienes conjugated polyenes,. Fieser Woodward rule (conjugated dienes and carbonyl compounds), uv spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls. effect of solvent on electronic transitions, spectra of transition metal complexes, charge transfer spectra.

UNIT IV **Vibrational spectroscopy : Infrared Spectroscopy:** 9

Review of linear harmonic oscillator and vibrational energies of di atomic molecules, force constants, overtones, hot bands, Morse potential energy diagrams, vibration-rotation spectroscopy, Zero point energy PQR branches, anharmonicity,breakdown of Oppenhimer approximation.

Vibration of poly atomic molecules, selection rules, normal modes of vibrations, group frequencies, overtones, hot bands, factors affecting band positions and intensities, far IR region, metal ligand vibrations, normal coordinate analysis.

Instrumentation and sample handling, characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines.Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. FT–IR. IR of gaseous, solids and polymeric materials.

UNIT V **Rotational spectroscopy : Microwave Spectroscopy:** 6

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities , non rigid rotors. Stark effect and effect of external field. Applications. Symmetry and shapes of AB_2, AB_3, AB_4, AB_5, and AB_6 mode of bonding of ambi-dentate ligands, ethylenediiamine and diketoneto complexes,

Raman Spectroscopy: Classical and quantum theories of Raman effect. Pure vibrational- rotational Raman Spectra, mutual exclusion principle, Resonance Raman Spectroscopy, coherent anti-stokes Raman Spectroscopy (CARS). Applications of resonance Raman spectroscopy, particularly for the study of active sites of metallo–proteins. 6

M.Sc. Chemistry, Semester – I
CHE-CC-125A
Mathematics for Chemists

Credits :2 30 Hrs

UNIT I	Vectors in Matrix algebra A. **Vectors :** Vectors , dot, cross and triple products etc.. The gradient, divergence and curl. Vector calculus, Gauss' theorem, divergence theorem etc., B. **Matrix Algebra :** Addition and multiplication,; inverse, adjoint and transpose of matrices, special metrics (symmetric, skew –symmetric, Hermitian, skew- Hermitian, unit diagonal , unitary etc) and their properties. Matrix equations: Homogenous, non-homogenous linear equations and conditions for the solution, linear dependence and independence. Introduction to vectors spaces, vectors eigenvalues and eigenvectors, diagonalization, determinants (examples from Huckel theory). Introduction to tensors, polarizability and magnetic susceptibility as examples.	8
UNIT II	**Permutation and Probability** Permutations and combinations, probability and probability curves, average, root mean square and most probable errors, examples from the kinetic theory of gases etc, curve fitting (including least square fit etc.) with a general polynomial fit.	6
UNIT III	**Differential calculus** Functions, continuity and differentiability, rules for differentiation, application of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc), exact and inexact differentials with their applications to thermodynamic properties.	4
UNIT IV	**Integral calculus**, basic rules for integration, integration by parts, partial fraction and substitution, Reduction formulae, applications of integral calculus. Functions of various variables, partial differentiation, coordinate transformations (for example Cartesian to spherical polar), curve sketching.	4
UNIT V	**Elementary Differentla equations** Variables – separable and exact first order differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry etc. Solutions of differential equations by power series method, Fourier series, solution of harmonic oscillator and Legendre equation etc., speherical harmonics, second order differential equations and their solutions.	8

M.Sc. Chemistry, Semester – I
CHE-CC-125B
Biology for Chemists

Credits :2 30 Hrs

UNIT I	**Cell Structures and Functions** : Structure of prokaryotic and eukaryotic cells, inter cellular organelles and their functions, comparison of plant and animal cells. Overview of metabolic processes – catabolism and anabolism. ATP – a biological energy currency. Origin of life – unique properties of carbon, chemical evolution and rise of living systems, Introduction to bio-molecules, building block of bio-macro molecules	6
UNIT II	**Carbohydrates** : Conformation of mono saccharides, structure and functions of important derivatives of mono- saccharides viz., glycosides, deoxy sugars, myoinositol, amino sugars. N – acetyl muramic acid, sialic acid, di- saccharides and ploy saccharides,. Sturctural poly saccharides, cellulose and chitin.storage poly saccharides – starch and glycogen. Structural and biological functions of glucosaminoglycans or mucoploy saccharides. Carbohydrates of glycoproteins and glycol lipids. Role of sugars in biological recognition. Blood group substances. Ascorbic acid. Carbohydrate metabolism – Kreb's cycle, glycosis, glycogenisis and glycogenolysis, gluco neogenisis, pentose phosphate pathway.	6
UNIT III	**Lipids :** Fatty acids, essential fatty acids, structure and function of triglycerols, glycerol phospholipids. Sphingolipids, cholesterol, bile acids, prosta glandins, lipoproteins – composition and function, role in atherosclerosis. Properties of lipd aggregates – micelles, bilayers liposomes and their possible biological functions. Biological membranes. Fluid mosaic model of membrane structure. Lipid metabolism, □□□ oxidation of fatty acids.	6
UNIT IV	**Amino acids, Peptides and Proteins :** Chemical and enzymatic hydrolysis of proteins to peptides, amino and sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, □ -helix, □□□□sheets , super secondary structure, triple helix structure of collagen. Tertiary structures of proteins- folding and domain structures. Quaternary structures. Amino acid metabolism – degradation and biosynthesis of amino acids, sequence determination: chemical / enzymatic / mass spectral , racemization/ detection. Chemistry of oxytocin and tryptophan releasing hormones (TRH).	6
UNIT V	**Nucleic Acids :** Purine and pyramidine bases of nucleic acid, base pairing via H- bonding. Structure of ribonucleic acid (RNA) and di oxyribo nucleic acid (DNA), double helix model of DNA and forces responsible for holding it, an over view of replication of DNA, transcription, translation and genetic code. Chemical synthesis of mono and trinucleoside.	6

M.Sc. Chemistry, Semester – I
CHE-CC-126
Laboratory Course - Inorganic Chemistry

Credits :2 30 Hrs

Qualitative and Quantitative Analysis:

(a). Less Common metal ions – Tl, Mo, W, Ti, Zr, Th, U, (two metal ions in cationic / anionic forms)

(b). Insoluble – oxides, sulphates and halides

(c). Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe, Ag-Ni, Ag-Cu etc involving Volumetric and gravimetric methods.

M.Sc. Chemistry, Semester – I
CHE-CC-127
Laboratory Course - organic chemistry

Credits :2 30 Hrs

Qualitative Analysis:

Separation, purification and identification of compounds of Binary mixture preferably one liquid and one solid) using tlc and column chromatography, chemical tests, IR spectra to be used for functional group identification.

Organic Synthesis :

Acetylation of Cholesterol and separation of cholesteryl acetate by column chromatography.

Oxidation : Adipic acid by chromic acid oxidation of cyclohexanol.

Grignard reaction : Synthesis of triphenylmethanol from benzoic acid.

Aldol Condensation : Dibenzal acetone from benzaldehyde.

Sandmeyer reaction , p-chloro toluene and para toluidine

The products be characterized by spectral techniques.

Quantative Analysis

Determination of iodine and saponofication values of an Oil sample

Determination of DO, COD, BOD of water sample.

M.Sc. Chemistry, Semester – I
CHE-CC-128
Laboratory Course - Physical Chemistry

Credits :2

Errors And Analysis And Statistical Data Analysis :

Statistical treatment of errors analysis, student's 't' test , null hypothesis, rejection criteria , F & Q test; Linear regression analysis, curve fitting.

Calibration of Volumetric Apparatus, burette, pipette and standard flasks.

Note : Such exercise be incorporated as practice work while verifying the experimental data.

Adsorption

To Study surface tension – concentration relationship for solutions (Gibbs equation).

Phase Equibliria

Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone system)

Determination of glass transition temperature of a given salt (e.g.$CaCl_2$) conduct metrically.

To construct the phase diagram for three component system (e.g. chloroform – acetic acid – water).

Chemical Kinetics

Determination of the effect of (a) Change of temperature (b) Change of concentration of reactants and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester / ionic reactions.

Determination of the velocity constants of hydrolysis of an ester / ionic reactions in micellar media.

Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.

Flowing clock reactions (Ref:: Experiments in Physical chemistry by Showmaker).

Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodide ion is oxidised by persulphate ion).

Oscillatory reaction.

Solutions

Determination of molecular weight of non-volatile and non-electrolyte /electrolyte by cryoscopy method and to determine the activity coeffieient of an electrolyte.

Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

Polarimetry

Determination of the rate constant for hydrolysis/ inversion of sugar using polarimeter.

i. Enzyme kinetics – inversion of sucrose

Books Suggested

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. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
4. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
6. Handbook of Organic Analysis-Qualitative and quantitative, H. Clark, Adward Arnold.
7. Vogel's Textbook of Practical Organic Chemistry, A. R. Tatchell, John Wiley
8. Practical Physical Chemistry, a. M. James and F. E. Prichard, Longman
9. Findley's Practical Physical Chemistry, B. P. Levitt, Longman
10. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill.

Inorganic Chemistry

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E.Huhey, Harpes & Row.
3. Chemistry of Elements, N.N. Greenwood and A Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier
5. Magnetochemistry, R.L.Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D.gillars and J.A.McCleverty, Pergamon.
7. Coordination Chemistry, D.Banerjee, TMH,N.Delhi,1995
8. Coordination Chemistry, M.Satake, Discovery Publication House N.Delhi.
9. Essential Trends in Inorganic Chemistry, D.M.P. Mingos, Oxford Univ. Press, N.Delhi 1995.
10. Structural Inorganic Chemistry, A.F.Wells, ELBS
11. Modern Aspects of Inorganic Chemistry, H.J.Emeleus, UBSID, N.Delhi

Organic Chemistry

1. Advanced Organic Chemistry-Reactions. Jerry March, John Wile
2. Advanced Organic Chemistry, F.A. Carey and n J.Sundberg, Plenum
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K.Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison and R.N.Byd. Prentice Hall.
6. Modern Organic reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M.Coxon, Blackie Academic & Professional
8. Pericyclic Reactions, S.M.Mukherji, Macmillan, India.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P.Singh, Macmillan.
10 Stereochemistry of Organic Compounds D. Nasipuri, New Age International
11 Setereochemistry of Organic Compounds, P.S.Kalsi, New Age International
12 Basic Stereochemistry of Organic Molecules, S.Sengupta, Book, Syndicate Pvt.Ltd. Kolkata, 1987.
13 Organic Photochemistry and Pericyclic Reactions, M.G.Arora, Anmol Publications, N.Delhi, 1994.

Physical Chemistry

Physical Chemistry; P.W. Alkins, ELBS
Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill,1995

Quantum Chemistry, Ira N. Levine, Prentice Hall, 1975
Coulson's Valence, R.McWeeny, ELBS.
Chemical Kinetics, K.J.Laidler, McGraw Hill.
Kinetics Mexchanism of Chemical Transformations, J.Rajaram and J. Kuriacose, McMillan.
7. Micelles, Theoretical and Applied Aspects. V.Moroi, Plenum.
8 Modern Electrochemistry Vol. 1 and II J.O.M. Bockris and A.K.N. Reddy, Plenum.
9 Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J.Sridhar, wiley Eastern.
10. Electroanalyutical Chemistry, R.T.Sane, Quest Publications,Mumbai, 1999.
11. Introduction to Electrochemistry, S.Glasstone, Affiliated East West Press N.Delhi, 1995.
12. Chemical kinetics, G.L. Agrawal, TMH, N.Delhi
13. Physical Chemistry for Macromolecules, D.D. Deshpande, Vishal Publications.
14. Quantum Chemistry, R.K. Prasad, New Age Intl., N.delhi.
15. Physical Chemistry for Macromolecules, D.D.Deshpande Vishal Publications.
16. Introductory Polymer Chemistry, G.S.Misra, New Age Intl., N.Delhi.
17. Introduction to Chemical Thermodynamics, R.P. Rastogi, Vikas, Pub. House, N.Delhi. 1997.
18. Statistical Thermodynamics, M.C.Gupta, New Age Intl., N.Delhi.
19. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Sears and Salinger. Narosa Publishing House, New Delhi.
20. Physical Chemistry, G.W.Narosa Publ.H.,N.Delhi,1994.
21. Statistical Thermodynamics (in Hindi) Farid Khan, M.P.Hindi Grantha Academy, Bhopal, 2001.
22. Irreversible Thermodynamics (in Hindi), Farid Khan, M.P.Hindi Grantha Academy, Bhopal, 2001.

Analytical Chemistry

1. Modern spectroscopy, J.M.Hollas, John Eiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H.Windai and F.L. Ho Wiley Interscience.
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V.parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S.Drago, Saunders College,
5. Chemical Application of Group Theory, F.A.Cotton.
6. Introduction to Molecular Spectroscopy, G.m.Borrow, MsGraw Hill.
7. Basic Principles of Spectroscopy, R.Chang, McGraw Hill.
8. Theory and Applications of UV Spectroscopy, P.K.Gosh, John Wiley.
9. Introduction to Magnetic Resonance, A. Carrington and A.D.Maclachalan, Harper & Row.

Dr. Hari Singh Gour Vishwavidyalaya, Sagar
M.Sc., CHEMISTRY
SCHEME OF EXAMINATION
Semester-II

Semester II			
	Course Code	Course Name	Credits
1	CHE-CC-221	Inorganic Chemistry	4
2	CHE-CC-222	Organic Chemistry	4
3	CHE-CC-223	Physical Chemistry	4
4	CHE-CC-224	Spectroscopy and Diffraction Methods	3
5	CHE-CC-225	Computer for Chemists	2
6	CHE-CC-226	Laboratory Course - Inorganic Chemistry	2
7	CHE-CC-227	Laboratory Course – Organic Chemistry	2
8	CHE-CC-228	Laboratory Course – Physical Chemistry	2
9	CHE-CC-229	Laboratory Course – Computers for Chemists	1
10	CHE – OE - 2210	Environmental Chemistry	2

Distribution of Marks :

Mid Sem. Exam 20 marks	Internal Assessment 20 marks			Total 40 Marks	End Sem Marks	Total Marks
20	Attendance	Assessment	Total	40	60	100
	5	15	20			

M.Sc. Chemistry
CHE-CC-221 : Inorganic Chemistry
Semester - II

Credits :4 60 Hrs

UNIT I	**Reaction Mechanism of Transition Metal Complexes** Energy profile of a reaction, reactivity of metal complexes , inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidence in favor of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage.	12
UNIT II	**Substitution reactions** in square planer complexes, the trans effect, mechanism of the substitution reaction; Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.	12
UNIT III	**Metal Clusters** – Higher Boranes, carboranes, metalloboranes and metallo carboranes, metal clusters (carbonyl and halide) and compound with metal – metal multiple bonds (Binuclear and trinuclear). *Interlocked macromolecules:* catenanes, rotaxanes, pseudorotaxanes. Structurally diverse π-cyclopentadienyl complexes of the main group elements.	12
UNIT IV	**Electronic Spectra and Magnetic Properties of Transition Metal complexes** Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano energy diagrams for transition metal complexes (d1to d9 states) Calculations of Dq. B and β parameters, Charge transfer spectra-(LMCT), (MLCT) and (LLCT).	12
UNIT V	Spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereo-chemical information. **Molecular Magnetism*:*** Ferromagnetic & Antiferromagnetic exchange interactions; Neel and Curie Temperature, Magnetic Susceptibility. anomalous magnetic moments, magnetic exchange coupling and spin crossover; Exchange Coupled Dinuclear and Trinuclear Compounds.	12

M.Sc. Chemistry
CHE-CC-222 : Organic Chemistry
Semester – II

Credits :4 60 Hrs

UNIT I. **Aliphatic Electrophilic Substitution** 6

Bimolecular mechanism-S_E^2 and S_E^1. The S_E1 mechanism, electrophilic substitution accompanied by double bond shifts. Effects of substrates, leaving group and the solvent polarity on the reactivity

UNIT II. **Aromatic Electrophilic Substitution and Nucleophilic substitution** 10

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

The S_NAr, S_N1, benzyne and S_RN1 mechanism. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The Richter, Sommelet- Hauser and Smiles rearrangements.

UNIT III **Stereochemistry** 15

Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding.

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

UNIT IV **Addition to Carbon-Carbon Multiple Bonds and Elimination Reactions** 14

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

The E2, E1 and E1CB mechanisms and their spectrum. Orientation of the double bond . Reactivity - effects of substrate structures. Attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination. Claisen and Cope rearrangements. Fluxional tautomerism. Ene reactions.

UNIT V. **Pericyclic Reactions** : 15

Molecular orbital symmetry. Frontier Orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of Pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electro-cyclic reactions- con-rotatory and dis-rotatory motions, 4n, 4n+2 systems, Cycloadditions- antra-facial and supra-facial additions, 4n, 4n+2 systems, 2,2+2 addition of ketenes and 1,3 dipolar cyclo-additions,Sigma tropic rearrangements- suprafacial and antarafacial shifts of H-, sigma tropic shifts involving carbon moieties, 3,3- and 5.5. sigma tropic rearrangements

M.Sc. Chemistry, Semester - II
CHE-CC-223
Physical Chemistry

Credits :4 60 Hrs

UNIT I **Quantum Chemistry :** 12

A Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operators using ladder operators, addition of angular moments, spin, antisymmetry and Pauli exclusion principle.

B Electronic Structure of Atoms : Electronic configuration. Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the p^n configuration, term separation energies for the d^n configurations, magnetic effects: spin-orbit coupling and Zeeman splitting introduction to the methods of self consistent field, the virial theorem.

UNIT II **Phase Equilibria** : Application of phase rule to three component systems: Graphical representation, Solid-liquid equilibrium, Liquid-liquid equilibrium, 12

Second order phase transitions.

Macromolecules : A. Polymer-definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization.

B. Molecular mass, number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering methods) sedimentation, chain configuration macromolecules, calculation of average dimension of various chain structures.

UNIT III **Statistical Thermodynamics** : A. Concept of distribution, thermodynamic and probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and micro canonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). 12

B. Partition functions- translational, rotational, vibrational electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.

Heat capacity behaviour of solids- chemical equilibrium constant in terms of partition. Femi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics- distribution law and application to helium.

Non Equilibrium Thermodynamics : Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (i.e. heat flow, chemical reaction etc.) fluxes and forces, non equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electro-kinetic phenomena, diffusion, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

UNIT IV **Chemical Dynamics** : A. Dynamic chain(hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane). Photochemical(Zhabotinsky reaction). Homogeneous catalysis, 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 molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions (Lindemann- Hinshelwood and Rice-Ramsperger- Kassel-Marcus - RRKM theories of unimolecular reactions). 12

UNIT V **Electrochemistry**: 12

A. Fuel cell, type of fuel cell, oxide ion and proton conducting fuel cells. Superoxide ion conductor and its applictions. Electrocardiography. Solide State Batterries.

B. Polarography theory, Ilkovic equation; half wave potential and its significance. Amperometric titrations.

C. Introduction to corrosion, homogenous theory, forms of corrosion, corrosion monitoring and prevention methods.

M.Sc. Chemistry, Semester - II
CHE-CC-224
Spectroscopy and Diffraction Methods

Credits :3 45 Hrs

UNIT I	**Magnetic Resonance Spectroscopy : Nuclear Magnetic Resonance Spectroscopy** Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift, factors influencing chemical shift, deshielding, spin-spin interaction, factors influencing coupling constant 'J' , classification, (ABX, AMX, ABC, A_2B_2 etc.), spin decoupling, basic ideas about instrument, NMR studies of nuclei other than proton, ^{13}C, ^{19}F and ^{31}P. FT-NMR and its advantages, use of NMR in medical diagnostics.	12
UNIT II	**Electron Spin Resonance Spectroscopy** Basic principles, Zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine constant, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications. Hyperfine Coupling, spin polarization for atoms and transitional metal ions, spin orbit coupling and significance of g-tensors, application to transitional metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as PH_4, F_2^- and $[BH_3]^-$	12
UNIT III	**Photo electron spectroscopy** Basic principles, photo-electric effect, ionization process, Koopman's theorem, photo electron spectra of simple molecules, ESCA, chemical information from ESCA. Auger electron spectroscopy – basic idea.	3
UNIT IV	**X-RAY Diffraction** Braggs condition, Miller Indices, Laue method, Bragg method, Debye – Scherr method of X-ray structural analysis of crystals, index reflections, identification of unit cell 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 a molecules, Ramchandran diagrams.	10
UNIT V	**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. **Neutron Diffraction**: Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques, Elucidation of structure of magnetically ordered unit cell.	8

M.Sc. Chemistry, Semester – II
CHE-CC-225
Computers for Chemists

Credits :2 30 Hrs

UNIT I	**Introduction to computers and computing** Basic structure and functioning of computers with a PC as an illustrative example. Memory, I/O devices. Secondary storage. Computer languages. Operating systems with DOS as an example. Introduction to Unix and Windows, data processing, principles of programming. Algorithms and flow charts.	5
UNIT II	**Computer programming in FORTRAN/ C/ BASIC** (The language features are listed here with respect to FORTRAN. The instructoir may choose another language such as BASIC or C and the features mey be replaced appropriately). Elements of the computer language. Constants and variables. Operations and symbols. Expresion. Arithmetic assignment ststement. Input and Out put . Format statement. Termination statement. Branching statements such as IF or GO TO statements. LOGICAL variables. Double precision variables. Subscripted variables and DIMENSION. DO statement. FUNCTION and SUBROUTINE. COMMON and DATA ststements.(Note: Students learn these programming logics by “hand on ” experience on a personnel computer).	10
UNIT III	**Programming in Chemistry :** Development of small computer codes involving simple formulae in chemistry, such as van der Waal equation, pH titration, kinetics, radioactive decay. Evaluation of lattice energy and ionic radii from experimental data. Linear simultaneous equation to solve secular equation with Huckel theory. Elementary structural features such as bond lengths, bond angles, dihedral angles etc of molecules extracted from a data base such Cambrige data base.	5
UNIT IV	Programmes with data preferably from physical chemistry laboratory. Execution of linear regression such as X Y plot, numerical integration and differentiation as wel as differential equation solution programmes. Monte Carlo and molecular dynamics.	5
UNIT V	**Use of Computer Programmes :** The students will learn to how to operate a PC and how to run stsndard programmes and packages. Further, the students will operate one or two or more packages such as MATLAB, EASYPLOT, EXCEL, FOXPRO and Word Processing software – MS Word and Power point.	5

M.Sc. Chemistry, Semester - II
CHE-CC-226
Laboratory Course – Inorganic Chemitry

Credits :2

Synthesis and Physico-chemical characterization:

(a)Preparation of selected inorganic compounds;

1. $VO(acac)_2$
2. $TiO(C_9H_8NO)_2.\ 2(H_2O)$
3. cis- $K[Cr(C_2O_4)_2(H_2O)_2]$
4. Na $[Cr(NH_3)_2(SCN)_4]$
5. $Mn(acac)_3$
6. $K_3[Fe(C_2O_4)_3]$
7. $Co(NH_3)_6][Co(N)_2)_6]$
8. cis – $[Co(trien)(NO_2]Cl.H_2O$
9. $Hg[Co(SCN)_4]$
10. $[Co(Py)_2Cl_2]$
11. $[Ni(NH)_6)Cl_2$
12. $Ni(dmg)_2$
13. $[Cu(NH_3)_4]SO_4.H_2O$

(b) **Interpretation/calculations based on pre-recorded spectra of complexes** – electronic (UV-Vis), IR, ESR, Thermograms (TGA),Magnetic and electrochemical behaviour.

M.Sc. Chemistry, Semester – II
CHE-CC-227
Laboratory Course - Organic Chemistry

Credits :2

Organic Synthesis :

Acetoacetic acid ester condensation: Synthesis of ethyl n-butylacetonatoacetate by AEE condensation.

Cannizziro reaction : 4-Chlorobenzaldehyde as substrate,

Friedel Crafts Reaction ; β-benzoylpropionic acid from succinic anhydride and benzene,

Aromatic electrophilic substitutions : Synthesis of p-nitroaniline and p-bromoaniline.

The products may be Characterized by Spectral Techniques.

Quantative Analysis

Determination of the precentage or number of hydroxyl groups in an organic compound by acetylation method.

Estimation of amines / phenols using bromate solution / or acetylation method

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M.Sc. Chemistry, Semester – II
CHE-CC-228
Laboratory Course-Physical Chemistry

Credits :2

Instrumental : Electrochemistry *A. Conductometry :*

Determination of the Velocity constant, order of reaction and energy of activation for saponification of ethylacetate by sodium hydroxide conductometrically.

Determination of solubility and solubility product of sparingly soluble salts (e.g. $PbSO_4$, $BaSO_4$) conductometrically.

- Determination of the strength of strong and weak acids in a given solution by conductometry.
- 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 their mixtures (DMSO, DMF, dioxane, acetone, water) and
- to test the validity of Debye-Huckel-Onsager theory.
- Determination of activity coefficient of Zn ions in the solution of 0.002 M $ZnSO_4$ using Debye-Huckel's limiting law.

B. Potentiometry / pH metry

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

Acid-base titration in a non-aqueous media using a pH meter.

- Determination of activity and activity coefficient of electrolytes.
- Determination of dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
- Determination of thermodynamic constants ΔG, ΔH, ΔS for the reaction by e.m.f. method. $Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H$.

M.Sc. Chemistry, Semester - II
CHE -CC-229
Laboratory Course - Computer for Chemists

Credits :1

The students will learn to how to operate a PC and how to run standard programmer and packages – for chemistry applications.

Execution of linear regression such as X Y plot, numerical integration and differentiation as well as differential equation solution programmer .

Monte Carlo and molecular dynamics – PC Model, Programming with data preferably from physical chemistry laboratory-Basic/C/Fortran.

Operation of one or two or more packages such as EXCEL, Word Processing software – MS Word and Powerpoint, MATLAB, EASYPLOT, FOXPRO.

M.Sc. Chemistry, Semester – II
CHE – OE – 2210
Environmental Chemistry

Credits :2 30 Hrs

UNIT I	**Chemical Background:** Chemical constituents of Universe: Concepts of atoms and molecules, Structure of atom, introduction of atomic orbitals and formation of molecules, types of bonding, intermolecular forces of attraction	6
UNIT II	**Chemistry of Life:** Type of elements and Periodic Table, Essential, non-essential and toxic elements, General aspects of Biogeochemical cycles (Carbon cycle, Nitrogen cycle, Phosphorus Cycle, Tactonic cycle, Hydrologic cycle)	6
UNIT III	**Atmospheric Chemistry and Challenges:** Constituents of atmosphere and its role in maintaining life on the earth, Balance of atmospheric constituents, Causes of misbalance: natural and anthropogenic reasons, Ozone layer depletion, Green House Effect and Acid rain, probable solutions.	6
UNIT IV	**Soil: constituents and pollution** Constituents of Soil, Importance of soil constituents, Essential and toxic elements, organic and inorganic pollutants, mysterious crop cycle and bad farming practices, Current soil health, Nuclear wastes	6
UNIT V	**Water Constituent and pollution:** Chemistry of water and its role in controlling life, Some essential molecules and relation with water, causes of water pollution, effects of pollution, How to solve the issue	6

Books Suggested

Inorganic Chemistry

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson,John Wiley.
2. Inorganic Chemistry, J.E.Huhey, Harpes & Row.
3. Chemistry of Elements, N.N. Greenwood and A Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier
5. Magnetochemistry, R.L.Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D.gillars and J.A.McCleverty, Pergamon.
7. Coordination Chemistry, D.Banerjee, TMH,N.Delhi,1995
8. Coordination Chemistry, M.Satake, Discovery Publication House New Delhi.
9. Essential Trends in Inorganic Chemistry, D.M.P. Mingos, Oxford Univ. Press, N.Delhi 1995.
10. 10.Structural Inorganic Chemistry, A.F.Wells, ELBS
11. 11.Modern Aspects of Inorganic Chemistry, H.J.Emeleus, UBSID, N.Delhi

Organic Chemistry

1. Advanced Organic Chemistry-Reactions. Jerry March, John Wile
2. Advanced Organic Chemistry, F.A. Carey and n J.Sundberg, Plenum
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K.Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison and R.N.Byd. Prentice Hall.
6. Modern Organic reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M.Coxon, Blackie Academic & Professional
8. Pericyclic Reactions, S.M.Mukherji, Macmillan, India.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P.Singh, Macmillan.
10. Stereochemistry of Organic Compounds D. Nasipuri, New Age International
11. Setereochemistry of Organic Compounds, P.S.Kalsi, New Age International
12. Basic Stereochemistry of Organic Molecules, S.Sengupta, Book, Syndicate Pvt.Ltd. Kolkata, 1987.
13. Organic Photochemistry and Pericyclic Reactions, M.G.Arora, Anmol Publications, N.Delhi, 1994.

Physical Chemistry

1. Physical Chemistry; P.W. Atkins, ELBS
2. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill,1995
3. Quantum Chemistry, Ira N. Levine, Prentice Hall, 1975
4. Coulson's Valence, R.McWeeny, ELBS.
5. Chemical Kinetics, K.J.Laidler, McGraw Hill.
6. Kinetics Mexchanism of Chemical Transformations, J.Rajaram and J. Kuriacose, McMillan.
7. Micelles, Theoretical and Applied Aspects. V.Moroi, Plenum.
8. Modern Electrochemistry Vol. 1 and II J.O.M. Bockris and A.K.N. Reddy, Plenum.
9. Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J.Sridhar, wiley Eastern.
10. Electroanalyutical Chemistry, R.T.Sane, Quest Publications,Mumbai, 1999
11. Introduction to Electrochemistry, S.Glasstone, Affiliated East West Press N.Delhi, 1995.

12. Chemical kinetics, G.L. Agrawal, TMH, N.Delhi
13. Physical Chemistry for Macromolecules, D.D. Deshpande, Vishal Publications.
14. Quantum Chemistry, R.K. Prasad, New Age Intl., N.delhi.
15. Physical Chemistry for Macromolecules, D.D.Deshpande Vishal Publications.
16. Introductory Polymer Chemistry, G.S.Misra, New Age Intl., N.Delhi.
17. Introduction to Chemical Thermodynamics, R.P. Rastogi, Vikas, Pub. House, N.Delhi. 1997.
18. Statistical Thermodynamics, M.C.Gupta, New Age Intl., N.Delhi.
19. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Sears and Salinger. Narosa Publishing House, New Delhi.
20. Physical Chemistry, G.W.Narosa Publ.H.,N.Delhi,1994.
21. Statistical Thermodynamics (in Hindi) Farid Khan, M.P.Hindi Grantha Academy, Bhopal, 2001.
22. Irreversible Thermodynamics (in Hindi), Farid Khan, M.P.Hindi Grantha Academy, Bhopal, 2001.

Analytical Chemistry

1. Modern spectroscopy, J.M.Hollas, John Eiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H.Windai and F.L. Ho Wiley Interscience.
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V.parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S.Drago, Saunders College,
5. Chemical Application of Group Theory, F.A.Cotton.
6. Introduction to Molecular Spectroscopy, G.m.Borrow, MsGraw Hill.
7. Basic Principles of Spectroscopy, R.Chang, McGraw Hill.
8. Theory and Applications of UV Spectroscopy, P.K.Gosh, John Wiley.
9. Introduction to Magnetic Resonance, A. Carrington and A.D.Maclachalan, Harper & Row.

Computers

10. Computers and Common Sense, R.Hunt and J.Wiley, Prentice Hall.
11. Computational Chemistry, A.C.Norris,
12. Microcomputers Quantum Mechanics, J.P.Lillingbeck, Adam Hilger.
13. Computer Programming in FORTRAN IV,V.Rajaraman, Prentice Hall,
14. An Introduction to Digital Computer Design, V.Rajaraman and T.Radhakrishnan, Prentice Hall.

Dr. Hari Singh Gour Vishwavidyalaya, Sagar
M.Sc. CHEMISTRY
SCHEME OF EXAMINATION SEMESTER III

S. No.	Course Code	Course Name	Credits
		COMPULSORY	
01.	CHE-CC-321	Spectroscopy, Photochemistry, Solid state Chemistry	4
02.	CHE-CC-322	Bioinorganic, Bioorganic, Biophysical Chemistry	3
03.	CHE-CC-323	Environmental Chemistry	2
		ELECTIVE (Any Two)	
04.	CHE-EC-324	Organo transitional chemistry	3
05.	CHE-EC-325	Bio inorganic & Supramolecular chemistry	
06.	CHE-EC-326	Heterocyclic chemistry	
07.	CHE-EC-327	Chemistry of Natural Products	
08.	CHE-EC-328	Chemistry of Materials	
09.	CHE-EC-3210	Analytical Chemistry	
		COMPULSORY	
10.	CHE-CC-3211	Laboratory course-Inorganic Chemistry	1
11.	CHE-CC-3212	Laboratory course-Organic Chemistry	1
12.	CHE-CC-3213	Laboratory course-Physical Chemistry	1
		OPEN ELECTIVE	
13.	CHE-OE-3214	Applied Chemistry	2

Distribution of Marks :

Mid Sem. Exam 20 marks	Internal Assessment 20 marks			Total 40 Marks	End Sem Marks	Total Marks
20	Attendance	Assessment	Total	40	60	100
	5	15	20			

M.Sc. Chemistry, Semester - III

CHE-CC-321

Spectroscopy, Photochemistry and Solid State Chemistry

Credits :4 60 Hrs

UNIT I	**Photoacoustic spectroscopy** Basic principles of photoacoustic spectroscopy (PAS), PAS gases and condensed systems, chemical and surface applications. **Optical Rotatory Dichroism** [ORD] and Circular Dichorism{CD} Definition, deduction of absolute configuration, octant rule for ketones. **Nuclear Magnetic Resonance of Paramagnetic Substances in Solutions** The Complex, Contact and Pseudo-contact shifts, factors affecting nuclear relaxation, shift reagents, contrast agents, some applications including biochemical systems and over view of NMR of metal nuclides with emphasis on Pt^{195} & Sn^{119} NMR.	12
UNIT II	**Nuclear Magnetic Resonance Spectroscopy** General introduction and definition, Chemical shift, spin spin interaction, shielding mechanism, mechanism of measurement, 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), virtual cpoupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra- nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear overhauser effect (NOE). Resonance of other nuclei-F, P.	12
UNIT III	**Mass spectrometry** Introduction, ion production-EI, CI, FD and FAB, Factors affecting fragmentation ion analysis, ion abundance, mass spectral fragmentation of organic compounds of common functional groups. Molecular ion peak, metastable peak, McLafferty rearrangement, Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.	12
UNIT IV	**Photochemical Reactions:** Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecules, quantum yield, transfer of excitation energy,actinometry. Determination of Reaction Mechanism , Classification, rate constant and life times of reactive energy states — determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions, photo-dissociation, gas - phase photolysis. Photochemistry of Alkenes : Intramolecular reactions of the olefinic bond — geometrical isomerism, cyclisation reactions, rearrangement of 1,4 and 1,5- dienes	12
UNIT V	Solid state reactions : General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions **Crystal Defects and Non stochiometry** Perfect and imperfect crystals, intrinsic and extrinsic defects-point defects, line and plane defects, vacancies-Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non stochiometry and defects.	12

M.Sc. Chemistry semester III
CHE-CC-322
Bioinorganic, Bioorganic and Biophysical Chemistry

Credits : 3 45 Hrs

UNIT I	**Bioinorganic Chemistry**	9
	Metal ions in biological systems :Essential and trace metals; Na^+/K^+Pump : Role of metalions in biological processes. ; Bioenergetics and ATP Cycle DNA polymerisation, glucose storage, metal complexes in transmission of energy, chlorophylls, photosystem I and photosystem II in cleavage of water, model systems.	6
	Nitrogenase; Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenase model systems. Bioorganic Chemistry – Introduction : Basic considerations, proximity effects and molecular adaptation.	
UNIT II	**Enzymes**. : Introduction and historical perspective, chemical and biological catalysis.	6
	Remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Kosohfand's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labelling and enzyme modification by site directed mutagenesis, enzyme kinetics, Michaelis and Lineweaver- Burk plots, reversible and irreversible inhibition.	
	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 chymotrypsin, ribonuclease, lysoztyme and carboxypeptidase A	6
UNIT III	**Co-enzyme** Chemistry:Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological function of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD, NADP, FMN, FAD, lipoic acid, vitamin B12. Mechanisms of reactions catalyzed by the above cofactors	3
UNIT IV	**Biophysical Chemistry** :Biological Cell and its constituents.Biological cell, structure and function of proteins, enzymes, DNA and RNA in living systems,Helix coil transition.	6
	Bioenergetics :Standard free energy change in biochemical reactions, exergonic, endergonic, Hydrolysisof ATP, Synthesis of ATP from ADP.Statistical Mechanics in Biopolymers, Chain configuration of macromolecules, statistical distribution end to end dimensions,calculation of average dimensions for various chain structures, Polypeptide and proteinstructures, introduction to protein folding problem.	
UNIT V	**Biopolymer Interactions** :Forces involved in biopolymer interaction, electrostatic charges and molecular expansion,hydrophobic forces, dispersion force interactions, multiple equilibria and various types ofbinding processes in biological systems, Hydrogen ion titration curves.	9

M.Sc. Chemistry semester III

CHE-CC-323

Environmental Chemistry

Credits : 2 30 Hrs

UNIT I	**Environment** : Introduction, Composition of atmosphere, vertical temperature, heat budget of earth atmospheric system, the Biogeochemical cycle of C, N, P, S and O.	8
UNIT II	**Hydrosphere** :Chemical composition of water bodies-lakes, streams, rivers and wet lands etc. Hydrological cycle.Aquatic pollution- inorganic, organic, agricultural, industrial and sewage, detergents, oil spills and oil pollutants, Water quality parameters – dissolved oxygen, biochemical oxygen demand, solids, content of chloride, sulphate, nitrate and nitrite, Water quality standards. Analytical methods for measuring metals (As, Cd,Cr,F,Pb,Hg,Se,) Purification and treatment of water	7
UNIT III	**Soils** :Composition, micro and macro nutrients, Pollution- fertilizers, pesticides, plastics and metals. Waste treatment.	8
UNIT IV	**Atmosphere** :Chemical composition of atmosphere- particles, ions and radicals and their formation. Chemical and photochemical reactions in atmosphere, smog formation, oxides of N,C,S and their effect.	3
UNIT V	Pollution by chemicals, petroleum, chlorofluorohydrocarbons. Green house effect, acid rain, air pollution controls. Analytical methods for measuring air pollutants.	4

M.Sc. Chemistry semester III
CHE-EC-324
Organometallic Chemistry

Credits : 3 45 Hrs

UNIT I	**Alkyls and Aryls of Transition Metals :** Types, routes of synthesis, stability and decomposition pathways, organo copper in organic synthesis	9
UNIT II	**Compounds of Transition Metal-CarbonMultiple Bonds :**Alkylidenes, alkylidynes, low valent carbenes and carbynes-synthesis, nature of bond structural characteristics, nucleophilic and electrophilic reactions on the ligands,role in organic synthesis.	9
UNIT III	**Transition Metal Π-Complexes :** Transition metal Π-complexes with unsaturated organic molecules, alkenes, alkynes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligiands and to organic synthesis.	12
UNIT IV	Transition Metal Compounds with Bonds to Hydrogoen ;	2
	Homogeneous catalysis : Stochiometric reactions for catalysis homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reactions, activation of C-H bond.	8
UNIT V	**Fluxional Organometallic Compounds**Fluxionality and dynamic equilibria in compounds such as n^2-olefin, n^3-allyl and dienyl complexes.	5

Books Suggested

- Principles and Applications of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
- The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley
- Metallo-organic Chemistry, A.J. Pearson, Wiley
- Organometallic Chemistry, R.C. Mehrotra and A.Singh, New Age International

M.Sc. Chemistry semester III
CHE-EC-325
Bioinorganic and Supramolecular Chemistry

Credits : 3 45 Hrs

UNIT I	**Metal Storage Transport and Biomineralization**.: Ferritin, transferring, and siderophores	5
UNIT II	**Calcium in Biology:** Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extra cellular binding proteins.	4
UNIT III	**Metalloenzymes:** Zinc enzymes – carboxypeptidase and carbonic anhydrase, Iron enzymes – catalase, proxidase and cytochrome P-450. Copper enzymes- superoxide dismutase. Molybdenum oxatransferase enzymes – xanthine oxidase. Coenzyme vitamin B_{12}	10
	M**etal—Nucleic Acid Interactions :**Metal ions and metal complex interactions. Metal complexes – nucleic acid	5
UNIT IV	**Metals in Medicine :**Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.	3
UNIT V	**Supramolecular Chemistry :**Concepts and language.Molecular recognition: Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of co receptor molecules and multiple recognition.Supramolecular reactivity and catalysisTransport processes and carrier design.	18
	Supramolecular devices. Supramolecular photochemistry, supramolecular electronic, ionic and switching devices.Some example of self-assembly in supramolecular chemistry	

Books Suggested

1. Principles of Bioinorganic Chemistry, S.J.Lippard and J.M.Berg. University Science Books
2. Bioinorganic Chemistry, I Bertomo, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books
3. Inorganic Biochemistry vols I and II ed. G.L. Eichhorn, Elsevier.
4. Progress in Inorganic Chemistry, Vols 18 and 38 ed. J.J. Lippard, Viley
5. Supramolecular Chemistry, J.M. Lehn. VCH

M.Sc. Chemistry semester III
CHE-EC-326
Heterocyclic Chemistry

Credits : 03 45 Hrs

UNIT I	**Nomenclature of heterocycles :** Systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles.	05
	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).	05
	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 interaction.Stereo-electronic effects- anomeric and related effects.	05
UNIT II	**Heterocyclic synthesis:** Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions.	05
UNIT III	**Small ring heterocycles :** Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes; Benzo-fused five membered heterocycles ; Synthesis and reactions of benzopyrroles, benzofurans and benzothiophenes; Meso-ionic heterocycles General classification,Chemistry of some important meso-ionic heterocycles of type-A and B and their applications.	10
UNIT IV	**Six-membered heterocycles with one heteroatom :** Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium, thiopyrylium salts and pyridones; Six-membered heterocycles with two or more heteroatoms ;Synthesis and reactions of diazines, triazines, tetrazines and thiazines. Seven and large-membered heterocycles :Synthesis and reactions of azepines, oxepines, thiepines, diazepinesthiazepines, azocines, diazocines, dioxocines and dithiocines.	10
UNIT V	**Heterocyclic systems**:Heterocyclic rings containing P, As, Sb and B: Introduction, nomenclature, synthesis and characteristics of 5-and 6-membered ring systems.	05

Books Suggeste Heterocyclic Chemistry Vol. 1-3, R. R. Gupta, M. Kumar and V. Gupta, Springer Verlag.

1. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
2. Heterocyclic Chemistry, J. A. Joule, K. Mills and G. F. Smith, Chapman and Hall.
3. Heterocyclic Chemistry, T. L. Gilchrist, Longman Scientific Technical.
4. Contemporary Heterocyclic Chemistry, G. R. Newkome and W. W. Paudler, Wiley-lnter Science.
5. An Introduction to the Heterocyclic Compounds, R. M. Acheson, John Wiley.

M.Sc. Chemistry semester III
CHE-EC-327
Chemistry of Natural Products

Credits : 3 45 Hrs

UNIT I	**Terpenoids and Carotenoids :** Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry and synthesis of the following molecules: Citral, Geraniol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-Carotene.Biosynthesis of terpenoids	7
UNIT II	**Alkaloids :** Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry and synthesis of the following: Ephedrine, Nicotine, Atropine, Quinine and Morphine: Biosynthesis of alkaloids.	10
UNIT III	**Steroids** Occurrence, nomenclature, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Bile acids, Testosterone, Progestrone. Biosynthesis of steroids.	8
UNIT IV	**Plant Pigments :** Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Myrcetin, Quercetin-3-glucoside, Vitexin, Daidzein, Cyanidin-3, 5-diglucoside, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway. **Porphyrins :**Structure and synthesis of haemoglobin and Chlorophyll.	12
UNIT V	**Prostaglandins :** Occurrence, nomenclature, classification, biogenesis and physiological effects of Prostaglandins. Pyrethroids and Rotenones : Chemistry and importance of Pyrethroids and Rotenones. (For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible)	8

Books suggested

1. Natural Products: Chemistry and Biological Significance, J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthrope and J. B. Harborne, Longman, Essex.
2. Organic Chemistry, Vol. 2, I. L. Finar, ELBS.
3. Stereo selective Synthesis: A Practical Approach, M. Nogradi, VCH.
4. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
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 Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers.
8. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.

M.Sc. Chemistry semester III
CHE-EC- 328
Chemistry of Materials

Credits : 3 45 Hrs

UNIT I	**Multiphase Materials:** Ferrous alloys; Fe-C phase transformations in ferrous alloys; stainless steels, non-ferrous alloys, properties of ferrous and non-ferrous alloys and their applications. **Thin film and Langmuir-Blodgett Films :**Preparation techniques; evaporation / sputtering, chemicalprocesses, MOCVD, sol-gel etc. Langmuir-Blodgett (LB) Film, growth techniques, photolithography, properties and applications of thin and LB Films.	9
UNIT II	**Glasses, Ceramics, Composites and Nanomaterials :** Glassy state, glass former and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Refractories, characterization, properties and applications.**Microscopic composites**; dispersion-strengthened and particle-reinforced, fibre-reinforced composites, macroscopic composites. Nanocrystalline phase, preparation procedures, special properties, applications.	9
UNIT III	**Liquid Crystals :**Mesmorphic behavior, thermotrophic liquid crystals, positional order, bond orientational order, nematic and smecticmesophases; smectic–nematic transition and clearing temperature-homeotrophic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic A and smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals. **Polymeric Materials :** Molecular shape, structure and configuration, crystallinity, stress-strain behaviour, thermal behaviour, polymer types and their applications, conducting and ferro-electric polymers	9
UNIT IV	**Ionic Conductors :** Types of ionic conductors, mechanism of ionic conductions, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors. **High T_c materials :** Defect perovskites, high Tc superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials, normal state properties; anisotropy; temperature dependence of electrical resistance; optical phonon modes, superconducting state; heat capacity; coherence length, elastic constants, position life times, microwave absorption–pairing and multigap structure in high Tc materials, applications of high Tc materials.	9
UNIT V	**Organic Solids, Fullerenes, Molecular Devices :** Conducting organics, organic superconductors, magnetism in organic materials.Fullerenes-doped, fullerenes as superconductors.Molecular rectifiers and transistors, artificial synthetic devices, optical storage memory and switches-sensors. **Nonlinear optical materials**: nonlinear optical effects, second and third order-molecular hyperpolarisability and second order electric susceptibility-materials for second and third harmonic generation.	9

Books Suggested

1 Solid State Physics, N. W. Ashcroft and N. D. Mermin, Saunders College.
2 Materials Science and Engineering, an Introduction, W. D. Callister, Willey.
3 Principles of the Solid State, H. V. Keer, Willey Eastern.
4 Materials Science, J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings, ELBS
5 Thermotropic Liquid Crystals, Ed., G. W. Gray, John Willey.
6 Handbook of Liquid Crystals, Kelker and Hatz, ChemieVerlag.

M.Sc. Chemistry semester III

CHE-EC-3210

Advanced Analytical Chemistry

Credits : 3 45 Hrs

UNIT I	**Classification and Sample Preparation** :Classification of Analytical methods–classical and instrumental. Types of instrumental analysis. Volumetric analysis glassware calibration, Samples and sample preparation - Introductory idea of sampling, dissolution and decomposition. Gravimetric techniques. Reagents in analysis and their application	9
UNIT II	**Errors and Evaluation** :Definition of terms in mean and median. Precision-standard déviation, relative standard déviation. Accuracy-absolute error, relative error. Type of error in experimental data determinate (systematic), indeterminate (or random) and gross, Sources of errors and the effects upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data-indeterminate errors. The uses of standard statistical packages.	9
UNIT III	**Food Analysis** ;Moisture, ash, crude protein, fat crude fibre, 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.	9
UNIT IV	**Analysis of Water Pollution** :Origin of waste water, types, water pollutants and their effects. Sources of water pollution domestic, industrial, agricultural soil and radioactive wastes as sources of pollution. Objectives of analysis-parameter for analysis-colour, turbidity, total solids, conductivity, acidity, alkalinity, hardness, chloride, sulphate, fluoride, silica, phosphates and different forms of nitrogen. Heavy metal pollution public health significance of cadmium, chromium copper, lead, zinc, manganese, 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.	9
UNIT V	**Analysis of Soil, Fuel, Body Fluids and Drugs** :Analysis of soil: moisture, pH, total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts. Fuel analysis: solid 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. **Clinical chemistry**: Composition of blood collection and preservation of samples Clinical analysis. Serum electrolytes, blood glucose blood urea nitrogen, uric acid albumin, globulins, barbiturates, acid and alkaline phosphates, immunoassay principles of radio immunoassay (RIA) and applications. The blood gas analysis trace elements in the body. **Drug analysis;** Narcotics and dangerous drugs. Classification of drugs. Screening by gas and thin layer chromatography and spectrophotometric measurements.	9

Books Suggested

1. Analytical Chemistry, G.D. Christian, J. Wiley
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Hooller,
3. W.B. Saunders.Analytical Chemistry Principles, J.H. Kennedy, W.B. Saunders.
1. Analytical Chemistry Principles and techniques, L.G. Hargis, Prentice Hall.
2. Principles of Instrumental analysis, D.A. Skoog and J.L. Loary, W.B. Saunders.
3. Principles of instrumental analysis, D.A. Skoog, W.B. Saunders.
4. Quantitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall
5. Environmental Solution Analysis, S.M. Khopkar Wiley Eastern
6. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.
7. Handbook of Instrumental Techniques for Analytical Chemistry, F.Settle, Prentice Hall.

M.Sc. Chemistry semester III
CHE-CC-3211
Laboratory Course -Inorganic Chemistry

Credits : 2

(X) Preparation of Selected inorganic compounds.

1.Synthesis and thermal analysis of group II metal oxalate hydrate. J.Chem.Ed., 1988, 65, 1024.
2.Atomic absorption of group II metal oxalate hydrate.
3.Synthesis of trichlorodiphenylantimony (V) hydrate.
4.Sodiumtetrathionate $Na_2S_4O_6$.
5.Metal complexes of dimethyl sulfoxide: $CuCl_2$.2DMSO, $PdCl_2$.2DMSO, $RuCl_2$.4DMSO. J.Chem.Educ., 1986, 63, 90.
6.Synthesis of metal acetylacetonate: Inorg.Synth, 1957, 5, 130; 1963, 1, 183.
7.Bromination of $Cr(acac)_3$. J.Chem.Edu., 1986, 63, 90.
8.Magnetic moment of $Cr(acac)_2H_2O$.
9.Cis and Trans $[Co(en)_2Cl_2]^+$.
10.Determination of Cr(III) complexes. $[Cr(H_2O)_6]NO_3.3H_2O$, $[Cr(H_2O)_4Cl_2]Cl.2H_2O$, $[Cr(en)_3]Cl_3$, $Cr(acac)_3$. Inorg. Synth. 1972, 13, 184.
11.Preparation of N,N bis(salicyldehyde)ethylenediamine, salen H_2, Co(salen). J.Chem.Educ., 1977, 54, 443; 1973, 50, 670. Determination of O_2 absorption by Co(salen). Acct. Chem. Res., 1975, 8, 384. Reaction of oxygen adduct with $CHCl_3$ (deoxygenation).
12. Preparation of [Co(phenonthroline-5,6-quinone)]. J.Chem.Soc., A., 1970, 447; J.Chem.Edu., 1977, 54, 710.
13.Preparation and use of Ferrocene. J.Chem.Edu., 1966, 43, 73, 730.
14.Preparation of Copper glycine complex-cis and trans bis (glycinato Copper (II)). J.Chem.Soc.Dalton, 1979, 1901, J.Chem.Edu.1982, 59, 1052.
15.Conversion of p-xylene to terephthalic acid catalyzed by $Co(Br)_2$ (homogeneous catalysis).

(y) Study and interpretation of spectra of inorganic complexes: by IR, electronic spectra, ESR, XRD, Magnetic and electrochemical behaviour. Handling of air and moisture sensitive compounds involving vacuum lines.

M.Sc. Chemistry semester III
CHE-CC-3212
Laboratory Course- Organic Chemistry

Credits : 2

Qualitative Analysis

Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid), using TLC for checking the purity of the separated compounds, chemical analysis, IR, PMR and mass spectral data.

- Extraction of Organic Compounds from Natural Sources
- Isolation of caffeine from tea leaves.
- Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).
- Isolation of lactose from milk (purity of sugar should be checked by TLC, PC and Rf value reported.)
- Isolation of nicotine dipicrate from tobacco.
- Isolation of cinchonine from cinchona bark.
- Isolation of piperine from black pepper.
- Isolation of lycopene from tomatoes.
- Isolation of β- carotene from carrots.
- Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid).
- Isolation of eugenol from cloves.
- Isolation of (+) limonine from citrus rinds.

Spectrophotometric (UV/VIS) Estimations

- Amino acids, Proteins , Carbohydrates, Cholesterol, Ascorbic acid, Aspirin, Caffeine

M.Sc. Chemistry semester III
CHE-CC- 3213
Laboratory Course-Physical Practical

Credits : 2

Thermodynamics

Determination of partial molar volumes of solute (eg KCL) and solvent in a binary (alcohol+ H_2O + NaCl + H_2O) mixture .

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

Spectroscopy :

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

Determination of stoichiometry and stability constant of inorganic (eg. Ferric – salicylate acid) and organic (eg. Amine – iodine) complexes.

Characterisation of complexes by electronic and R spectral data.

M.Sc. Chemistry semester III
CHE – OE – 3214
Applied Chemistry

Credits : 2 30 Hrs

UNIT I	Chemistry of Drugs: Pharmalogical activity, uses of Antipyretics, Analgesics, Antiseptics, Antibacterials.	06
UNIT II	Definition of Paints, varnishes and lacquers, their constitutions and functions. General classification of surface coating. What is cement and its importance in construction, Cement manufacturing process, material composition of cement, Description and use of various type of Cement : Portland Cement, Low heat Cement and Oil Well Cement.	06
UNIT III	High Energy Materials, and Chemical Safety: Definition, classification, synthesis and uses: nitrobenzene, TNT, picric acid, mono and ethylene glycol, nitroglycerine, nitrocellulose, manitol and RDX, Fire retardants: Definition and classification.	06
UNIT IV	Classification of commercial nitrogenous fertilizers, manufacturing of ammonium sulphate, Urea, Ammonia nitrate, Commercial phosphatic fertilizers, manufacturing process and properties of phosphatic fertilizers, Biofertilizers: demands and production.	06
UNIT V	Metal Finish: Basics of electrodeposition, Electroplating principles and practice, Electrochemistry applied to electroplating, Electroplating of metals chromium, cadmium, nickel, copper, silver, gold. Glass & Ceramics: Physical and chemical properties of glasses, Raw materials, manufacturing of special glasses. Ceramics and their properties, raw materials.	06

Dr. Hari Singh Gour Vishwavidyalaya, Sagar
M.Sc. CHEMISTRY
SCHEME OF EXAMINATION SEMESTER IV

S.No.	Course Code	Course Name	Credits
		COMPULSORY	
01.	CHE-CC-421	Spectroscopy, Photochemistry, Solid state Chemistry	4
02.	CHE-CC-422	Bioinorganic, Bioorganic, Biophysical	3
03.	CHE-CC-423	Environmental Chemistry	2
		ELECTIVE (Any Two)	
04.	CHE-EC-424	Photo Inorganic chemistry	3
05.	CHE-EC-425	Organic Synthesis	
06.	CHE-EC-426	Medicinal chemistry	
07.	CHE-EC-428	Chemistry of Nanomaterials	
08.	CHE-EC-429	Electro Chemistry	
09.	CHE-EC-4210	Advanced Analytical Chemistry	
		COMPULSORY	
10.	CHE-CC-4212	Project in Chemistry	6

Distribution of Marks :

Mid Sem. Exam 20 marks	Internal Assessment 20 marks			Total 40 Marks	End Sem Marks	Total Mark
	Attendance	Assessment	Total			
20	5	15	20	40	60	100

M.Sc. Chemistry semester IV

CHE-CC- 421

Spectroscopy, Photochemistry and Solid State Chemistry

Credits : 4 60 Hrs

UNIT I	**Nuclear Quadrupole Resonance Spectroscopy** Quadrupole nuclei, quadrupole moments, electric field gradients, coupling constants, splitting, applications **Moss Bauer Spectroscopy:** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structure of Fe^{2+} and Fe^{3+} compounds including those of intermediate spin, (2) Sn^{2+} and Sn^{4+} compounds – nature of M-L bond, co-ordination number, structure and (3) detection of oxidation states in equivalent MB atoms.	12
UNIT II	**C-13 NMR spectroscopy:** General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbon), coupling constants. Two dimension NMR spectroscopy-COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques **Photochemistry of Carbonyl Compounds:** Intramolecular reactions of carbonyl compounds – saturated, cyclic and acyclic, unsaturated and - unsaturated compounds. Cyclohexadienones. Intermolecular cycloaddition reactions- dimerisation and oxetane formation **Photochemistry of Aromatic compounds :** Isomerisations, additions and substitutions.	12
UNIT III	**Miscellaneous Photochemical Reactions:** Photo- Fries reactions of anillides. Photo-Fries rearrangement, Barion reaction, Single molecular oxygen reactions, Photo-chemical formation of Smog, Photo-degradation of polymers. Photochemistry of vision	12
UNIT IV	**Electronic Properties and Band Theory:** Metals, insulators and semiconductors, electronic structure of solids- band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors. Optical properties – Optical reflectance, photo-conduction, photoelectric effects, Magnetic Properties – Classification of materials: Quantum theory of Paramagnetics - cooperative phenomena-magnetic domains, hysteresius: behaviour of substances in a magnetic field, effect of temperature on magnetic materials, calculation of magnetic moment.	12
UNIT V	**Combinatorial Spectroscopy :** General guidelines for the interpretation of UV-spectra. Characteristic vibrational frequencies of Organic compounds, Characterization of simple organic compounds by combinatorial spectroscopy using methodology for joint application of UV,IR,^{1}H and ^{13}C-NMR and Mass spectral data.	12

M.Sc. Chemistry semester IV
CHE-CC-422
Bio inorganic, Bioorganic and Bio Physical Chemistry

Credits : 3 45 Hrs

UNIT I	**Bioinorganic Chemistry** Transport and Storage of Dioxygen:-Heme proteins and oxygen uptake, structure and function of Haemoglobin, Myoglobin, Hemocyanins and Hemerythrin, model synthetic complexes of Iron, cobalt and copper. Electron Transfer in Biology:- Structure and function of metalloproteins in electron transport process – cytochromes and Iron – sulpher proteins, synthetic models.	13
UNIT II	**Bio-organic Chemistry:** Kinds of 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 isomerization reactios, β - cleavage and condensation, some isomerization and rearrangement reactions, Enzyme catalyzed carboxylation and decarboxylation.	8
	Enzyme Models : Host – guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crown ether, cryptates.Cyclodextrins, cyclodextrin- based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes or synzymes	5
UNIT III	**Bio-technological 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 corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.	6
UNIT IV	**Biophysical Chemistry :** Thermodynamics of Biopolymer Solutions ; Thermodynamics of biopolymer solutions, osmotics pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.	8
	Cell Membrane and Transport of Ions : Structure and function of cell membrane, ion transport through celll membrane, irreversible thermodynamics treatment of membrane transport, Nerve conduction.	
UNIT V	**Biopolymers** and their Molecular Weights : Evaluation of size, shape molecular weight and extent of hydration of biopolymers by various experimental techniques, Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, viscosity, electrophoresis and rotational motions.	5
	Diffraction Methods : Light scattering, low angle X-Ray scattering, X-Ray diffraction and photo correlation spectroscopy, ORD.	

M.Sc. Chemistry semester IV
CHE-CC-423
Environmental Chemistry

Credits : 2 30 Hrs

UNIT I	**Industrial Pollution:** Cement, distill, paper and pulp sugar	6
UNIT II	Thermal power plant, nuclear power plant	6
UNIT III	Metallurgy, polymers, drugs, radionuclide analysis, disposal of wastes and their management.	6
UNIT IV	**Environmental Toxicology:** Chemical solutions to environmental problems, biodegradability, principles of decomposition, better industrial processes.	6
UNIT V	Bhopal Gas Tragedy, Chernobyl, Three Mile Island and Minamata disasters.	6

M.Sc. Chemistry semester IV
CHE-EC-424
Photo-inorganic Chemistry

Credits : 3 45 Hrs

UNIT I	Basis of Photochemistry Absorption, excitation, photochemical laws, quantum yield, electronically excited states life times-measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck-Condon principle, photochemical stages-primary and secondary processes.	8
UNIT II	Properties of Excited States Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Bimolecular deactivation- quenching.	7
UNIT III	Excited State of Metal Complexes Excited State of Metal Complexes: comparison with organic compounds, electronically excited states of metal complexes, charge-transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.	7
UNIT IV	Redox reactions by Excited Metal Complexes Energy transfer under conditions of weak interaction and strong interaction-exciplex formation; condition of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2′-bipyridine and 1,10-phenthroline complexes), illustration of reducing and oxidizing character of Ruthenium^{2+}(bipyridal complexes), comprasion with $Fe(bipy)_3$; role of spin orbital coupling-life time of these complexes, Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light.	15
UNIT V	Metal Complexes Sensitizers Metal complex sensitizer, electrons relay, metal collide systems,and semiconductor supported metal or oxide systems, water photolysis, and nitrogen fixation and carbon dioxide reduction.	8

M.Sc. Chemistry semester IV

CHE-EC-425

Organic Synthesis

Credits : 3 45 Hrs

UNIT I	**Organometallic reagents**:Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details. Group I and II metal organic compounds Li, Mg, Zn and Ce compounds ;Transition metals : Cu, Fe, Rh and Ti compounds.Other elements Si and B.	9
UNIT II	**Rearrangements** General mechanistic considerations- nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hofman, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction.	9
UNIT III	**Metallocenes**, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds General considerations, synthesis and reactions of some representative compounds.	9
UNIT IV	**Disconnection approach** An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis.	9
UNIT V	**Two Group C-C disconnections** Diels-Alder reaction, α,β-unsaturated carbonyl compounds, Micheal addition and Robinson annelation. **Ring synthesis** Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis.Synthesis of Cortisone, Vitamin-D and Juvabione.	9

Books Suggested

1. Modern Synthetic Reactions, H. O. House, W. A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, CambridgeUniv. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March, John Wiley.
4. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, Blackie Academic and Professional.
5. Advanced Organic Chemistry Part B, F. A. Carey and R. J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compouns, Ed. S. Coffey, Elsevier.
7. Designing Organic Synthesis, S. Warren, Wiley.
8. Organic Synthesis- Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlage VCH.

M.Sc. Chemistry semester IV
CHE-EC- 426
Medicinal Chemistry

Credits : 3 45 Hrs

UNIT I **Drug design** 9

Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure activity relationship (QSAR). History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-chemical parameters; lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials. Free-Wilson analysis, Hansch analysis, relationships between Free-Wilson and Hansch analysis. LD-50, ED-50 (Mathematical derivations of equations excluded).

UNIT II **Pharmacokinetics** 9

Important pharmacokinetic parameters in defining drug disposition in therapeutics. Uses of pharmacokinetics in drug development process.

Pharmacodynamics

Introduction, Enzyme stimulation, enzyme inhibition, drug metabolism, xenobiotics, biotransformation. Significance of drug metabolism in medicinal chemistry.

UNIT III **Antineoplastic agents** 9

Introdudction, cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer, carcinolytic antibiotics and mitotic inhibitors.

Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards, and 6-mercaptopurine. Recent development in cancer chemotherapy.

UNIT IV **Cardiovascular drugs** 9

Introduction, cardiovascular diseases, drug inhibitors . Synthesis of amyl nitrate, sorbitrate, diltiazem, quinidine, verapamil, methyldopa, atenolol, oxyprenolol.

Local antiinfective drugs

Introduction and Synthesis of sulphonamides, furazolidone, nalidixic acid, ciprofloxacin, norfloxacin, dapsone, isoniazid, fluconazole, griseofulvin and chloroquin.

UNIT V **Psychoactive drugs** 9

Introduction, CNS depressants, general anesthetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, benzodiazepines. Synthesis of diazepam, oxazepam, chlorazepam, alprazolam and barbiturates.

Antibiotics

β-lactam rings antibiotics, Synthesis of penicillin-G, penicillin-V, chloramphenicol, cephalosporin, tetracycline and streptomycin

Books Suggested

1. Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH.
2. Wilson and Gisvold's Text Book of organic Medicinal and Pharmaceutical Chemistry, Ed Robert F. Dorge.
3. An Introduction to Drug Design, S. S. Pandeya and J. R. Dimmock, New Age International.
4. Burger's Medicinal Chemistry and Drug Discovery, Vol. 1 (Chapter-9 and Ch-14), Ed. M. E. Wolff, John Wiley.
5. Goodman and Gilman's Pharmacological Basis of Therapeutics, Mc Graw-Hill.
6. The Organic Chemistry of Drug Design and Drug Action, R. B. Silverman, Academic Press.
7. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.

M.Sc. Chemistry semester IV
CHE-EC-428
Chemistry of Nanomaterials

Credits : 3 45 Hrs

UNIT I	**Nanoparticles and its Chemistry** Nanoparticles, Methods of synthesis of nanoparticles, different reducing agents and stabilizing agents, reactivities and catalytic activities of nanoparticles. Characterization of nanoparticles. Applications of nanoparticles.	9
UNIT II	**Soft and Hard Template Chemistry** Different templates and their importance, surfactants, type of surfactants, Micelle formation, vesicle formation, Sol – Gel method, Top down and Bottom up approachs in nanomaterials.Applications of soft and hard templates.	9
UNIT III	**Nanoporous Materials** Micro, Meso and Macro porous materials, methods o f synthesis, different additions in nanoporous materials. Surface area of porous materials and its determination.	9
UNIT IV	**Applications of Nanoporous materials:** Thermogravimetric studies of nanoporous materials. Applications of porous materials in drug delivery, molecular catalysis, biosensor technology and Bio-filtration.	9
UNIT V	**Quantum dots and its Chemistry** Quantum dots, mechanism on the basis of band gap, excitons, quantum confinement effect, Bohr's radius in quantum dots, Different applications.	9

M.Sc. Chemistry semester IV
CHE-EC-429
Electrochemistry

Credits : 3 45 Hrs

UNIT I	**Electrodeposition:** Factors affecting elctrodeposition of metals, Simultaneous discharge of cations, depolarisation of metal deposition, separation of metals by electrolysis. Electrochemical passivity, Passivity and current density, chemical passivity, theories of passivity, Mechanical passivity, Electroplating.	2
UNIT II	**Corrosion:**The corrosion of metals, hydrogen evalution type and differential oxygenation type-corrosion. Corrosion inhibition. Electrochemical theory of Corrosion.	8
UNIT III	**Newer Polarographic techniques:** General treatment and applications of the following techniques: Oscilographic polarography ; AC polarography ; Pulse polarography, NPP and DPP, Anodic stripping voltammetry and cyclic voltammetry , ChronopotentiometrySpectroelctrochemistry.	18
UNIT IV	**Environmentally Oriented Electrochemistry:**The environmental situation, the electrochemical advantages. The solar-hydrogen solution. The CO_2 fixing, Photo-electrochemical reduction of CO_2. Electrochemical removal of wastes: (i)Waste water (ii) Sulphur dioxide (iii) Removal of metals (iv) Destruction of nitrates. Electrochemical treatment of low level nuclear wastes. Bactericidal effects.	9
UNIT V	**Designer of Electrodes:** Introduction,formation of monolayers of organic molecules on electrodes. Different electrodes of carbon as electrode material: Glassy corban electrode, carbonfibre electrode, carbon paste electrode and carbon nano-tube paste based electrode and their applications.	8

M.Sc. Chemistry semester IV
CHE-EC-4210
Advanced Analytical Chemistry

Credits : 3 45 Hrs

UNIT I	**Basic theory and instrumentation** Functional Elements of a Measuring System,Measuring Instruments , Control Instruments,Calibration Instruments, Testing Instruments, Analytical Instrument, Analog Instrument ,Digital Instrument**,** Transducer or sensors in Instruments. Some of the important sensors along with their properties for Laboratory techniques and application : thermal pressure, ion and gas sensing probes, micro-electrodes, optical spectrophotometers, ICP in AAS / AES. Hyphenated techniques.	9
UNIT II	**Thermo analytical methods**, thermogravimetric analysis, Thermogravimetric analysis (TGA): mass ; differential thermal analysis (DTA): temperature difference and differential scanning calorimetry (DSC): heat difference ; Thermomechanical analysis (TMA): dimension ; Dilatometry (DIL): volume ; Dynamic mechanical analysis (DMA) : mechanical stiffness & damping ; Dielectric thermal analysis (DEA): dielectric permittivity & loss factor ; Evolved gas analysis (EGA) : gaseous decomposition products ; Thermo-optical analysis(TOA) : optical properties	9
UNIT III	**Electro chemical methods,**spctro electrochemistry. Modification of the electrodes for the analytical applications and development of biosensors for the study of mechanism of drug action and bio electrodes.	9
UNIT IV	**Chromatographic methods,** Classification: Technique and Mechanism; paper and thin layer chromatography adsorption, liquid liquid partition, ion exchange, HPTLC, DCC, gel permeation, and gel electrophoresis and gas chromatography, HPLC.Columns and detectors in GC-HPLC - Hyphenated techniques	9
UNIT V	**Radio chemical methods,** traces in chemical analysis, isotopic exchange, isotope dilution analysis. NAA, **Optical microscopy:** transmission electron microscope and scanning electron microscope. Atomic force microscopy, electron and neutron scattering, osmometry, tensiometry, ultrasonic absorption study	9