Vivekanand College (Autonomous), Kolhapur

M. Sc. Part-II (Inorganic Chemistry) CBCS Syllabus with effect from June-2022

Semester-III,

Paper No. I Inorganic Chemical Spectroscopy

Unit I: Molecular Symmetry and Group Theory **15 Hrs**

Introduction to Symmetry, Symmetry operations, Symmetry elements, Point group and its classification (Cn-type, Dn-type, Special-type), Schoenflies symbol for point groups, Determination of point group for AB2 (Bent), AB3 (Trigonal pyramid), AB3 (Trigonal Planar), AB4 (Square planar), AB5 (Trigonalbipyramidal), AB6 (Octahedral), CO2, HCl, CO, Ortho–, meta– &para–disubstituted benzene molecules. Symmetry and dipole moment of molecule, Symmetry and optical activity, Group and its Properties, Group multiplication table, Matrix representation of symmetry elements, Reducible and Irreducible representations, Character of a representation (character of matrix), Properties of Irreducible representation, Great orthogonally theorem (without proof) and its importance, Construction of character table for C2v& C3v point groups, Mulliken symbolism rules for irreducible representations & its illustrations, Direct product, Standard reduction formula.

Unit II: IR and Raman Spectroscopy **15 Hrs.**

A) Infrared spectroscopy: The vibrating diatomic molecule, The simple harmonic oscillator, The anharmonic oscillator, The diatomic vibrating rotator, Vibration– rotation spectrum of carbon monoxide, Breakdown of Born–Oppenheimur approximation, The vibration of polyatomic molecules, Overtones and combination frequencies, The influence of rotation of the spectra of polyatomic molecules, Techniques and Instrumentation, Applications.

B) Raman spectroscopy: Classical and Quantum theory, Pure rotational Raman Spectra, vibrational Raman spectra, Rule of mutual exclusion, Overtone and combination vibrations, Rotational fine structure, Outline of technique and instrumentation, Applications. Modes of vibrations, Selection Rules for Infrared and Raman Spectra, Normal modes of vibrations in AB2 (Linear/Bent), AB3, AB4, AB5, Octahedral AB6 molecules with factors affecting band frequencies.

Unit III: Mass Spectroscopy: 15 Hrs.

Basic principle, Instrumentation, Electron-impact Induced and Fast Atom Bombardment (FAB) spectrometry, qualitative and semiquantitative theories including QET, concept of metastable ions transitions, Stevensons's rules. Applications to metal compounds containing carbonyl, alkyl, cyclopentadienyl and acetylacetonate.

Unit IV: A) NMR Spectroscopy: 8 Hrs

Principle Instrumentation of NMR, the chemical shift, mechanism of electron shielding and factors contributing to the magnitude of chemical shift. Local & remote effect, spin-spin splitting, applications of spin coupling to structural determination, double Resonance techniques. The contact and Pseudo contact shifts Factors affecting nuclear relaxation, an overview of NMR of metal nucleus with emphasis on 195Ag &119Sn NMR, applications of solid-state NMR technique.

B) X-ray Photo electron Spectroscopy (XPS) 7 Hrs

Introduction and basic theory, Instrumentation, sample selection and preparation, spectral analysis, Ar ion sputtering technique and applications of XPS.

Reference Books:

1. K. Burger, Coordination Chemistry-experimental methods, Butterworth's
2. R. Drago: Physical method in Inorganic Chemistry, DUSAP.
3. Hill & Day advanced methods in Inorganic Chemistry, J.Weily
4. F.A. Cotton, chemical application of group theory, Weily eastern
5. Figgis, Introduction to ligand field theory field
6. Schaefer & Gilman: Basic principles of ligand field Theory, J. Wiely
7. P.R. Backer: Molecular symmetry and Spectroscopy A.P.
8. Ferraro Ziomeek, Introduction to Group theory, plenum
9. Scotland Molecular symmetry DVN
10. Dorian: symmetry in Chemistry EWAP
11. Hall: Group theory and symmetry in Chemistry MGLt
12. Nakamoto Infrared R Raman Spectra of Inorganic & Coordination compounds J.Weily
13. Nakanisha: Spectroscopy and structure J. Weily
14. Ferroro: Metal ligand and related vibrations
15. CNR Rao Spectroscopy in Inorganic Chemistry Vol I, II, III

16. Durie: vibrations spectra and structure Vol. I to IV, Elsevier
17. Dudd, chemical Spectroscopy Elsevier
18. Popel: H.N.M.R. Spectroscopy J.Weily
19. R.J. Abraham, J.Fisher and P Loftus Wiley Introduction to NMR spectroscopy.
20. P.K. Bhattacharya: Group Theory & Its Chemical Applications
21. K.V. Reddy: Symmetry & spectroscopy of Molecules.
22. M. R. Litzow and T R Spelding, Mass Spectroscopy of Inorganic & Organometallic Compounds, Elsevier,73

Paper No. II: Organometallic and Bioinorganic Chemistry

Unit I: Organo transition Metal Chemistry: 15 Hrs

Alkyls and Aryls of Transition Metals: Types, routes of synthesis, stability and decomposition pathways of alkyls and aryls of transition metals, Organocopper in Organic synthesis.

Compounds of Transition Metal – Carbon multiple bonds: Alkylidenes, alkylidynes, low valent carbenes and carbynes–synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on ligands, role in organic synthesis.

Unit-II: Transition Metal Pi-complexes: 15 Hrs

Carbon multiple bonds. Nature of bonding, structural characteristics & synthesis, properties of transition metal Pi-Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, Application of transition metal, organometallic intermediates in organic synthesis relating to nucleophilic and electrophilic attack on ligands, role in organic synthesis.

Unit III: Metal Compounds in Medicine: 15 Hrs

Medicinal use of metal complexes as antibacterial, anticancer, use of cis-platin as antitumor drug, antibiotics & related compounds. Metal deficiency and disease, iron deficiency, zinc deficiency and copper deficiency, Metal used for diagnosis and chemotherapy with particular reference to anti cancer drugs. Chelate therapy, chemotherapy with compounds of some non essential elements; platinum complexes in cancer therapy. Antiviral activity of metal complexes. Gold containing drugs used in the therapy of Rheumatic-Arthritis, Gold complexes as anticancer drug. Lithium in psycho pharmacological drugs. Antimicrobial agents

Unit-IV: Oxygen Transport and Storage: 15 Hrs

Hemocyanins & hemerythrin. Synthetic oxygen carriers-Collmans compound, Vaskas complex, Co(II) schiff base complexes, perflurochemicals (PFCs), Perutz mechanism for structural changes in porphyrin ring system, Oxygenation and deoxygenation, Oxygen adsorption isotherm and cooperativity, role of globin chain in gaemoglobin, Siderophores, Vanadium compounds as insulin mimetic agents in the treatment of diabetics

Reference Books

1. Bioinorganic Chemistry, A. K. Das
2. Organometallic and Bioinorganic Chemistry, Ajaykumar
3. Bioinorganic Chemistry, K. Hussain Reddy
4. Organometallic Compounds, Dr. Indrajeet Kumar, Pragati Prakashan Meerut
5. Yamamoto, Organo Transition Metal Chemistry, Wiley (1986).
6. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals (4th edn.), John Wiley (2005).
7. A. J. Pearson. Metallo-Organic Chemistry, John Wiley & Sons (1985).
8. M. Bochmann. Organometallics-I Complexes with Transition Metal-Carbon σ-Bonds, 13 Oxford Chemistry Primers (1994).
9. Principles of Biochemistry, A. L. Lehinger, Worth Publications.
10. Biochemistry, L. Stryer, W. H. Freeman
11. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford Univ. Press, 1990.
12. J. E. Huheey, E. A. Keiter and R.L. Keiter Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2004.
13. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, Univ. Science Books, 1994.
14. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life (An introduction and Guide), John Wiley & Sons, 1994.

Paper III: Co-ordination chemistry-I

Unit -I Photochemistry of Metal Complexes 15 Hrs

Photochemistry of Coordination compounds, electronically exited states of metal Complexes, types of photochemical reactions, substitution reactions, rearrangement reactions, redox reaction, and photochemistry of metallocene.

Unit-II Reactions of coordinated ligands **15 Hrs**

i)Non-chelate forming reactions: Reaction of donor atoms(Halogenation of coordinated N atoms, Alkylation of coordinated S and N atoms, Solvolysis of coordinated phosphorus atoms). Reactions of non-donor atoms (nucleophilic behaviour of the ligand, electrophilic behaviour of the ligand).

ii) Chelate ring forming reactions: (reactions predominantly involving thermodynamic template effects, reactions predominantly involving kinetic affects).

iii) Chelate modifying reactions

Unit-III Magnetic Properties of transition metal complexes **15 Hrs**

Types of magnetic behaviour, Origin of paramagnetism, Spin-orbit interaction, Diamagnetism, Pascal constants, Ferromagnetism and antiferromagnetism of metal complexes, temperature dependent paramagnetism, Van Vleck's equation, Its derivation and applications, Spin orbit coupling and magnetic moment, Spins crossover phenomenon, Determination of magnetic susceptibility.

Unit-IV

A] Mixed Ligand complexes **7 Hrs**

Stabilities of ternary complexes, Dynamics of formation of ternary complexes reaction of Coordination ligand in ternary complexes, Mimicking reactions in biological systems, enzyme models, Amino acids ester hydrolysis, peptide synthesis & hydrolysis, Detarbodylation of B keto acids

B] Catalysis of Transition metal complexes **8 Hrs**

Introduction, General Principle, catalysis by transition metal complexes, Hydrocarbons Oxidation by Molecular oxygen, olefin Oxidation, olefin polymerization, olefin hydrogenation, Arene reactions catalyzed by metal complexes, catalysis of condensation polymerization reaction, Current and feature trend in catalysis.

Reference books:

1. K. K. Rastogi and Mukharjee, Fundamentals of photochemistry, Wiley eastern.
2. J. G. Calverts and J. N. Pits, Photochemicals of Photochemistry, John Wiley.
3. Wells, Introduction to 4Photochemistry.
4. V. Balzani& V. Cavassiti, Photochemistry of Coordination compounds, AP, London, 1970.

5. Comprehensive Coordination Chemistry, Vol.1. G Wilkinson (Ed) Wiley, New York, 1967.
6. Inorganic Chemistry by J.E.Huheey, E.A.Keiter and R.L.Keiter 4th edn. Harper Collins, 1993
7. Mechanisms of Inorganic Reactions, by C.F.Basolo and R.G.Pearson, Wiley, New York, 1967
8. Earnshaw: Introduction to Magneto Chemistry
9 Mabbs&Machin Magnetism & transition metal complexes Chamman hall
10. Calvin, Magnetic properties of transition metal complexes.
11. L.N. Maley: Magneto Chemistry
12. Datta&Shymlal: Elements of Magneto Chemistry
13. James E. Huheey: Inorganic Chemistry Principles of Structure and reactivity, Harber & Row, Publishers Inc. New York 1972.
14. K.P. Purcell & J.C. Kote: An Introduction to Inorganic Chemistry Holt Sounders, Japan 1980.
15. William L. Jolly: Modern Inorganic Chemistry, Mecgrow Hill USA,1984
16. F.A. Cotton & R.G. Willkinson: Advanced Inorganic Chemistry.

Paper-IV Material Science

Unit-I: Superconductivity Materials, Crystal defects and Non stoichiometry 15 Hrs

Superconductivity Materials: Introduction, superconductivity, critical temperature, critical field, BCS theory, properties & classification of superconductors, high Tc superconductors, examples with structure and applications, fullerenes, intermetallic superconductors, synthesis, applications.

Crystal defects and Non stoichiometry:Diffusion in solids, phase transformation in solids, solid state reactions and crystal growth,Preparation methods of solids.

Unit-II: Magnetic materials 15 Hrs

Introduction, Atomic magnetism and solids, type of magnetic materials, exchange interactions, hysteresis loop and their classification, calculation of magnetic moment from saturation magnetization, magnetic domains, examples of magnetic materials, soft & hard ferrites, structure & magnetic interactions in spinel, garnet hexagonal ferrites, application of magnetic materials

Unit-III: Ceramic and Composite Materials **15 Hrs**

Ceramic Materials

Classification of ceramics, dielectric properties and polarization properties of ceramics, piezo-, pyro- and ferro-electric effect of ceramics, sol-gel processing of ceramics. Examples and application of ceramics: oxides, carbides, borides, nitrides.

Composite Materials

Introduction, glass transition temperature,fibersfor reinforced plastic composite materials (i.e. glass fibers, carbon fibres, and aramid fibers); concretes and asphalt materials. Application ofcomposite material

Unit-IV: Cementitious and Biomaterials **15 Hrs**

Cementitious Materials

Introduction, Difference between Blended and Non-Portland cements; Non-portland cements; high alumina cements, calcium sulfo-aluminate cements, phosphate cements.Chemicals in cement hydration; hydration process, set retardersandaccelerators, plasticizers, slip-casting processing. Application of cementitiousmaterials.

Bio-materials

Introduction, Definition of biomaterials and biocompatibility; Type of bio-materials: Metallic materials, Biopolymeric materials, Bioceramic materials (dense hydroxyapatite ceramics, bioactive glasses and bioactive composites); Basic requirement of bone implants; Coating of hydroxyapatite on porous ceramics; Biomaterials in tissue attachments; Application of Biomaterials.

References:

1. Solid state Chemistry: An Introduction – L.E. Smart & E.A. Moore, CRC, Taylor & Francis, 3rd Edn.

2. Materials Science & Engineering – V. Raghvan, 2nd Edn.

3. Introduction to Solids – L.V. Azarroff, 2nd Edn. 1980

4. Elements of materials science and engineering – Van Vleck, 5th Edn.

5. Insight to Speciality Inorganic Chemicals – D. Thompson, Royal Society of Chemistry, 1995.

Sem IV

Paper I: Instrumental Technique

UNIT I: X ray Diffraction techniques **15 Hrs**

Part A: X-ray powder diffraction (XRD): **10 Hrs**

X-ray source, Diffraction of X-rays with powder diffraction,Instrumentation and use ofstandards,identification of compounds using powder diffraction.The significance of intensities, Absencesdue to lattice centring;Determination of unknown cubic crystal structure. Parameter to be determined from XRD: Qualitative analysis; Quantitative analysis-percent crystallinity, Crystallite size, surface area, unit cell dimension.

Part B: Single crystal X-ray diffraction: **5 Hrs**

Solving single crystal structures;refining a structure, X-ray crystal structures in the literature.

Unit II: Nuclear Quadra pole Resonance Spectroscopy [NQR] and XPS and XRF techniques **15 Hrs**

Part A: Nuclear Quadra pole Resonance Spectroscopy [NQR] **8 Hrs**

Basic concepts of NQR (Nuclear electricquadrupole moment, Electric field gradient, Energy levels and NQR frequencies). Effect ofmagnetic field on spectra, Factors affecting the resonance signal (Line shape, position of resonancesignal). Relationship between electric field gradient and molecular structure. Interpretation of NQRdata.

Part B:X-ray Photoelectron spectroscopy (XPS) and X-ray Fluorescence spectroscopy (XRF) techniques **7 Hrs**

X-ray Photoelectron spectroscopy (XPF): Introduction and basic theoryInstrumentation; Sample selection and preparation, Spectral analysis; XPS imaging.

X-ray Fluorescence spectroscopy (XRF): Introduction and basic theory

Instrumentation, Spectral analysis; Analytical information, Applications.

UNIT-III **15 Hrs**

Mossbaur Spectroscopy

Introduction and Basic principles of ^{57}Fe Mössbauer spectroscopy, Instrumentation and Mössbauer Parameters- recoilless emission & absorption of x-rays,Isomer Shifts, quadrupole splitting, Magnetic hyperfine interaction.

Application of Mössbauer spectroscopy with respect to

i) Oxidation states of metal ion in compounds

ii) Structural elucidation, investigations of compounds of iron and tin.

iii) Covalent and ionic compounds

iv) High spin low spin behaviour

v) Magnetically ordered compounds

UNIT-IV **15 Hrs**

Advance Instrumental tools for analysis

Time resolved studies of chemical reactions such as material synthesis (solid state, hydrothermal, sol/gel, thin film growth etc.), cathode/anode materials in lithium ion batteries during charge/discharge cycles,

In situ x-ray diffraction methods for thermal expansion/contraction studies. Structural studies as a function of temperature and pressure (XRD methods). Temperature programmed techniques (temperature programmed desorption/oxidation/reduction: TPD/TPR).

Methods of determination of surface acidity and basicity of solid catalysts. Computer softwares for plotting and analysis of the XRD data,

Structure drawing softwares (VESTA)

Reference Books:

1. Principles of Instrumental analysis, Skoog, III rdedn., Sounders, 1985

2. Mossbaur Spectroscopy, Greenwood N.N., Gibbs T.C., Chapmann Hall, 1971.

3. Chemical Application of Mossbaur Spectroscopy, Goldanski V.I &Harber R.H.,Academic Press 1968.

4. Mössbauer Spectroscopy and Transition Metal Chemistry, P. Gütlich,R. Link, A.Trautwien, Springer-Verlag (1978).

5. Mössbauer Spectroscopy, N.N. Greenwood, T.C. Gibb, Chapman and Hall Ltd. (1971).

6. Instrumental method of analysis (7th edition) By- H.H. Willard , L.L. Merritt. Jr. J.A. Deanand F.A. Settle,Jr (Publisher: CBS Publishers and distributors Pvt .Ltd. (Copyright –wardsworth publishing copy USA .2000).

7 Element of X-ray Diffraction-B.D.Cullity (1967)

8. CNR Rao Spectroscopy in Inorganic Chemistry Vol I, II, III

9. Powder Diffraction Theory and Practice, Edited by R E Dinnebier and S J L Billinge, RSC publishing, 2008.

10. In situ X-ray diffraction study of the hydrothermal crystallization of hierarchical Bi2WO6 nanostructures, Y. Zhou, et al., Nanoscale, 2010, 2, 2412-2417, RSC Publishing Journal.

11. Physical Methods for Chemists, Russel Drago, Surfside Scientific Publishers, 1992

Paper II: Co-ordination chemistry-II

Unit I: Inorganic Reaction Mechanism 15 Hrs

Types of Mechanisms: Basic concepts as stability and lability, stability constants; HSAB principle, chelate effect, Macrocyclic effect; Ligand transfer and electron transfer reactions in coordination compounds, Intimate and stoichiometric mechanism of ligand substitution. Substitution in square planar complexes: trans effect, trans series, applications of trans effect., Electron Transfer reactions: Potential energy diagrams as a conceptual tool, Marcus equation, Types of and factors affecting electron transfer reactions.

Unit II: Reaction Mechanism of Transition Metal complexes 15 Hrs

Substitution reaction, reactions of Transition Metal complexes, kinetics and mechanism of substitution reactions of octahedral complexes, Stereochemical aspects of substitution reaction of Octahedral Complexes: Stereochemical changes in dissociation (SN2) and displacement (SN2) mechanism through various geometries of coordination compounds. Isomerization and racemization reactions in octahedral complexes. steric effects on substitutions.

Unit III: Catalysis-Homogenous and Heterogeneous 15 Hrs

Basic principles, thermodynamic and kinetic aspects, industrial requirements, classification, theories of catalysis, homogeneous and heterogeneous catalysis. Introduction, types & characteristics of substrate-catalyst interactions, kinetics and energetic aspects of catalysis, selectivity, stereochemistry, orbital symmetry and reactivity. Catalytic reactions of coordination and Organometallic compounds

Unit IV: Applications of Coordination Compounds **15 Hrs**

Metal Complexes in Analytical Chemistry Inorganic Qualitative Analysis, The 'brown ring' test, Complexometric Titrations, Complexes in Colourimetry, Coordination Compounds in Gravimetry, Stabilization of Oxidation States, Complexes in Separation of Metals. Metal Complexes in Medicinal Chemistry:- Complexation in Food Poisoning, Metal Complexes in Therapy. Metal Complexes in Industrial Processes:-Heavy Metals-protein Complexes in the Rasching Process, The Ziegler-Natta Catalyst, Metal complexes in alkene conversions, Complexes and Electroplating, Complexes in Metallurgy. Copper Metal dissolves in Aqueous Potassium Cyanide, Complexes in water softening. Metal complexes in Agriculture.

Reference books:

1. R. Gopalan and V. Ramlingam: Concise Coordination Chemistry.
2. J. E. Huheey, Ellen A. Keiter and Okhil K. Medhi: Inorganic Chemistry: Principle of Structure and Reactivity.
3. A.K. Das and M.Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers.
4. F. Basolo and R. Pearsons: Mechanism of Inorganic Reactions: A Study of Metal Complexes in Solution.
5. Obe, M. L. Inorganic reaction mechanism, Nelson, London, 1972.
6. Taube, Electron transfer reactions of metal complex ions in solution. Academic Press.
7. E. S. Gould, Inorganic Chemistry.
8. K. Burger, Coordination Chemistry Experimental methods, Butterworths.
9. Heterogeneous catalysis 2nd edn. Bond C. Chapman all (1987).
10. The application & Chemistry of catalysis by suitable transition metal complexes Parashall. W. Weily N. 1980.
11. Homogeneous transition metal catalysis, A general art, Masters C. Chapman and Hall, London 1981.
12. Introduction to the principles of heterogeneous catalysis, Thomas J.M., Thomas W.J. Academic press N.Y. 1967.
13. K. M. Macky, R. A. Macky, Modern Inorganic Chemistry, 4th edn., Blackie, London-1989.

14. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vallabh Publications, Delhi,2005.

Paper III: Energy and Environmental Chemistry

UNIT I: Energy Conversion Devices

Introduction:

Fuel Cells: Working of Fuel Cell, Types of fuel cells, uses. Fuel cell stacks and systems, Hydrogen as a fuel cell.

Production of Hydrogen: Electrolysis, Thermochemical processes, Steam Reformer processes, Water gas process, Bosch process, Biosynthesis and photochemical processes, Coal Gasification, Steam Iron processes, Partial Oxidation processes, Storage Transport and Handling of Hydrogen.

UNIT II : ENERGY STORAGE DEVICES

BATTERIES :

Li- ion Batteries :

Principle of operation, Battery components and design, electrode material (LiCoO2,LiNiO2,LiNi1/3Mn1/3Co1/3O2,LiMn2O4,LiFePO4, graphitic carbon) their synthesis and characterization.

Theoretical capacity, Energy density, power density, cycle life, electrode and battery fabrication,battery modula and packs,Li- polymer batteries and applications, Electrolytes for Li-ion batteries,all solid state batteries.

Future developments and beyond lithium batteries : Li-S battery, LI-air battery, Advanced Lead –acid batteries, sodium batteries,

Mg ,Si, Al batteries., Batterry Recycling technologies.

UNIT III: Air Pollution and Control Methods

Introduction, Source Correction Methods, Control of Particulate emissions, Selection of a particulate collector, Control of Gaseous Pollutants – NOx and Sox, Removal of H2S, Control of CO-pollution, Control of Hydrocarbon emission, Control of Pollutant emission from Mobile sources

UNIT IV: Water Pollution and Monitoring Control Methods

Introduction

A. Sewage and Industrial Waste, COD and BOD Estimation methods, Toxic Heavy metal Analysis – Cd, Hg, As, Pb and Cr

Control Methods :Water Softening and Municipal water Purification

B. Techniques in Environmental analysis –

ND-IR , FT- IR, AAS, ICT- AES, GCMS, HPLC

Anodic Stripping ,Voltametry etc.

References:

1. Fuel Cell Fundamentals, R.O.Hayre, et.al., John Wiley and Sons, 2016

2. Environmental Pollution, A.K.De

3. Environmental Pollution Analysis, S. M. Khopkar

4. Lithium Ion Batteries Materials, Technology and new Applications, K.Ozawa, Wiley.

5. Electronic Waste Magement. , Ed. Ramchandra, CRC

Press 2015 1st edition.

Paper IV: Inorganic Nanomaterials

Unit 1 Advanced synthetic methods of inorganic nanomaterials 15 Hrs

Nanomaterials: Preparative methods: Chemical methods, Hydrothermal, Solvothermal, Combustion synthesis, Co-precipitation, Langmuir Blodgett (L-B) method, Sputtering method, Inert Gas Condensation, Microemulsion, Laser ablation, sonchemical materials

Unit 2 Characterization Techniques for inorganic Nanomaterials 15 Hrs

Principle instrumentation and application X- Ray diffraction: Index reflections, Identifications of unit cell from systematic absences in diffraction pattern. Structure of simple lattices and X-Ray intensities. Structure factor and its relation to intensity and electron density, phase problems in XRD.

Principle instrumentation and application of and electron spectroscopy for chemical analysis (ESCA), transmission electron microscopy (TEM), Scanning electron microscopy (SEM)

Unit 3 Applications of Nanomaterials **15 Hrs**

a) Carbon nanomaterials

b) Nanocomposites include metal nanomaterials such as single particle as well as coreshell nanomaterials. Fuel cell, Solar cell, medicinal aplications, agro-food applications

c) Polymer Nanotechnology

d) Organic Electronics

e) Nanotribology

f) Nanobiotechnology

Unit 4 Nanotoxicity and Biosafety **15 Hrs**

Nanotoxicology

1. Introduction to Nanotoxicology

2. Nano etymology

3. Nanotoxicology challenges

4. Physico-chemical characteristic dependent toxicology

5. Epidemiological evidences

6. Mechanism of nanotoxicity

7. Assessment of nanomaterial toxicity: In vitro toxicity assessment-cell viability and in vivo toxicity assessment

Reference Books

1. The Chemistry of Nanomaterials edited by C.N.R.Rao, A.Muller, A.K.CheethamWileyVCHVerlag GmbH & co. Volumes 1&2.

2. Nanomaterials by Dr.Sulbha Kulkarni.

3. T. Pradeep, “A Textbook of Nanoscience and Nanotechnology”, Tata McGraw Hill Education Pvt. Ltd., 2012

4. Hari Singh Nalwa, “Nanostructured Materials and Nanotechnology”, Academic Press, 2008

5. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano

6. Nanomaterials and Nanochemistry, 2007, Catherine Brechignac, Philippe Houdy,MarcelLahmani, ISBN 978-3-540-72992-1 Springer Berlin Heidelberg New York.

7. Nanomaterials Chemistry, Recent Developments and New Directions C.N.R. Rao,A. Muller, and A.K. Cheetham, ISBN 978-3-527-31664-9, 2007 WILEY-VCH Verlag GmbH and Co. KGaA, Weinheim.

8. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, MarcelDekker Inc. New York.

9. Principles of Instrumentals Analysis: D.Skoog& West

Practicals

Semester III

1) Ore Analysis- Bauxite and Eleminite
2) Alloy Analysis – Bronze and Stainless Steel
3) Preparation of, Acetyl Ferrocene, Silver Nanomaterials, CuO, NiO, ZnO
4) Cement Analysis
5) Estimation of Mg /Fe/ Ca / Zn
6) Ion –Exchange Chromatography
7) Photochemistry of Ferric Oxalate
8) Nephelometry – Sulphate ion Concentration
9) Turbidometry
10) Soil Analysis
11) Synthesis of Choloropentamine Cobaltic (III) Chloride

Semester IV

1) Conductometry – Ibuprofen Analysis, Strength of HCl and CH_3COOH
2) PH metry- Dissociation constant of EDTA and Orthophosphoric Acid
3) Spectrophotometry- Electronic Spectrum and molar Extinction Coefficient of $KMnO_4$ and $K_2Cr_2O_7$
4) To determine the stability constant of ferric Ammonium Sulphate (Job Continues and Variation method)
5) Nephelometry – Sulphate content in water
6) Synthesis of Nickel, Zinc Ferrite, tris-thiourea Copper (I), Copper Sulphate
7) Dicholro bis ethylene diamine Co-Chloride
8) Photo degradation of $KMnO_4$by UV-Lamp