#### Syllabus PG (First and Second semester):

Semester Course Structure (M.Sc. in Chemistry)



# <u>First Semester</u> Paper – I (Physical Chemistry)

(20-25 L for each Unit)

Marks: 40 + 10

#### Unit –01

#### (a) Quantum Mechanics: Formalism 1:

Introduction and objectives; Wave- particle duality, wave packet, phase velocity, group velocity, matter waves of de-Broglie; Classical wave theory, Gedanken experiments to derive an expression for the uncertainty principle. Operators, shifting of classical wave function to quantum mechanical wave function, development of Schrödinger equation, interpretation of  $\psi$ , vector interpretation, normalization and ortho glonalization of wave function, localization of matter waves. Commutation relations; Postulates of quantum mechanics with necessary explanations, Hermitian operator, turn over rule, theorems concerning hermitian operators, Stationary states in quantum mechanics, derivation of exact uncertainty relation, Problems.

#### (b) Thermodynamics :

Maxwell's relations, thermodynamic equation of state; Partial molar quantities, thermodynamics of mixing, activity and fugacity. Nernst heat theorem, third law of thermodynamics. Thermodynamic probability and entropy. Maxwell. Boltzman, Bose – Einstein and Fermi Dirac statistics. Partition functions of diatoms, (translational, rotational, vibration and electronic), Distribution molecular velocities, principle of equipartition of energy, collision frequency.

#### (a) Chemical Kinetics 1:

Principle of detailed balancing (simple idea only), opposing and consecutive reactions, static, flow and relaxation methods of measurement of reaction rates, flash photolysis. Kinetics of fast reaction; collision theory of reaction rates (detailed), preliminary idea of transition state theory.

# (b) Electrochemistry 1:

Mean activity co-efficient of electrolyte solutions. Debye – Huckel theory, ion association, precise determination of dissociation constants of weak electrolyte - emf and conductometric methods.

## (c) Molecular Spectroscopy:

General features of molecular spectra, quantum mechanical rigid rotator, pure rotational spectra of linear molecules, non-rigid rotator, expression for centrifugal distortion constant, quantum mechanical harmonic oscillator, vibrational spectra of diatoms, anharmonicity and molecular dissociation, hot band and overtones, zero point energy and uncertainty, rotational and vibrational Raman spectra - general features and applications, principle of mutual exclusion. Vibrational structure of electronic spectra Franck -Condon principle. Photoionisation of atoms and molecules, electron energy analyzer and photoelectron spectra, molecular orbital and photoelectron spectra.

## Paper – II (Organic)

#### (20-25 L for each Unit)

Marks: 40 + 10

#### UNIT - 01

#### (a) Percyclic reaction 1:

Pericyclic reactions characteristic features, conservation of orbital symmetry MO of different polyenes, electrcyclic, cycloaddition, sigmatropic reactions, Rationalisation of different example with the basis of frontier orbital interaction, wood word-Hofmann symmetry rules for pericyclic reactions, exceptions to symmetry rules, correlation diagram of different perevclic reactions. Problems relating to these reactions.

#### (b) Spectroscopy:

NMR <sup>1</sup>H, Aromaticity, Antiaromaticity, Homoaromaticity, Annulene systems, Application of spectroscopy NMR,UV, IR in structure determination of organic compounds.

#### (c) Stereochemistry 1:

molecular chirality, stereochemistry Symmetry and and acvclic molecules, confirmation in acyclic and cyclic systems with energy beerier to

rotation, potential energy profiles conformation and physical properties of 6 membered ring and reactivity in acyclic system stereochemistry of trivalent compounds.

## UNIT-02

## (a) Heterocyclic compounds:

Heterocyclic: Monocyclic and bicyclic heterocyclic having one and two hetero atoms. Synthesis, structure and reactivity.

## (b) Reagents in Organic Synthesis 1:

Multicomponent reactions : Definition, early examples, Passerine reaction, Ugi reaction. Olefin metathesis reaction : Definition, Ring closing metathesis reaction, examples.

Fragmentation reactions. Cation-olefin cyclization reaction : application to the synthesis of triterpenes. Remote functionalization : biomimetic reactions / template effect, examples. Functional group inter conversion. Phase transfer catalysis.

# PAPER –III (Inorganic)

(20-25 L for each Unit)

Marks: 40 + 10

#### <u>UNIT- 01:</u>

#### (a) Symmetry and Group Theory -1

Groups and their properties. The concept of groups, Group Multiplication tables and rearrangement theorem, subgroups and classes

Symmetry elements and operations of molecules and crystal systems. Point groups: molecular crystallographic. Matrix representation of symmetry operations.

Representation of point groups: Matrix representation of point groups. Reducible and irreducible representations, the great Orthogonality theorem (without derivation) and its corollaries.

# (b) Coordination Chemistry -1

Crystal Field theory. Adjusted Crystal Field Theory. Distortions (tetragonal and trigonal), crystal field stabilization energy, thermodynamic aspects of crystal field splitting (variation of ionic radii, lattice-energy, hydration energy), kinetic aspects of crystal field splitting (labile and inert complexes). Qualitative MO treatment: the electronic structure of the  $ML_6$  (octahedral) and  $ML_4$  (tetrahedral) complexes on the basis of simple symmetry and overlap principles, energy level diagrams. d-d transitions in weak field cases. Orgel diagram and electronic spectra of transition metal complexes (d<sup>1</sup>-d<sup>9</sup>), effect of substitution, spectrochemical series, and charge transfer spectra.

Magnetic properties of free ions and metal complexes – a qualitative approach.

## (c) Chemistry of Main Group:

Relative effects on chemical properties, noble gas clathrates compounds, structure and bonding in Boranes and carbenes, organo boranes, silicates and silicone, inorganic chain and ring compounds: B-N, P-N, P-O and S-N compounds, interhalogen, halogen oxides and oxygen fluorides.

## <u>UNIT- 02:</u>

## (a) Bioinorganic Chemistry :

Essential molecules in Biology (major and trace), beneficial and toxic elements, role of metal ions in biology – metalloproteins and metalloenzymes: transport and storage proteins (Ferritin and Transferrin), dioxygen carrier and storage proteins (hemoglobin and myoglobin), electron transfer proteins: ferredoxin, rubredixin etc. nitrogen fixation.

## (b) Chemistry of d-block elements

Chemistry of 3d, 4d and 5d transition metals i.e. Ti - Hf, V – Ta, Cr – W, Mn – Re and platinum metals with reference to

- (i) Aqueous chemistry, oxidation states, coordination number and complexes, redox behaviour.
- (ii) Iso- and hetero- polyacids and salts of Mo, W.
- (iii) Di nitrogen and di oxygen complexes.
- (iv) Intermolecular charge transfer: Creutz-Taube ion.
- (v) Binary carbonyl complexes: structures and bonding.
- (vi) Property, structure and bonding of molybdenum blue, tungsten blue, tungsten bronze, ruthenium red. Creutz-Taube complex. Nb, Ta halide clusters.

# Paper – IV (Chemical Technology)

(20-25 L for each Unit)

Marks: 40 + 10

#### <u>UNIT-01</u>

#### (a) Fluid Mechanics:

Fundamental principles of fluid mechanics, Newtonian and Non-Newtonian fluids .Stream line and turbulent flow.

#### (b) Pressure drop:

Pressure drop calculation for flow through pipes and channels, Hagen paisonallies equation. Bernoli's equation. Flow measuring instruments, Manometer, Filtration, different filters.

#### (c) Heat Transfer:

Heat transfer by conduction. Steady and unsteady state of heat transfer, Heat transfer by convection. Natural and forced convection. Heat transfer by radiation, heat emission and absorption by black, natural and grey bodies.

#### <u>UNIT-02</u>

## (a) Unit Processes:

Unit processes in organic synthesis including nitration, hydrogenation, oxidation, sulfonation, esterification, and polymerization. Industrial stoichiometry, material and energy balance, solution of problems.

#### (b) Ore processing 1:

Ore processing/ Beneficiation: Definition of ore. Types of ores, operating steps involved in ore processing / dressing / beneficiation: coominution, sizing and screening, concentration and filter processing.

#### Semester-1

#### **Physical Chemistry Practical**

#### (Two days examination- 6 hours per day, Full Marks: 50)

#### List of Experiments:

- (1) Determine the specific rotation of an optically active compound.
- (2) Study the kinetics of Inversion of Cane sugar by polarimetry.
- (3) Estimate the strength of the strong acid and the weak acid in a mixture by conductometric titration.
- (4) Determine the rate constant of saponification of methyl acetate conductometrically at room temperature.
- (5) Determine the ionization constant (K<sub>a</sub>) of a weak acid by conductometric method at room temperature and find the equivalent conductance at infinite dilution (Λ<sub>o</sub>) of the weak acid by graphical extrapolation. (Verification of Ostwald's dilution law)
- (6) Potentiometrically estimate the strength of Mohr salt with the help of a standard potassium dichromate solution. Find the  $E^{0}_{Fe^{3+}/Fe^{2+}}$  using graphical methods.
- (7) Potentiometrically estimate the strength of  $AgNO_3$  solution with a standard KCl solution. Determine the solubility product ( $K_{sp}$ ) of AgCl at room temperature.
- (8) Estimate the strength of a weak acid (monobasic/dibasic)  $p^{H}$ -metrically. Find  $p^{Ka}$  of this acid at room temperature using a graphical procedure.
- (9) Study the kinetics of the reaction  $(KI + K_2S_2O_8)$  by colorimetric method and determine the rate constant of the reaction at room temperature.

- (10) Test the validity of Lambert-Beer's law for  $KMnO_4$  solution. Construct similarly the calibration curve for  $K_2Cr_2O_7$  solution and hence determine the concentration of an unknown  $K_2Cr_2O_7$  solution.
- (11) Study the kinetics of Iodination of Acetone in presence of acid. Hence find out the order with respect to iodine/acetone/acid.
- (12) Determine the Critical Solution Temperature of Phenol-water system.
- (13) Determine the Solubility Product of PbI<sub>2</sub> and verification of Debye-Hückel limiting law.
- (14) Determination of  $E^0$  of quinhydrone electrode.

# (Inorganic Chemistry Practical) (Two days examination – 6 hours per day, Full Marks = 50)

- 1) Qualitative Analysis : Detection of six radicals (Including two from rare metals) from mixture.
- 2) Quatitative Analysis : Mixture: Ni<sup>2+</sup> /Mn<sup>2+</sup> : Cr<sup>3+</sup>/ Mn<sup>2+</sup>

Alloys : Gun metal (Cu/Sn)

- Ore : Pyrolusite
- Preparation and composition study : (at least one)
  Potassium trioxalato ferrate (III)
  Potassium trioxalato chromate (III)
  Ammonium tetra nitro nickelate (II)

# Paper-V (Physical) (20-25 L for each Unit)

Marks: 40 + 10

## <u>UNIT – 01</u>

#### (a) Quantum Mechanics: Formalism 2:

Free particle, particle in one dimensional box, potential barrier, potential step problems, tunneling, nature of energy, nature of wave function, calculation of  $\Delta x - \Delta P_x$ , free electron molecular orbital model. Ladder operator – (Step up, step down operators) quantum mechanics of linear harmonic oscillators, operator method for eigen value spectrum, eigen functions, of the L.H.O., derivation of uncertainty product, traditional method of solution of L.H.O. Quantum mechanics of rigid rotor – polar coordinate transformation, angular momentum eigen values, eigen funcitions of rigid rotator, operator method, traditional method, Quantum mechanics of hydrogen atom, detailed solution, shapes of hydrogenic orbital, radial distribution functions. Zeeman effect, magnetic properties etc. Problems in each unit.

#### (b) Surface and Transport Phenomena:

Young Laplace equation, Kelvin equation, surface (interface) thermodynamics. Adsorption, adsorption isotherms (Langmuir, and BET with derivation). Surfactants, micelles, reverse micelles and emulsions and their applications.

Thermal conductivity, general diffusion expression and Fick's Laws, general features of transport of matter (diffusion), thermal energy (thermal conductivity and momentum viscosity).

#### <u>UNIT – 02</u>

#### (a) Chemical Kinetics 2:

Homogeneous and heterogeneous catalysis, autocatalysis, oscillatory reactions (general introductions only), redox reactions, preliminary idea of inner sphere and outer sphere reactions of transition metals.

#### (b) Electrochemistry 2:

Onsagar conductance equation, effect of high electric field and high frequency on ion conductance; polarography, overvoltage, surfacetension of electrolytic solutions, polyelectrolyte, Basic principle of cyclic voltametry and coulometry.

#### (c) Molecular Structure:

Dielectric polarization, Debye – Langevin equation, dipole moment determination and applications, intermolecular forces and their contribution to intermolecular potential.

## Paper – VI (Organic)

## (20-25 L for each Unit)

Marks: 40 + 10

## <u>UNIT – 01</u>

#### (a) Pericyclic reaction 2:

Perturbation molecular orbital theory (PMO), energy diagram of ethylene and butadiene system with different substitutions and study of their cycloaddition reactions, orbital coefficient and diagram of polyene systems with various substitutions. Regioselectivity, Periselectivity and Site selectivity, secondary interactions in pericyclic reactions, cheletropic reactions. Problems relating to these reactions.

#### (b) Stereochemistry 2:

Prostereoisomerism, Asymmetric synthesis, Addition of achiral reagents to chiral ketones and aldehydes, model of stereo chemical control, Cramm, Karabatros, and fehlkin model, stereo-specific and stereo-selective reactions, Molecular rearrangement- generalized treatment of stereo-chemical features.

#### (c) Natural products- Terpenoids:

Teopenoids: Isoprene rules, acyclic monoterpenoids, cetral geraniol neral, linalool monocyclic monoterpenoids;  $\alpha$ - terpeinol, structure elucidation, synthesis and biogenesis.

#### <u>UNIT-02</u>

#### (a) Natural products- Alkaloids:

Alkaloids: Phenyl ethyl amine, quinine, nicotine, peptides, nucleoside and nucleotide structure, synthesis, biogenesis.

#### (b) Reagents in Organic Synthesis 2:

Oxidations reactions: Hydroxylation reagents, use of peroxy acids, Woodward prevost hydroxylation, sharpness asymmetric epoxidation. Transformation of epoxides. Organophosphorus reagents, organo sulfer reagents, organo boranes, organo silanes, organo stannaues, metal hydrides, Birch reduction, Bayer Villiger reactions, chichibabin reaction, Merrifield resin, solid phase synthesis. Retro synthetic analysis: disconnection approach. Examples to illustrate disconnection approach in organic synthesis.

# Paper-VII (Inorganic)

# (20-25 L for each Unit)

#### <u>Unit- 01</u>

## (a) Symmetry and Group Theory -2

Construction of character tables in simple cases ( $C_{3v}$ ,  $C_{2v}$ ,  $D_{4h}$ ), reduction of a reducible representation, direct product and its decomposition.

Models of MO and VB theories – application to  $H_2$ .  $H_2$  qualitative M.O. theory – energy levels of homo- and hetero- nuclear diatomic molecules of second period elements, equivalence of MO and VB theories, electronic structure of solids – band theory.

# (b) Coordination Chemistry -2

Complex formation in solution: stability constants (overall and stepwise). Irving-Williams order, methods for the determination of complex composition (Job's mole ratio and slope ratio methods). Bjerrum's half integer method for the decomposition of stability constants, chelate effect and macrocyclic effect.

Reaction mechanism : preliminary ideas on different types of mechanisms (A. D. I,  $I_a$ ,  $I_d$  etc.) of substitution reactions for inorganic complexes, examples, an idea on trans effect.

## (c) E.S.R. spectroscopy

E.S.R. spectroscopy: general background, representation of ESR spectrum, 'g'-value, spectra of simple organic free radicals, hyperfine coupling, prediction of expected number of lines and intensities. Spectra of transition metal complexes, metal hyperfine anisotropic spectra. Zero-field splitting, applications.

#### <u>Unit- 02</u>

#### (a) Reaction mechanism-1:

Reaction mechanism: preliminary ideas on different types of mechanisms (A. D. I,  $I_a$ ,  $I_d$  etc.) of substitution reactions for inorganic complexes, examples, an idea on trans effect.

#### (b) Organometallic Chemistry 1:

Introduction to organometallic chemistry : definition and classification ( on basis of ligand type), example of carbine and carbyne complexes. Hapticity, structure, bonding and reactivity in ethylenic and allylic complexes, Synthesis, structure, bonding and reactivity in carbene and carbyne complexes, fluxional behaviour.

#### (c) Analytical Techniques and Methods-1

Spectroscopic methods: spectrophotometry- basic principles, applications (photometric titration, estimation). Atomic Absorption Spectroscopy: basic principle, concentration and absorbance, calibration, interferences, an idea on instrumental set up, applications (detection / estimation of metallic elements in ores and alloys). Fluorescnce spectroscopy – basic principles and application. Flame photometry – basic principles and application. Electro analytical methods: Polarography, Cyclic voltametry and coulometry and some applications.

Paper – VIII (Chemical Technology)

(20-25 L for each Unit)

Marks: 40 + 10

## <u>UNIT-01</u>

## (a) Chemical Kinetics:

Chemical reactions, isothermal, adiabatic and non-isothermal and nonadiabatic, Design equation, Heat and mass transfer effect on catalytic reaction.

#### (b) Mass Transfer:

Mass transfer: principal of diffusion and mass transfer, mechanism of mass transfer, simultaneous heat and mass transfer. Fick's law application.

## (c) Refractories:

Refractory materials: Nomenclature, classification acidic, basic and neutral refractories, production, important properties and uses.

# <u>UNIT-02</u>

## (a) Fuels:

Solid, liquid and gaseous fuels, coal origin, proximate analysis and ultimate analysis, combustion. petroleum and refineries, products, synthetic liquid fuels. Bergious process, Fischer Tropsch process.

# (b) Ore processing 2:

Different process of concentration of ore minerals, Beneficiation of Pb-Zn-Cu ore iron ore, Zn ore etc. Beach sands and graphite, leaching as a means of ore processing.

#### Semester-2

#### (Organic Chemistry Practical)

(Two days examination – 6 hours per day, Full Marks = 50)

# <u>Unit-01</u> (a) Qualitative Analysis of Solid Organic Compounds leading to

- (i) Detection of elements (N,C1, Br, I,S); Solubility tests.
- (ii) Systematic Analysis to detect the functional groups: alcoholic/phenolic OH, carboxylic, aldehydes, ketone, ester, nitro, amino, amido, N-substituted amino, imido groups, unsaturation (C=C), aromatic hydrocarbons, and halogenated derivatives.

(iii) Preparation of Crystalline derivatives/suitable derivatives to identify the compound.

Students will have to analyse atleast 6 (six) samples including solid compounds during their course work.

Each candidate during the examination shall be assigned one solid sample for analysis during the examination.

(b) **Preparation** of pure organic compound single-step or two step procedure. Submission of crystallized produced.

## 02 Sessional Work

To be awarded by the class teacher on the basis performance of the students during the course work.

## 03 Viva Voce

To be jointly conducted by the external and internal examiners during the the examination.

# **Computer Fundamental**

MARKS 25

#### **1. Introduction to computing:**

What is computer? Generation of computers, Classification of Computer, Computer Hardware and software, Block diagram of Computer. Input devices, Output devices, Storage devices, Printers, Bits and Bytes, Memory: Primary Memory, Secondary Memory. Definition of operating system. Types of operating system, Function of operating system, Generation of Language, Machine Language, Assembly Language and Higher Level Language.

#### 2. Data Storage:

Data storage : The decimal number system, the binary number system, hexadecimal notation, octal number system. Conversion from one number system to another number system. Codes, ASCII, BCD etc. Arithmetic Operation for Binary Numbers: addition, subtraction, multiplication, and division. Representation of numbers in 1's and 2's Complement method. Subtraction using 1's and 2's Complement method.

## **3. Data Manipulation**:

Logical Operations: AND, OR, NOT, NANT, NOR, EX-OR, EX-NOR. Logic gates with truth table, Universal Gates, Representation of function using gates. Boolean algebra: Postulates, Minimization of functions.

#### INDUSTRIAL CHEMISTRY PRACTICAL

Marks = [25]

[15]

01. (a) Quantitative Analysis Experiments

- (1) Analysis of Portland cement
- (2) Analysis of Soda ash/coal ash/ fly ash
- (3) Analysis of basic slag
- (4) Analysis of water (herdness)

(b) Demonstration type experiments to be performed in groups Study and use orifice meter venture meter, pitot tube. Rayleigh

- (1) Distillation and other skills, Bomb calorimeter, Junckers calorimeter.
- (2) Determination of surface area by air permeability method.
- (3) Determination of viscosity of liquid by falling sphere method
- (4) Determination of viscosity of fuel oil (Redwoods viscometer)
- (5) Proximate analysis of coal samples.
- (6) Orsat analysis
- (7) Determination of flash point of a fuel oil.
- (8) Determination of diffusion coefficient of liquid vapour through air by
- (9) Stefens method.
- (10) Distillation of binary liquid mixture to verify Reileigh eqation.

03. Sessional

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#### **Suggested Reference Books**

#### **Physical Chemistry**

- 1. Physical Chemistry; Berry, Rice and Ross.
- 2. Physical Chemistry; Moore
- 3. Physical Chemistry; Atkins
- 4. Physical Chemistry; Levine
- 5. Chemical Kinetics; Laidler
- 6. Kinetics and Mechanism; Zemansky and Dittman
- 7. Heat and Thermodynamics; Zemansky and Dittman
- 8. A Treatise on Heat; Saha and Srivastava
- 9. Quantum Chemistry; Eyring, Walter and Kimbal
- 10. Quantum Chemistry; Pilar
- 11. Quantum Chemistry; Levine
- 12. Electrochemistry; Glasstone
- 13. Electrochemistry; Bockris and Reddy
- 14. Molecular Spectroscopy; Banwell
- 15. Molecular Spectroscopy; Barrow
- 16. Molecular Spectroscopy; Grabeal
- 17. Molecular Spectroscopy; Chang

### **Inorganic Chemistry**

- 1. Chemical Application of Group Theory F. A. Cotton
- 2. Group Theory Robert L. Carter
- 3. Symmetry in Chemistry Jeffe & Archin
- 4. Symmetry in Molecules J. M. Hollar
- 5. Symmetry Orbitals & Spectra Jeffe & Archin
- 6. Physical Methods in Inorganic Chemistry R. S. Drago
- 7. Electron Spin Resonance Assculieien
- 8. Fundamentals of Molecular Spectroscopy C. W. Banwell
- 9. Introduction to Molecular Spectroscopy G. M. Barrow
- 10. Advanced Inorganic Chemistry- F. A. Cotton & G. Wilkinson

- 11. Inorganic Chemistry- J. E. Huheey, E. A. Keiter & R. L. Keiter
- 12. Chemistry of the Elements N. N. Greenwood & A. Earnshaw
- 13. An Introduction to Inorganic Chemistry K. F. Purcell & J. C. Kotz
- 14.Concepts and Models in Inorganic Chemistry Douglass, McDanniel & Alexander
- 15. Coordination Chemistry -S.F.A. Kettle
- 16. Valence Theory S.F.A. Kettle, J. N. Murrall & S. Teddler
- 17.Valence C. A. Coulson
- 18. Theoretical Approach to Inorganic Chemistry A. F. Williams
- 19. Theoretical Inorganic Chemistry M. C. Day and I. Selbin
- 20. Introduction to Ligand Field Theory C. J. Ballhausen
- 21. Introduction to Ligand Field B. N. Figgis
- 22. Inorganic Electronic Spectroscopy- A. B. P. Lever
- 23. Elements of Magnetochemistry R. L. Dutta and A. Shyamal
- 24. Organo Transition Metal Chemistry S. G. Davies
- 25.Principles and Applications of Organotransition Metal Chemistry J. P. Collman, L. S. Hegedus,. Borton & R. G. Finke
- 26. Organometallic Chemistry An Introduction R. C. Mahrotra & A. Singh
- 27.Principles of Organometallic Chemistry G. E. Coates, H.L.H. Green, P. Powell & K. Wade
- 28. Basic Organometallic Chemistry J. J. Zuckerman and I. Haiduc
- 29. The Organometallic Chemistry of Transition Metals R. H. Carbtree
- 30. Bioinorganic Chemistry R. W. Hay
- 31. Introduction to Bioinorganic Chemistry D. R. Williams
- 32. Elements of Bioinorganic Chemistry G. N. Mukherjee & A. Das
- 33. Inorganic Chemistry D. F. Shriver, P. W. Atkins & C. H. Langford
- 34.Instrumental Methods of Analysis Williard, Meritt, Dean & Sett
- 35. Electroanalytical Chemistry A. J. Bard
- 36. Electroanalytical Techniques for Inorganic Chemistry J. B. Headri

- 37.Comprehensive Coordination Chemistry G. Wilkinson, R. A. Gillard & J. A. McCleverty (eds)
- 38. Inorganic Chemistry A. G. Sharpe
- 39. Inorganic Chemistry Modern Introduction
- 40. Fundamentals of Analytical Chemistry D. A. Skoog, D. M. West and F. J. Holler
- 41. Analytical Chemistry G. D. Christian
- 42. Analytical Chemistry, Principles J. H. Kennedy

# **Practical:**

- 1. Spot tests in Inorganic Analysis F. Feigel & V. Anger (translated by R. Oesper).
- 2. Macro and Semi micro Qualitative Inorganic Analysis A. J. Vogel
- 3. Quantitative Inorganic Analysis : A. I. Vogel
- 4. Quantitative Inorganic Analysis- G. Charlot & D. Bezier (translated by R. C. Murray)
- 5. Quantitative Chemical Analysis I. M. Kolthoff, E. B. Sandel, J. Meehan and S. Bruckenstein