

M.Sc CHEMISTRY
SEMESTER III
PAPER XI - SPECTROSCOPY

Time : 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C: Part A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 words). Part-C (30 marks) contains six question one from each unit. Each question is of ten marks(400 words).

UNIT-I

¹³C NMR Spectroscopy

Difficulties and solution for recording, ¹³C- NMR spectra recording of ¹³C NMR spectra scale solvent signals and their positions, multiplicity, ¹³C-¹H coupling constant- proton coupled and decoupled ¹³C spectra broad bands decoupling off resonance technique. Chemical shifts in ¹³C spectra- calculation in internal and terminal substituted compounds, aromatic compounds. Use of ¹³C spectra in differentiating in primary, secondary and tertiary carbons by Dept-45, Dept-90, dept-135 Spectra.

²D NMR Spectroscopy: Theory and Principles of ²D NMR Spectroscopy, Interpretation of ¹H-¹H COSY, ¹H-¹³C Hector, HMQC, HMBC, Inadequate Spectra.

UNIT-II

Mass Spectroscopy

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

UNIT-III

Applications of spectroscopy

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

Books Suggested :

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

PAPER XII -PHOTOCHEMISTRY AND SOLID STATE CHEMISTRY

Time : 3 Hours

Max. Marks: 50

Note: Paper is divided in to three independent units. The question paper is divided in three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five question at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 marks). Part-C (30 marks) contains six question from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks(400 words).

UNIT-I

Electronic Properties and Band Theory

Metals, Insulators and semiconductors, electronic structure of solids- band theory. Band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junction.

Super conductors- Definition types and BCS theory

Optical properties- optical reflectance, photoconduction- photoelectric effects. Magnetic Properties- Classification of materials-magnetic domains, hysteresis.

UNIT-II

(a) Photochemical Reactions

Interaction of electromagnetic radiation with matter, type of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

(b) Determination of Reaction Mechanism

Classification, rate constants and life time of reactive energy state-determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Type of photochemical reactions-photodissociation, gas-phase photolysis.

(c) Photochemistry of Alkenes.

Intermolecular reactions of the olefinic bond-geometrical isomerism cyclisation reaction, rearrangement of 1,4-and 1,5-dienes.

UNIT-III

(a) Photochemistry of Carbonyl Compounds

Intermolecular reactions of the carbonyl compounds- saturated, cyclic and acyclic, - unsaturated and unsaturated compound, cyclohexadienones. Intermolecular cycloaddition reaction-dimerisation and oxetane formation.

(b) Photochemistry of Aromatic Compounds

Isomerisations, additions and substitutions.

(c) Miscellaneous Photochemical Reactions

Photo-Fries reactions of anilides. Photo-Fries rearrangement. Barton reaction. Singlet molecular oxygen reactions. Photochemical formation of smog. Photo Degradation of polymers. Photochemistry of vision.

Books Suggested :

1. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rakin and S. Craddock, EIBS.
2. Progress in Inorganic Chemistry vol., 8th ed., F.A Cotton, vol., 15, ed, S.J. Lippard, Wiley.
3. Transition Metal Chemistry ed. R.L. Carlin vol.3 Dekker.
4. Inorganic Electronic Spectroscopy, A.P.B. Lever Elsevir.
5. Fundamentals of Photochemistry, K.K Rohtagi- Mukherji, Wiley-Eastern.
6. Essentials of Molecular Photochemistry A. Gilbert and J.Baggott, Blackwell Scientific Publication.
7. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
8. Introductory Photochemistry, A Cox and T.Chap. Mc-Graw Hill.
9. Photochemistry. R.IP. Kundall and A Gilbert, Thomson Nelson.
10. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.

PAPER XIII - ENVIRONMENTAL CHEMISTRY

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided in to three independent units. The question paper is divided in three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five question at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 marks). Part-C (30 marks) contains six question from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks(400 words).

UNIT-I

(a) Air

Chemical composition of atmosphere, ions and radicals and their formation, chemical and photochemical reactions in atmosphere. Greenhouse effect, acid rain, ozone hole phenomenon, temperature inversion.

Source and toxic effects of Pb, Cd, Hg, As, Cr, Ni, and Mn.

(b) Air Pollution

Classification of air pollutants- sources, effect and control of CO, SO₂, NO, HC as gaseous pollutants, suspended particulate matter aerosols, photochemical air pollution.

UNIT-II

(a) Water

Water quality parameters and their analysis, treatment of drinking water and waste water.

(b) Water Pollution

Sources of water pollution-solid waste, industrial, agricultural, oil, radioactive waste, thermal pollution. Classification of water pollutants- basis, effects and controls. Sampling of water pollutants.

UNIT-III

Soil and Soil Pollution

Chemical profile of soils, definition, fertility management of soils, soil sediment analysis- physical and chemical parameters.

Soil-pollution- sources, detrimental effects and control.

Books Suggested

1. Environmental Chemistry, S.E. Mannahan, Lewis Publishers.
2. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern.

5. Standard Method of Chemical Analysis. F.J. Welcher Vol.III Van Nostrand Reinhold Co.
6. Element Analysis of Airborne Particles, Ed.S. Landsbergeer and M. Creatchman,Gordon and Breach Science Publication.
7. Environmental Chemistry, C Baird, W.H. Freeman.

PAPER XIV- CHEMISTRY OF LIFE

Time: 3 Hours.

Max. Marks: 50

Note: Paper is divided in to three independent units. The question paper is divided in three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five question at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 marks). Part-C (30 marks) contains six question from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks(400 words).

Unit-I

(a) Metals (Mg, Ca, Mn, Fe, and Co) in Biological Systems Definition and classification of metals.

(b) Na^+/K^+ Pump

Role of bulk and trace metals ions in biological processes.

(c) **Bioenergetics**

Standard free energy change in biochemical reactions, exergonic,endergonic, Hydrolysis of ATP, synthesis of ATP from ADP.

(d) **Cell Membrane and Transport of Ions**

Ion transport through cell membrane, irrversible thermodynamic, treatment of membrane transport. Nerve conduction.

Unit-II

(a) Enzymes

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

(b) Mechanism of Enzyme Action

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

Unit-III

(a) Co-Enzyme Chemistry

Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate., NAD^+ , NADP^+ , FMN, FAD, lipoic acid, Vitamin B_{12} .

(b) Biotechnical Application of Enzymes

Use of enzymes in food and drink industry-brewing and cheese making, syrups from corn starch, enzymes as targets for drug design, recombinant DNA technology.

Books Suggested

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M Berg. University Science Books.
2. Bionorganic Chemistry, I Bertini. H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books
3. Inorganic biochemistry vols I and II G.L. Eichorn, Elsevier.

4. Progress in Inorganic Chemistry, Vols 18 and 38 ed. J.J. Luippard, Wiley.
5. Bioorganic Chemistry: A Chemical Approach to Enzyme Action. H.Dugas and C. Penny, Springer Verlag.
6. Understanding Enzyme, Trevor Palmer, Prentice Hal.
7. Enzyme Chemistry: Impact and Application, Ed. Collin J. Suckling. Chapman and Hall.
8. Fundamental of Enzymology, N.C. Price and L. Stevens. Oxford University Press.
9. Immobilized Enzymes: An introduction and Application in Biotechnology. Michael D. Trevan. John Wiley.
10. Enzymatic Reaction Meachanisms, C. Walsh, W.H. Freeman.
11. Enzyme Structure and Mechanism, A Fersht, W.H. Freeman.
12. Biochemistry: The Chemical reaction of Living Cells, D.E. Metzler, Academic Press.
13. Enzyme Mechanisms Ed. M.I. Page and A Williams, Royal Society of Chemistry.
14. Principle of Biochemistry, A.L. Lehninger, Worth Publishers.
15. Biochemistry, L.Stryer. W.H. Freeman
16. Biochemistry, J. David Rawn. Neil Patterson.
17. Biochemistry, Voet and Voet, John Wiley.
18. Outline of Biochemistry. E.E. Conn and P.K. Stumpf, John Wiley.
19. Bioorganic Chemistry: A chemical Approach to Enzyme Action. H. Durgas and C. Penny, Springer- Verlag.
20. Macromolecules: Structure and Function, F. World, Prentice Hall.

PAPER XV - PRACTICALS

TIME: 07 HOURS

MAX. MARKS: 100

INORGANIC

A. INORGANIC PREPARATIONS (At least seven preparations)

1. Prepare sodium amide
2. Prepare calcium oxalate
3. Prepare magnesium oxalate
4. Prepare sodium tetrathionate $\text{Na}_2\text{S}_4\text{O}_6$
5. Prepare vanadyl acetylacetonate $\text{VO}(\text{acac})_2$
6. Prepare $\text{Fe}(\text{acac})_2$
7. Prepare $\text{R}_2\text{Sn}(\text{acac})_2$
8. Prepare $\text{Cr}(\text{acac})_2$
9. Prepare $\text{Cu}(\text{acac})_2 \cdot \text{H}_2\text{O}$
10. Prepare $\text{Al}(\text{acac})_3$
11. Prepare tris (acetyl acetanato) manganese(II)
12. Prepare Fe (II) chloride
13. Prepare ferrocene
14. Prepare copper glycine complex

B. ORGANIC CHEMISTRY (At least seven mixtures)

QUALITATIVE ANALYSIS

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

C. PHYSICAL (Perform at least seven experiments.

1. Determine the partial molar volume of solute and solvent in a binary mixture
2. Study the effect of addition of an electrolyte on the solubility of an organic acid.
3. Determine the composition of binary mixture containing $\text{K}_2\text{Cr}_2\text{O}_7$ and KMnO_4 using spectrophotometer.
4. Determine the heat of neutralization of hydrochloric acid by sodium hydroxide.
5. Determine the heat neutralization of two acids eg HCl and CH_3COOH and hence their relative strengths.
6. Study the adsorption of iodine from alcoholic solution on charcoal
7. Study the adsorption of certain dyes such as methyl violet, picric acid or malachite green on charcoal.
8. Find the specific rotation and molecular rotation of cane sugar polarimetrically and also find the concentration of the unknown solution (concentration lies 1% and 5%). Calculate intrinsic rotation for cane sugar.
9. Study the influence of added impurity on rotation of a solute.
10. Investigate the inversion of cane sugar in the presence of an acid say HCl at 30 degree Celsius
11. Calculate the molecular weight of a high molecular weight polymer by means of viscosity measurements.
12. Study the complex formation and find the formula of silver amine complex by partition method.

13. Determine the solubility product of calcium hydroxide using common ion effect of sodium hydroxide or of any other strong alkali.
14. Determine the transition temperature of sodium sulphate dehydrate by solubility method.
15. Determine the rate constant of a reaction between acetone and iodine in presence of mineral acid and a catalyst and to show that this reaction is of zero order with respect to iodine.
16. Estimate the amino acid using ninhydrin method
17. Study the kinetics of reaction between glycolic acid and ceric ammonium sulphate.
18. Determine the effect of concentration of salt on the reaction between glycolic acid and ceric ammonium sapphire.
19. Determine Na and K in a mixture by flame photometry
20. Determine Na and K in mixture by flame photometry
21. Determine Li, Na and K individually in three different solutions by flame photometry.
22. Verify Beer's law for the solubility and determine the concentration of the given unknown aqueous solution of KMnO_4
23. Determine the solubility of various salts like NaCl , KCl , KNO_3 , NaNO_3 at the different temperature and draw solubility curve.

M.SC. CHEMISTRY

SEMESTER-IV

GROUP-A

PAPER XVIA- CONTEMPORARY INORGANIC CHEMISTRY

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided in to three independent units. The question paper is divided in three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five question at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 marks). Part-C (30 marks) contains six question from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks(400 words).

Unit-I

(a) Alkyls and Aryls of Transition Metals

Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis.

(b) Compounds of Transition Metal-Carbon Multiple Bonds

Alkylidenes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic reactions on the ligands, role in organic synthesis. Compounds with metal - metal multiple bonds.

Unit-II

(a) Transition Metal - Complexes

Transitions Metal- Complexes with unsaturated organic molecules alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions related to nucleophilic and electrophilic attack on ligands and applications in organic synthesis.

Unit-III

(a) Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^2 -olefin, η^3 -allyl and dienyl complexes.

(b) Homogenous Catalysis

Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reactions), Oxopalladation reactions, activation of C-H bond.

Books Suggested:

1. Principles and Application of Organotransition Metal Chemistry J.P. Collman, L.S. Hegdus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metal
3. Metallo-Organic Chemistry, A.J. Pearson, Wiley.
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.

PAPER XVII A- BIOINORGANIC CHEMISTRY

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided in to three independent units. The question paper is divided in three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five question at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 marks). Part-C (30 marks) contains six question from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks(400 words).

Unit-I

(a) Metalloenzymes and their role in biological systems

Zinc enzymes-carboxypeptidase and carbonic anhydrase. Iron enzyme catalyses, peroxidase and cytochrome P-450. Copper enzyme- superoxide dismutase. Molybdenum oxatransferase enzyme- xanthine oxidase, Coenzyme, Vitamin B₁₂.

(b) Metals In Medicines

Metals deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

Unit-II

(a) Metal Storage Transport and Biomineralization with reference to

Ferritin, transferrin, and siderophores.

Unit III

Oxygen transport and oxygen uptake proteins. Basic requirement for effective oxygen carriers, biological oxygen carriers. Haemoglobin (Hb) and Myoglobin (Mb) in oxygen transport mechanism. Structural feature of Heme group in Hb and Mb. Functions of Hb and Mb. Characteristics of oxygen binding interactions with Hb and Mb.

Books Suggested:

1. Bioinorganic Biochemistry, Bertini, H.B. Gray, S.J. Valentine, University Science Books.
2. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, 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, Wiley.

PAPER XVIIA-ADVANCE COORDINATION CHEMISTRY

Time: 3 Hours

Max. Marks: 50

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Unit-I

Supra molecular Chemistry (Concepts and language)

- (i) Molecular recognition: Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of co-receptor molecules and multiple recognition.
- (ii) Supra molecular reactivity and catalysis.
- (iii) Transport processes and carrier design.
- (iv) Supra molecular devices-electronic, ionic and switching, supra molecular photochemistry, some examples of self-assembly in supra molecular chemistry.

Unit-II

(a) Excited States of Metal Complexes

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

(b) Metal complex Sensitizers

Matal complex sensitizer, electron relay, metal colloid system, semiconductor supported metal or oxide system, water photolysis, nitrogen fixation and carbon dioxide reduction.

Unit-III

(b) Redox Reactions by Excited Metal Complexes

Energy transfer under conditions of weak interaction and strong interaction-exiplex formation, conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2' -bipyridine and 1, 10 phenanthroline complexes), illustration of reducing and oxidising character of Ru (II) (bipyridal complex, comparison with Fe (bipy)₃ role of spin-orbit 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.

Books Suggested:

1. Supramolecular Chemistry, J.M.Lehn, VCH.
2. Supramolecular and Bioinorganic Chemistry. By Dr. AK Goswami & Dr. Rekha Dashora, Pragati Prakashan
3. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegus, J.R. Norton and R.G. Finke, University Science Books.
4. The Organometallic Chemistry of the Transition Metals, H.R. Crabtree, John Wiley.
5. Metallo-Organic Chemistry, A.J. Pearson, Wiley.
6. Organometallic chemistry, R.C. Mehrotra and A. Singh, New Age International.
7. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
8. Bioinorganic Biochemistry, I.Bertini, H.B. Gray, S.J. Valentine, University Science Books.
9. Inorganic Biochemistry vols I and II. Ed. G.L.Eichhorn Elsevier.
10. Progress in Inorganic Chemistry. Vols 18 and 38 ed. J.J. Lippard, wiley.
11. Supramolecular Chemistry, J.M.Lehn, VCH.
12. Concepts of Inorganic Photochemistry, A. W. Adamson and P.D. Fleischauer, Wiley.
13. Inorganic Photochemistry, J.Chem. Educ. Vol. 60, no, 10, 1983.

14. Progress in Inorganic chemistry, vol 30, ed. S.J. Lippard, Wiley.
15. Coordination Chem Revs, 1981, vol. 39, 121, 131; 1975, 15, 321; 1990, 97313,
16. Photochemistry of Coordination Compounds, V. Balzari and V. Carassiti, Academic Press.
17. Elements of Inorganic Photochemistry, G.J.Ferraudi, Wiley.

PAPER XIXA-INORGANIC POLYMERS.

Time: 3Hours

Max. Marks:50

Note: Paper is divided in to three independent units. The question paper is divided in three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five question at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks (100 marks). Part-C (30 marks) contains six question from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks(400 words).

Unit-I

(a) Basics Polymers

Importance of polymers. Basic concepts: monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition, radical chain-ionic and co-ordination and co-polymerization. Polymerization in homogeneous and heterogeneous systems.

(b) Polymer Characterization

Poly dispersion-average molecular weight concept. Number, weight and viscosity average molecular weights, Poly dispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weights. End-group, viscosity, light scattering, osmotic and ultra-centrifugation methods. Analysis and

testing of polymers-chemical analysis of polymers, spectroscopic methods. X-ray diffraction study, microscopy. Thermal analysis and physical testing-tensile strength. Fatigue, impact, tear resistance. hardness and abrasion resistance.

Unit-II

(a) Structure and Properties of Polymers

Morphology and order in crystalline polymers-configurations of polymer chains. Crystal structure of polymers. Morphology of crystalline polymers, strain induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point (T_m) melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, (T_g) Relationship between T_m and T_g , effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

Unit-III

(b) Polymer Processing

Plastics, elastomers and fibers. Compounding, Processing techniques:- calendaring, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fiber spinning.

(c) Properties of Commercial Polymers

Polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers-Fire retarding polymers and electrically conducting polymers. Biomedical polymers-contact lens, dental polymers, artificial heart, kidney, skin and blood cells.

Books Suggested:

1. Text book of Polymer Science, F.W. Billmeyer Jr, Wiley.
2. Polymer Science, V.R. Gowarikar, N.V. Vuswanathan and J. Srcehar, Wiley-Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and RM. Ottanbrite.

4. Cotemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.
5. Physics and Chemistry of Polymers, J.M.G. Cowie, Blackie Academic and Professional.

GROUP-B

PAPER XVI B-ORGANIC SYNTHESIS-I

Time: 3 Hours

Max. Marks: 50

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Unit-I

(a) Oxidation

Introduction, Different Oxidative Processes.

Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and inactivated), Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids. Amines, hydrazines and sulphides.

(b) Reduction

Introduction, Different reductive processes.

Hydrocarbons- alkanes, alkenes, alkynes and aromatic rings.

Carbonyl compounds- aldehydes, ketones. Acids and derivatives. Epoxides.

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, Beckmann, Hofmann, Curtius, Schamidt, Baeyer-Village, Shapiro reaction.

Unit-III

(a) Organometallic Reagents

Principles, preparations, properties and applications of the following in organic synthesis with mechanistic details.

(i) Group I and II metal organic compounds

Li, Mg, Hg, Cd, Zn Compounds

(ii) Transition Metals

Cu, Pd, Ni, Fe, Co, Rh, Cr and Ti Compounds.

(b) Protecting Groups

Principle of Protection of alcohol, amine, carbonyl and carboxyl group.

Books Suggested

1. Modern Synthetic Reactions, H.O House, W.A. Benjamin.
2. Some modern methods of Organic Synthesis, W. Carruthers, Cambridge Univ. 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 & Professional.
5. Advanced Organic Chemistry Part B. F.A. Carey and R.J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compounds, ed. S Coffey, Elsevier.

7. Designing Organic Synthesis. S. Warren, Wiley.
8. Organic Synthesis- Concept, methods and starting Materials. J. Fuhrhop and G. Penzillin, Veriage VCH.

PAPERXVII B- ORGANIC SYNTHESIS-II

Time: 3 Hours

Max. Marks: 50

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Unit-I

(a) One Group C-C Disconnections

Alcohols and carbonyl compounds, regioselectivity. Alkene Synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

(b) Two Group C-C Disconnections

Diels-Alder reactions 1,3-difunctionalised compounds. - unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalized compounds . Micheal addition and Robinson annelation.

Unit-II

Synthesis of Some Complex Molecules

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

Unit-III

(d) Ring Synthesis

Saturated heterocycles, synthesis of 3-,4-5 and 6 membered rings, aromatic heterocycles in organic synthesis

Books Suggested

1. Modern Synthetic Reactions, H.O House, W.A. Benjamin.
2. Some modern methods of Organic Synthesis, W. Carruthers, Cambridge Univ. 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 & Professional.
5. Advanced Organic Chemistry Part B. F.A. Carey and R.J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compounds, ed. S Coffey, Elsevier.
7. Designing Organic Synthesis. S. Warren, Wiley.
8. Organic Synthesis- Concept, methods and starting Materials. J. Fuhrhop and G. Penzillin, Veriage VCH.

PAPER XVIIIIB- HETEROCYCLIC CHEMISTRY

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each questions is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question of ten marks (400 words)

Unit-I

(a) Nomenclature of Heterocycles

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

(b) Aromatic Heterocycles

General chemical behavior of aromatic heterocycles, classification (structural type), criteria of aromaticity (Bond lengths, ring current and chemical shifts in ^1H NMR-spectra, empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations.)

Heteroaromatic reactivity and tautomerism in aromatic heterocycles.

(c) 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. Attractive interactions-hydrogen bonding and intermolecular nucleophilic- electrophilic interactions.

Unit-II

(a) Heterocyclic Synthesis

Principles of heterocyclic synthesis involving cyclization reaction and cycloaddition reactions.

(b) Small Ring Heterocycles

Three - membered and four - membered heterocycles - synthesis and reactions of aziridines, oxiranes, azetidines, oxetanes.

(c) Heterocyclic Systems containing P- Heterocyclic ring containing phosphorus: Introductions, nomenclature, synthesis and characteristics of 5-and 6 membered ring systems-phosphorinanes, phospholanes and phospholes.

(d) Six-Membered Heterocycles with one Heteroatom

Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones.

Unit-III

(a) Benzo Fused Five-membered Heterocycles

Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes. Meso-Ionic heterocycles.

(b) Seven-Membered heterocycles with Two or More Heteroatoms

Synthesis and reactions of tetrazines and thiazines.

Books Suggested :

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

PAPER XIX B- NATURAL PRODUCTS

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10

questions (50 words each). Each questions is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question of ten marks (400 words)

Unit-I

(a) Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.

Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol, -Terpeneol, Menthol, Farnesol, Santonin, Phytol, Abietic acid and -Carotene.

(b) Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants.

Structure, stereochemistry, synthesis and biosynthesis of the following:

Ephedrine, Nicotine, Atropine, Quinine and Morphine.

Unit-II

(a) Prostaglandins

Occurrence, Nomenclature, Classification, biogenesis and physiological effects.
Synthesis of PGE₂ and PGF_{2a}

(b) Pyrethroids and Rothenones

Synthesis and reactions of Pyrethroids and Rotenones.

(For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible.)

(c) **Steroids**- Occurrence, nomenclature, basic skeleton , Diel's hydrocarbon and stereo chemistry isolation, structure determination and synthesis of Cholesterol. Bile acids, androsterone, estosterone, Estrone Progesterone, Aldosterone. Biosynthesis of Steroids.

Unit-III

(a) Plant Pigment

Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Quercetin, Myrcetin, Diadzein, Butein, Cychanidin, Hirsutidin.

Biosynthesis of flavonoids; Acetate pathway and Shikimic acid pathway.

(b) **Porphyryns**- Structure and synthesis of Haemoglobin and Chlorophyll.

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, Vol2.1L. Finer, ELBS.
3. Rodd's Chemistry of Carbon Compounds, ED, S. Coffey, Elsevier.
4. Chemistry, Biological and Pharmacological Properties of Medical Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston Harwood Academic Publishers.
5. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers.
6. New Trends in Natural Products Chemistry, Atta-ur-rahman and M.I. Choudhary, Harwood Academic Publishers.
7. Insecticides of Natural Origin, Sukhdev, Harwood Academic Publishers.

GROUP-C

PAPER XVI C- CHEMICAL DYNAMICS-I

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each questions is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question of ten marks (400 words)

Unit-I

(a) Inorganic Substitution Reactions

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

Unit-II

Electron transfer reactions.

(a) **Inner sphere electron transfer reactions.** Henry taube's classical study of electron transfer reactions between chloropentammine cobalt (III) and Cr(II). A general mechanism involving precursor complex. Various types of bridges, Electron transfer mechanisms: adjacent attack, remote attack, resonance mechanism and chemical mechanism.

sintra-molecular electron transfer reactions.

(b) **Outer sphere electronic transfer reactions.** Outer sphere electron transfer mechanism Marcus cross relation and its applications. Bridged outer sphere electron transfer mechanism. Kinetics of electron exchange mechanism.

Unit-III

(a) **Radiation Chemistry** Introduction, sources of high energy raditation, dose, primary and secondary process, radiolysis of water, reaction of hydrogen atoms and hydroxide radicals, radiation chemical yield.

(b) **Photochemistry** Unimolecular photophysical processess and their rate laws, kinetics and mechanism of photochemical hydrogen-Bromine reaction, Kinetics of collisional quenching and Stern-Volmer equation, Semi conductor photocatalysis-formation of hole.

Excited state electron transfer reaction of $[\text{Ru}(\text{bipy})_3]^{2+}$ and photocatalytic splitting of water.

Suggested Books

1. Keith J. Laidler, Chemical Kinetics. Harper and Row, New York 1987
2. Donald A McQuirrie and John D. Simo, Physical Chemistry A Molecular approach viva Books New Delhi. 2013.
3. J.E. Huheey E.A. Keiter, O.K Medhiu, Inorganic Chemistry Darling kindersley, New Delhi. 2013.
4. S.K. Upadhyay, Chemical Kinetics and Reaction Mechanism, Anamya, Delhi, 2006.
5. J. Rajaram and J.C. Kuriacose, Kinetics and Mechanism of Chemical transformations, Mcmillan India and National Book Trust, Delhi, 1993.
6. K.K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age, Delhi, 1986
7. Progress in Inorganic Chemistry, Vol. 30, 1967.
8. R. Lumry and R.W. Raymond, Electron transfer Reactions, Inter science.
9. N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein Wiley.
10. A.G. Sykes, Kinetics of Inorganic reactions, Pergamon.
11. S.W. Benson, Mechanism of Inorganic Reactions, Reactions, Academic Press.
12. Physical Chemistry Vol. 2 Ed. Prof. Ya Grasimov, Mir Publisher.
13. Basolo and Pearson, Inorganic Reaction Mechanism, Wiley.
14. H. Taube, Electron Transfer Reaction, Oxford Press.
15. Jingwei Luo, Allen G. Oliverb and J. Scotr McIndoe, A detailed Kinetic analysis of rhodium -catalyzed alkyne hydrogenation, Dalton Trans. 2013, 42, 11312

16. V.Y. Gankin & G.S. Gurevich, Chemical Technology of oxosynthesis, "Khimiya" (Chemistry) in Leningrad.
17. F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn., John Wiley, Singapore, 1999.

PAPER XVII C -CHEMICAL DYNAMICS-II

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each questions is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question of ten marks (400 words)

Unit-I

(a) Atmospheric Kinetics

Kinetics and mechanism of photodissociation of NO₂ and formation of ozone in troposphere. Mechanism of Operation of ClO_x cycle in stratosphere and depletion of ozone. Mechanism and kinetics of oxidation of methane by oxygen in atmosphere, Mechanism of hydrogen-oxygen reaction.

(b) Kinetics of gas surface reactions

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

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

Unit-II

(a) Enzymes kinetics

Kinetic and mechanism of one enzymes - two substrate systems

Kinetics mechanism of inhibition of enzyme catalysis.

(b) Miceller catalysis

Micelles - their formation and structure and CMC. Kinetics and mechanism of micelle catalyzed reactions. Different models of miceller catalysis. Micelle inhibited reactions.

Unit-III

(a) Oscillatory Reactions

Autocatalysis and oscillatory reactions, Outline of kinetics and mechanism of Belousov-Zhabotinski (B-Z) reaction.

(b) Induced Reactions-

Induced Reactions and their characteristics. Mechanism of iron (II) induced oxidation of iodine by chromium (VI) Mechanism of arsenic (III) induced oxidation of manganese (II) by chromium (VI) in acid solutions.

(c) Industrial Catalysis-

Kinetics of hydroformylation reaction, kinetics of Wacker process of formation of acetaldehyde from ethylene. Kinetics of hydrogenation catalysed by Wilkinson catalyst.

Books Suggested

1. Keith J. Laidler, Chemical Kinetics, Harper and Row, New York, 1987
2. Donald A McQuarrie and John D. Simon, Physical chemistry A Molecular approach, Viva Books, New Delhi, 2013
3. J.E. Huheey, Chemical and Reaction Mechanism, Anamya, Delhi, 2006
4. S.K. Upadhyay, Chemical Kinetics and Reaction Mechanism, Anamya, Delhi, 2006

5. J. Rajaram and J.C. Kuriacose, Kinetics and Mechanism of Chemical transformations, Mcmillan India and National Book Trust, Delhi, 1993
6. N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein Wiley.
7. A.G. Sykes, Kinetics of Inorganic reactions, Pergamon.
8. Physical chemistry Vol. 2 Ed. Prof. Ya Grasimov, Mir Publisher.
9. Jingwei Luo, Allen G. Oliverb and J. Scott McIndoe, A detailed kinetic analysis of rhodium -catalyzed alkyne hydrogenation, Dalton Trans. 2013, 42, 11312
10. F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn., John Wiley, Singapore, 1999

PAPERXVIII C-ELECTRO CHEMISTRY-I

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks (400 words).

Unit-I

Conversion and storage of Electrochemical Energy:

Present status of energy consumption: Pollution problem. History of fuel cells. Direct energy conversion by electrochemical means. Maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the

Carnot efficiency factor in electrochemical energy convertors. Power outputs. Electrochemical Generators (Fuel Cells) Hydrogen oxygen cells, hydrogen Air cell,

Hydrocarbon air cell, alkaline fuel cell, phosphoric fuel cell, direct NaOH fuel cells. Applications of fuel cells.

Unit-II

(a) Electrochemical Energy Storage:

Properties of Electrochemical energy stores; measure of battery performance. Charging and discharging of a battery. Storage density, Energy density

Classical Batteries (i) Lead-Acid (ii) Nickel-Cadmium. (iii) Zinc-Manganese dioxide.

Modern batteries: (1) Zinc-Air (ii) Nickel-Hydrate, (iii) Lithium Battery.

Future electricity stores: storage in (i) Hydrogen, (ii) Alkali metals (iii) Non aqueous solutions.

Unit-III

(a) Corrosion and Stability of Metals:

Civilization and surface mechanism of the corrosion of the metals, thermodynamics and the stability of metals, Potential pH (or pourbaux) Diagrams. Uses and abuses, Corrosion current and corrosion potential-Evans diagrams.

Measurement of corrosion rate: (i) Weight loss Method (ii) Electro chemical Method.

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

(b) Passivation:

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

Books suggested:

1. Modern Electrochemistry vol. I,IIA Vol. IIB, J'OM Bochriss and A.K.N. Reddy, Plenum Publication, New York.
2. Polarographic. Techniques by L. Meites, Interscience.

3. "Fuel Cells; Their electrochemistry" McGraw Hill Book Company New York.
4. Modern Polarographic Methods by A.M. Bond, Marcell Dekker.
5. Polarography and allied technique by K. Zutshi, New Age Publication New Delhi.
6. "Electroanalytical Chemistry" by Badil H. Vessor & Galen W. Wiley Interscience.
7. Topic in Pure and Applied Chemistry. Ed. S.K. Rangrajan, SAEST Publication, Kararikudi (India).

PAPERXIXC-ELECTROCHEMISTRY-II

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each questions is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question of ten marks (400 words).

Unit-I

(a) Kinetics of Electrode Process:

Essential of electrode reaction. Current density, Overpotential, Butler Volmer equation, Standard rate constant. Transfer coefficient (α), exchange current,

(b) **Irreversible Electrode Processes:** Criteria of irreversible information from irreversible wave. Methods of determining kinetic parameters for quasi-reversible and irreversible waves: Koutecky's method. Meits Israel methods, Gelling's method.

Unit-II

(a) **Bioelectrochemistry:** Bio-electrodes, membrane, potentials, simplistic theory, modern theory. Electrical conductance in biological organism. Electronic, protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

(b) Electro catalysis: Chemical catalysis and Electrochemical catalysis with special reference to purostates, porphyrin oxides of rare earths, Electro catalysis in simple redox reactions, in reaction involved adsorbed species, Influence of various parameters.

Unit-III

(a) Potential Sweep Method:

Linear sweep voltammetry, Cyclic voltammetry, theory and applications, Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode technique, comparison with controlled potential methods Chronopotentiometry, theory and applications.

(b) Bulk Electrolysis Methods

Controlled potential coulometry, Controlled coulometry, Electro organic synthesis and its importance, application, stripping analysis, anodic and cathodic modes, pre electrolysis and stripping steps, application of stripping analysis.

Books suggested:

1. Modern Electrochemistry vol. I,IIA Vol. IIB, J'Om Bockris and A.K.N. Reddy, Plenum Publication, New York.
2. Polarographic. Techniques by L. Meites, Inr\terscience.
3. "Fuel Cells; Their electrochemistry" McGraw Hill Book Company New York.
4. Modern Polarographic Methods by A.M. Bond, Marcell Dekker.
5. Polarography and allied technique by K. Zutshi, New Age Publication New Delhi.
6. "Electroanalytical Chemistry" by Badil H. Vessor & Galen W. Wiley Insterscience.
7. Topic in Pure and Applied Chemistry. Ed. S.K. Rangrajan, SAEST Publication, Kararikudi (India).

GROUP-D

PAPER XVI D-FORENSIC CHEMISTRY

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks (400 words).

Unit-I

(a) **Proteins-** Definition, classification, General properties molecular weight, denaturation, isoelectric point, coagulation of proteins, salting and salting out of proteins & reactions.

(b) **Nucleic acids** - Chemistry of purines, pyrimidine and uric acid-synthesis and uses of uracil, cytosine, thymine, adenine, guanine- isolation of caffeine from its natural source-constitution of RNA and DNA, DNA profiling. DNA finger printing.

Unit-II

(a) **Vitamins-Definition**, occurrence, properties and types with special reference to Vitamins A and B.

(b) **Hormones** - Definition, types, biological activities of Pituitary. Thyroid and Sex Hormones.

(c) **Blood** - General composition and Antigenic properties, Blood coagulation. Preliminary idea of Antigen, Antibody and immunological principle. Structure of antibodies. Forensic identification and grouping of Blood stains.

Unit-III

Identification & estimation of following narcotics - Opium, Morphine. Heroine, Barbiturate, Cocaine and Diazepam

PAPER XVIII-ANTHROPOMETRY AND TOXICOLOGY

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks (400 words).

Unit-I

(a) Introduction to body as a whole: The various body systems and organs injuries from burn, scald, lightning, electricity, Ante mortem and post mortem burn; Injuries on road, air crash, explosion; Wound-definition, types and classification, medicological importance. Ante and Post mortem wounds. Self inflicted wounds.

(b) Alcohol & alcoholic beverages - Manufacture of ethanol and liquors-chemical properties and identification of alcohol, constituents of liquors-estimation of alcohol content in liquors-denaturation, denaturants, industrial alcohol and power alcohol, breath alcohol analysis, Analysis of alcohol in Blood and urine samples.

Unit-II

(a) Drug action and effect - Isolation, synthesis and estimation of alkaloids, drug dose relationship, mechanism of drug action. Absorption, distribution and elimination.

(b) Anthropometry : Elementary knowledge of human skeleton. Importance of anthropometry in Forensic science. Determination of height from bones. Determination of sex from bones. Age determination from cranium and other body bones. Identification of deceased by super imposition of skull. Identification of species by small bone fragments.

Forensic odontology: Forensic examination of semen stains. Teeth-identification, type, functions, determination of species origin and race from teeth, individualization from teeth and bite marks.

Unit-III

Toxicology Definition and general introduction to toxicology, Poisons-types, mode of action, extraction of poisons in toxicological analysis. Absorptions, distribution, metabolism, chemistry of poison, excretion of poisons, Detection and estimation of CO, Cyanide, formaldehyde, methanol, chloral, chloroform, phenols, cresols, phosphorus, As, Hg, Pb and Cd. Organophosphorus, organochlorine and carbamate pesticides and pyrethroids, corrosive poisons. Elementary knowledge of food poisoning.

PAPER XVIII D- METHODS OF INSTRUMENTAL ANALYSIS

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each question is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks (400 words).

Unit-I

(a) **Electron microscopy**-principle, instrumental components, transmission electron microscopy, preparation of sample with special reference to biological tissue, applications.

Scanning electron microscopy-principle, electron specimen interactions, instrumental components, preparation of samples, applications.

Inductively coupled plasma atomic emission spectroscopy (ICPAES)- Principles and instrumentation.

Unit-II

Chromatography and Electrophoresis

Principle, instrumentation and application of:

Gas Chromatography

High performance liquid chromatography

Ion exchange chromatography.

Electrophoresis-paper electrophoresis, thin layer electrophoresis, gel electrophoresis and immune electrophoresis.

Unit-III

Principal, instrumentation, application of:

Atomic absorption spectrophotometry (AAS)

X-ray fluorescence spectrometry (XRF)

Radio immuno assay (RIA)

Neutron activation analysis (NAA)

PAPER XIXD-INSTRUMENTAL AND BIOCHEMICAL ANALYSIS

Time: 3 Hours

Max. Marks: 50

Note: Paper is divided into three independent units. The question paper is divided into three parts Part-A, Part-B and Part-C. Part-A (10 marks) is compulsory and contains 10 questions (50 words each). Each questions is of one mark. Part-B (10 marks) is compulsory and contains five questions at least one from each unit. Candidate is required to attempt all five questions. Each question is of two marks(100 words). Part-C (30 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each unit. Each question is of ten marks (400 words).

Unit-I

(a) Thermal Methods - principle, instrumentation and applications of thermogravimetry (TGA), differential thermal analysis (DTA) and differential scanning calorimetry (DSC)

(b) Optical Methods - Principle instrumentation and applications of refractometry, polarimetry, nephelometry and turbidimetry colorimetry.

Unit-II

Analysis of biological fluids

Determination of blood group, red cell isoenzymes and serum protein in paternity determination, ABO blood group system and MNS group system. Laboratory examination of semen stain, saliva stain, urine stain.

Unit-III

(a) Food analysis and food adulteration - Analysis of major and minor components of food, common adulterants in food, microscopic examination of foods for adulteration, pesticide analysis in food products.

(b) Elements of Statistics- mean, mode, median, correlation and regression analysis, null hypothesis, variance, t-test, chi-square test.

PAPER XX-PRACTICALS (FOR GROUP - A, B, C)

Time: 07 Hours

Max. Marks-100

A. Inorganic

(a) Spectrophotometric Determination (Any Three)

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

(b) Flame Photometric Determinations (Any Three).

1. Sodium and potassium when present together.
2. Lithium/Calcium/barium/strontium

3. Cadmium and magnesium in tap water.
4. Sulphate,
5. Phosphate
6. Silver.

(c) Chromatographic Separations (Any Three)

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

B. Organic

(a) Organic synthesis

Multi-step Synthesis of Organic Compounds (any four)

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

(i) Photochemical reaction

Benzophenone benzpinacol benzpinacolone

(ii) Beckmann rearrangement: benzanilide from benzene

Benzene Benzphenone Benzophenone oxime benzanilide

(iii) Benzoin benzil benzilic acid

- (iv) Preparation of Quinoline from aniline; Preparation of 2-phenylindole from phenylhydrazine.
- (v) Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S(+) ethyl-3-hydroxybutanoate and determine its optical purity.
- (vi) Biosynthesis of ethanol from sucrose.
- (vii) Synthesis using microwave-Alkylation of diethylmalonate with benzyl chloride.
- (viii) Synthesis using phase transfer catalyst.

Extraction of organic compound from natural source

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins.)
3. Isolation of lactose from milk (Purity of sugar should be checked by TLC and PC and R_f (value reported).)
4. Isolation of nicotine dipicrate from tobacco.
5. Isolation of cinchonine from cinchona bark.
6. Isolation of piperine from black pepper.
7. Isolation of lycopene from tomatoes.
8. Isolation of β -carotene from carrots.
9. Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid.
10. Isolation of eugenol from cloves.
11. Isolation of (+) limonene from citrus rinds.

(b) Spectroscopy

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

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

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

C Physical

(a) Major

1. Determination of pKa of indicator (e.g. methyl red).
2. Determination of stoichiometry and stability constant of inorganic (e.g. ferric-salicylic acid) organic (e.g. amine and iodine) complexes.
3. Characterisation of complexes by electronic and IR spectral data.
4. Estimation of Pb^{2+} and Cd^{2+}/Zn^{2+} by polarography.
5. To obtain solubility curve for a ternary system of liquids, water-acetic acid, acid-chloroform system.
6. To estimate oxalic acid by carrying out suitable conductometric titration in the following solutions.
 - (i) A solution of pure Oxalic acid.
 - (ii) A solution of Oxalic acid and HCl.
 - (iii) A solution of Oxalic acid and CH_3COOH

(b) Minor

1. Capacitor as charge storage device.
2. To study the behaviour of parallel charged capacitor in series charged capacitor placed in parallel.
3. The use of LCR bridge.
4. Response characteristics of LCR network.
5. Measurement of e.m.f. of thermocouple.
6. To plot characteristics curve of diode.
7. Capacitor filter for full wave rectifier.

Books suggested

1. Inorganic Experiments, J. Kerek Woollins, VCH
2. Microscale Inorganic Chemistry, A Sqafran, R.M. Pike and M.M. Singh, Wiley.
3. Practical Inorganic Chemistry, G.Marr and B. W. Rockett, Ban Nostrand.
4. The Systematic Identification of Organic Compounds, R.L. Shriner and D.Y.Cutin.
5. Semimicro Qualitative Organic Analysis, N.D. Cheronis, J.B. Entrikin and E.M. Hodnett.
6. Experimental Organic Chemistry. M.P. Doyle and W.S. Mugall.
7. Small Scale Organic Preparations, P.J. Hill.
8. Organometallic Synthesis, J.J. Fisch and R.B. king, Academic.
9. Experimental Physical Chemistry, D.P. Shoemaker, C.W. Garland and J.W. Niber, McGraw Hill, Interscience.
10. Finalay's Practical Physical Chemistry, revised B.P. Levitt, longman.
11. Experiments in Physical Chemistry, J.C. Ghosh, Bharti Bhavan.

INSTRUCTIONS FOR PRACTICALS

Max. Marks: 100

Time: 07 Hours

The Board of Examiners will constitute of one External Examiner and one Internal Examiner.

Marks

(A) Inorganic

Spectrophotometric or Flame Photometric or Chromatographic

(one exercise). -15

(B) Organic

(a) Multi-step Synthesis or Extraction of organic compound -15

(b) Spectroscopy or Spectrophotometric estimations -10

(C) Physical

1. One experiment is to be performed from major and

one from minor

Major -20

Minor -05

(D) Viva -10

(E) Record -10

(F) Seminar -15

PAPER XX-PRACTICALS (FOR GROUP-D)

Time: 07 Hours

Max. Marks-100

A. Microscopic and forensic examination (any five)

1. Microscopical examination of hair; - measurement of medullary index, hair index, scale count etc.
2. Drawing and identification of the skull sacrum & pelvis.
3. Determination of height of an individual by the measurements of long bones.
4. Determination of the sex of a person by the examination of bones.
5. Determination of age of the person by the bones.
6. Some anthropological measurements of head length and width. cephalic index, measurement of height, measurements of arm span, measurements of upper limbs and lower limbs.
7. Examination of blood sample; Preliminary colour test, crystal test and species determination and Blood Group.
8. Drawing and Identification of bones- forelimb.
9. Laboratory examination of urine stain.
10. Laboratory examination of saliva stain.
11. Drawing and Identification of bones- lowerlimb.
12. Forensic examination of some fibers:- microscopical & Chemical tests.
13. Comparison of tool marks by comparison microscope.
14. Spottings of forensic specimens

B. Qualitative Analysis (Any five)

1. Identification of some ink by paper chromatography and TLC.
2. Identification of Some insecticides and pesticides by TLC.
3. Identification of amino acids, sugars, Drugs, by paper chromatography and TLC.
4. Identification of some barbiturates by TLC

5. Identification of pesticides, vegetable poisons from bio- specimen by Spot test.
6. Identification of pesticide, opium and morphine.
7. Identification of ganja.
8. Colour reactions of amino acids- qualitative analysis of amino acid.
9. Qualitative Analysis of compounds containing purine group.
10. Qualitative Analysis of Alkaloids.
11. Qualitative Analysis of alkaloids
12. Preparation of Lactose from milk.
13. Preparation of Casein from milk.
14. Preparation of Caffeine from tea leaves.
15. Preparation of Cystine from human hair
16. Preparation of D(+) glucose from cane sugar.
17. Preparation of Hippuric acid from urine.

C. Quantitative Analysis (Any five)

1. Determination of concentration of liquid by spectrophotometer.
2. Determination of pH of given acid/base/buffer.
3. Estimation of morphine by spectrophotometer .
4. Estimation of methyl alcohol by spectrophotometer.
5. Wavelength calibration of UV-VIS spectrophotometer.
6. Spectrophotometric determination of cobalt UV-VIS spectrophotometer./ spectronic 20
7. Estimation of total reducing sugars in molasses.

8. Qualitative analysis of opium and the estimation of morphine content.
9. Qualitative estimation of carbohydrate, protein, non- protein nitrogen, lipids, etc.
10. Estimation of lead in blood and urine by dithiozone methods.
11. Estimation of saponification value of polymers
12. Estimation of As, H_g (*Macro and micro methods).
13. Determination of blood alcohol by various methods.
14. Estimation of formaldehyde
15. Spectrometric estimation of glucose, urea creatinine and cholesterol
16. Use of pH meter- preparation of buffer of forensic biochemical relevance.
17. Estimation of glucose.
18. Estimation of glycine
19. Determination of Acid Value of polymer
20. Determination of Iodine Value of polymer
21. Determination of Rancidity of oil sample.

(D) Separation and identification (any five)

1. Separation and identification of volatile organic solvent from the mixture of liquids by distillation method.
2. Separation and identification of non-volatile organic solvents from urine sample. Solvents for urine sample. Solvents: methyl alcohol, ethyl alcohol, chloroform diethyl. ether, carbon tetra chloride acetone, benzene, etc.
3. .Separation and estimation of a mixture containing ethanol, methanol and isopropanol using gas chromatography.

(E) Identification of metallic poisons and anions

1. Separation and identification of acidic and neutral volatile poisons from urine sample by steam distillation. Volatile Poisons: chloral hydrate, phenol.
2. Separation and identification of some basic volatile poisons from urine sample by steam distillation method, E.g., amphetamine, nicotine, ephedrine, etc.
3. Identification of some metallic poisons by colour/chemical/ spot/ crystal tests As, Sb, Cu, Ag, Pb, Hg, Fe, Co, Ni, Cr, Cd etc
4. Identification of some anions by colour / chemical tests; sulphate, sulphide, nitrate, carbonate, chloride, bromide, iodide, etc.
5. Separation, Purification & identification of compounds in a ternary mixture (three solids) using chemical tests.

INSTRUCTIONS FOR PRACTICALS

Max. Marks: 100

Time: 7 Hours

The Board of Examiners will constitute of one External Examiner and one Internal Examiner.

Marks

(A) Microscopic and Forensic Examination (one Exercise)	-20
(V) Qualitative Analysis (One exercise)	-10
(C) Quantitative Analysis (one exercise)	-15
(D) Separation and Identification (one exercise)	-10
(E) Identification of metallic poisons and anions (one exercise)	-10
(F) viva	-10
(G) Record	-10
(F) Seminar	-15

Books Suggested for group "D"

1. VK Sharma Instrumental Methods of Chemical Analysis.
2. Skoong Principles of Instrumental Analysis.
3. Ewing Instrumental Methods of Chemical Analysis
4. HE Thomas Hand Book of Pharmaceutical and Clinical Measurement and Analysis
5. GH Morrison Trace Analysis- Physical Method
6. Krishnan An Introduction to Modern Criminal Investigation.
7. Willard, Merrit & Dean Instrumental method of analysis.
8. BK Sharma Instrumental Methods of Chemical Analysis
9. S.N. Tiwari Monograph on toxicology
10. Sharma JD Vidhi Vigyan and Vish Vigyan
11. Remington Text Book of Pharmaceutical Science.
12. Clark Toxicology
13. Welcher Standard methods of Chemical analysis.
14. Gliaster Medical Jurisprudence and Toxicology.
15. Curry Forensic Medicine.
16. Keith Simpson & Benard Forensic Medicine.
17. Alan Curry Poison detection in human organ.
18. OP Agarwal Chemistry of Organic Natural Products Vol. 1
19. Hawk Physiological Chemistry
20. Morrison and Boyd Organic Chemistry

21. SN Tiwari Manual on toxicological Analysis
22. Culliford Manual on Examination of Blood Stains
23. Stryer Bio-Chemistry.
24. Taylor Medical Jurisprudence
25. Parikh Chikitsa Nyaya Shastra aur Vish Vigyan (Hindi)
26. C.C. Chatterji Human Physiology.
27. Ross & Wilson Foundations of anatomy and Physiology
28. Krogman The Human Skeleton in Forensic Medicine.
29. Surander Nath An introduction of Forensic Medicine
30. Tedeschi, etc. Forensic Medicine Vol. I, II, III
31. Nandi Forensic Medicine
32. EJ Gardner, MJ Simmons Principles of Genetics (John Wiley, New York).
33. Thaddeus Mann The Biochemistry of Semen and of the Male Reproductive Tract (Methuen & Co. Ltd.)
34. PL. Williams & R. Warwick Gray's anatomy (Churchill Livingstone, London).
35. Metropolitan Police Forensic Science Laboratory London Biology Methods manual.
36. N.G. Dey & T.K. Dey Medical bacteriology (Allied Agency, Calcutta.)
37. Brain Lane The Encyclopedia of forensic science (Headline London)

38. Richard Safestein Criminalistics; An introduction to forensic science (5th Edn. Prentice Hall Englewood Cliffs, New Jersey)
39. CEO' Hara and GLO Hara Fundamental of Crimal investigation (6th Edn. Cahrls C Thoma Springfiled Illinois)
40. BS Nabar Forensic Science (SVP National Police Academy Hyadrabad).
41. R. Safferstein Rorensic Science Hand book Vol, I,II, III (Prentice Hall Englewood Cliffs, New Jersey.)
42. A.S. Curry Methods of forensic science Vol.III (Interscience Publisher London.)
43. CGG Aitken and The use of statisitics in forensic science (Ellis D.A. Stoney Howood Ltd. New York.)
44. B.R. Sharma Forensic Science in Criminal investigation and trails (Central law Agency Allahabad)
45. L Zechmeister and L Principles and practices of chromatography (Cholnoky chapman & Hall , London
46. RE Dodd Chemical Spectroscopy (Elsevier Amsterdam)
47. Willard, H Hobart et al Instrumental methods of analysis (CBS Publishers Delhi).
48. Wischnitzer, Saul Introduction to Electron Microscopy (Pegamon Press New York)
49. GH Jeffery, et al Vogel's Textbook of Quantitativ Chemical analysis (5th Edn, Wesley Longman. Singapore.)
50. Christian, d Gray and Atomic Absorption Spectroscopy (Eiley Feldamn Interscience, New York.

51. Wlecher., J Frank Standard Methods of chemical analysis (6th Edn. Vol 3 Part A Robert E Krieger Publishing Co. New York)
52. A.B. Littlewood Gas Chromatography: Principles, Techniques and Application (academic Press, New York)
53. G. Chatwal & S. Anand Instrumental Mehods of chemical Analysis (Himalya Publishing House Bombay)
54. Lawes, Grahame Microscopy and X-Ray
55. Ewing Glalenwood Analytical Instrumental hand book 2nd rev Ed (Marcel dekker New York)
56. Genel, L Barbra Biological Electron Microscopy (Van Nostrand Reinhold Co., New York)
57. Reimer and Ludwig Scanning Electronic Microscopy: Physics of image formation microanalysis (Springer- veriage Berlin)
58. Frank M Biffen and Modern Instrumental in Chemical Analysis (Mc William Seaman Graw Hill New york)
59. Gerald W. King Spectroscopy And Molecular Structure (Holt Rine Hart and Wiinston, New york.)
60. K Kackschalger Drrors mesurements & Result in Chemical analysis (Van Nostand Reionhold London.)
- 61 J. Bassett, et al Vogel's Text Book of Quantitative Inorganic analysis (4th Edn. Longmans Essex).
62. Iras Lurie and High Performance Liquid chromatography in Jhon D Wittor Jr. Forensic Chemistry
63. GL Goberman Ultrasonics- Theroy and applications (English University Press London.)

64. David M. Mercules Fluorescence and Phosphorescence analysis
Principles and Applications (Interscience
Publishers)
65. H. Ward Smith Methods of determining alcohol of forensic
science Vol. IV(Interscience Publishers New
York)
66. I C Grret The quantitative analysis of drugs (Chapman
and Hall)
67. FD Smell & FD Biffen Commercial method of analysis 2nd Edn.
(Chemical Pub. Co. Lnc.)
68. John Steward The Paint-Laboratory Note-book (Leonard Hill
Remington Hall)
69. R.S. Dargo Physical methods of inorganic chemistry
70. D.G. Peters et al Chemical Separation and measurement (Sauders
Co.)
71. G.W. Himus Fuel Testing (Leonard Hill)
72. F. Fiegl and V Anger Spot Tests in Organic analysis (Elsevier,
Amsterdam).
73. F. Fiegl and V Anger Spot Tests in Organic analysis (Elsevier,
Amsterdam).
74. Snell & Snell Colorimetric Method of Analysis (Van
Nortland)
75. N.D. Cheroins et al Identification of organic compounds using
semi micro techniques
76. Erich Leschle Clinical Toxicology (J.A. Churchill London)
77. C.J. Polson and Clinical Toxicology (English University Press,
R. Tattessall London.

78. A. Looms essentials of Toxicology (Less & Febiger, Philadelphia)
79. William H Warren Laboratory manual for the detection of poisons and powerful drugs (P blakiston' s Son & Co. Philadelphia)
80. C.P. Stewart Toxicology-Mechainms and Analytical and Stolman Methods Vol. I&II (Academic Press New York)
81. Franck Bamford Poisons-Their Isolation and identification (J.A. Churchill London)
82. Irving Sunshine et al Guidance for analytical Toxicology Programs Vol. I (CRC Press)
83. Alan Curry Poisons Detection in Human organs (Charles C Thomas)
84. F. Lundgist et at Method in forensic Science (Vo. I to IV Interscience Publicans New York)
85. A Stolman Progress in Chemical Toxicology Vol. I & II (Academic Press New York)
86. M.J. Pelezar, ECS Reid Microbiology V Edn. (Tata Mc Graw Hill Publishing & Canh Co., New Delhi.)
87. Stites D.P. et al Basic & Clinical Immunology 5th Edn. (Lange Medical Publications, Lasatios)

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SYLLABUS

**SCHEME OF EXAMINATION AND
COURSES OF STUDY**

FACULTY OF SCIENCE

M.Sc. CHEMISTRY

M.Sc. Semester I & II Examination

(w.e.f. 2018-19)

M.Sc. Semester III & IV Examination

(w.e.f. 2019-20)



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