Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara

(Autonomous)

Department of Chemistry

M.Sc. II Inorganic Chemistry: Programme Structure

Course Code	Title of Course	Credits	Teaching Scheme (h/w)		Evaluation Scheme (Marks)			
			L	P	ISE-I	ISE-II	ESE	Total
M.Sc.-II Semester-III								
MCT-I-301	Inorganic Chemical Spectroscopy	4	4	-	10	10	80	100
MCT-I-302	Coordination chemistry – I	4	4	-	10	10	80	100
MCT-I-303	Nuclear chemistry	4	4	-	10	10	80	100
MCT-I-304	Organometallic chemistry	4	4	-	10	10	80	100
MCP-I-305	Chemistry Practical-V	4	-	12	-	-	85+15 (Pro)	100
MCP-I-306	Chemistry Practical-VI	4	-	12	-	-	85+15(Pro)	100
Total		**24**	**16**	**24**	**40**	**40**	**520**	**600**
M.Sc.-II Semester-IV								
MCT-I-401	Instrumental techniques	4	4	-	10	10	80	100
MCT-I-402	Coordination chemistry-II	4	4	-	10	10	80	100
MCT-I-403	Chemistry of inorganic materials	4	4	-	10	10	80	100
MCT-I-404	Environmental chemistry	4	4	-	10	10	80	100
MCP-I-405	Chemistry Practical-VII	4	-	12	-	-	85+15 (Pro)	100
MCP-I-406	Chemistry Practical-VIII	4	-	12	-	-	85+15(Pro)	100
Total		**24**	**16**	**24**	**40**	**40**	**520**	**600**

M.Sc.-II

STRUCTURE OF COURSE:

1. THIRDSEMESTER

Semester III										
Paper	ESE	Internal Exam		Practical					Total	Grand Total
		ISE- I	ISE-II		Exam	Journal	Project Part-II	Day to day perform-ance		
MCT-I-301	80	10	10	MCP-305-V	70	10	15	5	100	
MCT-I-302	80	10	10							
MCT-I-303	80	10	10	MCP - 306-VI	70	10	15	5	100	
MCT-I-304	80	10	10							
Total	**320**	**40**	**40**		**140**	**20**	**30**	**10**	**200**	**600**

2. FOURTH SEMESTER

Semester IV										
Paper	ESE	Internal Exam		Practical					Total	Grand Total
		ISE- I	ISE-II		Exam	Journal	Project Part-II	Day to day perform-ance		
MCT-I-401	80	10	10	MCP-405-V	70	10	15	5	100	
MCT-I-402	80	10	10							
MCT-I-403	80	10	10	MCP - 406-VI	70	10	15	5	100	
MCT-I-404	80	10	10							
Total	**320**	**40**	**40**		**140**	**20**	**30**	**10**	**200**	**600**

Structure and Title of Papers of M. Sc. Course:

- **M. Sc. II Semester III**

  Paper IX: Inorganic Chemical Spectroscopy

  Paper X: Coordination chemistry – I

  Paper XI: Nuclear chemistry

  Paper XII: Elective

  Organometallic chemistry

  Selected topics in inorganic Chemistry

- **M. Sc. II Semester IV**

  PaperXIII: Instrumental techniques

  Paper XIV: Coordination chemistry-II

  Paper XV: Chemistry of inorganicMaterials

  Paper XVI: Elective

  Environmental chemistry

  Energy and environmental Chemistry

Course Code	Elective -I	Course Code	Elective –II
MCT-I-304-A	Selected topics in inorganic Chemistry	MCT-I-404-A	Energy and environmental Chemistry

Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara(Autonomous)

Department of Chemistry

Syllabus of M. Sc. Part II

Inorganic Chemistry

To be implemented from June- 2020

GENERAL OBJECTIVES OF THE COURSE:

1. To educate and prepare post graduate students from rural and urban area who will get employment on large scale in academic institutes, R & D and Quality control laboratories of Indian chemical/pharmaceutical industries as well as multinational and forensic Laboratories.
2. To provide students with broad theoretical and applied background in all specialization of Chemistry with emphasis on qualitative and quantitative technique.
3. To provide broad common frame work of syllabus to expose our young graduates to the recent and applied knowledge of interdisciplinary branches of chemistry involving applied organic, inorganic, physical, analytical, industrial, pharmaceutical, polymer, nano science & technology.
4. To conduct lesser written tests and to encourage on non-written tests.
5. To focus on encouraging students to conduct various academic activities like midterm tests, online tests, open book tests, tutorial, surprise test, oral, seminar, assignments and seminar presentation.

Learning Objectives:

1. A graduate with a Master's degree in Chemistry has in-depth and detailed functional knowledge of the fundamental theoretical concepts and experimental methods of chemistry.
2. The graduate has expert knowledge of a well-defined area of research within chemistry. The graduate has specific skills in planning and conducting advanced chemical experiments and applying structural-chemical characterization techniques. Skilled in examining specific phenomena theoretically and/or experimentally, the graduate is able to contribute to the generation of new scientific insights or to the innovation of new applications of chemical research.

STRUCTURE OF COURSE: SEMESTER

Semester	Paper code	Paper title	Total No. of lectures / practicals	Credits
SEM I	**Theory Course**			
	MCT-I-301	Inorganic Chemical Spectroscopy	60 hrs	4
	MCT-I-302	Coordination chemistry – I	60 hrs	4
	MCT-I-303	Nuclear chemistry	60 hrs	4
	Elective paper			
	MCT-I-304	Organometallic chemistry	60 hrs	4
	MCT-I-304	Selected topics in inorganic Chemistry	60 hrs	4
	Practical Course			
	MCP-I-305	Chemistry Practical-V		4
	MCP-I-306	Chemistry Practical-VI		4
SEM II	**Theory Course**			
	MCT-I-401	Instrumental techniques	60 hrs	4
	MCT-I-402	Coordination chemistry-II	60 hrs	4
	MCT-I-403	Chemistry of inorganic Materials	60 hrs	4
	Elective paper			
	MCT-I-404	Environmental chemistry	60 hrs	4
	MCT-I-404	Energy and environmental Chemistry	60 hrs	4
	Practical Course			
	MCP-I-405	Chemistry Practical-VII		4
	MCP-I-406	Chemistry Practical-VIII OR Internship, Industrial Training		4
			Total Credits	**48**

- The semester examination will be conducted at the end of each term (both theory and practical examination)
- Theory paper will be of 80 marks each and 20 marks for internal evaluation test conducted in the mid of the term. Two practicals will be of 100 marks each.
- Question papers will be set in the view of the entire syllabus and preferably

covering each unit of the syllabus.

Laboratory Safety Equipment's:

Part: I Personal Precautions:

1. All persons must wear safety Goggles at all times.
2. Must wear Lab Aprons/Lab Jacket and proper shoes.
3. Except in emergency, over – hurried activities is forbidden.
4. Fume cupboard must be used whenever necessary.
5. Eating, Drinking and Smoking in the laboratories strictly forbidden.

Part: II: Use of Safety and Emergency equipment:

1. First aid Kits
2. Sand bucket
3. Fire extinguishers (dry chemical and carbon dioxide extinguishers)
4. Chemical Storage cabinet with proper ventilation
5. Material Safety Datasheets.
6. Management of Local exhaust systems and fume hoods.
7. Sign in register if using instruments

M. Sc. Part – II (Semester – III)

MCT-I-301: Inorganic Chemical Spectroscopy

Learning Objectives: Students should

1. Learn instrumentation and applications of X-ray diffraction and neutron diffraction.
2. Study Electronic absorption Spectroscopy and adsorption spectra.
3. Learn basic concepts of IR, Raman and X- ray Fluorescence spectroscopy.
4. Learn instrumentation and applications of NMR and X-ray Photo electron Spectroscopy.

UNIT-I: X-ray diffraction and neutron diffraction

A) X-ray powder diffraction (07)

X-ray source, Diffraction of X-rays-ray powder diffraction, Instrumentation and use of standards, identification of compounds using powder diffraction. The importance of intensities, Absences due to lattice centering, Determination of unknown cubic structure by $\sin 2\theta$, parameter to be determined from XRD.

B) Single crystal X- ray diffraction: (05)

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

C) Introduction to neutron diffraction, theory, Instrumentation and application. **(03)**

UNIT-II: Electronic absorption Spectroscopy (15)

Term symbols, energies of atomic and Molecular transitions, Selection rule, and Morse potential energy diagram, electronic transitions, polarized absorption spectra. Nature of absorption spectra, nature of absorption spectra of transition metal complexes, Orgel diagram, Tanabe Sugano diagram, and charge transfer spectra.

UNIT-III: A] Infrared and Raman Spectroscopy (10)

Molecular vibrations, force constants, Molecular vibrations and absorption of Infrared Radiations Raman Spectroscopy, polarized Raman lines, Use of symmetry considerations to determine the no. of lines in IR and Raman Spectra, Spectra of gases, applications of Raman and Infrared spectroscopy. Selection rule in Inorganic structure determinations, Hydrogen bonding and infrared spectra, metal ligand and related vibrations.

B] X-ray Fluorescence spectroscopy (XRF) (5)

Introduction and basic theory, instrumentation, spectral analysis and applications.

UNIT-IV: A] Nuclear Magnetic Resonance Spectroscopy (NMR) (9)

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) (6)

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

Learning Outcomes: After completion of units students are able to

1. Understand instrumentation and applications of X-ray diffraction and neutron diffraction.
2. Understand basic concepts of Electronic absorption Spectroscopy and adsorption spectra.
3. Understand the basic theory and instrumentation of IR, Raman and X- ray Fluorescence spectroscopy.
4. Understand instrumentation and applications of NMR and X-ray Photo electron Spectroscopy.

Recommended 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.

MCT-I-302, Coordination chemistry – I

Learning Objectives: Students should

1. Learn broad theoretical and applied background of Inorganic crystal field theory.
2. Study principles of Molecular orbital Theory.
3. Study basic idea about structural studies of coordination compound.
4. Learn magnetic properties of transition metal complexes
5. Learn catalytic properties of transition metal complexes.

Unit I: Metal-ligand bonding [15]

Crystal Field Theory: Splitting of d-orbital in tetragonal, square planar, square pyramidal, octahedral, tetrahedral and trigonal bipyramid complexes. CFSE-factors affecting the magnitude of 10 Dq-evidence for crystal field stabilization, tetragonal distortion from octahedral symmetry, John teller effect, nephelauxetic effect. CFSE and their uses, factors affecting CFSE, Limitations of crystal field theory.

Molecular Orbital Theory: Molecular orbital diagram for octahedral, tetrahedral and square planar complexes with and without π-bonding.

Unit II: Structural studies of coordination compounds [15]

Compounds of first transition series elements with respect to their electronic spectra, magnetic & thermal properties (DTA, TGA)

Unit III: Magnetic properties of Transition metal complexes [15]

Types of magnetic behavior, 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) Transition metal complexes and catalysis [5]

Introduction, General Principle, Transition metal ion catalysts for organic transformations and their applications in various reactions, Current and feature trend in catalysis.

B) Transition metal complexes and catalysis [10]

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, Decarboxylation of β- keto acids

Learning outcomes:

1) Students will understand the bonding between metal and ligand.
2) They will understand nature of bonding on basis of CFT and MOT
3) They will understand different structural studies of coordination compounds like TGA and DTA.
4) They will know the magnetic properties of metal complexes.
5) They will know catalytic properties of metal complexes.

Reference books:

1) Jones: Elementary Coordination Chemistry. J. Wiley
2) Graddon: Introduction to Coordination Chemistry. J. Wiley
3) Drago: Physical methods of Inorganic Chemistry. J. Wiley.
4) Graddon: Introduction to coordination Chemistry, Parasmom
5) Lewis and Wilkins: Coordination Chemistry. J. Wiley
6) Msrtel: Coordination Chemistry Vol I, II VNR
7) Earnshaw: Introduction to Magneto Chemistry
8) Mabbs & Machin Magnetism & transition metal complexes Chamman hall
9) Calvin, Magnetic properties of transition metal complexes.
10) L.N. Maley: Magneto Chemistry
11) Datta & Shymlal: Elements of Magneto Chemistry
12) Martel & Taqui Khan: homogeneous catalysis with metal complexes Vol.I & II AP.
13) James E. Huheey: Inorganic Chemistry Principles of Structure and reactivity, Harber and Row, Publishers Inc. New York 1972.
14) A.K. Das and M.Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers.
15) F.A. Cotton & R.G. Wilkinson: Advanced Inorganic Chemistry

MCT-I-303, Nuclear chemistry

Learning Objectives:

1. To improve students view for broad theoretical and applied background of Nuclear Chemistry.
2. To provide knowledge of basic principles of Nuclear Chemistry.
3. To give idea about Nuclear structure and stability.
4. To give idea to the students about Reactor Theory.
5. To improve students view for study of inner transition elements and nuclear chemistry.

Unit I: Systematics of alpha, beta and gamma decays [15]

Alpha decay, energy curve, spectra of alpha particles, Giger-Nuttal law, theory of alpha

decay, penetration of potential barrier, beta decay, range of energy relationship, beta spectrum, sergeants curve, Fermi theory of beta decay, matrix elements, allowed and forbidden transitions, curie plots, gamma decay, Nuclear energy levels, selection rule, isomeric transitions, Internal conversion, Auger effect

Unit II: Nuclear Structure and Stability [15]

Binding energy, empirical mass equation, The nuclear models, the liquid drop model, Single particle shell model, Fermi gas model & collective/lunified nuclear model, nuclear spin, parity & magnetic moments of odd mass number nuclei and numerical.

Unit III: Nuclear reactions and Nuclear fission [15]

Introduction, Production of projectiles, nuclear cross section, nuclear dynamics, threshold energy of nuclear reaction, Coulomb scattering, potential barrier, potential well, formation of a compound nucleus, Nuclear reactions, direct Nuclear reactions, and heavy ion induced nuclear reactions, photonuclear reactions.

Liquid drop model of fission, fission barrier and threshold, fission cross section, mass energy and charge distribution of fission products, symmetric and a symmetric fission, decay chains and delayed neutrons

Unit IV: Reactor Theory and Applications of Radioactivity [15]

Nuclear fission as a source of energy, Nuclear chain reacting systems, critical size of a reaction, research reactors, graphite moderated, heterogeneous, enriched uranium reactors, light water moderated, heterogeneous, enriched uranium reactors, water boilers enriched aq. Homogeneous reactors, Thermonuclear reactors, gamma interactions, shielding and health protection. Reactors in India.

Tracer technique in the field of analytical chemistry structure determination elucidation of reaction mechanism, isotopic dilution analysis, neutron activation analysis applications in biological, medical, industrial fields, Age determination.

Learning outcomes:

1) Student will understand process and effects of decay of radioactive elements.
2) Student will understand different nuclear structures and stability of radioactive elements
3) Student will know nuclear reactions and their process.
4) Student will know detailed process of nuclear fission.
5) Student will know the reactor theory and different applications of radioactivity.

Reference books:

1. Friedlander, Kennedy and Miller, Nuclear and Radio Chemistry: John Wiley
2. B. G. Harvey, Nuclear Chemistry
3. Hassinsky: Translated by D. G. Tuck, Nuclear Chemistry and its application: Addison Wiley

4. B.G. Harvey, Introduction to Nuclear Physics and Chemistry
5. Maeclefort: Nuclear Chemistry: D. Van Nostrand
6. An N. Nesmeyannoy: Radiochemistry: Mir
7. Jacobs et al: Basic Principles of nuclear Science and Reactors, V. Nost & EWAP
8. N. Jay: Nuclear Power Today Tomorrow: ELBS
9. Kenneth: Nuclear Power Today, Tomorrow: ELBS
10. Essentials of Nuclear Chemistry, W. J. Arnikar, John Wiley
11. Nuclear and Radiation Chemistry: B. K. Sharma, Krishna Publication
12. A Introduction to Nuclear Physics: R. Babber. And Puri.
13. A.K. Das and M.Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers.

Elective Paper

MCT-I-304, Organometallic chemistry

Learning Objectives:

1. To improve students view for broad theoretical and applied background of Organometallic Chemistry.
2. To provide knowledge of basic principles of Organometallic Chemistry.
3. To give idea about pi and sigma bonding for organometallic compound.
4. To give idea to the students about organometallic compound.
5. To provide basic knowledge of Organometallic practices.
6. To provide knowledge of inorganic oxygen Organometallic compound.

Unit I: Transition metal- Carbon bond [15]

Brief review of Stability of transition metal alkyls, classification of σ-bonded hydrocarbyls, preparation, structure and bonding, General characteristics of metal alkyl and aryls, organocopper compounds, Transition metal carbene complexes, Transition metal alkylidene complexes

Unit II: Transition Metal Pi-complexes [15]

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 & trienyl complexes. Application of transition metal, organometallic intermediates in oraganic synthesis relating to nucleophilic & electrophilic attack on ligands, role in organic synthesis.

Unit III: Metal Complexes in medicine [15]

Medicinal use of metal complexes as antibacterial, anticancer, use of cis-platin as antitumor drug, antibiotics & related compounds. Metal used for dignosis 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]

Heme proteins & oxygen uptake, structure and functions of haemoglobin, myoglobin, hemocyanins & hemerythrin. Oxygenation and deoxygenation. Oxygen adsorption isotherm and cooperativity, physiological significance of haemoglobin, role of globin chain in gaemoglobin, Cyanide poisoning and treatment.

Learning outcomes:

1) Student will understand nature, stability of metal and carbon bond in organometallic compounds.
2) Student will understand Pi bond and its effect on organometallic compound.
3) Student will know different applications of organometallic compounds in medicines.
4) Student will know process of oxygen transport and storage.

Reference books:

1. Yamamoto, Organo Transition Metal Chemistry, Wiley (1986).
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals (4th edn.), John Wiley (2005).
3. A. J. Pearson. Metallo-Organic Chemistry, John Wiley & Sons (1985).
4. M. Bochmann. Organometallics-I Complexes with Transition Metal-Carbon σ-Bonds, Oxford Chemistry Primers (1994).
5. Principles of Biochemistry, A. L. Lehinger, Worth Publications.
6. Biochemistry, L. Stryer, W. H. Freeman
7. Biochemistry, J. David Rawn, Neil Patterson.
8. Biochemistry, Voet and Voet, John Wiley.
9. Outlines of Biochemistry, E. E. Conn and P. K. Stumpt, John Wiley.
10. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford Univ. Press, 1990.
11. J. E. Huheey, E. A. Keiter and R.L. Keiter Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2004.
12. F. A. Carey G. Wilkinson, C. A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, Wiley Interscience, 2003
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.
15. A.K. Das and M.Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers.

MCT-I-304, Selected topics in Inorganic Chemistry

Learning Objectives:

1. To provide knowledge of basic principles of Inorganic Catalysis Chemistry.
2. To give idea about inorganic polymers and bonding for main group elements.
3. To give idea to the students about supramolecular chemistry.
4. To provide basic knowledge of Inorganic Catalysis practices.
5. To provide knowledge of inorganic catalysis and polymers.

Unit I: Catalysis [15]

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 II: Inorganic Polymers [15]

Classification, types of Inorganic polymers, Chemistry of following polymers a)Silicones b) phosphonitric halides c) condensed phosphates d) coordinated polymerse)silicates f) Isopoly & heteropoly acids g) Geopolymers as alternative cement materials.

Unit III: Energy Sources and their harvesting technologies [15]

a) Solar Energy
b) Geothermal energy
c) Energy from biogas sources, biodiesel,
d) Tidal wind sources
e) Energy from fission and fusion reaction.

Unit IV: Supramolecular Chemistry [15]

Concepts and principles, Host-Guest Chemistry, Non-covalent bonds, crown ethers, cryptands and their metal complexes, Molecular recognition for different types of molecules, spherical recognition, Tetrahedral recognition, cooperativity and multivalency, Design and synthesis of co-receptor molecules and multiple recognition, supramolecular reactivity and catalysis, supramolecular devices, supramolecular photochemistry.

Learning outcomes:

1) Student will understand catalysis and catalytic reactions.
2) Student will understand different types of inorganic polymers.
3) Student should understand Energy Sources and their harvesting technologies.
4) Student should understand basic concept of supramolecular chemistry.

Reference books:

1. Heterogeneous catalysis 2nd edn. Bond C. Chapman all (1987).
2. The application & Chemistry of catalysis by suitable transition metal complexes Parashall. W. Weily N. 1980.
3. Homogeneous transition metal catalysis, A general art, Masters C. Chapman and Hall, London 1981.
4. Introduction to the principles of heterogeneous catalysis, Thomas J.M., Thomas W.J. Academic press N.Y. 1967
5. Inorganic polymers: Mark J.F., Allock H.R. West, Prentice hall
6. Inorganic polymers: Ring N.H., Academic Press N.Y. 1978
7. The Inorganic heterocyclic chemistry of sulphur, nitrogen, phosphorous, Heal A.G. Acta, Press N.Y. 1980.
8. Solar energy Principles of thermal collections and storage, Sukhatme S.P., Tata Macgrow Hill New Delhi 1984.
9. Fuel Cells, Bockeris JOM, Sriniwasan S. and Mac grow Hills 1969
10. Solar Energy Rai C.D.
11. Energy Resources, Simon A.L. 1975
12. Direct Energy Conversion, Addison Wesley, 1970, All M and Kottani S.
13. Outlines in Chemical Technology Vol I, S.D. Sukla & Pandey G.N.M.

Practical Course

Inorganic Chemistry Practical-V & VI
MCP-I-305 and MCP-306

Learning objective: Students should

1) Learn ore , alloy analysis
2) Study preparation of coordination complexes.
3) Learn instrumentation techniques.
4) study magnetic and thermal properties of transition metal complexes.

A: Non-instrumentation Practicals

1. Ore Analysis - 2
2. Alloy Analysis - 2
3. Preparation of coordination complexes
4. Ion exchange study of separation of mixtures & estimations
5. Soil analysis
6. Synthesis and Characterization of metal nanoparticles

B: Instrumentation Practicals

1. Spectrophotometry
2. Potentiometry
3. Conductometry
4. pH Metry

5. Thermal analysis
6. Magnetic properties of transition metal complexes
7. Spectro Fluorimetry
8. Nephelometry
9. Polarography
10. Electrogravimetry

(Any other experiments may be added when required)

Learning outcomes: After completion of experiments students are able to

1) Understand ore, alloy analysis
2) Understand preparation of coordination complexes.
3) Learn instrumentation techniques.
4) Understand magnetic and thermal properties of transition metal complexes.

Reference books:

1. A.I.Vogel, "A Textbook of Quantitative Inorganic Anaysis", Longman
2. Gurudeep Raj, Advanced Practical Inorganic Chemistry, Krishna Prakashan.
3. W.G.Palmer, "Experimental Inorganic Chemistry", Cambridge University Press
4. Shikha Gulathi, J. L. Sharma and Shagun Manocha, Practical Inorganic Chemistry, CBS publisher and Distributors.
5. J. B. Yadav, Advanced Practical Physical Chemistry, Krishna Publishers.
6. I.M.Kolthoff, V.J.Elving and Sandell, "Treatise on Analytical Chemistry", Interscience.
7. I.M.Kothoff and Strenger, "Volumetric Analysis", Interscience
8. Fruman and Welcher, "Standard Methods of Inorganic Analysis", Van Nostrand
9. G.Schwarzenback, "Complexomtric Titrations", Interscience
10. D.A.Skoog and D.M.West, "Analytical Chemistry – An Introduction", Reinholdt.
11. R.S.Drago, "Physical Methods in Inorganic Chemistry", Affiliated East-West Press
12. Instrumental Methods for Chemical Analysis-H. Kaur
13. Spectroscopy- B. K. Sharma
14. Instrumental Methods of Analysis-Willard, Merritt, Dean, Settle
15. Nanotechnology: Principles and Practices- Sulbha Kulkarni
16. Principles of Inorganic Chemistry-Puri, Sharma, Kalia
17. Concise Coordination Chemistry-R. Gopalan, V. Ramalingam
18. Elements of Magnetochemistry-Datta and Shymal
19. G.Zhong Cao. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press (2004).
20. T. Pradeep, Nano The Essentials: Understanding Nanoscience and Nanotechnology.

M. Sc. Part – II (Semester –IV)

MCT-I-401, Instrumental techniques

Learning Objectives: students should

1. To provide knowledge of basic principles of thermal analysis.
2. Study the instrumentation and applications of Mossbauer and NQR spectroscopy.
3. Study instrumentation of Electron Spin Resonance Spectroscopy
4. Learn Advanced Instrumental Tools for Analysis of Inorganic materials.

Unit I: Thermal analysis [15]

a) Thermogravimetriy [TGA]: Defination, Types of TGA, Instrumentation, Information of TGA curve, factor affecting TGA curves (Instrumental as well as characteristic of sample factors); Applications of thermogravimetry, calculation of percent decomposition and composition of compounds; Limitations and Advantages of TGA

b) Differential thermal analysis (DTA): Definitions, Theoretical Basis of DTA, Instrumentation of DTA apparatus, Factors affecting the DTA curve; Application of DTA; Advantages and disadvantages of DTA.

c) Differential Scanning Calorimetry [DSC]; Defination; Comparison of DTA and DSC techniques; Instrumentation of DSC, Factors affecting to DSC curves.

d) Thermometric titrations: Theory, Instrumentation and applications.

e) Thermomechanical analysis: Theory, Instrumentation and applications

Unit II: Mossbauer and NQR Spectroscopy [15]

a) Mossbauer Spectroscopy: Principle of Mossbauer spectroscopy, Recoiless absorption and emission of gamma-rays (Mossbauer effect), Doppler shift, Instrumentation, Isomer shift and its factors affecting, Quadruple splitting with illustrations, Zeeman Splitting (Six fingered MB lines), Applications, Numericals.

b) NQR Spectroscopy: Quadruple nuclei, Electric field gradient, Theory of NQR, NQR splitting diagram, Zeeman effect in NQR, Applications.

Unit III: Electron Spin Resonance Spectroscopy [15]

Principle of ESR Spectroscopy, Presentation of spectrum, Hyperfine splitting in some proton systems, Rules for evaluating ESR lines (Naphthalene anion radical, Pyrazine anion radical, Isomers of Xylene anion radicals, VO2+, Quinoline radical, Isoquinoline radical, Quinoxaline radical, Anthracene radical, Phenanthracne radical, Pyrene radical, Alkyl halide radicals, Quinone & Isoquinone anion radicals, nitrogen/deuterium containing radicals), Superhyperfine splitting, Instrumentation, 'g' value and its factors affecting, Zero field splitting, Karmers's degeneracy, Applications, Numericals.

Unit IV: Advanced Instrumental Tools for Analysis of Inorganic materials [15]

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)

Learning outcomes:

1) Student will understand different thermal analysis techniques for characterization of solid samples.
2) Student will understand basics of Mossbauer spectroscopy and Nuclear quadrupole resonance.
3) Student will know Electron Spin Resonance Spectroscopy.
4) Student will know different advanced instrumental tools for analysis of inorganic materials.

Reference books:

1. Powder Diffraction Theory and Practice, Edited by R E Dinnebier and S J L Billinge, RSC publishing, 2008.
2. 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.
3. Catalysis, Principles and Applications, Editors: B. Viswanathan, S. Sivasanker, A.V. Ramswamy, Narosa Publishing House
4. VESTA 3 for three-dimensional visualization of crystal, volumetric and morphology data, K. Momma and F. Izumi (2011), J. Appl. Crystallogr., 44, 1272-1276.
5. VESTA: a Three-Dimensional Visualization System for Electronic and Structural Analysis, (www.xray.cz/kryst/Vesta_manual.pdf)
6. Elements of X-ray Diffraction, B.D. Cullity, Second Edition, Addison Wesley, 1978.
7. "Fundamentals of Powder Diffraction and Structural Characterization of Materials. 2nd Edition" by V.Pecharsky & P.Zavalij. Springer 2009
8. Fundamentals of Molecular Spectroscopy, C.N. Banwell, E.M. McCash, McGraw Hill Publishers, 5th Edition
9. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR, D.N. Sathyanarayana, I K International Publishing House Pvt. Ltd; 2nd Revised edition edition (30 November 2013)
10. Physical Methods for Chemists, Russel Drago, Surfside Scientific Publishers, 1992
11. Mossbauer Spectroscopy, N.N. Greenwood & T.C. Gibb, Springer 2012.
12. Mossbauer Effects and its Applications, V.G. Bhide, TATA McGraw Hill Publishing Company, 1973.
13. Elements of MagnetoChemistry, R.L. Dutta, Rabindra Lal Dutta and Arun Syamal, Affiliated East-West Press, 1993

MCT-I-402, Coordination chemistry-II

Learning Objectives:

1. To improve students view for broad theoretical and applied background of Coordination Chemistry.
2. To provide knowledge of basic principles of Inorganic reactions.
3. To give idea about stereochemistry and bonding for coordinate compound.
4. To give idea about chemistry of photochemistry and co-ordinate compound.
5. To provide knowledge of applications of coordinated compound.

Unit I: Reaction Mechanism of Transition Metal complexes [15]

Classification of Inorganic reactions, Energy profile of reaction with terminology, Inert and labile complexes, VBT as well as CFT approaches for lability of complexes, Nucleophilic substitution reactions in octahedral complexes with their mechanism (associative and dissociative mechanism) and types of intermediates involved acid hydrolysis, Acid hydrolysis and factors affecting acid hydrolysis, Base hydrolysis and its conjugate base mechanism, Direct & indirect evidences in favour of conjugate mechanism, Anation reaction.

Unit II: Substitution Reactions of Complexes [15]

Substitution reaction, reactions of Transition Metal complexes, kinetics and mechanism of substitution reactions of octahedral complexes, acid hydrolysis, base hydrolysis, kinetics and mechanism of substitution reaction.

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.

Unit III: Photochemistry [15]

Absorption, excitation, photochemical laws, quantum yield, Electronically excited states of Metal complexes, type of photochemical reactions, substitutions reactions, rearrangement reactions, redox reaction, Photochemistry of Coordination compounds, charge transfer spectra, charge transfer excitations, methods for obtaining charge transfer spectra.

Unit IV: Applications of Coordination Compounds [15]

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.

Learning outcomes:

1) Student will understand different reaction mechanisms of transition metal complexes.
2) Student will understand different substitution reactions and their mechanisms.
3) Student will know different interactions of light with metal complexes.
4) Student will know various applications of coordination compounds.

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. K. K. Rastogi and Mukharjee, Fundamentals of photochemistry, Wiley eastern.
10. J. G. Calverts and J. N. Pits, Photochemicals of Photochemistry, John Wiley.
11. Wells, Introduction to Photochemistry.
12. K. M. Macky, R. A. Macky, Modern Inorganic Chemistry, 4th edn., Blackie, London-1989.
13. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vallabh Publications, Delhi,2005.

MCT-I-403, Chemistry of Inorganic Materials

Learning Objectives:

1. To improve students view for broad theoretical and applied background of Material Chemistry.
2. To provide knowledge of basic principles of Material Chemistry.
3. To give idea to the students about semiconducting nanomaterials and nanotechnology.
4. To provide basic knowledge of Material Chemistry practices.
5. Students should know the different practical techniques.

Unit I: Solid State Materials [15]

A) Classification in crystals, Crystal systems and Bravais Lattice, Lattice planes and their designation. Metallic Crystal structures:Face-centered cubic (fcc), body-centered cubic

(bcc), hexagonal close-packed (hcp) structure.Radius ratio rule (2, 3,4,6,8 co–ordinate structures), octahedral and tetrahedral voids. Isomorphism and polymorphism, Numericals.

B) Structures of the followings:

AB type: NaCl, CsCl, Zincsulphide (sphalerite or cubic and hexagonal), AB2 type: Fluorite (CaF2), TiO2(Rutile), CdCl2, CdI2 structures, AB3 type: ReO3, BiI3, A2B3 type: Corundum Al2O3, α-Fe2O3 ,Mn2O3., ABO3type: Perovskite Structures (Barium titanate, lead titanate, CaTiO3, FeTiO3), AB2O4 type- Spinel structure, Normal & Inverse,Factors causing distortion in spinel, A2B2O7 type: Pyrochlores (La2Sn2O7).

Unit II: Solid electrolytes [15]

Typical ionic Crystals: Alkali metal halides (vacancy conduction), Silver chloride (interstitial conduction); Solid Electrolytes – -alumina, silver iodide, halide and oxide ion conductors; Applications of Solid Electrolytes. Fuel cells: electrochemical power generator (hydrogen-oxygen cell), Solid state Galvanic cell; Thermoelectric Effects: Seebeck effects; Hall effect.

Unit III: Synthesis and Characterization of Nanomaterials [15]

Introduction to Nanomaterials, Nanoscience and nanotechnology, History, Classifications

Chemical Methods: Metal nanoparticles: Reduction method, Semiconducting or composite nanomaterials: Hydrothermal and Solvothermal method, Sol-gel,Arrested Precipitation, and other methods include), Micelles-Microemulsions.

Characterization Tools: Electron Microscopy (TEM & SEM), Probe Microscopy (STM & AFM), Diffraction Technique (XRD), UV-Visible-NIR spectroscopy, BET.

Unit IV: Properties and Applications of Nanomaterials [15]

Properties of Nanomaterials: Optical, Magnetic, Electrical, Mechanical, Structural properties

Illustrative Nanomaterials: Carbon nanostructures (CNTs, Graphene and its derivatives, fullerenes, Metal oxides (TiO2 and ZnO)& its composites, Quantum dots, Porous materials, Zeolites.

Applications in the various fields: Electronic devices, Energy generation and storage, Automobiles, Sports and toys, Textile Industries, Cosmetics Products, Domestic appliances, Sensors, Biotechnology and medical field, Space and Defense, Catalysis, Environment.

Learning outcomes:

1) Students will understand different solid state materials and their different crystal systems.
2) Students will understand different solid electrolytes used for different applications.
3) Students will know chemical cells and thermoelectric effect
4) Students will know different synthesis and characterization techniques of

nanomaterials.

5) Students will know different properties as well as applications of nanomaterials

Reference books:

1. A.K. Das and M. Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers.
2. S.K. Kulkarni, Nanotechnology: Principles and Practices, 3rd Edition, Capital Pubishing Company, 2014.
3. T. Pradeep, Nano: The Essentials, McGraw Hill Education, 2007.
4. Solid State Chemistry: A.H. Hanny
5. C.N.R. Rao, Solid State Chemistry : Dekker
6. Wilcox : Preparation and Properties of Solid State Materials: Vol I & II, Dekker
7. Hagenmuller, Preparative Methods in Solis State Chemistry
8. Lohn Wulff, The Structure and Properties of Materials Vol. IV, Electronic Properties (Wily Eastern).
9. N.N. Greenwood: Ionic Crystals, Lattice Defects and Nonstiochiometry (Butterworth's)
10. L.V. Azoroof and J.J. Brophy: Electronic Processes in Materials, McGraw Hills.
11. T.J. Rey et al : The Defect Solid State (Interscience)
12. E.A. Kroger, Chemistry of Imprefect Crystals (Holland).
13. A.R. West, Solid State Chemistry.
14. H.V.K Keer, Principles of the Solid State Chemistry, Wiley Eastern..
15. S.O. Pillai Academic press: Solid State Physics
16. C.P. Poole C P and F.J. Owens, Introduction to Nanotechnology, Wiley Publisher.
17. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific Publisher.
18. S. Reich and J. Maultzsch, Carbon Nanotubes – Basic Concepts and Physical Properties, Wiley-VCH Publisher.
19. K.K. Chattopadhyay, Introduction to Nanoscience and Nanotechnology, PHH Publisher.
20. Gabor L Hornyak and H F Tibbals, Introduction to Nanoscience and Nanotechnology, Wiley Publisher.

Elective Paper

MCT-I-404, Environmental chemistry

Learning Objectives:

1. To improve students view for broad theoretical and applied background of environmental Chemistry.
2. To provide knowledge of basic principles of environment pollution.
3. To give idea about water pollution and air pollution.
4. To give idea to the students about control of air and water pollutants.
5. To improve students view for study of monitoring Sampling and analysis of air and water pollutants.
6. To provide knowledge of Environmental Chemistry.

Unit I: Air pollution and water pollution [15]

Air pollution – types and sources; Atmospheric chemistry, depletion of stratospheric ozone, industrial and transport-related air pollution; Global warming and its effects. Acid rain

Water pollution – types and sources, physical and chemical water pollutants, waste water treatment, criteria of water quality, mercury pollution and estimation of organomercurials.

Effect of Air pollutant and Water pollutant on living and nonliving things.

Unit II: Control of Air and water pollutants [15]

Method of control of air pollution, electrostatic precipitation wet & dries scrubber, filters, gravity and cyclonic separation, Adsorption, absorption and condensation of gaseous effluent.

Water and waste water treatment, aerobic and anaerobic, aeration of water, principle of coagulation, flocculation, softening, disinfection, demineralization and fluoridation.

Unit III: Electrochemical and spectral methods for pollutant analysis [15]

Polarography: Principle, instrumentation and applications, Cyclic Voltammetry, Anodic stripping voltammetry, Amperometry, Coulometry, and conductance methods; Potentiometry: Ion selective electrodes; Atomic absorption spectroscopy; Atomic fluorescence spectrometry; Turbidimetry and Nephelometry. GC & HPLC.

Unit IV: Monitoring, sampling and Analysis of Air and water pollutants [15]

Methods of monitoring and sampling of gaseous, liquid and solid pollutants, analysis of CO, CO2, NO2, SO2, H2S, analysis of toxic heavy metals, Cd, Cr, Hg, As, Pb, Speciation Separation and analysis of Co, Cu, Mg, Mn, Fe, Al, analysis of anions SO42-, PO43-, NO3-, NO2-. Pesticide, residue analysis soil pollution, Sources of pesticide residue in the Environment, pesticide degradation by natural forces, effect of pesticide residue on life, Analytical techniques for pesticide residue analysis.

Learning outcomes:

1) Student will understand different sources and reasons of air and water pollution.
2) Student will understand different control measures of air and water pollution.
3) Student will understand electrochemical and spectral method for analysis of different pollutants.

4) Student will know the process of monitoring, sampling and analysis of air and water pollution.

Reference books:

1. Environmental Pollution, A. K. De
2. Air Pollution, Wark & Werner
3. Environmental Pollution Control in Process Industries, S. P. Mahajan
4. Environmental Pollution, B. K. Sharma & H. Kaur
5. Introduction to Air Pollution, P. K. Trivedi
6. Environmental Pollution Analysis, S. M. Khopkar
7. A Text Book of Environmental Pollution: A. D. Tyagi, M. Mehre
8. Environmental Pollution Engineering and Control, C. S. Rao
9. Chemical in the Environment, Satake & M. Midu
10. Environmental Sciences, E. G. Engel
11. Fundamentals of Electroanalytical chemistry: John Willey & Sons (2001) P. M. S. Monk
12. Environmental Chemistry at a Glance: Blackwell publishing (2006), I. Pulford 4 H. Flowers
13. Instrumental Methods of Chemical Analysis, H. Kaur.

MCT-I-404, Energy and environmental Chemistry

Learning Objectives:

1. To provide knowledge of basic principles of energy and Environmental Chemistry.
2. To give idea about energy generation devices.
3. To give idea to the students about energy storage devices.
4. To provide basic knowledge of pollution and waste treatment.
5. To provide knowledge of analysis of pollutants.

Unit I: Energy Generation Devices [15]

Solar Cells: Solar energy, Solar devices, Efficiency of Solar energy conversion, Generations in Solar devices, Silicon-based solar devices, chalcogenide thin films-based devices, Sensitized solar devices (dye and QDs), Pervoskite solar devices, Mechanism of Solar energy generations, Characterization of solar devices.

Fuel Cells: Working of Fuel Cells, Types of fuel cells, Current capabilities/uses, Fuel cell stacks and systems, Hydrogen as a fuel,

Production of hydrogen: Electrolysis, Thermochemical Processes, Steam Reformer Processes, Water Gas Processes, Bosch Process, Biosynthesis and Photochemical Processes, Coal Gasification, Steam Iron Process, Partial Oxidation Processes. Storage, Transport, and Handling of Hydrogen

Unit II: Energy Storage Devices [15]

Batteries

Li-ion batteries: Principle of operation, Battery components and design, Electrode materials ($LiCoO_2$, $LiNiO_2$, $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$, $LiMn_2O_4$, $LiFePO_4$, graphitic carbon) their synthesis and characterization, Theoretical capacity, Energy density, power density, cycle life, Electrode and battery fabrication, Battery modules 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-battery, Magnesium battery, Aluminum battery, Silicon battery, Battery Recycling Technologies.

Unit III: Pollution and Waste Treatment [15]

a) Waste Management: Electronic waste recycling programs, E-waste – non-recycling impacts, Materials Used in Manufacturing Electrical and Electronic Products.

Solid Waste Management: Gas to Energy projects, Incandescent vs. compact florescent light bulbs, Value-added Material Recovery, Cost effective treatment of refractory organics, Treatment of waste Sand.

b) Air and Water Pollution control

Control of NOx SOx and particulate pollution, Sewage and industrial waste water treatment, water softening, municipal water purification.

Unit IV: Analysis of Pollutants [15]

a) Monitoring, sampling and Analysis of Air and water pollutants

Methods of monitoring and sampling of gaseous, liquid and solid pollutants, analysis of CO, CO_2, NO_2, SO_2, H_2S, analysis of toxic heavy metals, Cd, Cr, Hg, As, Pb, analysis of anions SO_{2-}, PO_{3-}, NO_-, estimation of COD, BOD.

b) Techniques in Environmental Analysis

ND-IR Spectroscopy, FTIR, AAS, ICP-AES, GC, GC-MS, HPLC, Anodic stripping voltammetry, with case studies.

Reference books:

1) Lithium ion Batteries: Basics and Applications, R. Korthauer, Springer
2) Lithium ion Batteries: Fundamentals and applications, Yuping Wu, CRC Press, Taylor & Francis group
3) Lithium ion batteries: Materials, Technology and new applications, K. Ozawa, Wiley
4) 30 Years of Lithium-Ion Batteries, Advanced Materials, M. Li et al., Vol 30, issue 33, 2018,1800561
5) Fuel Cell Fundamentals, R. O'Hayre, et al., John Wiley & Sons, 2016
6) George Techobanoglous et al,"Integrated Solid Waste Management" McGraw - Hill, 1993.
7) Environmental Chemistry, H. Kaur, Pragati Prakashan, 10th edition 2016.
8) Environmental Pollution, A. K. De

9) Environmental Pollution Analysis, S. M. Khopkar
10) Compendium of R&D Projects, Waste Management Technologies (WMT) Programme, Technology Development and Transfer Division, Department of Science and Technology, New-Delhi 2018-2019.
11) Environmental Waste Management, Ed. Ram Chandra, CRC Press 2015, 1st Edition
12) Electronic Waste Management, RSC Publishers, Editors: R E Hester, R M Harrison, 2009
13) Introduction to Semiconductor Materials and Devices, M.S. Tyagi, Wiley Publisher.
14) Principles of Solar Cells, LEDs and Diodes, Kitai Adrian, Wiley Publisher.

Practical Course

Inorganic Chemistry Practical-VII & VIII
MCP-I-405 and MCP-I-406

Learning objective: Students should

1) Learn ore analysis
2) Learn different instrumentation techniques.
3) study X- ray diffraction analysis
4) Learn interpretation of IR spectrum.

A) Practicals

1. Ore Analysis -3
2. Preparation of coordination compounds and preparations of mixed metal oxides.
3. Ion Exchange chromatography; separation of multicomponent mixtures
4. Solvent extraction
5. Spectrophotometry
6. PH Metry
7. Conductometry
8. Polarography
9. Electrogravimetry

B) Interpretation exercises

1. X-ray powder diffraction analysis of cubic compound
   a. Determination of lattice constants and geometry
   b. Partical Size
   c. Density
2. Interpretation of Mossbaur spectrum with reference to determination of a) isomer shift b) quadruple splitting c) Internal magnetic field d) general comment
3. Interpretation of IR spectrum with reference to stretching vibration 0-2 C=N, C=O, N-, M-O.
4. Interpretation of NMR spectrum with reference to calculation of chemical shifts and general comments.

5. Interpretation of absorption spectra for
   a. Verification of position of ligands in spectrochemical series
   b. Determination of geometry (Octahedral, Square planar, tetrahedral) of a given compound.
   c. Calculation of spectral splitting parameters.
6. Interpretation of polar gram for determination of half wave potentials and unknown concentration.
7. Calculation of band gap of semiconductors with the help of plots.
8. Industry oriented Practicals

(In all experiments with at least five experiments in each course should be completed. Addition of other experiments in place of existing one may be allowed.)

Research project: Lab Project in Parent Institute

External and internal examiners will examine the project (50 Marks)jointly at the time of practical examination

(Any other experiment may be added when required)

Study tour is compulsory for M.Sc. Part- II Students to visit Chemical Industries in India.

OR

Internship, Industrial Training:

Students should complete their internship programme or industrial training or research project work in well reputed organisations like IIT, NIT, IISER, NCL, ICT, Universities, Chemical Industries and Pharmaceutical Industries etc. The minimum period of their internship is 30 days. Students should submit their project report in details with certificate is compulsory.

Learning outcomes: After experiments Students are able to

1) Understand ore analysis, preparation of coordination compounds.
2) Understand the different instrumentation techniques.
3) Understand X- ray diffraction analysis.
4) Interpret the IR spectrum.

Reference books:

1. A.I.Vogel, "A Textbook of Quantitative Inorganic Anaysis", Longman
2. Gurudeep Raj, Advanced Practical Inorganic Chemistry, Krishna Prakashan.
3. W.G.Palmer, "Experimental Inorganic Chemistry", Cambridge University Press
4. Shikha Gulathi, J. L. Sharma and Shagun Manocha, Practical Inorganic Chemistry, CBS publisher and Distributors.
5. J. B. Yadav, Advanced Practical Physical Chemistry, Krishna Publishers.
6. I.M.Kolthoff, V.J.Elving and Sandell, "Treatise on Analytical Chemistry", Interscience.

7. I.M.Kothoff and Strenger, “Volumetric Analysis”, Interscience
8. Fruman and Welcher, “Standard Methods of Inorganic Analysis”, Van Nostrand
9. G.Schwarzenback, “Complexomtric Titrations”, Interscience
10. D.A.Skoog and D.M.West, “Analytical Chemistry – An Introduction”, Reinholdt.
11. R.S.Drago, “Physical Methods in Inorganic Chemistry”, Affiliated East-West Press
12. Instrumental Methods for Chemical Analysis-H. Kaur
13. Spectroscopy- B. K. Sharma
14. Instrumental Methods of Analysis-Willard, Merritt, Dean, Settle
15. Nanotechnology: Principles and Practices- Sulbha Kulkarni
16. Principles of Inorganic Chemistry-Puri, Sharma, Kalia
17. Concise Coordination Chemistry-R. Gopalan, V. Ramalingam
18. Elements of Magnetochemistry-Datta and Shymal
19. G.Zhong Cao. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press (2004).
20. T. Pradeep, Nano The Essentials: Understanding Nanoscience and Nanotechnology.