

M.Sc. CHEMISTRY

ANALYTICAL CHEMISTRY SPECIALISATION

SYLLABUS OF III & IV SEMESTERS

REVISED AS PER NEW (CB) SYLLABUS

FOR STUDENTS ADMITTED FROM THE YEAR

2016 ONWARDS

M.Sc. CHEMISTRY (ANALYTICAL CHEMISTRY SPECIALISATION)
Syllabus for III and IV Semesters
(for the batches admitted in academic year 2016 & later under CBCS pattern)
[Under Restructured CBCS Scheme]
Grand total marks and credits (all 4 semesters) 2400 marks – 96 credits
(Approved in the P.G. BOS meeting held on 01-07-2017)

Semester - III (ANALYTICAL CHEMISTRY)

[Under CBCS Scheme]

(for the batches admitted in academic year 2016 & later under CBCS pattern)

	Hrs/week	Internal assessment	Semester exam	Total	Credits
CH(AC)301T (core)	4	20 marks	80 marks	100 marks	4
CH(AC)302T (core)	4	20 marks	80 marks	100 marks	4
CH(AC)303T (Elective)	4	20 marks	80 marks	100 marks	4
CH(AC)304T (Elective)	4	20 marks	80 marks	100 marks	4
CH(AC)351P (LAB-I)	9			100 marks	4
CH(AC)352P (LAB-II)	9		100 marks		4
Total				600 marks	24

Semester - IV (ANALYTICAL CHEMISTRY)

	Hrs/week	Internal assessment	Semester exam	Total	Credits
CH(AC)401T (core)	4	20 marks	80 marks	100 marks	4
CH(AC)402T (core)	4	20 marks	80 marks	100 marks	4
CH(AC)403T (Elective)	4	20 marks	80 marks	100 marks	4
CH(AC)404T (Elective)	4	20 marks	80 marks	100 marks	4
CH(AC)451P (LAB-I)	9			100 marks	4
CH(AC)452P (LAB-II)	9		100 marks		4
Total				600 marks	24

Grand total marks and credits (all 4 semesters) 2400 marks - 96 credits

M.Sc.ANALYTICAL CHEMISTRY
Semester III

Paper I :CH (AC) 301T: CORE :

Sampling, Data handling, Classical and Atomic spectral methods of analysis

- AC-1: Sampling & Data handling
- AC-2: Titrimetric & Gravimetric analysis
- AC-3: Thermal & Radiochemical methods of analysis
- AC-4: Atomic Spectroscopy

Paper II:CH (AC) 302T: CORE :

Spectroscopic methods of Analysis-I

- AC-5: Multinuclear NMR
- AC-6: Advanced NMR
- AC-7: Electron Spin Resonance Spectroscopy
- AC-8: Mossbauer and NQR

Paper III:CH (AC) 303T: ELECTIVE IIIa:

Miscellaneous Methods of Analysis

- AC-9 : Surface Analysis Methods
- AC-10: Diffraction Methods, X-Ray Absorption and X-Ray Fluorescence
- AC-11 : Electroanalytical Methods
- AC-12 : Micromeritics, Dissolution and disintegration

Paper III:CH (AC) 303T: ELECTIVE IIIb:

Bonding, Group Theory and its Applications

- AC-09: Group Theory, Normal mode analysis and Spectral activity
- AC-10: MOT of Metal Complexes
- AC-11: Electronic Spectroscopy of Metal Complexes
- AC-12: IR and Raman Spectroscopy

Paper IV:CH (AC) 304T: ELECTIVE IVa:

Applied Analysis

- AC-13: Industrial Analysis
- AC-14: Analysis of Air and Water Pollutants
- AC-15: Clinical and Pharmaceutical analysis
- AC-16: Food and Agricultural analysis

Paper-IV: CH(IC) 304T: ELECTIVE IVb

Nuclear Chemistry, Zeolites, Solid State, and Surface Chemistry

- AC-13: Nuclear Chemistry
- AC-14: Zeolites and Molecular Sieves
- AC-15: Solid State Chemistry
- AC-16: Surface Chemistry & Superconductors

LABORATORY COURSE

Paper CH (AC) 351P: Titrimetry, Solvent extraction, Chromatography and Water analysis.

Paper CH (AC) 352P: Colorimetry, Spectrophotometry

Semester IV

Paper I:CH (AC) 401T: CORE :Spectroscopic Methods of Analysis-II

AC-17: U.V. visible spectroscopy,
AC-18: IR & Raman spectroscopy
AC-19: Optical Methods
AC-20:Fluorimetry, Phosphorimetry,Nephelometry and Turidimetry

Paper II:CH (AC) 402T:CORE Separation Methods

AC-21:Solvent extractions
AC-22:Chromatography
AC-23:Mass spectrometry & Hyphenated techniques
AC-24:Electrophoresis

Paper III:CH (AC) 403T:ELECTIVE IIIa: Laboratory Management

AC-25:Automation in laboratory
AC-26:LIMS & Computer aided analysis
AC-27:Laboratory Management & Standard reference materials
AC-28:Accreditation of Laboratories, Quality management

Paper IV:CH(AC) 403T: ELECTIVE IIIbApplied analysis and Green Analytical Chemistry

AC-25: Enzyme catalysis- Analytical applications
AC-26:Forensic Chemical Analysis
AC-27: Limit tests
AC-28:Green Analytical Chemistry

Paper IV:CH (AC)404 T:Ida Quality Assurance and Accreditation

AC-29: Quality Assurance – I
AC-30: Quality Assurance – II
AC-31: Quality Assurance – III
AC-32: Quality Accreditation

Paper IV:CH (AC)404 T:IDb Inorganic Material Chemistry

AC-29:Composite Materials
AC-30:Liquid Crystals
AC-31:Explosives and Propellants
AC-32:Fuels and Combustion

Paper CH (AC) 451P: Electro analytical techniques:

Paper CH (AC) 452P: Spectroscopy and Evaluation of Physical Parameters Of Tablets

M.Sc. ANALYTICAL CHEMISTRY SPECIALIZATION

Syllabus for III and IV Semesters

III Semester Syllabus

Paper- I: CH (AC) 301T: CORE :Sampling, Data handling, Classical and Atomic spectral methods of analysis

AC – 01 Sampling & Data handling

AC – 02 Titrimetric & Gravimetric analysis

AC – 03 Thermal & Radiochemical methods of analysis

AC – 04 Atomic Spectroscopy

AC – 01 Sampling & Data handling

15 Hrs

Classification of Analytical Methods. Types of samples, Preparation of sample for analysis, effect of sampling uncertainties, sample treatment, moisture in sample, decomposition of organic & inorganic compounds, procedure of sampling of solids, liquids and gases.

Errors and Evaluation: -Accuracy, precision, sensitivity, detection limits, significant figures, rounding off. Types of errors – determinate and indeterminate errors. Ways of expressing accuracy, absolute and relative errors. Significant figures and propagation of errors. Confidence limit, Test of significance – the F-test and T-test. The statistical Q-test for rejection of a result, statistics for small data sets. Linear least squares method. The correlation coefficient. Calculation for the above parameters.

AC – 02 Titrimetric and Gravimetric Analyses

15 Hrs

Redox titrations: Formal and Standard potentials in various media, standardization, Oxidizing systems: Mn(VII), Ce(IV), Cr(VI). V(V). Reducing systems: V(II), Ti(III), Sn(II), Fe(II) in H_3PO_4 . Detection of end point in redox titrations – selection of suitable indicator.

Complexometric titrations: Introduction, stability constants of EDTA complexes, titration curves, types of EDTA titrations with examples. Standard EDTA solutions, some practical considerations during EDTA titrations. Titration of mixtures (Mg^{2+} & Ca^{2+} ; Pb^{2+} & Ca^{2+} ; Mn^{2+} & Mg^{2+}), selectivity, masking and demasking agents. Metal ion indicators: General properties, theory of the use of metal ion indicators, use of Murexide, Eriochrome black-T, Calcon, Xylenol orange, Methyl thymol blue, Fast sulphon black-F.

Gravimetric Analysis: Theory, principles, precipitation reagents (DMG, Oxine), Determination of Nickel as dimethylglyoximate, Aluminium as 8-hydroxyquinolate & Chloride as silver chloride.

AC – 03 Thermal and Radiochemical methods of Analysis

15 Hrs

Thermal methods of analysis: Thermogravimetry, Differential Thermal Analysis and Differential Scanning Calorimetry, instrumentation. Methodology of TG, DTA and DSC. Application of TG to study of oxalates and chromates. Determination of Glass transition, Heat capacity determination, Characterization of polymer blends. Problems based on decomposition path way and % composition. Evolved gas analysis.

Thermometric titrimetry – theory, instrumentation, applications.

Radiochemical methods of analysis: Radioactive tracer techniques and its applications, isotope dilution analysis, neutron activation analysis, radiometric titrations: principle, theory, applications and problems.

AC – 04 Atomic Spectroscopy

15 Hrs

Atomic Absorption Spectroscopy (AAS): Principles of AAS, Instrumentation – flame AAS and furnace AAS, resonance line sources, sensitivity and detection limits in AAS, interferences –chemical and spectral, evaluation methods in AAS and applications in qualitative and quantitative analysis.

Atomic Emission Spectroscopy (AES): Principle of AES, Instrumentation, Interferences, evaluation methods, Application in quantitative analysis.

Inductively Coupled Plasma- Atomic Emission Spectroscopy (ICP-AES): Limitations of AES, Principles of plasma spectroscopy, plasma as an excitation source. Inductively coupled plasma source, ICP-AES – Instrumentation. Applications of ICP-AES. Comparison with AAS.

Suggested Books

1. Principles of Instrumental Analysis - Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
2. Analytical Chemistry – Gary D. Christian, 6th ed., John Wiley and sons. Inc., New York 1994.
3. Instrumental methods of Analysis - Willard, Merit, Dean, 6th ed., CBS Publishers & distributors, 1986.
4. Hand Book for Instrumental Techniques for Analytical Chemistry, Ed. Frank Settle, Prentice Hall, New Jersey, USA, 1997.
5. Vogel's Text book of Quantitative Analysis – GJ Jeffery, J Bassett et al, 5th ed., Longman, ELBS Publications, 2000.
6. Principles and practice of Analytical Chemistry, F.W. Fifield & D Kealey, 5th Ed. Blackwell Science, 2000.
7. Quantitative Chemical Analysis, Daniel C. Harris, 6th Ed. WH Freeman & Co. New York, 2003.
8. Analytical Chemistry An Introduction, Crouch, 7th Ed. Saunders College Publishing, 2000.
9. Organic Analytical Chemistry theory and practice, Jag Mohan, Narosa Publications, 2003.
10. Pharmaceutical analysis, Watson
11. Electronic Absorption Spectroscopy and related techniques, D.N. Satyanarayana, University Press, 2001.

Paper-II: CH (AC) 302T: CORE :Spectroscopic methods of Analysis-I

AC – 05 Multinuclear NMR

AC – 06 Advanced NMR

AC – 07 Electron Spin Resonance Spectroscopy

AC – 08 Mossbauer and NQR

AC – 05 Multinuclear NMR

^{13}C nmr spectroscopy: CW and PFT techniques. Types of ^{13}C nmr spectra: uncoupled, proton- decoupled, single frequency off-resonance decoupled (SFORD) and selectively decoupled spectra. ^{13}C chemical shifts, factors affecting the chemical shifts

Chemical equivalence and magnetic equivalence. Virtual Coupling and its importance in study of Metal Complexes $[\text{Pd}\{\text{P}(\text{CH}_3)_3\}_2\text{I}_2]$. Spin Dilute Systems-Satellites in Pt(II) Complexes cis- $[\text{Pt}(\text{PEt}_3)_2\text{Cl}_2]$, $\text{Sn}(\text{CH}_3)_4$. NMR Time Scale and its use in studying Stereo chemical Non –rigidity (PF_5 , $[\text{Rh}(\text{PR}_3)_5]^+$, $[\text{Rh}\{\text{Cp}\}_2(\text{CO})_2]$) - ΔR , the Ring Contribution to ^{31}P Chemical Shifts –Metal and Chelate size on ΔR . Applications of ^1H , ^{13}C , ^{19}F , ^{31}P and ^{15}N to simple inorganic and Coordination Compounds - 1) ^1H -NMR: $\text{PtHCl}(\text{PEt}_3)_2$, $\text{Pt}(\text{NH}_3)_3(\text{CH}_3)_3$, BH_4^- , NH_4^+ , CH_3CN , $[\text{h-C}_7\text{H}_8 \text{Mo}(\text{CO})_3]$, $[\text{h-C}_7\text{H}_7\text{Mo}(\text{CO})_3]^+$, B_2H_6 ; $^{29}\text{SiH}_3\text{SiH}_3$, 2) ^{19}F : BF_4^- , H_2PF_3 ; 3) ^{31}P : $\text{Mo}(\text{CO})_3(\text{PPh}_3)_3$, $[\text{Rh}(\text{PPh}_3)_3\text{Cl}]$, trans- $[\text{PtCl}_4(\text{PEt}_3)_2]$, $^{31}\text{PF}_2\text{H}(\text{NH}_2)_2$ 4) ^{13}C ; $[\text{h-C}_8\text{H}_8 \text{Ru}(\text{CO})_3]$, $\text{Fe}(\text{CO})_5$, $\text{Fe}_2(\text{CO})_9$, $\text{Fe}_3(\text{CO})_{12}$, $\text{FeCp}(\text{CO})_2$, $\text{Cl}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$, $[\text{C}^{13}\text{N}^{15} \text{Co}(\text{DH})_2\text{Pyridine}]$. $^{13}\text{C}\{^1\text{H}\}$ NMR spectrum of σ -bonded C_6H_5 ligand

AC – 06 Advanced NMR Spectroscopy:- Spin-Lattice (T_1) and Spin-Spin Relaxation (T_2). pin Echo Polarization Transfer – Spin Echo Measurements. ^{13}C -NMR spectral editing techniques: Attached proton test (APT spectra) by Gated Spin Echo, Cross polarization, INEPT spectra, DEPT spectra (Distortionless enhancement by polarization transfer) (eg $\text{Cl}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$). INADEQUATE spectra (Incredible Natural Abundance Double Quantum Transfer Experiment).

Two Dimensional NMR: Basic principles, Types of 2-D NMR ;i)J- resolved spectroscopy a)homo and b)Heteronuclear J- resolved spectroscopy ii) Correlation spectroscopy ; Homo nuclear shift correlation spectroscopy (COSY) and Hetero nuclear shift correlation spectroscopy (HETCOR) iii) NOESY(Nuclear Overhauser Enhancement Spectroscopy). HOESY (two dimensional heteronuclear NOE). Advantages of 2-D NMR

AC – 07 Electron Spin Resonance Spectroscopy

Principle- Selection Rules – Instrumentation- Microwave source(energy bands). Application of ESR to the study of simple free radicals: methyl (CH_3)., amine (NH_2)., diphenyl picryl hydrazyl, cyclopentadienyl (C_5H_5)., hydroxy methyl(CH_2OH).radicals. Zero-Field Splitting (ZFS) - Effective Spin - Orbital Non-degenerate and Degenerate States. ESR Spectra of d^1 - d^9 Transition Metal Complexes with examples. Interpretation of g in cubic ,axial and rhombohedral geometries. Factors affecting g values. Calculation of g values with simple examples. Intensities of g_{\parallel} and g_{\perp} peaks . Evidence for Metal-Ligand Bond

Covalency- Cu(II)- Bis –Salicylaldimine. $[(\text{NH}_3)_5 \text{Co O}_2 \text{Co} (\text{NH}_3)_5]^{5+}$, Cu(II)- diethyldithio phosphinate, Vanadyl dithio phsphinat, Copper(II) tetraphenyl porphyrin, Co(II)-phthalocyanine, $\text{K}_2[\text{IrCl}_6]$. Interpretation of ‘g’ and ‘A’ values from esr spectral data in- i) MnF_6^{4-} , ii) CoF_6^{4-} , and CrF_6^{3-} . ESR spectra of dinuclear Cu (II) complexes.

AC – 08 Mossbauer and Nuclear Quadrupole Resonance Spectroscopy

Mossbauer Spectroscopy: Principle, Experimental Considerations and Presentation of the Spectrum - Isomer Shifts – Quadrupole splitting and Magnetic hyperfine splitting - Selection Rules.

Applications

Iron Compounds: Low-spin and High-spin Fe(II) and Fe(III) Complexes - π -bonding Effects in Iron complexes - Study of High-spin Low-spin Cross-over c) Diamagnetic and Covalent Compounds - Structural aspects of Iron Carbonyls and Iron-Sulfur Proteins

Tin Compounds: Tin Halides and Organotin Compounds.

Iodine Compounds: Isomer Shifts of ^{127}I and ^{129}I – Applications to Alkali metal iodides and Molecular Iodine. .

Nuclear Quadrupole Resonance Spectroscopy : Principle, nuclear quadrupole resonance experiment, structural information from NQR spectra, Interpretation of nuclear quadrupole coupling constants.

SUGGESTED BOOKS

1. Structural Methods in Inorganic Chemistry, E. A. V. Ebsworth, D. W. H. Rankin and S. Craddock, ELBS.
2. Physical Methods in Chemistry, R. S. Drago, W.B. Saunders Co., 1977.
3. Physical Methods for Chemists, Russell S. Drago Second edition, Saunders College Publishing, 1992.
4. Principles of Mossbauer spectroscopy, T. C. Gibb, Chapman and Hall, London, 1976.
5. Mossbauer Spectroscopy, N. N. Greenwood and T. C. Gibb, Chapman and Hall, London, 1971.
6. Principles of Instrumental Analysis, Skoog, Holler and Nieman.
7. Instrumental Techniques for Analytical Chemistry, Frank Settle.
8. Principles of Analytical Chemistry, M. Valcarcel.
9. Physical Methods in Advanced Inorganic Chemistry, Hill and Day
10. Magneto Chemistry, Dutta & Shyamal
11. Oxford Chemistry Primers, Vol 62

Paper-III CH (AC) 303T: ELECTIVE IIIa: Miscellaneous Methods of Analysis

AC – 09 Surface Analysis Methods

AC – 10 Diffraction Methods, X-Ray Absorption and X-Ray Fluorescence

AC –11 Electroanalytical Methods

AC – 12 Micromeritics, Dissolution and disintegration

AC-09 Surface Analysis Methods

15 Hrs

Introduction, types of surface measurements.

Photon Probe Techniques: X-Ray Photoelectron spectroscopy - Principle, Instrumentation, applications.

Electron Probe Techniques: Scanning electron microscopy (SEM) – Principle, Instrumentation, applications. Electron Probe X-ray analysis (EPXMA) - Principle, Instrumentation, applications. Auger electron spectroscopy (AES) - Principle, Instrumentation, applications.

Ion Probe Techniques: Rutherford backscattering spectrometry (RBS) - Principle, Instrumentation, applications. Secondary ion mass spectrometry (SIMS) – Fundamental aspects of sputtering, Principle, Instrumentation (static & dynamic), applications

Scanning probe microscopy Techniques: Scanning Tunneling Microscopy – Principle, Instrumentation, applications. Atomic Force Microscopy - Principle, Instrumentation, applications.

AC-10 : Diffraction Methods, X-Ray Absorption and X-Ray Fluorescence

15 Hrs

X – ray Diffraction : X –rays and their generation – choice of radiation; Miller indices, Bragg's equation, Experimental methods – Powder and single crystal methods, Indexing the reflections, Systematic absences, Electron density studies by X – rays – Platinum phthalocyanine complex, Silyl acetate, Tetraalkyl biphosphate; Advantages and limitations of X – ray Diffraction.

Electron Diffraction by gases: Principles, Applications to Silyl monothioacetate and Germyl monothioacetate and HgCl_2 molecules, Advantages and Limitations

Neutron Diffraction: Principle, Application in Hydrogen bonding studies, Advantages and limitations.

X-ray absorption method: Principle, radiographic non-dispersive x-ray Absorptiometers

X-ray fluorescence method: Instrumentation, qualitative and quantitative applications of XRF– advantages and limitations.

AC-11: Electro Analytical Methods

15 Hrs

pH-metry: Accuracy of direct potentiometer measurements. The Glass pH electrode – Theory, construction, standard buffers, accuracy of pH measurements, measurements with the pH – meter, pH titration of unknown soda ash.

Electrogravimetry: Basic principles of electrogravimetry, Instrumentation, electrogravimetry determination with constant applied voltage and at constant current. Applications of electrogravimetry. Problems based on effect of concentration on electrode potentials, calculation of theoretical cathode potential at the start of deposition, effect of pH in electrolytic separations.

Coulometry: Basic principles, Types of coulometers, constant current coulometric analysis, coulometric titrations – principle, circuit and cell for coulometry, Application to neutralization, Redox, precipitation, complexometric titrations, Advantages of coulometric

titrations and errors. Controlled potential coulometry – Technique & applications of inorganic & organic compounds.

High Frequency Titrations

Introduction, Theory, Instrumentation, Applications, Advantages and disadvantages

AC-12: Micromeritics, Dissolution and disintegration

15 Hrs

Particle size analysis- concepts of particle size, size distribution, mean size of particulate system, methods of particle size analysis (sieving, microscopic method, sedimentation methods, electrical sensing zone method, optical sensing zone and light diffraction method). Dissolution: Drug absorption, theories of drug dissolution – Diffusion layer model, Danckwert's model & interfacial barrier model. Dissolution tests for tablets and capsules (basket apparatus, paddle apparatus, flow through cell apparatus). Disintegration tests for tablets, capsules and enteric coated tablets.

Suggested Books

1. Structural methods in Inorganic Chemistry - E.A.V. Ebsworth, et al., ELBS Publications, 1988.
2. Physical Methods in Chemistry - R.S. Drago, W.B. Saunders Co, 1977.
3. Instrumental Methods & Chemical Analysis – Galen Ewing, 5th ed., McGraw-Hill Publishing Company Ltd., 1985.
4. Analytical Chemistry - Gary D. Christian, 6th ed. John Wiley and sons. Inc, New York, 1994.
5. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998
6. Principles and practice of Analytical Chemistry, F.W. Fifield & D Kealey, 5th Ed. Blackwell Science, 2000.
7. Quantitative Chemical Analysis, Daniel C. Harris, 6th Ed. WH Freeman & Co. New York, 2003.

CH(AC)303T: ELECTIVE IIIb :Bonding, Group Theory and its Applications

AC-09: Group Theory, Normal mode analysis and Spectral Activity

AC-10: MOT of Metal Complexes

AC-11: Electronic Spectroscopy of Metal Complexes

AC-12: IR and Raman Spectroscopy

AC-09: Group Theory, Normal Mode Analysis and Spectral Activity

Properties of a Group-Closure rule, Identity rule, associative rule, inverse rule, Abelian and Non-abelian groups. Classes of Symmetry Elements of a Group: Similarity transformation, properties of conjugate elements, rules of Classes, Classes of C_{2v} , C_{2h} and C_{3v} . Matrix Representation of Symmetry Elements: Simple Matrices, Matrix addition, subtraction and multiplication, Block-Factorization. Matrix Representation of E , C_n , S_n , i and σ Elements and C_{2v} , C_{3v} , C_{2h} , C_{4v} & D_{2h} . Great Orthogonality Theorem: Reducible and Irreducible Representations, Properties of Irreducible Representations, Construction of Character Tables for C_{2v} , C_{2h} and C_{3v} . Mulliken Symbolism for Irreducible Representations - Standard Reduction Formula – Direct Products.

Use of Character tables for IR & Raman spectroscopy, symmetry based selection rules for IR and Raman activity. Standard reduction formula. Type and Symmetry of Normal Modes and IR and Raman activity of molecules: Cartesian coordinate method of analysis for C_{2v} (eg H_2O/SO_2 , SF_4 , ClF_3 , $Cis-N_2F_2$), C_{3v} ($NH_3/SO_3^{2-}/PCl_3$, $POCl_3$), C_{2h} ($trans-N_2F_2$), D_{3h} (CO_3^{2-}/BF_3), Td ($SO_4^{2-}/PO_4^{3-}/ClO_4^-/NH_4^+$), O_h (SF_6). Internal coordinate method of analysis for $C_{2v}(H_2O)$, $C_{3v}(NH_3)$, $Td(SO_4^{2-})$. Internal Coordinates and Redundancy (Qualitative concept).

AC-10: Molecular Orbital Theory of Metal Complexes

Symmetry Classification of Metal and Ligand Orbitals in Cubic and Non-Cubic Environments: Octahedral, Tetrahedral, Square Planar, Square Pyramidal, Trigonal Bipyramidal Geometries – Concept of Ligand Group Orbitals – Construction of Molecular Orbital Energy Level Diagrams for Octahedral, Tetrahedral and Square Planar Metal Complexes with Sigma (σ) and Pi (π) Bonding Contribution from the Ligands.

AC-11: Electronic Spectroscopy of Metal Complexes

Classification of Electronic Spectra for Metal Complexes, Selection Rules: Electric Dipole Transitions, Magnetic Dipole Transitions, Orbital Selection Rules, Spin Selection Rules, Relaxation in Selection Rules. Nature of Electronic Spectral Bands: Band Widths, Band Intensities. Factors Influencing Band Shapes: Jahn-Teller Effect, Spectrochemical Series, Nephelauxetic Effect. Orgel Diagrams for d_1 - d_9 Configurations, Crystal Field Spectra of O_h and T_d Metal Complexes of 3d Metals. Charge Transfer Spectra. Strong Field Configurations: The Method of Descending Symmetry, Correlation Diagrams and Tanabe-Sugano Diagrams for d_2 and d_8 Configurations. Calculation of $10Dq$ Values, Racah Parameter (B) and Nephelauxetic Ratio (β).

AC-12: Infrared and Raman Spectroscopy

Conditions for Infrared and Raman Spectroscopies – Structure Fitting. Determination of Coordination Sites and Linkage Isomers (NO_2^- , SCN^-), Assigning Denticity of Ligands (SO_4^{2-} , CO_3^{2-}), Prediction of Diagnostic Fundamentals in Isomers of Metal Complexes and Distinguishing Isomers of Metal Complexes. Effect of Coordination on Ligand Vibrations: Examples involving Mono, Bi and/or Polydentate Ligands of Oxygen, Sulfur, Nitrogen, Phosphorous, Carbon and Halogen Donors (NH_3 , H_2O , Glycine, PPh_3 , 2,2'-Bipy, 1,10-Phen, Carbonyl and halides). Raman effect and molecular structure- CO , HCN , CO_2 , N_2O , H_2O .

Principles of Resonance Raman Spectroscopy. Application of Resonance Raman Spectroscopy to Structural Elucidation of the active Sites of Heme and Non-Heme Oxygen Carriers.

SUGGESTED BOOKS

1. *Symmetry and Spectroscopy of Molecules*, K. Veera Reddy, Second Edition, New Age International (P) Limited Publishers (2009)
2. *Chemical Applications of Group Theory*, F. A. Cotton, 3rd edition, Wiley NY (1990)
3. *Symmetry and Group Theory In Chemistry*, Mark Ladd, Harwood Publishers, London (2000)
4. *Symmetry Through the Eyes of a Chemist*, I. Hargittai and M. Hargittai, 2nd Edition, Plenum Press, NY (1995)
5. *Molecular Symmetry and Group Theory*, Robert L. Carter, John Wiley & Sons (1998)
6. *Group Theory for Chemists*, G. Davidson, Macmillan Physical Science Series (1991)
7. *Molecular Symmetry*, Schoenland
8. *Electronic Spectroscopy*, A. B. P. Lever
9. *Introduction to Ligand fields*, B. N. Figgis
10. *Infrared and Raman Spectroscopy of Inorganic and Coordination Compounds*, K. Nakamoto
11. *Infrared spectroscopy of Inorganic Compound*, Bellamy.

Paper -IV CH(AC) 304T: ELECTIVE IVa:Applied Analysis

AC –13 Industrial Analysis

AC –14 Analysis of Air and Water Pollutants

AC – 15 Clinical and Pharmaceutical analysis

AC – 16 Food and Agricultural analysis

AC –13 Industrial Analysis

15 Hrs

Analysis of Ferroalloys: Analysis of steel - Molybdenum, Phosphorous. Analysis of Ferromanganese, Ferrovandium. **Analysis of non- Ferrous alloys:** Analysis of Tin, Zinc and Copper in Brass, Bronze. Analysis of Tin and lead in Solder. **Analysis of Cement:** Composition of Portland cement, estimation of Aluminium oxide and Ferrous oxide. Determination of Alumina in Cement by Polarography. **Analysis of Oils & Fats:** Theory, Melting point of fats, Chemical Characteristics: Saponification value, Iodine value, Thiocyanogen value, ketone or perfume rancidity. Analysis of fatty acid composition in oil by GLC, Oxidation levels of fats by TLC. **Soaps & Detergents:** Composition of Soaps. Determination of low level Surfactants, determination of Germicides in soaps and detergents by photometric method, analysis of phosphates by paper chromatography, determination of detergent alkylates by Mass Spectrometry. **Paints & Pigments:** Constituents of Paints, Analysis of TiO_2 in Titanium dioxide pigments by XRD. Determination of Zn, Pb in Paint pigments by Polarographic method. Analysis of polyesters, acrylics by Gel permeation chromatography.

AC-14 : Analysis of Air and Water Pollutants

15 Hrs

Analysis of Air Pollutants: Air quality standards, sampling, analysis of air pollutants- SO_2 (UV_Vis, IR), H_2S (Spectrophotometry and Non-dispersive IR Spectrophotometry), NO - NO_x (Chemiluminescence technique, Colorimetric technique- Saltzman method), CO & CO_2 (IR, AAS & GC), Hydrocarbons (GC, GC-MS), Aromatic hydrocarbons in automobile exhaust, petrol, air, O_3 (Chemiluminescence & Spectrophotometry), particulate matter analysis.

Analysis of Water Pollutants: Objectives of analysis, sampling, preservation and pre-concentration methods, physical analysis - colour, odour, temperature, pH, EC, redox potential, total dissolved solids (turbidimetry), Chemical analysis of anions – CN^- , Cl^- , F^- , NO_2^- , NO_3^- (spectrophotometry), SO_4^{2-} , PO_4^{3-} . Determination of BOD, COD, TOC & DO. Analysis of Toxic Metals: Hg, As, Pb, Cd, Be, Al, Cr (Atomic Absorption Spectroscopy and Spectrophotometry)

AC-15 : Clinical and Pharmaceutical Analysis

15 Hrs

Clinical Analysis: Determination of (1) Serum Calcium (2) Serum/Plasma Bicarbonate (Titrimetry). (3) Serum sodium and potassium (Flamephotometry). Determination of Serum Chloride (Coulometry) - Determination of (1) Cholesterol (2) Total Protein (3) Blood Urea in Serum (4) Amylase (5) Aspartate Amino Transferase (AST) and Alanine Amino Transferase (ALT) (by Spectrophotometry). Determination of (1) Thyroxin and (2) Thyroid-Stimulating Hormone (TSH)(by RIA Method)

Pharmaceutical analysis: Determination of Diclofenac (non-aqueous titration), Calcium in Vitamin D and Calcium formulations (Complexometry), Sulphanilamide (potentiometry), Pethidine hydrochloride (UV-Vis), Frusemide (UV-Vis), Aspirin, paracetamol and codein in APC tablets (NMR), Phenobarbitone in tablets (IR), pivalic acid in dipivefrin eye drops (GC),

Assay of hydrocortisone cream. (HPLC). Impurity profiling of Propranolol (GC-MS), famotidine (LC-MS).

AC -16: Food and Agricultural Analysis

15 Hrs

Food Analysis: Analysis of Chemical Additives in foods : Division of colour additives, Chromatographic identification of colours, and quantitative estimation of added dyes in foods (Titanium Trichloride Method) - chemical preservatives and synthetic sweetening agents (Organic-ether extractable and Non-ether extractable) - Analysis of SO₂ & Sodium Benzoate (Chemical Methods), Sorbic Acid (Chromatography) - Types of Antioxidants used in Foods, Analysis of Butylated Hydroxy Toluene (BHT) (Spectrophotometry).

Agricultural Analysis: Analysis of soils for available Major Nutrients - Estimation of available Nitrogen (Kjeldahl Method), Phosphorus (Olsen's Method and Bray and Kurtz Method), and Exchangeable Calcium & Magnesium (by EDTA). Soil analysis for Micronutrients - Estimation of Available Zinc, Copper, Manganese and Iron (AAS) - Analysis of Pesticide Residues - Determination of Methyl Parathion Residues in food grains & vegetables (Solvent Extraction and Titrimetry) - Determination of Organochlorine pesticides by Gas Chromatography (Cypermethrin) - Determination of Malathion and DDT Residues in food grains (Spectrophotometry).

SUGGESTED BOOKS

1. Analytical Chemistry, Gary Christian, VI Ed, John Wiley & Sons Inc, New York
2. Fundamentals of Analytical Chemistry, Skoog & West
3. Pharmaceutical Drug Analysis, Ashtoshkar
4. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed, Pearson Education Ltd
5. Environmental Pollution Analysis, S M Khopkar, Wiley Eastern Ltd 1995
6. Environmental Analytical Chemistry, F W Fifield, P J Haines, Blackie Academic & Professional.
7. Environmental Chemistry, B K Sharma, Goel Publishing House, Meerut.
8. Handbook of Analysis and quality control for fruit and vegetable products, S Ranganna, Tata Mc Graw Hill Publishers Ltd, 1986
9. Introduction to chemical analysis of foods, S Suzanna & Nielsen, CBS Publishers & Distributors
10. Practical pharmaceutical Chemistry, a H Beckett and J B Stenlake, III Ed, Vol I and Vol II, CBS Publishers & Distributors, 1997
11. Pharmaceutical Analysis, David G Watson, Churchill Livingstone Harcourt Brace and Company Ltd, 1999
12. Handbook of analysis of drugs, Nagavi
13. Medical Laboratory Technology – Mukherjee , Tata Mc Graw Ltd 1988.
14. Medical Laboratory Technology – Ramnik Sood , Jaypee Brothers Ltd 1999.
15. Text Book of Clinical Chemistry V Edn Carl.A. Burtis Edward R. Ashwood Saunders Harcourt India 2001.

Paper -IV CH(AC) 304T: ELECTIVE IVb: Nuclear Chemistry, Zeolites, Solid State and Surface Chemistry

AC-13: Nuclear Chemistry

AC-14: Zeolites and Molecular Sieves

AC-15: Solid State Chemistry

AC-16: Surface Chemistry & Superconductors

AC-13: Nuclear Chemistry

Introduction: The atomic nucleus-elementary particles, quarks, classification of nuclides based on Z and N values, nuclear stability, nuclear potential, binding energy.

Nuclear structure: Shell model-salient features, forms of the nuclear potential, magic numbers, filling of orbitals, nuclear configuration, Liquid drop model, Fermi gas model, Collective model and Optical model.

Nuclear reactors :- General aspects of reactor design, thermal, fast and intermediate reactors, reactor fuel materials, reactor moderators and reflectors, coolants, control materials, shield, regeneration and breeding of fissile matter, types of research reactors.

Nuclear reactions, fission and fusion, radio-analytical

Radioactivity, radioactive decay kinetics, Parent-daughter decay-growth relationship-secular and transient equilibria, theories of α , β^- , β^+ and γ -decay, internal conversion, Auger effect.

Radio isotopes & its applications.

AC-14: Zeolites and Molecular Sieves

Introduction to porous materials:

Classification into micro-, meso- and macro porous materials, the origin of pores and its significance, distinction from condensed materials.

Zeolites:

Definition, natural and synthetic zeolite or aluminosilicates, the primary and secondary building blocks, final framework structures, Lowensteins rule, sodalite and other structures, Nomenclature: Atlas of zeolite; structural distinctions, Novel zeolites, examples of small, medium, large and extra large pore zeolites; general properties and application of molecular sieves.

Characterization of zeolite:

XRD, SEM and other techniques; spectral techniques: FT-IR and solid-state NMR; sorption capacity, surface area by BET method, pore volume and pore structure, the origin of Brønsted and Lewis acidity in zeolites, the number and the strength, techniques for the estimation of acidity: adsorption of bases and IR spectra, temperature programmed desorption of bases.

AC-15: Solid State Chemistry

Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones.

Structure of ionic Crystals & Compounds: Ionic Crystals with stoichiometry MX, Ionic Crystals with stoichiometry MX₂, spinel structure, perovskite structure. AB [nickel arsenide (NiAs)], AB₂ [fluorite (CaF₂) and anti-fluorite structures, rutile (TiO₂) structure and layer structure [cadmium chloride and iodide (CdCl₂, CdI₂)].

Crystal Defects and non-stoichiometry:

Classification of Defects: subatomic, atomic and lattice defects in solids; Thermodynamics of vacancy in metals; Thermodynamics of Schottky defects in ionic solids ; Thermodynamics of Frenkel defects in silver halides; Calculation of number of defects and average energy

required for defect, Other examples of defect structure; Non-stoichiometry and its classifications.

Preparative method of solids:

Introduction, Ceramic method, microwave synthesis, Precursor method, Hydrothermal method, Chemical vapour deposition (CVD) Method, Chemical vapour Transport, Choosing a method for solids.

Crystal Growth: law governing nucleation; Growth of nuclei; Reaction between two solids; Improving the reactivity of solids; Zone refining method; Crystal growth.

AC-16: Surface Chemistry & Superconductors

Surface Chemistry:

Mechanism of catalytic reactions on the surfaces – diffusion of reactants to the surfaces, adsorption of reactants, reaction within the adsorbed layer, desorption of the products, diffusion of the products away from the surface; The mechanism of chemisorption on metals – The formation of chemisorptions layer, the character and nature of the chemisorption bond, the mechanism of chemisorptions for some gases; Nature of adsorbates on surfaces.

Superconductors:

Discovery of super conductors, Meissner effect, Type I and II conductors, Levitation, BCS theory and Cooper pairs, High Tc Super Conductors, applications of super conductors.

SUGGESTED BOOKS

1. Essentials of nuclear chemistry, 4th edition; H. J. Arniker, NAIL publishers (1995); Chapters 1, 3 and 4.
2. Nuclear and Radioactive chemistry; Friedlander, Kennedy and Miller; Chapters 8 and 9.
3. Introduction to zeolite science and practice, H. Van Bekkum, E. M. Flanigen, P. A. Jacobs and J. C. Jansen (Elsevier Pub. Amsterdam, 2001)
4. Breck.D.w. Zeolites molecular sieves- Structure, chemistry and use. John Wiley & Sons N.Y. (1974).
5. Solid-State Chemistry an Introduction (2nd Edition) – Lasley Smart and Elaine Moore (Chapman & Hall 1996)
6. Solid State Chemistry- D.K.Chakraborty (New Age International Pvt.Ltd.New Delhi, 2000)
7. Introduction to Solids-L.V.Azaroff (tata McGraw Hill Publication Ltd. New York)
8. Principles of the Solid State-H.V.Keer (Wiley Eastern Ltd.New Delhi, 1994)
9. Solid state Chemistry –N.B.Hannay (Prentice Hall, New Jersey, 1967)
10. Superconductivity, Joi, Khachan & Stephen Bio Science, ----
11. Chemisorption, B. M. W. Trapnell, Butterworths Scientific Publications, London, 1955.
12. Adsorption on solids, VladimirPonec, Zlatko Knor, Slavoj Cerny, Butterworth & Co – publishers, 1974.
13. Catalysis: Principle and Applications, B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, Narosa Publishing House, 2002.

LABORATORY COURSE

Paper CH (AC) 351P: Titrimetry, Solvent extraction, Chromatography and Water analysis.

I. Titrimetry:

1. Determination of Ca^{2+} , Mg^{2+} , CO_3^{2-} & HCO_3^- in soil sample.
2. Determination of Calcium in Vitamin-D and Calcium tablets
3. Determination of Fe & Ca in Cement
4. Determination of Saponification value and Iodine value of an oil sample

II. Solvent extraction:

1. Determination of Pb using Dithiazone

III. Chromatography (Demonstration):

1. Separation of Co & Ni in Cellulose column
2. Separation of amino acids in a mixture by TLC using Ninhydrin
3. Separation of additives in Ink by GC.
4. Separation of synthetic corticosteroids in by HPLC.

IV. Water analysis:

1. Determination of residual Chlorine in water by Iodometry
2. Determination of Dissolved Oxygen.
3. Determination of COD.
4. Determination of BOD.
5. Determination of residual Chlorine in water by Iodometry

Paper CH (AC) 352P: Colorimetry, Spectrophotometry

I. COLORIMETRY:

1. Determination of blood sugar
2. Determination of blood cholesterol
3. Determination of Paracetamol
4. Determination of Ampicillin
5. Estimation of Ascorbic acid

II. SPECTROPHOTOMETRY:

1. Determination of Manganese in steel
2. Determination of Phosphorous in human serum
3. Determination of Creatinine in a sample
4. Determination of pKa of an organic Indicator (Methyl Orange)
5. Simultaneous determination of Cr and Mn in an admixture
6. Spectrophotometric Titration of Fe(II) with o-Phen
7. Determination of composition of Complex by Job's Method and Mole ratio Method of Cu(II)-EDTA complex

SUGGESTED BOOKS

1. Chemistry Experiments for Instrumental Methods, Donald T Sawyer William
2. R. Hememan et al John Wiley & Sons 1984.
3. Analytical Chemistry by Gary D. Christian 6th Edition
4. John Wiley & Sons Inc New York 1994.
5. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel 3rd Edition

Elbs Publication 1969.

6. a) Vogel's Text Book Of Quantitative Inorganic Analysis Jeffery etal 4th edition Elbs Publications 1988.
b) Vogel's Text Book of Quantitative Chemical Analysis, 6th edition. Pearson Education Ltd 2002.
7. Analytical Chemistry Theory and Practice by R.M. Verma 3rd Edn. CBS Publishers & Distributors 1994.
8. Comprehensive Experimental Chemistry by V.K. Ahluwalia etal New Age Publications 1997.
9. Laboratory hand Book of Instrumental Drug Analysis. by B.G. Nagavi 2nd edn. 1996
10. Practical Pharmaceutical Chemistry, A.H. Beckett and J.B. Stenlake 4th edn. CBS publishers, 2001
12. Separation methods, MN Sastri, 2nd edn, Himalaya Publishing House 1996
13. Hand book of analysis and quality control for fruit and vegetable products. S. Ranganna,
2nd edn, Tata McGraw-Hill Publishing Company, 2002.
15. Gas Chromatography, Rajbir Singh, 1st edn, Mittal Publications, 2002

IV SEMESTER

Paper-I: CH (AC) 401T CORE: Spectroscopic methods of Analysis-II

AC – 17: U.V. visible spectroscopy,

AC –18 :IR & Raman spectroscopy

AC – 19:Optical Methods

AC – 20: Fluorimetry, Phosphorimetry,Nephelometry and Turbidimetry

AC – 17: UV and visible spectroscopy

15 Hrs

UV and visible spectroscopy: Beer Lamberts law, Real limitations to Beer's law, instrumentation for colorimetry and spectrophotometry – Numerical problems based on Beer's law, simultaneous & differential spectrophotometry. First derivative spectrophotometry. Classification of Electronic Spectra for Metal Complexes, Selection Rules: Electric Dipole Transitions, Magnetic Dipole Transitions, Orbital Selection Rules, Spin Selection Rules, Relaxation in Selection Rules. Nature of Electronic Spectral Bands: Band Widths, Band Intensities. Factors Influencing Band Shapes: Jahn-Teller Effect, Spectrochemical Series, Nephelauxetic Effect. Orgel Diagrams for d^1 - d^9 Configurations, Crystal Field Spectra of O_h and T_d Metal Complexes of 3d Metals – Calculation of 10Dq Values, Racah Parameter (B) and Nephelauxetic Ratio (β) – Charge Transfer Spectra.

AC – 18 : IR & Raman spectroscopy

IR Spectroscopy: Principle, Instrumentation, sample handling, Fourier transform infrared spectroscopy- Principle, instrumentation & its advantages. IR in quantitative analysis. Applications of IR spectroscopy: structure analysis of organic compounds, inorganic molecules-Sulphato, Carbonato, Nitrate & metal chelates - Acetylacetonato Complexes. Analysis of petroleum hydrocarbons, oil and grease contents by EPA method, Quantitative analysis of multi-component mixtures.

Raman Spectroscopy: Theory, Instrumentation, sample handling, Illumination diagnosis and structure analysis, polarization measurements, quantitative analysis, laser applications, Resonance Raman spectroscopy-Principle, theory and its applications.

AC – 19Optical Methods

15 Hrs

Refractometry: Theory, instrumentation, specific and molecular refraction, Abbe, Pulfrich and immersion types, applications

Polarimetry: Theoretical considerations – Plane polarized light, optical activity, specific and molecular rotations. Instrumentation, applications.

Optical rotator dispersion and Circular dichroism: Optical rotation, circular birefringence, circular dichroism and Cotton effect, Octet Rule, Experimental Techniques, Applications : quantitative analysis, determination of absolute configuration, conformational studies and equilibrium studies. Use of CD in the conformational studies of metal complexes, DNA and DNA-metal complexes.

AC –20: Fluorimetry, Phosphorimetry,Nephelometry and Turbidimetry

15 Hrs

Fluorimetry and Phosphorimetry: Theory of Fluorescence and Phosphorescence- Excited states producing Fluorescence and Phosphorescence. Rates of absorption and emission. Deactivation processes, Variables affecting Fluorescence and Phosphorescence. Types of Photoluminescence spectra for Phenanthrene. Instrumentation – Components of Fluorimeter,

Spectrofluorimeters and Phosphorimeters. Applications of Fluorimetry- Determination of Inorganic Cations, Fluorimetric reagents. Fluorimetric determination of organic species – Thiamine, Aneurine Hydrochloride, Polycyclic aromatic hydrocarbons. Phosphorimetry- Determination of Aspirin in blood serum. Chemiluminescence- Origin, measurements. Analytical applications- Atmospheric pollutants (Oxides of Nitrogen and Sulphur compounds, Ozone). Detection in Gas Chromatography, High Performance Liquid Chromatography and Capillary Electrophoresis. Detection of Enzyme reaction products. Immunoassay and Nucleic acid assays.

Nephelometry and Turbidimetry: Principles and instrumentation for Nephelometry and Turbidimetry, Applications

Suggested Books

1. Principles of Instrumental Analysis– Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
2. Introduction to Ligand Fields – Figgis, Wiley Eastern Ltd, 1966.
3. Inorganic Electronic Spectroscopy – A.B.P. Lever, Elsevier Publishing Company, London, 1968.
4. Chemical Analysis – A. K. Srivatsava & Jain, 3rd ed., S, Chand & Company Ltd., 1977.
5. Hand Book for Instrumental Techniques for Analytical Chemistry, Ed. Frank Settle. Prentice hall, New Jersey, USA, 1997.
6. Analytical Chemistry – Gary D. Christian, 6th ed, John Wiley and sons. Inc., New York, 1994.
7. Introduction to Inductively Coupled Plasma Emission Spectroscopy - GL Moore, Elsevier Science publishers, New York, 1989.
8. Analytical Chemistry – Skoog & West, 6th ed, W.B. Saunders, 1998.
9. Infrared and Raman Spectra of Inorganic and Coordination Compounds, Kazuo Nakamoto, 5th ed., John Wiley & Sons, 1995.
10. Vogel's Text book of Quantitative Analysis – J. Mendham et al, 6th ed., Pearson Education Ltd, 2002.
11. Instrumental methods of Analysis - Willard, 6th ed., CBS Publishers & distributors, 1986.
12. Analytical Chemistry Instrumental techniques, Maninder Singh, Dominant Publishers, New Delhi, 2002.

Paper-II: CH (AC) 402T: CORE: Separation Methods

AC - 21: Solvent extractions

AC -22: Chromatography

AC -23: Mass spectrometry & Hyphenated techniques

AC -24: Electrophoresis

AC-21: Solvent extractions

15 Hrs

The distribution coefficient, distribution ratio, relation between K_D & D , the percent extracted.

Solvent extraction of metals – ion association complexes, metal chelates, effect of pH and reagent concentration, extraction process, separation efficiency of metal chelates, analytical separations – multiple counter current distribution, solid phase extraction, solvent extraction of flow injection analysis. Super critical fluid extraction.

Organic reagents in Inorganic analysis :- Theoretical basis for the use of organic reagents in inorganic analysis. Extraction of metal ions by the use of organic reagents – acetylacetone,

thionyl-trifluoroacetone, tri-n-octyl phosphine oxide. Applications to extractions of metal ions by chelating agent (Dithiazone, 8-hydroxy quinoline and cupferron) Determination of salts of organic acids and bases, determination of alkaloids in crude drugs.

AC -22: Chromatography

15 Hrs

HPTLC: Principle, Technique, advantages over TLC

Gas Chromatography (GC) – Theory, Data acquisition and processing Applications - Derivatization techniques. Monitoring of ethylene dibromide (EDB) residue in Indian Black pepper by GC using electron capture detector. Analysis of petroleum products. Headspace analysis of tobacco. Preparative gas chromatography

High Performance Liquid Chromatography (HPLC) – Theory, and separation modes, Applications with respect to separation of enantiomers, Organic and inorganic systems.

Supercritical fluid chromatography (SFC) – Instrumentation of SFC, stationary and mobile phases used in SFC, Detectors, Advantages of SFC. Technique and applications of SFC.

Size Exclusion Chromatography: Principle of Gel Chromatography, Filtration Chromatography, Instrumentation, retention behaviour, resolution, selection of gel type – applications. Ion Exclusion – Principle and applications.

Ultra Performance Liquid Chromatography: Principle, Instrumentation

AC-23: Mass Spectrometry & Hyphenated techniques

15 Hrs

Advanced Mass spectrometry

Quadrupole analysers, Ion traps. Time of flight mass spectrometry.

Mass Spectrometry / Mass Spectrometry Tandem Mass Spectrometry. Ion cyclotron resonance spectrometers and Ion traps for MS/MS.

Quantitative mass spectrometry: Introduction, principle, calibration and internal standards.

Hyphenated techniques:

GC-MS: Principle, instrumentation, Interfaces, Mass analyzer, Mass chromatogram, Applications. Analysis of metabolite of drug Imipramine

GC-FT-IR: Principle, Instrumentation and Applications

LC-MS: Principle, Instrumentation, Interfaces and Applications.

LC-MS-MS : Principle, Instrumentation, Interfaces and Applications.

ICP-MS: Instrumentation, principles, Quantitative analysis and applications.

AC-24: Electrophoresis

Introduction, Definition

Paper Electrohoresis: Principle, Experimental Requirements, Technique, Factors governing the migration of ions, Applications

Capillary Electrophoresis: Electro osmotic flow, migration in CE, instrumentation, control of separation, applications

Gel Electrophoresis: Principle, technique, applications

Immuno electrophoresis: Principle, technique, applications

Suggested Books

1. Separation Methods - M. N. Sastri, 1st ed., Himalaya Publishers, 1991.
2. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.29
3. Analytical Chemistry - Gary D. Christian, 6th ed, John Wiley and sons. Inc., New York, sixth edition, 1994.

4. Mass spectrometry for Chemists and Biochemists, Robert A.W. Johnstone and Macolm. E. Rose, 2th ed Cambridge University Press 1996.
5. Structural methods in Inorganic chemistry - E.A.V. Ebsworth, et al ELBS Publications,1988
6. Introduction to analytical Gas Chromatography, Raymond PW Scott,2nd Ed. Marcel Dekker, Inc. New York,1988.
7. Techniques and practice of Chromatography, Raymond PW Scott, Marcel Dekker, Inc. New York,1995.
8. Liquid Chromatography-Mass Spectrometry Principles & Applications, WMA Neissen & JV Greef, Marcel Dekker, Inc. New York,1992.

Paper-III CH (AC) 403T: ELECTIVE IIIa: Laboratory Management

AC – 25 Automation in laboratory

AC – 26 LIMS & Computer aided analysis

AC – 27 Laboratory Management & Standard reference materials

AC – 28 Accreditation of Laboratories, Quality management

AC- 25 Automation in Laboratory.

15 Hrs

Introduction, classification of Analytical methods, Types of Instrumental methods, Instruments for analysis. Analog & Digital signals, Planning for laboratory automation. An overview of automatic instruments & instrumentation.

Flow Injection Analysis, Discrete Automatic systems.

Good laboratory practices: Instrumental standardization, optimization of procedures.

AC-26 LIMS and Computer aided Analysis

15 Hrs

Laboratory Information Management System: Laboratories as information producers, properties of good information, Laboratory information management system, conclusions. **Computer aided analysis:** Computer-instrument interaction, computer organization-Hardware -Basic Digital circuit components, Microprocessors and Microcomputers, Computer Software -Software control of the computer-instrument interfaces. Automated laboratory – Automated instruments (AAS), Applications of computers, Computer Networks.

AC- 27 Laboratory Management & Standard reference materials

15 Hrs

Introduction – Administration, Geographical location of the laboratory, relationship with the industrial exploratory and regulatory work and the analytical laboratory. Disciplines represented in the Laboratory. Educational requirements of the laboratory personnel. Work load statistics of the laboratory coordination between routine work and research cell. Regular academic research work, opportunities for training. Internal organization of the laboratory. Architectural issues, laboratory infrastructure of equipment and instrumentation.

Standard reference materials

Standards of Analysis, Analytical standards, reference materials, High purity substances, working and secondary standards.

AC- 28 Accreditation of Laboratories, Quality Management

15 hrs

Accreditation of Laboratories: International organization for standardization, National accreditation board for testing and calibration laboratories. Scope of accreditation.

Analytical Methods: choosing the methods- standard methods, official methods, literature methods. Validation of new methods - comparison of analytical methods.

Quality systems, the operational aspects required to deliver a quality system (Traceability, quality control, quality assurance, quality management and quality manual) calibration and test methods.

Total Quality Management (TQM) – Essentials of TQM: Quality Planning, Quality control, Quality Audit, Quality surveillance, Quality assurance, Quality circles.

Analytical methods of validation: Characteristics of Analytical procedures – Accuracy, precision, linearity, Range specificity, Detection limit, Quantitation limit, robustness process validation, Types of process validation – prospective, concurrent and retrospective process validation.

Suggested Books

1. Principles of Instrumental Analysis - Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
2. Model for Quality assurance in design/development production, installation and servicing, ISO 9001.
3. Journal of Validation technology, Vol.-III and IV, 1997.
4. Instrumental Methods of Analysis - Willard, Merit, Dean, 6th ed., CBS Publishers & distributors, 1986.
5. Hand Book for Instrumental Techniques for Analytical Chemistry, Ed. Frank Settle, Prentice Hall, New Jersey, USA, 1997.
6. Handbook of Quality Assurance for the analytical chemistry laboratory, James P. Dux, Van Nostrand Reinhold, New York, 1986.
7. Quality in Totality – Parag Diwan, Deep & Deep Publications, 1st ed., 2000.
8. QA manual – DH Shah, Business Horizons, 1st ed., 2000.

PAPER – III: CH (AC) 403T:IIIb : Applied analysis and Green Analytical Chemistry

AC-25 Enzyme catalysis- Analytical applications

AC-26 Forensic Chemical Analysis

AC-27 Limit tests

AC-28 Green Analytical Chemistry

AC-25: Enzyme catalysis- Analytical applications

Basic principles, Catalysis – measurement of catalytic reactions, Nonspecificity of catalysts, types of reactions catalyzed. Enzyme catalysis, enzyme kinetics, properties of enzymes, enzyme inhibitors and activators, enzyme specificity, Determination of enzymes and enzyme substrates. Example of enzymatic analysis: Dehydrogenase reactions, Substrate determinations: Glucose, Uric acid. Immobilized enzymes. Evaluation methods.

AC-26: Forensic Chemical Analysis:

Contact traces – Analysis of soil, fiber and paint evidence in forensic work.

Analysis of narcotic drugs and psychotropic substances (opiates, cannabinoids, barbiturates, benzodiazepines, amphetamines with one example each and LSD) by colour/micro crystal tests, chromatographic methods (TLC, GC, and LC) and spectroscopic methods (UV-Vis, IR, MS and GC-MS). Analysis of explosives and explosion residues (Low explosive residues – cations and anions; High explosive residues – RDX) by spot tests, chromatographic methods (TLC, GC AND GCMS) and spectroscopic methods (UV-Vis, IR, MS and GC-MS).

Analytical toxicology – extraction techniques for drugs and pesticides – analytical techniques in forensic toxicology for alcohols, drugs and pesticides involving spot tests (TLC, GC & LCMS). Interpretation of analytical data – court testimony.

AC -27: Limit tests

Limit tests for insoluble matter, limit tests of soluble matter, limits of moisture, volatile matter, residual matter, residual solvents, limits of nonvolatile matter, limits of residue on ignition, limits of loss on ignition, limits on ash value. Limit tests for metallic impurities: lead, arsenic, iron: Limit tests for acid radical impurities, chlorides, sulfates, arsenate, carbonate, cyanide, oxalate, phosphate. Limit tests for nonmetallic impurities: Boron, free Halogens, Selenium.

AC- 28: Green Analytical Chemistry

15 Hrs

Green Analytical Chemistry: Concepts and trends

“Greening” Sample Treatment: Reduced and solvent- free sample preparation methodologies, alternative solvents, energy saving procedures.

Green Instrumental Analysis: Assessment of analytical methods for “Greenness”, greening flow injection analysis, chemical sensors, liquid green chromatography.

Suggested Books

1. Analytical Chemistry - Gary D. Christian, 6th ed. John Wiley and sons. Inc, New York, 1994.
2. Kinetics methods of analysis – Marck & Rekniz Vol 25
3. Practical Pharmaceutical Chemistry, A.H. Beckett et al, 3rd ed. – Vol. 1 & Vol. 2 CBS Publishers & distributors, 1986.

4. Green Analytical Chemistry: Theory & Practice, Miguel De La Guardia, Sergio Armenta, Elsevier
5. Green Analytical Chemistry, Mihkel Koel, Mihkel Kaljurand, RSC Publishing

PAPER – IV: CH (AC) 404T: IDa: Quality Assurance and Accreditation

AC-29 Quality Assurance – I

AC-30 Quality Assurance – II

AC-31 Quality Assurance – III

AC-32 Quality Accreditation

AC -29: Quality Assurance – I

15 Hrs

Introduction to Quality Control and quality assurance: Concepts and significance.

Quality control and statistical techniques: Quality control charts, the X-quality control chart, the R-quality control chart and its interpretation, spiked sample control charts, use of blind samples in quality control, use of proficiency evaluations in quality control.

Calibration and maintenance of Instruments / Equipment: Instrument calibration – linear calibration curves, equipment calibration, frequency of calibration, calibration of common laboratory instrument and equipment (Analytical balances, volumetric glassware, ovens, furnaces, UV / Visible spectrophotometer, pH meter, conductivity meter, IR spectrophotometers, AAS, GC, HPLC etc.). Maintenance of instruments and equipment.

AC-30: Quality Assurance – II

15 Hrs

Documentation for quality assurance: Raw Data - Type of notebooks, control of notebook distribution and data entry. General Reagents and volumetric reagents. Sampling – sampling methods, sample labeling, sample log-in/register. Sample analysis, reporting, recording and personal training. Instrument calibration and maintenance. Analytical report. Personnel, training, records - professional personnel, technician personnel. Filing quality assurance documentation.

Good laboratory practices and personnel, Quality Programme, Instrument and Organisation calibration, Customer Satisfaction.

AC -31: Quality Assurance – III

15 Hrs

Computers and quality assurance: Sample handling. Data Acquisition. Quality control data and calculations. Computer generated analytical reports. Security considerations. Hardware and software.

Establishing a Quality Assurance program: Management commitment. Define the quality assurance program. Writing standard operating procedures. Topics for standard operating procedures. Consolidating the programme. Monitoring the program – monitoring quality assurance data, reporting quality assurance problems. Writing the quality assurance manuals.

AC -32: Quality Accreditation:

15 Hrs

Laboratory Accreditation: Need for laboratory accreditation. International aspects of laboratory accreditation and in India. Criteria for laboratory accreditation. Benefits of laboratory accreditation,

Evolution and significance of Quality Management, Background to ISO 9000, comparison between ISO-9001, ISO-9002 & ISO-9003., ISO 9000-2000 series of standards on quality

management system, - evolution of series of standards, introduction to ISO organization, Registration / certification - benefits of QMS certification. Structure of ISO 9000-2000 family of standards. Advantages of ISO 9000-2000. Requirements of ISO 9001-2000 QMS and applications, Steps for effective implementations. Significance of ISO - 9001, 9002, 9003 & 9004.

Requirements of ISO 9000/IS 14001. Concepts of OHSMS (BS 8800) Quality Management Principles in QMS, QMS documentation, Quality Manual, Quality policy, conformities and Non-conformities.

Suggested Books:

1. Handbook of Quality Assurance for the analytical chemistry laboratory, James P. Dux, Van Nostrand Reinhold, New York, 1986.
2. Applying ISO-9000 Quality Management Systems, International Trade Centre Publishing, UNCTAD/WTO. Geneva, Switzerland, Indian Edition Printed by D.L. Shah Trust.
3. How to practice GLP, PP Sharma, Vandana Publications, 2000, New Delhi
4. Training manuals on ISO 9000 / 2000 PQM, Girdhar J Gyani, Raj Publishing House, 2001
5. Quality Assurance in Analytical Chemistry, B.W. Wenclawiak, Springer, India, 2004.

PAPER – IV: CH (AC) 404T: IDb: Inorganic Material Chemistry

AC- 29: Composite Materials

AC- 30: Liquid Crystals

AC-31: Explosives and Propellants

AC-32: Fuels and Combustion

AC-29: Composite Materials

Introduction, Advantageous Properties of the Composites, Constituents of Composites, Types of Composites – Fibre-reinforced composites (Glass, carbon, Aramid, Alumina reinforced composites), Particulate composites, Layered composites, Processing of Fibre-reinforced Composites, Micromechanics of Fibre and Particle Reinforced Composites, Fabrication of the Composites.

Refractories: Characteristics and Classification of Refractories, Properties of Refractories, Manufacture of Refractories, Common Refractories Bricks – Silica Bricks, Alumina Bricks, Magnesite Bricks, Dolomite Bricks, Carbon Bricks and Chromite Bricks.

Ceramics: Plasticity of Clays, Whitewares or White-Pottery, Manufacture of White-Pottery, Glazing, Methods of glazing, Earthenwares and Stonewares.

AC-30: Liquid Crystals

Introduction, Types of Mesophases, Characterization of Liquid Crystals, Physical Properties of Liquid Crystals, Structure of Liquid Crystal forming compounds, Classification of Liquid Crystals- Thermotropic Liquid Crystals and Lyotropic Liquid Crystals, Chemical Properties of Liquid Crystals, Applications with special reference to Display systems, Applications and Importance of Lyotropic Liquid Crystals, Future of Liquid Crystals.

AC-31: Explosives and Propellants

Explosives: Introduction, Classification of Explosives, Primary Explosives, Low Explosives, High Explosives, Precautions During Storage of Explosives, Blasting Fuses, Manufacture of Important Explosives-Lead azide, Diazonitrophenol (DDNP), Trinitrotoluene (TNT), Nitroglycerine (NG) or Glycerol trinitrate (GTN), Pentaerythritol tetranitrate (PETN) and RDX; Recent uses of Explosives

Propellants: Rocket Propellants - Introduction, Principle of Rocket Propulsion, Classifications of Propellants-Solid propellants, Composite propellants, Liquid Propellants, Mono-propellants, Bi-propellants; Differences between Solid propellants and Liquid Propellants

AC-32: Fuels and Combustion

Introduction, Classification of Fuels, Calorific Value, Characteristics of a Good Fuel, Theoretical Calculation of Calorific value of a Fuel, Coal, Classification of Coal by Rank, Analysis of Coal – Proximate analysis and Ultimate analysis, Metallurgical Coke, Types of Carbonization of Coal – Low-temperature and high temperature carbonization, Manufacture of Metallurgical Coke by Beehive oven process, Petroleum, classification of petroleum, Refining of crude oil, Cracking – Thermal cracking, Catalytic cracking- Moving-bed catalytic cracking, LPG as a Fuel, Natural Gas, Producer Gas, Water Gas (or Blue Gas), Non-Conventional Sources of Energy-Solar energy, Solar cells and Uses of solar cells. Combustion: Combustion, Mass Analysis from Volume Analysis and Vice Versa, Analysis of Flue Gas

SUGGESTED BOOKS

1. "Liquid Crystals, Nature's delicate phase of matter", Peter J Collings, Princeton University Press, 2002
2. "Liquid Crystals: Fundamentals", Shri Singh, World Scientific Publishing Company; 1st edition (November 7, 2002)
3. "Science of Engineering Materials", C.M. Srivastava and C. Srinivasan, Wiley-Eastern Ltd. (1991).
4. "Engineering Chemistry", Jain P C and Monica Jain, 15th Edition, Dhanpat Rai Publishing Company Ltd, New Delhi, India, 2005.
5. "A Text book of Engineering Chemistry", Shashi Chawla" Dhanpat Rai Publishing Company (P) Ltd., New Delhi, India, 2007.
6. Textbook of Engineering Chemistry, C Parameswara Murthy, C V Agarwal, Andra Naidu, BS Publications, Hyderabad, India.
7. "A Textbook of Engineering Chemistry", Dr. Y. Bharathi Kumari and Dr. Jyotsna Cherukuri, VGS Publications, First Edison, India, 2009

LABORATORY COURSE

Paper CH (AC) 451P: Electro analytical techniques:

I. POTENTIOMETRY:

1. Determination of Ferrous using $K_2Cr_2O_7$
 2. Determination of iron in iron wire using $KMnO_4$
 3. Determination of a mixture of Ferrous and Vanadyl using Ceric ammonium nitrate
 4. Determination of silver in silver metal
 5. Assay of sulphanilamide in samples
- Use of ion selective electrodes:
6. Determination of mixture of halides using Ag ion electrode

II. pH METRY:

1. Strong acid Vs strong base titration
2. Mixture of acids Vs strong base
3. Determination of mixture of carbonates and bicarbonates
4. Determination of Dissociation constants of Histidine monohydrochloride
5. Determination of binary stability constants of Cu(II) – Histidine complexes

III. POLAROGRAPHY:

1. Polarographic determination of Cu & Zn in brass

IV. CONDUCTOMETRY:

1. Mixture of acids Vs strong base titration
2. Mixture of bases Vs strong acid titration
3. K_2SO_4 Vs $BaCl_2$ titration.
4. Determination of the composition of Cu(II) oxine complex
5. Determination of Quinine dihydrochloride with NaOH
6. Determination of Aspirin with KOH

Paper CH (AC) 452P: Spectroscopic Techniques , Spectral problems and Evaluation of Physical Parameters Of Tablets

I. FLAME PHOTOMETRY:

1. Determination of i)Na, ii)K, iii)Ca, iv)Li

II. FLUORIMETRY

1. Determination of Vitamin – B₁ (Thiamine)
2. Determination of Vitamin – B₂ (Riboflavin)
3. Determination of Quinine sulphate.

III. ATOMIC ABSORPTION SPECTROSCOPY

1. Determination of i) Fe, ii) Zn, iii) Cu, iv) Pb.

IV. Structural elucidation based on spectral data from UV – Vis, IR, NMR and Mass Spectrometry

V. EVALUATION OF SOME PHYSICAL PARAMETERS OF TABLETS:

1. Dissolution profile of Ampicillin.
2. Disintegration test for Ibuprofen (coated tablet).
3. Determination of friability of Paracetamol tablet.

SUGGESTED BOOKS

1. Chemistry Experiments for Instrumental Methods, Donald T Sawyer William R. Hememan et al John Wiley & Sons 1984.
2. Analytical Chemistry by Gary D. Christian 6th Edition John Wiley & Sons Inc New York 1994.
3. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel 3rd Edition Elbs Publication 1969.
4. Vogel's Text Book Of Quantitative Inorganic Analysis Jeffery et al 4th edition Elbs Publications 1988.
5. Vogel's Text Book of Quantitative Chemical Analysis, 6th edition. Pearson Education Ltd 2002.
6. Analytical Chemistry Theory and Practice by R.M. Verma 3rd Edn. CBS Publishers & Distributors 1994.
7. Comprehensive Experimental Chemistry by V.K. Ahluwalia et al New Age Publications 1997.
8. Laboratory hand Book of Instrumental Drug Analysis by B.G. Nagavi 2nd edn. 1996
9. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel 3rd Edition, ELBS Publication 1969.
10. Determination and use of Stability Constants – Martell and Motekaitis VCH Publishers INC 1988.
11. Metal Complexes in Aqueous Solutions A.E. Martell and R.D. Hancock, Plenum Press, New York – 1996.
12. Experiments in Chemistry, D.V. Jahagirdar, 2nd edn, Himalaya Publishing House, 2003
13. Practical Pharmaceutical Chemistry, A.H. Beckett and J.B. Stenlake 4th edn. CBS publishers, 2001

M.Sc. CHEMISTRY

**INORGANIC CHEMISTRY SPECIALISATION
SYLLABUS OF III & IV SEMESTERS
*REVISED AS PER NEW (CB) SYLLABUS***

**FOR STUDENTS ADMITTED FROM THE YEAR
2016 ONWARDS**

Osmania University
M.Sc. Chemistry (Inorganic Chemistry) III and IV Semesters Programme
(For the batch admitted during the academic year 2016-2017 under the CBCS pattern)
[Under Restructured CBCS Scheme]

III Semester				
	Course	Hours	Credits	Marks
<u>CORE</u>	Paper-I: CH(IC)301T: Bonding, Group Theory and its Applications IC-09: Group Theory, Normal mode analysis and Spectral Activity IC-10: MOT of Metal Complexes IC-11: Electronic Spectroscopy of Metal Complexes IC-12: IR and Raman Spectroscopy	4	4	100
<u>CORE:</u>	Paper-II: CH(IC) 302T: Organo Metallic Chemistry of Transition Metal Complexes IC-13: Mono, Di and Trihapto Complexes IC-14: Tetra, Penta, Hexa, Hepta and Octahapto Complexes IC-15: Catalytic Role of OTMC-I IC-16: Catalytic Role of OTMC-II	4	4	100
<u>ELECTIVE IIIa</u>	Paper-III: CH(IC) 303T: Analytical Techniques-I IC-17: Data Handling IC-18: AAS, AES, ICP-AES IC-19: Diffraction Methods IC-20: Advanced Mass spectrometry	4	4	100
<u>ELECTIVE IIIb</u>	Paper-III: CH(IC)303T: Supramolecular Chemistry, Photochemistry, Green Chemistry and Nanotechnology IC-21: Supramolecular Chemistry IC-22: Photochemistry of Metal Complexes IC-23: Green Chemistry IC-24: Nanotechnology	4	4	100
<u>ELECTIVE IVa</u>	Paper-IV: CH(IC) 304T: Analytical Techniques-II IC-25: Thermal Methods IC-26: Surface Analysis Methods/ Microscopic analysis IC-27: Advanced Separation Techniques IC-28: Optical Methods	4	4	100
<u>ELECTIVE IVb</u>	Paper-IV: CH(IC) 304T: Nuclear Chemistry, Zeolites, Solid State, and Surface Chemistry IC-29: Nuclear Chemistry IC-30: Zeolites and Molecular Sieves IC-31: Solid State Chemistry IC-32: Surface Chemistry & Superconductors	4	4	100
LABORATORY COURSE -I	CH (IC) 351P: Synthesis and Characterization of Metal Complexes	9	4	100
LABORATORY COURSE -II	CH (IC) 352P: Electro-Analytical techniques	9	4	100

	IV Semester			
	Course	Hours	Credits	Marks
<u>CORE</u>	Paper-I: CH(IC)401T: Molecular Spectroscopy of Inorganic Compounds IC-33: Multinuclear NMR IC-34: Advanced NMR techniques IC-35: Applications of ESR to Metal Complexes IC-36: Mossbauer Spectroscopy and Nuclear Quadrupole Resonance Spectroscopy	4	4	100
<u>CORE</u>	Paper-II: CH(IC) 402T: Bioinorganic Chemistry IC-37: Metal ions Interactions with Nucleic acids and their constituents. IC-38: Transport of Electrons and Metal ions. IC-39: Metallo-Enzymes of Iron, Zinc and Nickel. IC-40: Metallo-Enzymes of Cobalt, Copper Molybdenum and Manganese	4	4	100
<u>ELECTIVE IIIa</u>	Paper-III: CH(IC)403T: Medicinal Inorganic Chemistry, Spectroscopic Analysis of Drug/Metal Complexes and Applications of Nanomaterials IC-41: Metal complexes in Clinical Chemistry IC-42: Metal complexes as Drugs and Anticancer agents IC-43: Spectroscopic analysis of drug/metal complexes binding to DNA IC-44: Applications of Nanomaterials	4	4	100
<u>ELECTIVE IIIb</u>	Paper-III: CH(IC)403T: Analytical Techniques-III IC-45: Electroanalytical Methods IC-46: Radiochemical Methods IC-47: Fluorimetry, Phosphorimetry, Nephelometry and Turbidimetry IC-48: Industrial Analysis	4	4	100
<u>ELECTIVE IVa</u> (ID Paper)	Paper-IV: CH(ID) 404T: Interdisciplinary Course (Environmental and Applied Analysis) IC-49 : Clinical and Pharmaceutical Analysis IC-50: Food and Agricultural analysis IC-51: Analysis of Air and Water Pollutants IC-52: Drinking Water and Sewage Water Treatment	4	4	100
<u>ELECTIVE IVb</u> (ID Paper)	Paper-IV: CH(ID) 404T: Interdisciplinary Course (Inorganic Material Chemistry) IC-49 : Composite Materials IC-50: Liquid Crystals IC-51: Explosives and Propellants IC-52: Fuels and Combustion	4	4	100
LABORATORY COURSE –I	CH (IC) 451P: Conventional Methods of Analysis	9	4	100
LABORATORY COURSE –II	CH (IC) 452P: Spectroscopic Techniques	9	4	100

M.Sc. INORGANIC CHEMISTRY SPECIALIZATION
SEMESTER-III
PAPER I

CH(IC)301T: Bonding Group Theory and its Applications

IC-09: Group Theory, Normal mode analysis and Spectral Activity

IC-10: MOT of Metal Complexes

IC-11: Electronic Spectroscopy of Metal Complexes

IC-12: IR and Raman Spectroscopy

IC-09: Group Theory, Normal Mode Analysis and Spectral Activity

Properties of a Group-Closure rule, Identity rule, associative rule, inverse rule, Abelian and Non-abelian groups. Classes of Symmetry Elements of a Group: Similarity transformation, properties of conjugate elements, salient features about Classes, Classes of C_{2V} , C_{2h} and C_{3V} . Matrix Representation of Symmetry Elements: Simple Matrices, Matrix addition, subtraction and multiplication, Block-Factorization. Matrix Representation of E , C_n , S_n , i and σ Elements. Great Orthogonality Theorem: Reducible and Irreducible Representations, Properties of Irreducible Representations, Construction of Character Tables for C_{2V} , C_{2h} and C_{3V} . Mulliken Symbolism for Irreducible Representations - Standard Reduction Formula.

Use of Character tables for IR & Raman spectroscopy, symmetry based selection rules for IR and Raman activity. Type and Symmetry of Normal Modes and IR and Raman activity of molecules: Cartesian coordinate method of analysis for C_{2V} (eg. H_2O , SF_4), C_{3V} (NH_3 , $POCl_3$), C_{2h} ($trans-N_2F_2$), D_{3h} (BF_3), $Td(SO_4^{2-})$, $Oh(SF_6)$. Internal coordinate method of analysis for C_{2V} (H_2O), C_{3V} (NH_3), $Td(SO_4^{2-})$.

IC-10: Molecular Orbital Theory of Metal Complexes: Limitations of Crystal Field Theory, Adjustments to the Crystal Field Theory to allow for covalence -Experimental evidences for Metal - Ligand orbital overlap. The Adjusted Crystal Field Theory. Introduction to Molecular Orbital Theory. Symmetry Classification of Metal and Ligand Group Orbitals in Cubic and Non-Cubic Environments: Octahedral, Tetrahedral, Square Planar, Square Pyramidal, TrigonalBipyramidal Geometries – Concept of Ligand Group Orbitals – Construction of Molecular Orbital Energy Level Diagrams -Octahedral Metal Complexes with (i) Sigma (σ), (ii) sigma(σ) &Pi (π) and (iii) sigma (σ), Pi (π) and Pi* (π^*) bonding contribution from the Ligands - Tetrahedral Metal Complexes with (i) Sigma (σ) and (ii) sigma(σ) &Pi (π), and Square Planar Metal Complexes with (i) Sigma (σ) and (ii) sigma(σ) &Pi (π) bonding contribution from the ligands - Molecular orbital electron configurations and calculation of Magnetic Moments.

IC-11: Electronic Spectroscopy of Metal Complexes

Classification of Electronic Spectra for Metal Complexes, Selection Rules: Electric Dipole Transitions, Magnetic Dipole Transitions, Orbital Selection Rules, Spin Selection Rules, Relaxation in Selection Rules. Nature of Electronic Spectral Bands: Band Widths, Band Intensities. Factors Influencing Band Shapes: Jahn-Teller Effect, Spectrochemical Series, Nephelauxetic Effect. Orgel Diagrams for d^1 - d^9 Configurations, Crystal Field Spectra of O_h and T_d Metal Complexes of 3d Metals. Charge Transfer Spectra. Strong Field Configurations: The Method of Descending Symmetry, Correlation Diagrams and Tanabe-Sugano Diagrams for d^2 and d^8 Configurations. Calculation of $10Dq$ Values, Racah Parameter (B) and Nephelauxetic Ratio (β).

IC-12: Infrared and Raman Spectroscopy

Conditions for Infrared and Raman Spectroscopies, Direct product – symmetry requirements for overtones, binary and ternary combination bands. Partial Normal mode analysis-Structure Fitting, Determination of Coordination Sites and Linkage Isomers(NO_2^- , SCN^-), Assigning Denticity of

Ligands (SO_4^{2-} , CO_3^{2-}), Prediction of Diagnostic Fundamentals in Isomers of Metal Complexes and Distinguishing Isomers of Metal Complexes. Effect of Coordination on Ligand Vibrations: Examples involving Mono, Bi and/or Polydentate Ligands of Oxygen, Nitrogen, Carbon and Halogen Donors (NH_3 , H_2O , Glycine, Carbonyl and halides). Raman effect and molecular structure- CO , HCN , CO_2 , N_2O , H_2O . Principles of Resonance Raman Spectroscopy. Application of Resonance Raman Spectroscopy to Structural Elucidation of the active Sites of Heme and Non-Heme Oxygen Carriers

SUGGESTED BOOKS

1. Symmetry and Spectroscopy of Molecules, K. Veera Reddy, Second Edition, New Age International (P) Limited Publishers (2009)
2. Chemical Applications of Group Theory, F. A. Cotton, 3rd edition, Wiley NY (1990)
3. Symmetry and Group Theory In Chemistry, Mark Ladd, Harwood Publishers, London (2000)
4. Symmetry Through the Eyes of a Chemist, I. Hargittai and M. Hargittai, 2nd Edition, Plenum Press, NY (1995)
5. Molecular Symmetry and Group Theory, Robert L. Carter, John Wiley & Sons (1998)
6. Group Theory for Chemists, G. Davidson, Macmillan Physical Science Series (1991)
7. Molecular Symmetry, Schoenland
8. Electronic Spectroscopy, A. B. P. Lever
9. Introduction to Ligand fields, B. N. Figgis
10. Infrared and Raman Spectroscopy of Inorganic and Coordination Compounds, K. Nakamoto
11. Infrared spectroscopy of Inorganic Compound, Bellamy.

PAPER II

CH(IC)302T: Organo Metallic Chemistry of Transition Metal Complexes

IC-13: Mono, Di and Trihapto Complexes

IC-14: Tetra, Penta, Hexa, Hepta and Octahapto Complexes

IC-15: Catalytic Role of OTMC-I

IC-16: Catalytic Role of OTMC-II

IC-13: Mono, Di and Tri hapto Complexes

Nomenclature and Classification based on the number of Coordinated Carbons (hapticity) and number of electrons donated by the Ligand. 16 and 18 electron rules. Electron counting covalent and ionic models. η^1 – Complexes : General methods of Preparation – Bonding of Ligand to Metal : σ and β Interaction and agostic interaction – Stability and decomposition pathways – η^1 Complexes – Tertiary Phosphine – Transition Metal Alkyl and Aryl Complexes of Pt – Ortho-effect – Bonding in Metal – Carbene and Carbyne Complexes. η^2 – Complexes: General methods of preparation of Metal – Alkene Complexes – Structure and Bonding in η^2 Complexes-Zeises salt – Trans Effect – Rotation of Olefin around Metal-Olefin Bond. η^3 - Complexes: Metal-Allyl Complexes – General Preparative Routes – Structure and Bonding in η^3 Allyl Complexes – Fluxionality.

IC-14: Tetra, Penta, Hexa, Hepta and Octahapto Complexes

η^4 Complexes: Structure and Bonding in η^4 Complexes – Butadiene and Cyclobutadiene Complexes. η^5 – Complexes: General methods of Preparation – Bis (η^5 -cyclopentadienyl) metal complexes (Metallocenes) – Ferrocene: Structure and Bonding – Reactions of Ferrocene – Mechanism of Electropilic substitution – Friedel Crafts acylation, alkylation, nitration, halogenation and Metallation Reactions.

η^6 Complexes : Metal – Arene Complexes – Dibenzenechromium – Preparation, Structure and Bonding in Bis(arene)-Metal Complexes – Reactions. η^7 Complexes : Preparation , Structure and Reactions of η^7 –

C₇H₇ Complexes. η^8 Complexes : C₈H₈ as a Ligand – Cyclooctatetraene Complexes – Preparation, Structure and Bonding in Uranocene.

IC-15: Catalytic Role of OTMC-I

Oxidative addition and Reductive Elimination : Stereochemistry and Mechanism of Oxidative Addition – Insertion Reactions – Hydrogenation of Olefins –Transfer Hydrogenation –Hydrosilation of Olefins – Isomerisation of Olefins – Ziegler –Natta Polymerization of Olefins – Oligomerization of Butadiene Alkene Metathesis. Dupont-1,4-hexadiene synthesis.Oxidation of Olefins to Carbonyl Compounds – Oxidation of Hydrocarbons to Alcohols and Acids – Oxidation of Aldehydes, Cyclohexanol, Cyclohexanone, p-Xylene.

IC-16: Catalytic Role of OTMC- II

Reactions of Carbon monoxide and Hydrogen:Hydroformylation – Carbonylation –Syngas- Water gas shift Reaction (WGS) – Reactions of Syngas. Applications of Metal Clusters in Catalysis:Hydroformylation of Ethylene using [HRu₃(CO)₁₁] – , Hydrogenation of Olefins. Use of [Fe₄C(CO)₁₄] as a model for Fischer – Tropsch process. Recent Developments in Homogenous Catalysis: Phase Transfer Catalysis (PTC) – Homogeneous Transition Metal Catalyzed Reactions under Phase Transfer Conditions: Hydrogenation. Bio Catalysis : Enzyme Analogue Catalysis: Introduction, Examples of Enzymatic Conversions, Reduction of >C=O and >C=C< bonds, Templates: Introduction, Metal Cations as Templates, Covalent molecules as Templates, External and Internal Templates – Homogeneous Catalysts and theirHeterogenization or Immobilization by Aqueous Catalysis.

SUGGESTED BOOKS

- 1.Organometallics-A Concise Introduction, Ch.Eischeinbroich and Salzer-VCH
- 2.Organotransition Metal Chemistry Fundamental Concepts and Applications, John AkioYamamoto, Wiley & Sons.
- 3.Homogeneous Catalysis by Metal Complexes, M MTAqui Khan and A E Martel
4. Applied Homogenous Catalysis with Organo Metallic Compounds Vol I & II, Boy Cornillsand W A Herrmann – VCH
5. Organometallic Compounds, G E Coates, M C H Green, K Wade vol II
6. Advanced Inorganic Chemistry, Cotton and Wilkinson, V & VI Ed
7. Symmetry and spectroscopy, K Veera Reddy
8. Homogenous catalysis, G W Parshall, John Wiley & Sons, New York
9. Basic organometallic Chemistry, B.D. Gupta / A. J. Elias

PAPER III

CH(IC) 303T (Elective IIIa): Analytical Techniques - I

IC-17: Data Handling

IC-18: AAS, AES, ICP-AES

IC-19: Diffraction Methods

IC-20: Advanced Mass spectrometry

IC-17: Data Handling

Accuracy, Precision, Types of errors – determinate and indeterminate errors, minimization of determinate errors, statistical validation- statistical treatment of finite data (mean, median, average deviation, standard deviation, coefficient of variation and variance), significant figures – computation rules, comparison of results – student's t-test, F-test, statistical Q test for rejection of a result, confidence limit, regression analysis – method of least squares, correlation coefficient, detection limits. Calculations.

IC-18: AAS, AES, ICP-AES

Atomic Absorption Spectroscopy (AAS): Principles of AAS, Instrumentation – flame AAS and furnace AAS, resonance line sources, sensitivity and detection limits in AAS, interferences –chemical and spectral, evaluation methods in AAS and application in qualitative and quantitative analysis.

Atomic Emission Spectroscopy (AES): Principles of AES, Instrumentation, evaluation methods, Application in quantitative analysis.

Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES): Limitations of AES, Principles of plasma spectroscopy, plasma as an excitation source. Inductively coupled plasma source, ICP-AES – Instrumentation. Application of ICP-AES, Comparison with AAS.

Flame Photometry: Principle, Theory, Instrumentation and Applications

IC-19: Diffraction Methods

X – ray Diffraction : X –rays and their generation – choice of radiation ; Miller indices, Bragg's equation, Experimental methods – Powder and single crystal methods, Indexing the reflections, Systematic absences, Electron density studies by X – rays – Platinum phthalocyanine complex, Silyl acetate, Tetraalkylbiphosphate ; Advantages and limitations of X – ray Diffraction.

Electron Diffraction by gases :Principles , Radial distribution curves- Interpretation of results for PBrF₂S, PF₃S, PF₂HS, HClO₄, Silylmonothioacetate and Germylmonothioacetate and HgCl₂ molecules, Advantages and Limitations

Neutron Diffraction: Principle, Application in Hydrogen bonding studies, combined use of X – ray and Neutron diffraction studies, Advantages and limitations.

IC-20: Advanced Mass spectrometry

Mass Analyzers: Quadruple, Ion traps, Time of flight (TOF) mass analyzers

Mass Spectrometry / Tandem Mass Spectrometry: Tandem Mass Spectrometry, Instrumentation, Applications.

Hyphenated Techniques: GC-MS Principle, instrumentation, Interfaces- Direct coupling interface and open split interface. Application based on gas chromatography/mass spectrometry-Analysis of metabolite of drug Imipramine. **LC-MS-** principle, Instrumentation – Interfaces- Moving belt interface, particle beam interface, thermospray interface, Electrospray interface, atmospheric pressure chemical ionization interface.**ICP – MS -** Principle Instrumentation, and Applications.

Matrix-assisted laser desorption/ionization-Time of flight Mass spectrometry (MALDI-TOF-MS): Principle, Matrix, Sample Preparation for MALDI-MS - Dried droplet Crystallization, Thin layer method, Sandwich Crystallization, Instrumentation, Applications

SUGGESTED BOOKS

1. Analytical Chemistry, Gary Christian, VI Ed, John Wiley & Sons Inc, New York.
2. Instrumental Methods of Chemical Analysis, H. Kaur.
3. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed, Pearson Education Ltd.
4. Principles of Instrumental Analysis, Skoog, Holler and Nieman.
5. Instrumental Techniques for Analytical Chemistry, Frank Settle.
6. Principles of Analytical Chemistry, M. Valcarcel.
7. Solid State Chemistry and its Applications, West.
8. Introduction to Solids, Azaroff.
9. Solid State Chemistry, D.K. Chakrabarty
10. Physical Methods in Advanced Inorganic Chemistry, Hill and Day.
11. Instrumental Methods of Analysis, Sixth edition, CBS Publishers, Willard, Merrit, Dean, and Settle.
12. Mass spectrometry for Chemists and Biochemists, Robert A.W Johnstone and Molcolm. E.Rose, second Edn.
13. Physical methods for Chemists, Russell S. Drago second edition, Saunders College publishing 1992.
14. Structural methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H Rankin and S.Craddeck, ELBS.

15. Mass Spectrometry Basics, Herbert, Christopher G.; Johnstone, Robert A.W., CRC Press.
16. Mass Spectrometry-A Textbook by Jürgen H. Gross, © Springer-Verlag Berlin Heidelberg 2004, Printed in Germany.
17. Matrix-assisted laser desorption/ionization - https://en.wikipedia.org/wiki/Matrix-assisted_laser_desorption/ionization

PAPER III

CH(IC) 303T (Elective IIIb): Supramolecular Chemistry, Photochemistry, Green Chemistry and Nanotechnology
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IC-21: Supramolecular Chemistry

IC-22: Photochemistry of Metal Complexes

IC-23: Green Chemistry

IC-24: Nanotechnology

IC-21: Supramolecular Chemistry

Host – Guest chemistry: Definition and different types of host and guests with examples – types of non-covalent interactions – binding constants of host guest complex and thermo dynamics involved in it – designing principles of host.

Cation guest binding – binding between metal cations and macro cycles – chelate and cryptate effects – relationship between cavity size of host and cation radius and stability of resultant complexes – binding of macro cycles having secondary binding sites.

Anion guest binding – different hosts for anionic guests capable of binding through electro static interactions, hydrogen bonds, lewis acidic hosts – enhancement of binding strength using more than non-covalent interactions.

Neutral guest binding – binding of neutral guest using hydrogen bonding, π - π stacking, hydrophobic effect and charge transfer interactions – simultaneous binding of cation and anion guests – cascade approach, individual binding sites and zwitter ions approach –present and future applications – phase transfer agents – separation of mixtures – molecular sensors – switches and molecular machinery.

IC-22: Photochemistry of Metal Complexes

Energy, Structure, Electron Distribution and Chemical reactivity of Electronically Excited states of Coordination Compounds. Photochemistry of Cr(III) and Co(III) metal complexes . Photochemistry of $\text{Cr}(\text{CO})_6$, $\text{Mn}_2(\text{CO})_{10}$ and $\text{Fe}(\text{CO})_5$.

Structured phosphorescence of Ruthenium Bipyridyl and Ortho-phenanthroline Complexes. Energy transfer Spin Correlation energy levels in the energy Transfer Systems; $[\text{Ru}(\text{bipy})_3]^{2+}$ $[\text{Cr}(\text{CN})_6]^{3-}$. Metal Sensitizers and Quenchers - Electron Relay. Photochemical Hydrogen production by oxidative quenching of $[\text{Ru}(\text{bipy})_3]^{2+*}$ by Methyl Viologen.

IC-23: Green Chemistry

Principles and concepts of green chemistry

Introduction, sustainable development and green chemistry, atom economy, atom economic reactions, rearrangement reactions, addition reactions, atom uneconomic reactions- substitution reactions, elimination reactions, Wittig reactions.Reducing toxicity, measuring toxicity.

Organic solvents: Environmentally benign solutions: Organic solvents and volatile organic compounds, solvent free systems, super critical fluids- supercritical carbon dioxide and supercritical water. Water as a reagent solvent, water based coatings.

Industrial case studies: A brighter shade of green – greening of acetic acid, Vitamin C synthesis –enzyme routes. Polythene manufacture-metalocene catalysis.

IC-24: Nanotechnology

Metal Nanoclusters –Introduction, Magic numbers, theoretical modeling of nanoparticles, geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters, bulk to nanotransition.

Methods of synthesis: RF plasma, thermolysis, pulsed laser, chemical methods.

Carbon nanostructures- Introduction, carbon molecules, new carbon structures,

Carbon clusters- small carbon clusters, discovery of C_{60} , structure of C_{60} and its crystal, alkali doped C_{60} , superconductivity in C_{60} .

Carbon nanotubes: Fabrication, structure, electrical properties, vibrational properties, mechanical properties.

Nanophase and nanostructured materials: Micells and Microemulsions - Formation mechanisms of micelles and microemulsions, the critical Micelle Concentration (CMC) for surfactants, Solubilization and Formation of Microemulsions.

Synthesis of Nanoparticles from W/O Microemulsions: Preparation of Nanoparticles of Metals, Metal Sulfides, Metal Salts, Metal oxides, Nanowires. **Synthesis of Organic Nanoparticles from O/W Microemulsions:** Styrene Latex NanoParticles, Methylmethacrylate Nanoparticles. Sol -Gel process for the fabrication of Glassy and Ceramic materials.

SUGGESTED BOOKS

1. Supramolecular Chemistry – concepts and perspectives by Jean-Marie Lehn
2. Principles and methods in Supramolecular chemistry, Hans-Jorg Schneider and A.Yatsimirsky, John Wiley and Sons
3. Analytical Chemistry of Macrocyclic and Supramolecular Compounds, S.M.Khopkar, Narosa Publishing House
4. Concepts of Inorganic PhotoChemistry A.W. Adamson and P. D. Fleschaner, Wiley.
5. Inorganic Photochemistry, Journal of Chemical Education, Vol 60. No 10, 1983.
6. Progress in Inorganic Chemistry Vol 30 ed :S.J.Lippard.
7. Coordination Chemistry Reviews Vol 39 1981,p121
8. Photochemistry of Coordination compounds V.Balzani and Carassiti,academicpress.
9. Elements of inorganic Photochemistry G.J.Ferrendi,Wiley,
10. Structure and Bonding Vol 49 1982.
11. Separation Methods - M. N. Sastri, 1st ed., Himalaya Publishers, 1991.
12. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt CollegePublishers, 1998.
13. Analytical Chemistry - Gary Christian, 6th ed, John Wiley and sons. Inc., New York, sixth edition, 1994.
- 14.Green Chemistry- An Introductory text by Mike Lancaster- RSC.
15. Green Chemistry: Theory and Practice by John C. Warner Paul T. Anastas.
16. Introduction to nanotechnology by Charles P. Poole Jr, Frank J. Owens- Wiley StudentEdition 2006.
17. Hand Book of Nanophase Materials by A.N. Gold Stein ed,Marcel Decker, New York, 1997, Chapter1
18. Clusters of Transition Atoms” by Morse, Chem. Rev 86, 1049 (1986).
19. Hand Book of Nanostructured materials by P.M. Ajayan, H.S Nalwa, ed, AcademicPress, San Diego, 2000, Vol. 5, Chapter 6.
20. Hand Book of Nanophase and Nanostructured materials, volume I: Synthesis, Zhong Lin Wang, Yi Liu,Ze Zhang.

PAPER IV

CH(IC) 304T (Elective IVa): Analytical Techniques-II

IC-25: Thermal Methods

IC-26: Surface Analysis Methods/ Microscopic analysis

IC-27: Advanced Separation Techniques

IC-28: Optical Methods

IC-25: Thermal Methods

Thermogravimetric analysis (TGA): Principle, Instrumentation, working function of each component, applications of TGA, Study of oxalates, nitrates and chromates by TGA. Determination of carbon black in polythene.

Differential thermal analysis (DTA): Principle, Instrumentation, Methodology, applications. Differential thermogram of sulphur. TG and DTA of manganese phosphine monohydrate.

Differential scanning calorimetry (DSC): Principle, instrumentation, power compensated DSC instruments and Heat flow DSC instruments, Methodology, DSC experiment calibration and data analysis. Applications determination Glass transition temperatures and heat capacities, problems based on Thermal Techniques:

Thermometric titrations: Principle, apparatus, applications to acid base, precipitation, complexometric, redox and non-aqueous titrations.

Combined thermal instruments: Introduction to TGA/MS and TGA/FTIR, High resolution TGA, Microthermal analysis.

IC-26: Surface Analysis Methods/ Microscopic analysis

Introduction, types of surface measurements.

Photon Probe Techniques: X-Ray Photoelectron spectroscopy - Principle, Instrumentation, applications.

Electron Probe Techniques: Scanning electron microscopy (SEM) – Principle, Instrumentation, applications. Transmission Electron Microscopy (TEM) - Principle, Instrumentation, applications. Energy Dispersive X-ray Spectroscopy (EDX) - Principle, Instrumentation, applications. Electron Probe X-ray analysis (EPXMA) - Principle, Instrumentation, applications. Auger electron spectroscopy (AES) - Principle, Instrumentation, applications.

Ion Probe Techniques: Rutherford backscattering spectrometry (RBS) - Principle, Instrumentation, applications. Secondary ion mass spectrometry (SIMS) – Fundamental aspects of sputtering, Principle, Instrumentation (static & dynamic), applications

Scanning probe microscopy Techniques: Scanning Tunneling Microscopy – Principle, Instrumentation, applications. Atomic Force Microscopy - Principle, Instrumentation, applications.

IC-27: Advanced Separation Techniques

Separations by extractions: Solid phase extraction- Principle, methodology, applications. Solvent extraction of flow injection analysis. Applications to extractions of metal ions by chelating agents (Dithiazone, 8-hydroxy quinoline and cupferron). Organic reagents in Inorganic analysis - Theoretical basis for the use of organic reagents in inorganic analysis. Extraction of metal ions by the use of organic reagents – acetylacetone, thionyl-trifluoroacetone, tri-n-octyl phosphine oxide.

Affinity and chiral chromatography – Principle, technique, Instrumentation and applications.

Size Exclusion Chromatography – Principles of gel – filtration Chromatography, Instrumentation, retention behavior, resolution, selection of gel type, applications, **Ion exclusion** – Principle and applications.

Supercritical fluid chromatography (SFC) – Instrumentation of SFC, stationary and mobile phases used in SFC, Detectors, Advantages of SFC. Technique and applications of SFC.

GC-FT-IR: Instrumentation, Principles and Applications

IC-28: Optical Methods

CD, ORD and Fluorescence: Optical rotator dispersion and Circular dichroism: Principles - Optical rotation, circular birefringence, circular dichroism and Cotton effect, Octet Rule, Experimental Techniques, Use of CD in the conformational studies of metal complexes, DNA and DNA-metal complexes. Theory and principles of fluorescence spectroscopy. Characteristic of fluorescence emission, Fluorescence life time, quantum yield, Static and dynamic/collisional quenching and comparison. Fluorescence polarization and polarization spectra of a fluorophore. Application of Fluorescence quenching in general and ligand/drug/metal complex DNA binding studies

SUGGESTED BOOKS

1. Principles of Instrumental Analysis: Holler, Skoog and Crouch, 6th edition, Cengage Learning 2007.
2. Instrumental methods of chemical analysis B.K. Sharma, Goel Publishing House.
3. Instrumental Methods of analysis, Willard Mersritt, Dean and Settle, 7th edition, CBS Publishers 1986.
4. Analytical Chemistry – Gary D. Christian, 6th ed., John Wiley and sons. Inc., New York 1994.
5. Instrumental methods of Analysis - Willard, Merit, Dean, 6th ed., CBS Publishers & distributors, 1986.
6. Hand Book for Instrumental Techniques for Analytical Chemistry, Ed. Frank Settle, Prentice Hall, New Jersey, USA, 1997.
7. Vogel's Text book of Quantitative Analysis – GJ Jeffery, J Bassett et al, 5th ed., Longmann, ELBS Publications, 2000.
8. Principles of fluorescence spectroscopes – Lakowicz.
9. Fluorescence Quenching theory and applications – Maurice R. Eftink.
10. Circular Dichroism Spectroscopes of DNA Methods in Enzymology Vol 211.
11. Tris (Phenanthroline) Metal complexes: probes for DNA Helicity Journal of Biomolecular structure and Dynamics Adenine Press 1983. G.L. Eichorn.8
12. Tris (Phenanthroline) Ru(II) Enantiomers interactions with DNA : Mode and specificity of binding J.B. Chaires. Biochemistry 1993 (32) 2573

PAPER IV

CH(IC) 304T (Elective IVb): Nuclear Chemistry, Zeolites, Solid State, and Surface Chemistry
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IC-29: Nuclear Chemistry

IC-30: Zeolites and Molecular Sieves

IC-31: Solid State Chemistry

IC-32: Surface Chemistry & Superconductors

IC-29: Nuclear Chemistry

Introduction: The atomic nucleus-elementary particles, quarks, classification of nuclides based on Z and N values, nuclear stability, nuclear potential, binding energy.

Nuclear structure: Shell model-salient features, forms of the nuclear potential, magic numbers, filling of orbitals, nuclear configuration, Liquid drop model, Fermi gas model, Collective model and Optical model.

Nuclear reactors :- General aspects of reactor design, thermal, fast and intermediate reactors, reactor fuel materials, reactor moderators and reflectors, coolants, control materials, shield, regeneration and breeding of fissile matter, types of research reactors.

Nuclear reactions, fission and fusion, radio-analytical

Radioactivity, radioactive decay kinetics, Parent-daughter decay-growth relationship-secular and transient equilibria, theories of α , β^- , β^+ and γ -decay, internal conversion, Auger effect. Radio isotopes & its applications.

IC-30: Zeolites and Molecular Sieves

Introduction to porous materials:

Classification into micro-, meso- and macro porous materials, the origin of pores and its significance, distinction from condensed materials.

Zeolites:

Definition, natural and synthetic zeolite or aluminosilicates, the primary and secondary building blocks, final framework structures, Lowensteins rule, sodalite and other structures, Nomenclature: Atlas of zeolite; structural distinctions, Novel zeolites, examples of small, medium, large and extra large pore zeolites; general properties and application of molecular sieves.

Characterization of zeolite:

XRD, SEM and other techniques; spectral techniques: FT-IR and solid-state NMR; sorption capacity, surface area by BET method, pore volume and pore structure, the origin of Brønsted and Lewis acidity in zeolites, the number and the strength, techniques for the estimation of acidity: adsorption of bases and IR spectra, temperature programmed desorption of bases.

IC-31: Solid State Chemistry

Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones.

Structure of ionic Crystals & Compounds: Ionic Crystals with stoichiometry MX, Ionic Crystals with stoichiometry MX₂, spinel structure, perovskite structure. AB [nickel arsenide (NiAs)], AB₂[fluorite (CaF₂) and anti-fluorite structures, rutile (TiO₂) structure and layer structure [cadmium chloride and iodide (CdCl₂, CdI₂)].

Crystal Defects and non-stoichiometry:

Classification of Defects: subatomic, atomic and lattice defects in solids; Thermodynamics of vacancy in metals; Thermodynamics of Schottky defects in ionic solids ; Thermodynamics of Frenkel defects in silver halides; Calculation of number of defects and average energy required for defect, Other examples of defect structure; Non-stoichiometry and its classifications.

Preparative method of solids:

Introduction, Ceramic method, microwave synthesis, Precursor method, Hydrothermal method, Chemical vapour deposition (CVD) Method, Chemical vapour Transport, Choosing a method for solids.

Crystal Growth: law governing nucleation; Growth of nuclei; Reaction between two solids; Improving the reactivity of solids; Zone refining method; Crystal growth.

IC-32: Surface Chemistry & Superconductors

Surface Chemistry:

Mechanism of catalytic reactions on the surfaces – diffusion of reactants to the surfaces, adsorption of reactants, reaction within the adsorbed layer, desorption of the products, diffusion of the products away from the surface; The mechanism of chemisorption on metals – The formation of chemisorptions layer, the character and nature of the chemisorption bond, the mechanism of chemisorptions for some gases; Nature of adsorbates on surfaces.

Superconductors:

Discovery of super conductors, Meissner effect, Type I and II conductors, Levitation, BCS theory and Cooper pairs, High T_c Super Conductors, applications of super conductors.

SUGGESTED BOOKS

1. Essentials of nuclear chemistry, 4th edition; H. J. Arniker, NAIL publishers (1995); Chapters 1, 3 and 4.

2. Nuclear and Radioactive chemistry; Friedlander, Kennedy and Miller; Chapters 8 and 9.
3. Introduction to zeolite science and practice, H. Van Bekkum, E. M. Flanigen, P. A. Jacobs and J. C. Jansen (Elsevier Pub. Amsterdam, 2001)
4. Breck, D. W. Zeolites molecular sieves- Structure, chemistry and use. John Wiley & Sons N.Y. (1974).
5. Solid-State Chemistry an Introduction (2nd Edition) – Lasley Smart and Elaine Moore (Chapman & Hall 1996)
6. Solid State Chemistry- D.K.Chakraborty(New Age International Pvt.Ltd.New Delhi, 2000)
7. Introduction to Solids-L.V.Azaroff(tata McGraw Hill Publication Ltd. New York)
8. Principles of the Solid State-H.V.Keer(Wiley Eastern Ltd.New Delhi, 1994)
9. Solid state Chemistry –N.B.Hannay(Prentice Hall, New Jersey, 1967)
10. Superconductivity, Jai, Khachan & Stephen Bio Science, -----
11. Chemisorption, B. M. W. Trapnell, Butterworths Scientific Publications, London, 1955.
12. Adsorption on solids, Vladimir Ponoc, Zlatko Knor, Slavoj Cerny, Butterworth & Co – publishers, 1974.
13. Catalysis: Principle and Applications, B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, Narosa Publishing House, 2002.

LABORATORY COURSES (III Semester)

Paper CH (IC) 351: Synthesis and Characterization of Metal Complexes

Laboratory preparation and characterization of 3d transition metal complexes of *tetrahedral*, *square planar* and *octahedral* geometries.

1. VO(acac)₂
2. CoCl₂(Py)₂
3. Na[Cr(NH₃)₂(SCN)₄]
4. Prussian Blue, Turnbull's Blue Complexes
5. K₃[Cr(C₂O₄)₃] 3H₂O : UV, IR, TGA and estimation of oxalate.
6. Solid phase synthesis of trans-bis(glycinato)copper(II): IR, estimation of Cu by iodometry
7. Fe(acac)₃ : FTIR
8. Cis and trans [CoCl₂(en)₂]Cl : conversion of cis to trans and trans to cis by IR.
9. Potassium bis(peroxo)oxo(1,10-phenanthroline)vanadium(V) trihydrate: IR, TGA, estimation of vanadium and peroxide
10. Tetra-butylammoniumhexamolybdate(VI): IR, estimation of Mo
11. MnO₂ nano particles; SEM, SEM by adding CTAB

SUGGESTED BOOKS

1. *Practical Inorganic Chemistry*, G. Marr and B. W. Rockett.
2. *Practical Inorganic Chemistry* by G. Pass H. Sutchiffe, 2nd edn John Wiley & Sons.
3. *Experimental Inorganic/Physical Chemistry*, M. A. Malati, Horwood Publishing, Chichester, UK (1999)

Paper CH (IC) 352: Electro-analytical techniques

I Potentiometry

Potentiometric Titrations and Calculation of End Point Potentials for the following systems:

- i) Fe²⁺ and VO²⁺ Mixture vs Ce⁴⁺
- ii) Assay of sulphanilamide
- iii) Silver electrode for silver assay
- iv) Mixture of halide anions using Silver electrode

II pH-metry

1. Determination of CO_3^{2-} and HCO_3^- in a mixture
2. Determination of the dissociation constants of
(i) Ethylenediamine (en) (H_2L) (ii) Glycine (HL) (iii) Histidinemonohydrochloride (H_2L)
3. Determination of binary constants of i) Cu(II) -en and (ii) Ni(II) -His iii) Ni(II) – Gly Systems
4. Determination of stability constant of ternary (o-Phen-Ni(II)-His) system - Calculation of Log K.

III Conductometry:

1. Determination of the Composition of Cu(II)-oxine and Cu(II)-EDTA Complexes
2. Interaction of Pyrophosphate with Mg^{2+} , Ca^{2+} , Mn^{2+} and Cu^{2+}
3. Determination of Aspirin with KOH

IV Ion selective electrodes method (Ionimetry)

1. Estimation of fluoride ion in water
2. Estimation of nitrate ion in water
3. Estimation of ammonia in water

V Polarography

1. Determination of $E_{1/2}$ of Cd^{2+} and Pb^{2+}
2. Verification of Ilkovic equation by using Cd^{2+} solution
3. Determination of Stability Constants of Cd^{2+} and Pb^{2+} complexes

VI Electrogravimetry

1. Determination of Copper and Nickel individually and in a Mixture

SUGGESTED BOOKS

1. A Text Book of Quantitative Inorganic Analysis by A.I.Vogel 3rd Edition Elbs Publication 1969.
2. Vogel's Text Book Of Quantitative Inorganic Analysis Jeffery etal 4th edition Elbs Publications 1988.
3. Vogel's Text Book of Quantitative Chemical Analysis, 6th edition. Pearson Education Ltd 2002.
4. Determination and use of Stability Constants – Martell and Motekaitis VCH Publishers INC 1988.
5. Metal Complexes in Aqueous Solutions A.E.Martell and R.D. Hancock, Plenum Press, New York – 1996.
6. Analytical Chemistry by Gary D.Christian 6th Edition JohnWiley&SonsInc New York 1994.

M.Sc. INORGANIC CHEMISTRY SPECIALIZATION
SEMESTER-IV
PAPER I

CH(IC)401T: Molecular Spectroscopy of Inorganic Compounds

IC-33: Multinuclear NMR

IC-34: Advanced NMR techniques

IC-35: Applications of ESR to Metal Complexes

IC-36: Mossbauer Spectroscopy and Nuclear Quadrupole Resonance Spectroscopy

IC-33: Multinuclear NMR

¹³C nmr spectroscopy: CW and PFT techniques. Types of ¹³C nmr spectra: uncoupled, proton-decoupled, single frequency off-resonance decoupled (SFORD) and selectively decoupled spectra. ¹³C chemical shifts, factors affecting the chemical shifts.

Chemical equivalence and magnetic equivalence. Virtual Coupling and its importance in study of Metal Complexes [Pd{P(CH₃)₃}₂I₂]. Spin Dilute Systems-Satellites in Pt(II) Complexes cis-[Pt(PEt₃)₂Cl₂], Sn(CH₃)₄. NMR Time Scale and its use in studying Stereo chemical Non-rigidity (PF₅, [Rh(PR₃)₅]⁺, [Fe{Cp}₂(CO)₂]) -ΔR, the Ring Contribution to ³¹P Chemical Shifts -Metal and Chelate size on ΔR. Applications of ¹H, ¹³C, ¹⁹F, ³¹P and ¹⁵N to simple inorganic and Coordination Compounds - 1) ¹H-NMR: PtHCl(PEt₃)₂, Pt(NH₃)₃(CH₃)₃, BH₄⁻, NH₄⁺, CH₃CN, [⁶h-C₇H₈Mo(CO)₃], [⁷h-C₇H₇Mo(CO)₃]⁺, B₂H₆; ²⁹SiH₃SiH₃, 2) ¹⁹F: BF₄⁻, H₂PF₃ 3) ³¹P: Mo(CO)₃(PPh₃)₃, [Rh(PPh₃)₃Cl], trans-[PtCl₄(PEt₃)₂], ³¹PF₂H(¹⁵NH₂)₂ 4) ¹³C; [⁴h-C₈H₈Ru(CO)₃], Fe(CO)₅, Fe₂(CO)₉, Fe₃(CO)₁₂, FeCp(CO)₁₂, [¹³C¹⁵N Co(DH)₂Pyridine]. ¹³C{¹H} NMR spectrum of σ-bonded C₆H₅ ligand.

IC-34: Advanced NMR techniques

Spin-Lattice (T₁) and Spin-Spin Relaxation (T₂). Spin Echo Polarization Transfer – Spin Echo Measurements. ¹³C-NMR spectral editing techniques: Attached proton test (APT spectra) by Gated Spin Echo, Cross polarization, INEPT spectra, DEPT spectra (Distortionless enhancement by polarization transfer). INADEQUATE spectra (Incredible Natural Abundance Double Quantum Transfer Experiment).

Two Dimensional NMR: Basic principles, Types of 2-D NMR ;i)J- resolved spectroscopy a)homo and b)Heteronuclear J- resolved spectroscopy ii) Correlation spectroscopy ; Homo nuclear shift correlation spectroscopy (COSY) and Hetero nuclear shift correlation spectroscopy (HETCOR) iii) NOESY(Nuclear Overhauser Enhancement Spectroscopy). HOESY (two dimensional heteronuclear NOE). Advantages of 2-D NMR

IC-35: Applications of ESR to Metal Complexes

Principle- Selection Rules – Instrumentation- Microwavesource (energy bands). Application of ESR to the study of simple free radicals: methyl (CH₃·), amine (NH₂·), diphenylpicrylhydrazyl, cyclopentadienyl (C₅H₅·), hydroxy methyl (CH₂OH·) radicals. Zero-Field Splitting (ZFS) - Effective Spin - Orbitally Non-degenerate and Degenerate States. ESR Spectra of d¹-d⁹ Transition Metal Complexes with examples. Interpretation of g in cubic, axial and rhombohedral geometries. Factors affecting g values. Calculation of g values with simple examples. Intensities of 'g_{||}' and 'g_⊥' peaks. Evidence for Metal-Ligand Bond Covalency- Cu(II)- Bis -Salicylaldimine. [(NH₃)₅CoO₂Co(NH₃)₅]⁵⁺, Cu(II)- diethyldithiophosphate, Vanadyldithiophosphate, Copper(II) tetraphenylporphyrin, Co(II)- phthalocyanine, K₂[IrCl₆]. Interpretation of 'g' and 'A' values from esr spectral data in- i) MnF₆⁴⁻, ii) CoF₆⁴⁻, and CrF₆³⁻. ESR spectra of dinuclear Cu (II) complexes.

IC-36 Mossbauer and Nuclear Quadrupole Resonance Spectroscopy

Mossbauer Spectroscopy: Principle, Experimental Considerations and Presentation of the Spectrum - Isomer Shifts – Quadrupole splitting and Magnetic hyperfine splitting - Selection Rules.

Applications

Iron Compounds: Low-spin and High-spin Fe(II) and Fe(III) Complexes - π -bonding Effects in Iron complexes - Study of High-spin Low-spin Cross-over c) Diamagnetic and Covalent Compounds - Structural aspects of Iron Carbonyls and Iron-Sulfur Proteins.

Tin Compounds: Tin Halides and Organotin Compounds.

Iodine Compounds: Isomer Shifts of ^{127}I and ^{129}I - Applications to Alkali metal iodides and Molecular Iodine. Mossbauer spectra of IF_6^- and IF_6^+

Nuclear Quadrupole Resonance Spectroscopy: Principle, nuclear quadrupole resonance experiment, Structural information from NQR spectra- PFCl_4 , PCl_4Ph , Ga_2Cl_7^- and TeCl_4 Interpretation of nuclear quadrupole coupling constants.

SUGGESTED BOOKS

1. Structural Methods in Inorganic Chemistry, E. A. V. Ebsworth, D. W. H. Rankin and
2. S. Craddock, ELBS.
3. Physical Methods in Chemistry, R. S. Drago, W.B. Saunders Co., 1977.
5. Physical Methods for Chemists, Russell S. Drago Second edition, Saunders College Publishing, 1992.
6. Principles of Mossbauer spectroscopy, T. C. Gibb, Chapman and Hall, London, 1976.
7. Mossbauer Spectroscopy, N. N. Greenwood and T. C. Gibb, Chapman and Hall, London, 1971.
8. Principles of Instrumental Analysis, Skoog, Holler and Nieman.
9. Instrumental Techniques for Analytical Chemistry, Frank Settle.
10. Principles of Analytical Chemistry, M. Valcarcel.
11. Physical Methods in Advanced Inorganic Chemistry, Hill and Day
12. Magneto Chemistry, Dutta & Shyamal Oxford Chemistry Primers, Vol 62

PAPER II

CH(IC) 402T: Bioinorganic Chemistry
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IC-37: Metal ions Interactions with Nucleic acids and their constituents

IC-38: Transport of Electrons and Metal ions

IC-39: Metallo-Enzymes of Iron, Zinc and Nickel

IC-40: Metallo-Enzymes of Cobalt, Copper, Molybdenum and Manganese

IC-37: Metal ions Interactions with Nucleic acids and their constituents

Nucleic Bases, Nucleosides and Nucleotides. Proton Binding Sites of Nucleic Acid Constituents-Purine and Pyrimidine Bases, Nucleosides and Nucleotides. The covalent structure of polynucleotides, secondary structure of DNA: The double helix anti and syn conformations of nucleotides. B, A, & Z forms of DNA. General Factors that influence Metal Ion Binding Sites in Solution – Specific Metal Ion Binding to Nucleic Bases, Nucleotides and Nucleosides in Solution: Stability of Phosphate- Metal ion complexes, Metal binding Metal Ion Complexes, Metal Binding Sites in Nucleosides, Nucleotide - Metal Ion Interactions - Intramolecular Equilibrium Constant KI, Percentage of Closed Isomers - Outer Sphere and Inner Sphere Isomers of M-ATP Complexes and Metal Ion Nucleic Base Interactions.

Metal-DNA and RNA Interactions: Potential Binding Sites (Elementary Treatment) – Influence of Metal Ions on Stability of Nucleic Acids.

IC-38: Transport of Electrons and Metal ions

Transport of Electrons: Iron-Sulphur Proteins: Rubredoxins and Ferredoxins (2Fe, 3Fe, 4Fe, 8Fe Proteins) - High Potential Iron-Sulphur Proteins – Structural and Spectral features of Iron-Sulphur Proteins - Electron-transport by Cytochromes, Azurin and Plastocyanin - Importance of Structures of Azurin and Plastocyanin in facilitating Rapid Electron Transport, acotinase- Fe-S enzyme.

Transport and Storage of Metal Ions: Iron-Transport by Transferrin and Siderophores – Ferritin in Iron Storage - Transport of Na⁺ and K⁺ across Cell Membranes by Na⁺- K⁺ ATPase - Transport of Calcium across Sarcoplasmic Reticulum by Ca²⁺-ATPase.

IC-39: Metallo-Enzymes of Iron, Zinc and Nickel

Iron Enzymes: Structural and Mechanistic Aspects of Cytochrome P450, Cytochrome oxidase, Catalase and Peroxidase - Role of the Metal Ion.

Zinc Enzymes: Structural and Mechanistic Aspects of Carbonic Anhydrase, Carboxypeptidase, Leucine aminopeptidase, Thermolysin, Alcohol Dehydrogenase - Role of Zinc.

Nickel Enzymes: Urease, Hydrogenase and Factor F430: Reactions Catalyzed, Mechanistic Aspects.

IC-40: Metallo-Enzymes of Cobalt, Copper, Molybdenum and Manganese

Cobalt Enzymes: Cobalt in Vitamin B12 - Structural Features of Vitamin B12 with reference to coordination of Cobalt - Different Oxidation States of Cobalt - Various forms of Vitamin B12 and Active Enzyme forms - Types of Reactions Catalysed by i) Methyl Cobalamin ii) Deoxyadenosyl Cobalamin - Mechanism of the Methyl Malonyl CoA conversion to Succinyl CoA - Role of the Apoenzyme - Unique features of Cobalt to suit Vitamin B12.

Copper Enzymes: Types of Copper in Biological Systems - Structural and Mechanistic Aspects of Superoxide Dismutase, Laccase and Galactose oxidase.

Molybdenum Enzymes: Biological Roles and Mechanistic Aspects of Nitrogenase, Xanthine oxidase and Sulfite oxidase.

Manganese Enzymes: Arginase, Water – oxidase.

SUGGESTED BOOKS

1. Biochemistry - Geoffrey L. Zubay.
2. Biochemistry - Mary K. Campbell. (added these books)
3. Bioinorganic Chemistry, Bertini, Gray, Lippard and Valentine, University Science Books, California USA 1994.
4. Principles of Bioinorganic Chemistry, S.J. Lippard and M. Berg University Science Books, California 1994.
5. Biological Chemistry of Elements, J.J.R. Franstodasilva and R.J.P. Williams Oxford University Press 1991.
6. Metal Ions in Biological Systems (Series), Ed. H. Sigel Marcel Dekker, New York
7. Inorganic Biochemistry, J.A. Cowan, VCH publishers 1993.
8. Advances in Inorganic Biochemistry, edited by G.L. Eichorn & Marzilli
9. Bioinorganic Chemistry, Vol-I edited by G.L. Eichorn.
10. Interactions of metal ions with nucleotides and nucleic acids and their constituents Helmut Sigel Chem. Soc. Rev., 1993, 22, 255-267.

PAPER III

CH(IC)403T(Elective IIIa): Medicinal Inorganic Chemistry, Spectroscopic Analysis of Drug/Metal Complexes and Applications of Nanomaterials

IC-41: Metal complexes in Clinical Chemistry

IC-42: Metal complexes as Drugs and Anticancer agents

IC-43: Spectroscopic analysis of drug/metal complexes binding to DNA

IC-44: Applications of Nanomaterials

IC-41: Metal complexes in Clinical Chemistry

Theory and mode of action of therapeutic chelating agents, Single ligand Chelation Therapy – Aminopolycarboxylic acids, Desferrioxamine, pencillamine, triethylenetetramine, Mixed ligand chelation therapy - Metallothioneins in detoxification. Role of metal ions in the action of antibiotics: Bleomycin, adriamycin and tetracyclines. Gold-Containing drugs used in therapy of Rheumatoid arthritis - A therapeutic agent for Menkes disease: Copper-histidine - Anti viral chemotherapy and metal peptide interaction.

IC-42: Metal complexes as Drugs and Anticancer agents

Introduction to Pt(II) chemistry– Thermodynamic and kinetic principles – *Cis* and *Trans* influences – Thermodynamic and kinetic aspects. Steric and electronic tuning of reactivity.

Platinum complexes in cancer therapy: Discovery applications and structure-effect Relationships. Cis-platin($\text{cisPt}(\text{NH}_3)_2\text{Cl}_2$) mode of action. Potential binding sites on nucleic acids and their bases and proteins. Drug resistance and DNA repair mechanism.

Physical effects of metal complex: DNA binding, unwinding, shortening and bending of the double helix. Biological consequences of platinum –DNA binding. Organic intercalators as donor – acceptor pairs; Transition metal complexes as donor acceptor pairs. Non classical platinum antitumour agents.

IC-43: Spectroscopic analysis of drug/metal complexes binding to DNA

Introduction to DNA binding studies. Cooperativity/anticooperativity, the excluded site model. UV-Vis Absorption Spectroscopy and ligand/drug/metal complex DNA binding studies. Application of Fluorescence quenching in general and ligand/drug/metal complex DNA binding studies. Fluorescence titrations and binding constants. Salt back titrations interpretation of the data, the binding analysis, obtaining equilibrium binding isotherms. Dependence of K_{obs} on salt concentration, cation effects on ligand nucleic acid equilibria, Competitive effects of monovalent and divalent cations for binding. Record's polyelectrolyte theory and its importance. Equilibrium dialysis. Partition analysis, competitive equilibrium dialysis to assess B & Z DNA binding. Competition dialysis to assess base and sequence specificity, viscosity studies. Tertiary structure of DNA, Supercoiled DNA (Form-I), Nicked DNA (Form-II) and Linear DNA (Form-III). DNA cleavage activity with ligand/metal complexes - Analysis by Gel electrophoresis.

IC-44: Applications of Nanomaterials

Nanotechnology in modern technology in relation to electronic, biological, consumer and domestic applications. Energy related application: photo-volatile cells. Energy storage nanomaterials.

Sensors: Agriculture, health and medical, food, security.

Applied nanobiotechnology and nanobiomedical science drug delivery, drug targeting, biosensors, bioimaging, neutron capture therapy.

SUGGESTED BOOKS

1. Bioinorganic Chemistry. Inorganic elements in the Chemistry of life, Wolfgang Kaim & Brigitte Schwederki.
2. Bioinorganic Chemistry, Bertini, Gray, Lippard and Valentine, University Science Books, California USA 1994.
3. Handbook of Metal-Ligand interactions in Biological fluid Bioinorganic medicine, Vol – Edt. Guy Berthon.
4. Bioinorganic Chemistry, Rosette M. Roat Malone.
5. Photoreactions of Metal complexes with DNA, A. Krisch – De Mesmacker et al.
6. Drug - Nucleic Acid Interactions, Volume 340 Jonathan B. Chaires, Michael J. Waring Academic Press, 2001.
7. Mechanistic Bioinorganic Chemistry Edited by H. Holden Thorp and Vincent L. Pecoraro, Chemical Society, Washington DC 1995.
8. Metal Complex -DNA Interactions, Editor(s): Nick Hadjiladis, Einar Sletten, Copyright © Blackwell Publishing Ltd.
9. Gel Electrophoresis - Principles and basics edited by Sameh Magdeldin ISBN 978 - 958 -51-0458-2, 376 pages, Publisher: InTech, April 04, 2012
10. Encyclopedia of nanomaterials and nanotechnologies, H. S. Nalva.
11. Nanostructures materials: Processing, Properties and applications, C. C. Kouch, William Andrew publications, New York, 2002.
12. Introduction to nanotechnology, C. P. Poole Jr, F. J. Owens, 2nd edition, Wiley-India, Delhi, 2008.

PAPER III

CH(IC)403T(Elective IIIb):Analytical Techniques -III

IC-45: Electroanalytical Methods

IC-46: Radiochemical Methods

IC-47: Fluorimetry, Phosphorimetry, Nephelometry and Turbidimetry

IC-48: Industrial Analysis

IC-45: Electroanalytical Methods

pH-metry: Accuracy of direct potentiometer measurements. The Glass pH electrode – Theory, construction, standard buffers, accuracy of pH measurements, measurements with the pH – meter, pH titration of unknown soda ash.

Electrogravimetry: Basic principles of electrogravimetry, Instrumentation, electrogravimetry determination with constant applied voltage and at constant current. Applications of electrogravimetry. Problems based on effect of concentration on electrode potentials, calculation of theoretical cathode potential at the start of deposition, effect of pH in electrolytic separations.

Coulometry : Basic principles, Types of coulometers, constant current coulometric analysis, coulometric titrations – principle, circuit and cell for coulometry, Application to neutralization, Redox, precipitation, complexometric titrations, Advantages of coulometric titrations and errors. Controlled potential coulometry – Technique & applications of inorganic & organic compounds.

High Frequency Titrations: Introduction, Theory, Instrumentation, Applications, Advantages and disadvantages.

IC-46: Radiochemical Methods

Radioactive nucleotides, Instrumentation – measurement of alpha, Beta particles and Gamma radiation. Radio tracers and tracer techniques, applications of Tracer techniques,

Neutron activation analysis: Neutron sources, interaction of neutrons with matter. Theory of activation methods, Experimental considerations, Nondestructive and destructive methods, applications.

Isotopic dilution analysis: Principles, theory and Applications.

Radiometric titrations: Principle, Procedure, advantages & disadvantages, applications to various types of titrations, problems based on the techniques.

Applications of Radio Chemical Methods in Biology, Agriculture and Environment

IC-47: Fluorimetry, Phosphorimetry, Nephelometry and Turbidimetry

Fluorimetry and Phosphorimetry: Theory of Fluorescence and Phosphorescence- Excited states producing Fluorescence and Phosphorescence. Rates of absorption and emission. Deactivation processes, Variables affecting Fluorescence and Phosphorescence. Types of Photoluminescence spectra for Phenanthrene. Instrumentation – Components of Fluorimeter, Spectrofluorimeters and Phosphorimeters. Applications of Fluorimetry - Determination of Inorganic Cations, Fluorimetric reagents. Fluorimetric determination of organic species – Thiamine, Aneurine Hydrochloride, Polycyclic aromatic hydrocarbons. Phosphorimetry- Determination of Aspirin in blood serum. Chemiluminescence- Origin, measurements. Analytical applications- Atmospheric pollutants (Oxides of Nitrogen and Sulphur compounds, Ozone).

Nephelometry and Turbidimetry: Light scattering, principle and theory of Nephelometry and Turbidimetry, Effect of concentration, particle size and wavelength on scattering, instrumentation for Nephelometry and Turbidimetry. Turbidimetric titrations. Applications of Nephelometry and Turbidimetry.

IC- 48: Industrial Analysis

Analysis of Ferroalloys: Analysis of steel - Molybdenum, Phosphorous.

Analysis of non- Ferrous alloys: Analysis of Tin, Zinc and Copper in Brass, Bronze. Analysis of Tin and lead in Solder.

Analysis of Cement: Composition of Portland cement, estimation of Aluminium oxide and Ferrous oxide. Determination of Alumina in Cement by Polarography.

Analysis of Oils & Fats: Theory, Melting point of fats, Chemical Characteristics: Saponification value, Iodine value, Thiocyanogen value, ketone or perfume rancidity.

Soaps & Detergents: Composition of Soaps. Determination of low level Surfactants, determination of Germicides in soaps and detergents by photometric method, analysis of phosphates by paper chromatography, determination of detergent alkylates by Mass Spectrometry.

Paints & Pigments: Constituents of Paints, Analysis of TiO_2 in Titanium dioxide pigments by XRD. Determination of Zn, Pb in Paint pigments by Polarographic method. Analysis of polyesters, acrylics by Gel permeation chromatography.

SUGGESTED BOOKS

1. Principles and practice of Analytical Chemistry, F.W.Fifield & D Kealey, 5th Ed. Blackwell Science, 2000
2. Principles of Instrumental Analysis: Holler, Skoog and Crouch, 6th edition, Cengage Learning 2007.
3. Instrumental methods of chemical analysis B.K. Sharma, Goel Publishing House.
4. Analytical Chemistry: Gary D Christian. 6th edition.
5. Principles of Instrumental Analysis - Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
6. Principles and practice of Analytical Chemistry, F.W.Fifield & D Kealey, 5th Ed. Blackwell Science, 2000.
7. Quantitative Chemical Analysis, Daniel C. Harris, 6th Ed. WH Freeman & Co. New York, 2003.
8. Analytical Chemistry an Introduction, Crouch, 7th Ed. Saunders College Publishing, 2000.

9. Standard methods of Chemical analysis, 6th ed., volumes I to IV. Edited by F.J. Welcher: D. Von NostrnadCo. Inc., Princeton N.J. 1966.

10. Biochemical Methods – S. Sadasivam, A. Manickam, 2nd ed., New Age International (P) Ltd., 1997.

PAPER IV

CH(ID) 404T(Elective IVa): Interdisciplinary Course (ID) (Environmental and Applied Analysis)
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IC-49: Clinical and Pharmaceutical Analysis

IC-50: Food and Agricultural analysis

IC-51: Analysis of Air and Water Pollutants

IC-52: Drinking Water and Sewage Water Treatment

IC-49: Clinical and Pharmaceutical Analysis

Clinical analysis: Analysis of Carbohydrates and their significances – Fasting, random and post prandial glucose tests, Estimation of Glucose in serum. Analysis of lipids and their significances –Test for cholesterol. Analysis of proteins and their significance – Estimation of total protein in serum.

Analysis of Major metabolites and their significance – Determination of Blood urea and Creatinine in urine. Analysis of ions and their significance: Estimation of Na, K, Ca, bicarbonates and phosphate in serum. Analysis of Hormones and their significance-ELISA and RIA.

Pharmaceutical analysis: Determination of Diclofenac (non-aqueous titration), Calcium in Vitamin D and Calcium formulations (Complexometry), Sulphanilamide (potentiometry), Pethidine hydrochloride (UV-Vis), Frusemide (UV-Vis), Aspirin, paracetamol and codein in APC tablets (NMR), Phenobarbitone in tablets (IR), pivalic acid indipivefrin eye drops (GC), Assay of hydrocortisone cream. (HPLC). Impurity profiling of Propranolol (GC-MS), famotidine (LC-MS).

IC-50: Food and Agricultural analysis

Analysis of Chemical additives: Division of colour additives (Coal-tar dyes, vegetable colours and mineral colours). **Chemical preservatives** and synthetic sweetening agents (organic-ether extractable and non-ether extractable) SO₂, Sodium Benzoate, Sorbic acid, Benzoic acid.

Antioxidants: Types of Antioxidants used in foods, Analysis of Butylatedhydroxy toluene (BHT), propyl – gallates (PG), Octylgallates (GO), dodecyl gallates (DG) by TLC & GC.

Food adulteration: Common adulterants in food, contamination of food stuffs. Microscopic examinations for food adulterants.

Analysis of Soil – Determination of pH, conductivity, cation exchange capacity, total organic matter, nitrogen, phosphorous, potassium, S, Ca, Mg, Ca+Mg, Zn, Cu, Fe, Mn, B, Mo, Cd, Cr, Ni, Pb.

Analysis of Fertilizers – Moisture determination by Karl Fischer titration methods. Determination of Ammonical nitrogen and Ammonical nitrate nitrogen. Determination of total phosphates as P₂O₅. Estimation of potassium, Estimation of micronutrients by AAS.

Analysis of Pesticides: Analysis of Organo-chlorine pesticides (Cypermethrin) by Gas Chromatography. Determination of Malathion, Methyl parathion and DDT residues in vegetables and food grains.

IC-51: Analysis of Air and Water Pollutants

Air quality standards, sampling, analysis of air pollutants-SO₂ (UV-Vis, IR), H₂S (Spectrophotometry and Non-dispersive IR Spectrophotometry), NO-NO_x (Chemiluminescence technique, Colorimetric technique- Saltzman method), CO & CO₂ (IR, AAS & GC), Hydrocarbons (GC, GC-MS), Aromatic hydrocarbons in automobile exhaust, petrol, air, O₃ (Chemiluminescence & Spectrophotometry), particulate matter analysis. Objectives of analysis, sampling, preservation and pre-concentration methods, physical analysis - colour, odour, temperature, pH, EC, redox potential, total dissolved solids (turbidimetry), Chemical analysis of anions – CN⁻, Cl⁻, F⁻, NO₂⁻, NO₃⁻ (spectrophotometry), SO₄, PO₄.

Determination of BOD, COD, TOC & DO. Analysis of Toxic Metals: Hg, As, Pb, Cd, Be, Al, Cr (Atomic Absorption Spectroscopy and Spectrophotometry)

IC-52: Drinking Water and Sewage Water Treatment

Hardness: causes, measurement of hardness, units- types of hardness, estimation of temporary and permanent hardness, Alkalinity of water and its estimation.

Treatment of Water for Municipal Supply: Characteristics of potable water/Domestic water, WHO standards, and Indian Standards. Aeration, Sedimentation with coagulation, Filtration, Sterilization and Disinfection: Physical Methods-Boiling, Exposure to Sunlight, Disinfection with UV light, Chemical Methods – Ozonization, Chlorination, Breakpoint chlorination and Dechlorination

Desalination of Brackish Water:Treating saline water: distillation, electro dialysis, reverse osmosis (RO).

Mineral Water and Purified Water: Typical Manufacturing Process, Flow Sheet Diagram of Mineral Water Manufacturing Process, Purified Water-Purification methods-Distillation, Double distillation, Deionization - Co-current deionization, Counter-current deionization, Mixed bed deionization, Demineralization, Uses of purified water- Laboratory use, Industrial uses and other uses; Health effects of drinking purified water

Sewage Water Treatment: Domestic sewage - Physical, Chemical, and Biological Characteristics of Domestic Sewage, Municipal sewage, Sewage Composition and Contaminants, Sewage Treatment - On-Site Sewage Treatment Systems and Off-Site Sewage Treatment Systems

SUGGESTED BOOKS

1. Medical Laboratory Technology – Mukherjee, McGraw Hills, 1988.
2. Medical Laboratory Technology – Ramnik Sood, Medical Publishers Pvt. Ltd., 1999.
3. Biochemical Methods – S. Sadasivam, A. Manickam, 2nd ed., New Age International (P) Ltd., 1997.
4. Practical Pharmaceutical Chemistry, A.H. Beckett et al, 3rd ed. – Vol. 1 & Vol. 2 CBS Publishers & Distributors, 1986.
5. Pharmaceutical Analysis - P. Primoo. CBS Publishers, New Delhi, 1999.
6. Text book of Pharmaceutical Analysis – Kenneth. A. Connors, John Wiley & Sons, 1999.
7. Pharmaceutical Chemistry, Instrumental techniques vol-2, Ed. Lesile. G.Chatten.
8. Pharmaceutical Drug Analysis – Asuthoshkar, Minerva Press, 2001.
9. Handbook of analysis and quality control for fruit and vegetables products – S. Ranganna, 2nd edition, Tata McGraw-Hill Publishing Ltd., 1986
10. Introduction to the Chemical Analysis of Foods, S. Suzanne Neilsen, CBS Publishers, New Delhi, 2002.
11. A Text book of Soil Chemical Analysis – P.R. Hesse, CBS Publications, 1998.
12. Methods of Analysis of Soils, Plants, Water and Fertilizers – Ed, HLS Tandon, FDCO publications, New Delhi, 1999.
13. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed, Pearson Education Ltd.
14. Environmental Pollution Analysis, S M Khopkar, Wiley Eastern Ltd 1995.
15. Environmental Analytical Chemistry, F W Fifield, P J Haines, Blackie Academic Professional.
16. Environmental Chemistry, B K Sharma, Goel Publishing House, Meerut.
17. "A Textbook of Engineering Chemistry", Dr. Y. Bharathi Kumari and Dr. Jyotsna Cherukuri, VGS Publications, First Edition, India, 2009.
18. "Engineering Chemistry", Jain P C and Monica Jain, 15th Edition, Dhanpat Rai Publishing Company Ltd, New Delhi, India, 2005.
19. Textbook of Engineering Chemistry, C Parameswara Murthy, C V Agarwal, Andra Naidu, BS Publications, Hyderabad, India
20. Water Encyclopedia - Domestic, Municipal, and Industrial Water Supply and Waste Disposal, Jay H. Lehr and Jack Keeley, Wiley-Interscience, Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
21. Handbook of Water and Wastewater Treatment Technologies, Nicholas P. Cheremisinoff, Published by Butterworth-Heinemann, 225 Wildwood Avenue, Woburn, MA 01801-2041
22. Purified water: https://en.wikipedia.org/wiki/Purified_water#Purification_methods

PAPER IV

CH(ID) 404T(Elective IVb): Interdisciplinary Course (ID) (Inorganic Material Chemistry)
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IC-49: Composite Materials

IC-50: Liquid Crystals

IC-51: Explosives and Propellants

IC-52: Fuels and Combustion

IC-49: Composite Materials

Introduction, Advantageous Properties of the Composites, Constituents of Composites, Types of Composites – Fibre-reinforced composites (Glass, carbon, Aramid, Alumina reinforced composites), Particulate composites, Layered composites, Processing of Fibre-reinforced Composites, Micromechanics of Fibre and Particle Reinforced Composites, Fabrication of the Composites.

Refractories: Characteristics and Classification of Refractories, Properties of Refractories, Manufacture of Refractories, Common Refractories Bricks – Silica Bricks, Alumina Bricks, Magnesite Bricks, Dolomite Bricks, Carbon Bricks and Chromite Bricks.

Ceramics: Plasticity of Clays, Whitewares or White-Pottery, Manufacture of White-Pottery, Glazing, Methods of glazing, Earthenwares and Stonewares.

IC-50: Liquid Crystals

Introduction, Types of Mesophases, Characterization of Liquid Crystals, Physical Properties of Liquid Crystals, Structure of Liquid Crystal forming compounds, Classification of Liquid Crystals-Thermotropic Liquid Crystals and Lyotropic Liquid Crystals, Chemical Properties of Liquid Crystals, Applications with special reference to Display systems, Applications and Importance of Lyotropic Liquid Crystals, Future of Liquid Crystals.

IC-51: Explosives and Propellants

Explosives: Introduction, Classification of Explosives, Primary Explosives, Low Explosives, High Explosives, Precautions During Storage of Explosives, Blasting Fuses, Manufacture of Important Explosives-Lead azide, Diazonitrophenol (DDNP), Trinitrotoluene (TNT), Nitroglycerine (NG) or Glycerol trinitrate (GTN), Pentaerythritol tetranitrate (PETN) and RDX; Recent uses of Explosives

Propellants: Rocket Propellants - Introduction, Principle of Rocket Propulsion, Classifications of Propellants-Solid propellants, Composite propellants, Liquid Propellants, Mono-propellants, Bi-propellants; Differences between Solid propellants and Liquid Propellants

IC-52: Fuels and Combustion

Introduction, Classification of Fuels, Calorific Value, Characteristics of a Good Fuel, Theoretical Calculation of Calorific value of a Fuel, Coal, Classification of Coal by Rank, Analysis of Coal – Proximate analysis and Ultimate analysis, Metallurgical Coke, Types of Carbonization of Coal – Low-temperature and high temperature carbonization, Manufacture of Metallurgical Coke by Beehive oven process, Petroleum, classification of petroleum, Refining of crude oil, Cracking – Thermal cracking, Catalytic cracking- Moving-bed catalytic cracking, LPG as a Fuel, Natural Gas, Producer Gas, Water Gas (or Blue Gas), Non-Conventional Sources of Energy-Solar energy, Solar cells and Uses of solar cells.

Combustion: Combustion, Mass Analysis from Volume Analysis and Vice Versa, Analysis of Flue Gas

SUGGESTED BOOKS

1. "Liquid Crystals, Nature's delicate phase of matter", Peter J Collings, Princeton University Press, 2002
2. "Liquid Crystals: Fundamentals", Shri Singh, World Scientific Publishing Company; 1st edition (November 7, 2002)
3. "Science of Engineering Materials", C.M. Srivastava and C. Srinivasan, Wiley-Eastern Ltd. (1991).
4. "Engineering Chemistry", Jain P C and Monica Jain, 15th Edition, DhanpatRai Publishing Company Ltd, New Delhi, India, 2005.
5. "A Text book of Engineering Chemistry", Shashi Chawla" DhanpatRai Publishing Company (P) Ltd., New Delhi, India, 2007.
6. Textbook of Engineering Chemistry, C Parameswara Murthy, C V Agarwal, Andra Naidu, BS Publications, Hyderabad, India.
7. "A Textbook of Engineering Chemistry", Dr. Y. BharathiKumari and Dr. JyotsnaCherukuri, VGS Publications, First Edison, India, 2009

Paper CH (IC) 451: Conventional Methods of Analysis

I. Titrimetry:

1. Determination of Ca^{2+} , Mg^{2+} , CO_3^{2-} , HCO_3^- in soil sample
2. Determination of saponification value, Iodine number, acid value and ester value of an oil sample (5-6 samples and comparative study)
3. Determination of Ascorbic acid in Vit.C tablet by iodometry (2-3 samples)

II Water analysis:

1. Determination of Dissolved Oxygen
2. Determination of COD
3. Determination of residual Chlorine in water by Iodometry
4. Determination of Fluoride by Zirconium Alizarin Method
5. Determination of Sulphate by spectrophotometry, turbidimetry or nephelometry

III Separation Methods

1. Separation of Fe^{3+} and Ni^{2+} using tri-n-butyl phosphite (TBP) from HCl medium (Solvent extraction)
2. Determination of cations by paper chromatography; Co(II), Ni(II) and Cu(II)
3. Separation of Fe(III) and Al(III) by column chromatography
4. Separation of Fe^{3+} and Ni^{2+} using strongly basic anion resin.

SUGGESTED BOOKS

1. Chemistry Experiments for Instrumental Methods, Donald T Sawyer William R. Hememan et.al John Wiley & Sons 1984.
2. Analytical Chemistry by Gary D. Christian 6th Edition John Wiley & Sons Inc New York 1994.
3. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel 3rd Edition Elbs Publication 1969.
4. Vogel's Text Book of Quantitative Inorganic Analysis Jeffery et al 4th edition Elbs Publications 1988.
5. Vogel's Text Book of Quantitative Chemical Analysis, 6th edition. Pearson Education Ltd 2002.
6. Analytical Chemistry Theory and Practice by R.M. Verma 3rd Edn. CBS Publishers & Distributors 1994.
7. Comprehensive Experimental Chemistry by V.K. Ahluwalia et.al New Age Publications 1997.
8. Laboratory hand Book of Instrumental Drug Analysis. by B.G. Nagavi 2nd edn. 1996.

LABORATORY COURSES (IV Semester)
Paper CH (IC) 452: Spectroscopic techniques

I Spectrophotometry

1. Estimation of manganese.
2. Estimation of chromium.
3. Simultaneous determination of Manganese and Chromium in a mixture.
4. Determination of pKa of indicator (methyl orange/ methyl red)
5. Estimation of Nickel.
6. Determination of composition of Complex by Job's Method and Mole ratio Method in the following:
(i) Cu(II)-EDTA (ii) Fe(II) - o-Phen

II Colorimetry

1. Determination of blood sugar
2. Determination of blood cholesterol
3. Determination of creatinine
4. Determination of Paracetamol

III Fluorimetry

1. Determination of Riboflavin
2. Determination of Quinine Sulphate.

IV Flame photometry

1. Determination of Na
2. Determination of K
3. Determination of Ca
4. Determination of Li

V Atomic Absorption Spectroscopy

1. Determination of i) Fe, ii) Mg, iii) Cu, iv) Pb.

SUGGESTED BOOKS

- Text Book of Quantitative Inorganic Analysis Jafferyetal 4th edn. EdnElbs Publication
1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel 3rd EdnElbs Publication 1969.
 2. Quantitative Analysis by Day and Underwood Prentice Hall (India) VI Edn.
 3. Analytical Chemistry Theory and Practice by R.M. Verma 3rd Edn.CBS Publishers & Distributors 1994.
 4. Practical Pharmaceutical Chemistry, A.H. Beckett and J.B. Stenlake 4th edn. CBS publishers, 2001
 5. Medical Laboratory Technology – Mukherjee, McGraw Hills, 1988