Rayat Shikshan Sanstha's

YASHAVANTRAO CHAVAN INSTITUTE OF SCIENCE, SATARA

(An Autonomous College)

Reaccredited by NAAC with 'A+' Grade

New Syllabus For

Master of Science

Part - II

Inorganic Chemistry

Syllabus

To be implemented from June, 2022 onward

Structure of the course

M.Sc. Part II Semester III

Theory			
Course No. and Course code	**Title of Course**	**No. of lectures Per week**	**Credits**
MICT-301	Inorganic Chemical Spectroscopy	4	4
MICT-302	Coordination chemistry – I	4	4
MICT-303	Nuclear chemistry	4	4
Elective Course			
MICT-304A or MICT- 304B	Organometallic chemistry or Selected topics in Inorganic Chemistry	4	4
Practical			
MICP 305	Practical course: Lab V	16	4
MICP 306	Practical course: Lab VI	16	4
		48	24

M.Sc. Part II Semester IV

Theory			
Course No. and Course code	**Title of Course**	**No. of lectures Per week**	**Credits**
MICT-401	Instrumental techniques	4	4
MICT-402	Coordination chemistry-II	4	4
MICT-403	Chemistry of inorganic materials	4	4
Elective Course			
MICT-404A or MICT-404B	Energy and Environmental chemistry or Radiation Chemistry	4	4
Practical			
MICP 405	Practical course: Lab VII	16	4
MICP 406	Practical course: Lab VIII	16	4
		48	24

Evaluation pattern

M.Sc. II, Semester III and IV

Paper code	**Theory**			**Practical**			**Total**
	ESE	ISE	Total	ESE	ISE	Total	
Theory paper - I	60	ISE-I = 10 ISE-II = 10 (Online test) Activity = 20 (Book review) Total = 40	100	--	--	--	100
Theory paper - II	60	ISE-I = 10 ISE-II = 10 (Online test) Activity = 20 (Home assignment) Total = 40	100	--		--	100
Theory Paper - III	60	ISE-I = 10 ISE-II = 10 (Online test) Activity = 20 (Survey/Seminar) Total = 40	100	--	--	--	100
Theory paper - IV	60	ISE-I = 10 ISE-II = 10 (Online test) Activity = 20 (Group discussion / Innovative idea presentation) Total = 40	100	--	--	--	100
Practical paper - I	--	--	--	60	Journal = 10 Student performance = 10 Activity = 20 (case study/survey report) Total = 40	100	100
Practical paper - II	--	--	--	60	Journal = 10 Student performance = 10 Activity = 20 (model presentation/project) Total = 40	100	100
Total	**240**	**160**	**400**	**120**	**80**	**200**	**600**

M. Sc. Part – II (Semester – III)

MICT-301: Inorganic Chemical Spectroscopy

Course Objectives: Students will be able to

1. understand X-ray diffraction technique.
2. study of basic concepts of IR, and Raman spectroscopy.
3. study basic concepts of mass spectroscopy.
4. study instrumentation and applications of NMR spectroscopy for analysis of inorganic samples.

Credits=4	**SEMESTER-III** **MICT-301: Inorganic Chemical Spectroscopy**	**No. of hours per unit/ credits**
Credit –I UNIT I	**X-ray diffraction**	**(15)**
	X-ray Sources (X-ray tube and synchrotron sources with their principle of working characteristics of emission spectrum), Bragg's law of diffraction, methods of diffraction (powder and single crystal), Powder diffraction: instrumentation, use of standards, characteristics of powder XRD pattern, significance of peak intensities, systematic absences of reflections, indexing of powder XRD pattern, determination of lattice parameters and solving cubic crystal structure using powder XRD data, qualitative (identification of the phases) and quantitative analysis (phase quantification), crystallite size determination, determination of relative percentage crystallinity. Single crystal diffraction: Advantages of single crystal diffraction over powder diffraction, introduction to Laue, rotation photograph and oscillation methods. Introduction to crystallographic database and file formats (raw data files, cif and pdf), Open source computer based crystal structure building and visualization tools.	
Credit –1 UNIT II	**Infrared and Raman Spectroscopy**	**(15)**
	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.	
Credit –1 UNIT III	**Mass Spectroscopy**	**(15)**
	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.	
Credit –1 UNIT IV	**A] Nuclear Magnetic Resonance Spectroscopy (NMR)**	**(15)**
	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 ^{195}Ag &^{119}Sn NMR, applications of solid-state NMR technique. **B] X-ray Photo electron spectroscopy (XPS)** Introduction and basic theory, instrumentation, sample selection and preparation, spectral analysis, Ar ion sputtering technique and applications of XPS.	

Course Outcomes: Students should be able to

1. understand X-ray diffraction technique.
2. demonstrate basic concepts of IR, and Raman spectroscopy.
3. understand basic concepts of mass spectroscopy.
4. interpretation of NMR spectroscopy samples.

Recommended books:

[1] F. A. Cotton, chemical application of group theory, Wiley eastern (UNIT I, II)
[2] CNR Rao Spectroscopy in Inorganic Chemistry Vol I, II, III Academic Press Inc (UNIT I)
[3] B. N. Figgis, Introduction to ligand field theory field, Wiley (UNIT I, II, III, IV)
[4] H. Kaur, Instrumental Methods of Chemical Analysis, Pragati Prakashan (UNIT I, II, III, IV)
[5] R. Drago, Physical method in Inorganic Chemistry, DUSAP. (UNIT III, IV)
[6] G. R. Chatwal S. K. Anand, Instrumental methods of chemical analysis, Himalaya Publishing House, 2016 (UNIT I, II, III, IV)

MICT-302, Coordination chemistry – I

Course Objectives: Students will be able to

1. understand broad theoretical and applied background of crystal field theory.
2. study basic idea about electronic spectra of transition metal complexes.
3. understand magnetic properties of transition metal complexes
4. study reactions of coordinated ligand

Credits=4	**SEMESTER-III** **MICT-302, Coordination chemistry – I**	**No. of hours per unit/ credits**
Credit –I 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.	
Credit –1 UNIT II	**Electronic spectra of Transition Metal complexes**	**(15)**
	Determining the Energy terms, Spin-orbit (L-S) coupling scheme, Hund's rule, Derivation of the term symbol for a d1 to d9 configuration, Electronic spectra of transition metal complexes –Laporte 'orbital' selection rule, spin selection rule. Orgel diagrams for octahedral metal complexes. Racah parameters, calculations of 10 Dq, B and β parameters for octahedral complexes of cobalt and nickel, Tanabe-Sugano diagrams for octahedral complexes, Charge transfer spectra and Selection rule.	
Credit –1 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.	
Credit –1 UNIT IV	**Reactions of coordinated ligand**	**(15)**
	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 nondonor atoms (nucleophilic behaviour of the ligand, electrophilic bahaviour of the ligand). Chelate ring forming reactions: (reactions predominantly involving thermodynamic effects, reactions predominantly involving kinetic affects).	

Course outcomes: Students should be able to

1) perform broad theoretical and applied background of crystal field theory.
2) demonstrate basic idea about electronic spectra of transition metal complexes.
3) identify magnetic properties of transition metal complexes.
4) differentiate reactions of coordinated ligand.

Reference books:

[1] D. F. Shriver, P. W. Atkins, C. H. Langford, Inorganic Chemistry, Oxoford, 2nd Edition, 1994. (UNIT I, II, III, IV)
[2] R. Gopalan and V. Ramlingam: Concise Coordination Chemistry, Vikas Publishing House (UNIT I, II, III, IV)
[3] Messler and Tarr, Inorganic Chemistry, Pearson Publishers (UNIT I, II, III, IV)
[4] F. A. Cotton & R. G. Wilkinson: Advanced Inorganic Chemistry, Wiley (UNIT I, III, IV)
[5] J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th edn. Harper Collins College Publ. New York. (UNIT III, IV)

MICT-303, Nuclear chemistry

Course Objectives: Students will be able to

1. Study the different view for theoretical and applied background of Nuclear Chemistry.
2. understand idea about Nuclear structure and stability.
3. understand nuclear reactions.
4. study the Reactor Theory.

Credits=4	**SEMESTER-III** **MICT-303, Nuclear chemistry**	**No. of hours per unit/ credits**
Credit –I **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	

Credit –1 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.	
Credit –1 UNIT III	**Nuclear reactions**	**(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. symmetric and a symmetric fission, decay chains and delayed neutrons.	
Credit –1 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 and 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.	

Course outcomes: Students should be able to

1. understand different views for theoretical and applied background of Nuclear Chemistry.
2. demonstrate Nuclear structure and stability.
3. Understand nuclear reactions.
4. illustrate the Reactor Theory.

Reference books:

[1] H. J. Arnikar, Essentials of Nuclear Chemistry, New age international publisher, (UNIT I, II, III, IV)

[2] B. K. Sharma, Nuclear and Radiation Chemistry, Krishna Publication (UNIT I, II, III)

[3] A. K. Das and M. Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers (UNIT- I, II, IV)

[4] G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller, Nuclear and Radiochemistry, Wiley (UNIT II, III, IV)

Elective Course

MICT-304 A, Organometallic chemistry

Course Objectives: Students will be able to

1. understand broad theoretical and applied background of Metal-Carbon bond.
2. study pi bonding in organometallic complexes.
3. understand different metal complexes in medicine.
4. understand knowledge of oxygen transport and storage.

Credits=4	**SEMESTER-III** **MICT-304 A, Organometallic chemistry**	**No. of hours per unit/ credits**
Credit –I 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	
Credit –1 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.	
Credit –1 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.	
Credit –1 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.	

Course outcomes: Students should be able to

1. evaluate theoretical and applied background of Metal-Carbon bond.
2. demonstrate pi bonding in organometallic complexes.
3. differentiate various metal complexes in medicine.
4. differentiate oxygen transport and storage mechanism.

Reference books:

[1] A. Yamamoto, Organo Transition Metal Chemistry, Wiley (1986) (UNIT I, II)
[2] R. H. Crabtree, The Organometallic Chemistry of the Transition Metals (4th edn.), John Wiley (2005) - (UNIT I, II)
[3] R. Gopalan and V. Ramlingam: Concise Coordination Chemistry, Vikas Publishing House. (UNIT II, III, IV)
[4] A. K. Das and M. Das, Fundamental Concepts of Inorganic Chemistry, Vol. 1 to Vol. 7, CBS Publishers (UNIT III, IV)
[5] D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford Univ. Press (1990) (UNIT IV)

MICT-304 B, Selected topics in Inorganic Chemistry

Course Objectives: Students will be able to

1. Study of basic principles of Inorganic Catalysis Chemistry.
2. understand idea about inorganic polymers and bonding.
3. study different energy sources and harvesting technologies.
4. understand basic knowledge of supramolecular compounds.

Credits=4	SEMESTER-III **MICT-304 B, Selected topics in Inorganic Chemistry**	No. of hours per unit/ credits
Credit –I 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.	
Credit –1 UNIT II	**Inorganic Polymers**	**(15)**
	Classification, types of Inorganic polymers, Chemistry of following polymers a) Silicones b) phosphonitric halides c) condensed phosphates d) coordinated polymers e) silicates f) Isopoly & heteropoly acids g) Geopolymers as alternative cement materials.	

Credit –1 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.	
Credit –1 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.	

Course outcomes: Students should be able to

1. understand the basic principles of Inorganic Catalysis Chemistry.
2. demonstrate about inorganic polymers and bonding.
3. enlist energy sources and harvesting technologies.
4. identify different supramolecular compounds.

Reference books:

[1] C. Chapman and Hall, Homogeneous transition metal catalysis, A general art, Masters, London 1981. (UNIT I, II)
[2] G. C. Bond, Heterogeneous catalysis, Oxford science (1987). (UNIT I, IV)
[3] J. E. Mark, H. R. Allock, A. R. West, Inorganic polymers:, Prentice hall (UNIT II, IV)
[4] A. L. Simon, Energy Resources, Pergamon 1975 (UNIT III)
[5] S. P. Sukhatme, Solar energy Principles of thermal collections and storage, Tata Macgrow Hill New Delhi 1984. (UNIT III, IV)

Practical Course

MICP-305: Inorganic Chemistry Practical-V

Course objective: Students will be able to
1) understand analysis of ore and alloy.
2) study different preparations of coordination complexes.
3) understand separation of mixtures by ion exchange technique.
4) study different synthesis methods of nanoparticles.

Credits=4	**SEMESTER-III** **MICP-305: Inorganic Chemistry Practical-V**	**No. of hours (60)**
Lab V	**Non-instrumentation**	
	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 nanoparticles *(Any other experiments may be added when required)*	

Course outcomes: Students should be able to
1) analyze ore and alloy.
2) understand preparation of coordination complexes.
3) analyze mixtures by ion exchange technique.
4) enlist different synthesis methods of nanoparticles.

MICP-306: Inorganic Chemistry Practical-VI

Course objective: Students will be able to
1) understand spectrohotometric determination technique.
2) understand analysis of sample by conductometer.
3) study pH metric technique for analysis of sample.
4) study of different properties of inorganic materials.

Credits=4	SEMESTER-III **MICP-306: Inorganic Chemistry Practical-VI**	No. of hours (60)
Lab VI	**Instrumentation**	
	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)*	

Research project: Lab Project in Parent Institute
External and internal examiners will examine the project jointly at the time of practical examination

Course outcomes: Students should be able to
1) analyze sample by spectrohotometer.
2) analyze sample by conductometer.
3) understand pH metric technique for analysis of sample.
4) enlist different properties of inorganic materials.

Reference books:

[1] A. I. Vogel, J. Bassett 'Vogel's Textbook of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis', Longman Sc & Tech
[2] W. G. Palmer, "Experimental Inorganic Chemistry", Cambridge University Press
[3] H. Kaur, Instrumental Methods of Chemical Analysis, Pragati Prakashan
[4] Gurudeep Raj, Advanced Practical Inorganic Chemistry, Krishna Prakashan.

M. Sc. Part – II (Semester –IV)

MICT-401, Instrumental techniques

Course Objectives: Students will be able to

1. study basic principles of thermal analysis.
2. understand the instrumentation and applications of Mossbauer Spectroscopy.
3. study instrumentation of Electron Spin Resonance Spectroscopy.
4. understand advanced instrumental tools for analysis of inorganic materials.

Credits=4	**SEMESTER-IV** **MICT-401, Instrumental techniques**	**No. of hours per unit/ credits**
Credit –I 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	
Credit –1 UNIT II	**Mossbauer Spectroscopy**	**(15)**
	Principle of Mossbauer spectroscopy, Recoiless absorption and emission of gamma-rays, Doppler shift, Instrumentation, Isomer shift and its factors affecting, Quadruple splitting, Temperature Dependence of MB parameters, Zeeman Splitting (Six fingered MB lines), MB spectra of iron and tin compounds, Applications, Numericals	
Credit –1 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, VO^{2+}, 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.	
Credit –1 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)	

Course outcomes: Students should be able to

1. understand basic principles of thermal analysis.
2. evaluate instrumentation and applications of Mossbauer Spectroscopy.
3. Understand the working of instrumentation of Electron Spin Resonance Spectroscopy.
4. analyze inorganic materials using advanced instrumental tools.

Reference books:

[1] H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis, CBS Publishers and Distributors PVT LTD; 7th edition. (UNIT I)

[2] G. R. Chatwal S. K. Anand, Instrumental methods of chemical analysis, Himalaya Publishing House, 2016 (UNIT I, II, IV)

[3] C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, McGraw Hill Publishers, 5th Edition (UNIT I, IV)

[4] H. Kaur, Instrumental Methods of Chemical Analysis, Pragati Prakashan (UNIT II, III)

[5] D. L. Pavia. G. M. Lampman. G. S. Kriz., J. R. Vyvyan, Introduction to Spectroscopy, Cegate learning, Fifth edition (UNIT II, III, IV)

[6] Drago: Physical methods of Inorganic Chemistry. J. Wiley. (UNIT IV)

MICT-402, Coordination chemistry-II

Course Objectives: Students will be able to

1. understand broad applications of Coordination Chemistry.
2. study basic principles of Inorganic reactions.
3. understand photochemistry of co-ordinate compound.
4. Study of different applications of coordinated compound.

Credits=4	**SEMESTER-IV** **Coordination chemistry-II**	**No. of hours per unit/ credits**
Credit –I **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.	
Credit –1 **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.	
Credit –1 **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.	
Credit –1 **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.	

Course outcomes: Students should be able to

1. understand applied background of Coordination Chemistry.
2. understand basic principles of Inorganic reactions.
3. Use of photochemistry of co-ordinate compound.
4. use of different applications of coordinated compound.

Reference books:

[1] B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vallabh Publications, Delhi (2005) (UNIT I, II, III)

[2] J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4^{th} edn. Harper Collins College Publ. New York. (UNIT I, II, III)

[3] A. K. Das and M. Das, Fundamental Concepts of Inorganic Chemistry, CBS Publishers, Vol. 1 to Vol. 7 (UNIT I, II, III, IV)

[4] R. Gopalan and V. Ramlingam: Concise Coordination Chemistry, Vikas Publishing House. (UNIT I, II, IV)

MICT-403, Chemistry of Inorganic Materials

Course Objectives: Students will be able to

1. understand theoretical and applied background of Solid state materials.
2. study basic principles of solid state electrolytes.
3. understand different synthesis and characterization techniques of nanoparticles.
4. study different properties and applications of Nanomaterials.

Credits=4	SEMESTER-IV **MICT-403, Chemistry of Inorganic Materials**	No. of hours per unit/ credits
Credit –I 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. Packing fraction, Radius ratio rule (2,3,4,6,8 co–ordinate structures), octahedral and tetrahedral voids. Isomorphism and polymorphism. **B)** Structures of the followings: AB type: NaCl, CsCl, Zincsulphide (sphalerite or cubic and hexagonal), AB2 type: Fluorite (CaF_2), TiO_2(Rutile), $CdCl_2$, CdI_2 structures, AB_3 type: ReO_3, BiI_3, A_2B_3 type: Corundum Al_2O_3, α-Fe_2O_3 ,Mn_2O_3., ABO_3type: Perovskite Structures (Barium titanate, lead titanate, $CaTiO_3$, $FeTiO_3$), AB_2O_4 type-Spinel structure, Normal & Inverse,Factors causing distortion in spinel, $A_2B_2O_7$ type: Pyrochlores ($La_2Sn_2O_7$).	
Credit –1 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.	
Credit –1 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.	
Credit –1	**Properties and Applications of Nanomaterials**	**(15)**

UNIT IV		
	Properties of Nanomaterials: Optical, Magnetic, Electrical, Mechanical, Structural properties **Illustrative Nanomaterials:** Carbon nanostructures (CNTs, Graphene and its derivatives, fullerenes, Metal oxides (TiO_2 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.	

Course outcomes: Students should be able to

1. understand theoretical and applied background of Solid state materials.
2. demonstrate basic principles of solid state electrolytes.
3. perform different synthesis and characterization techniques of nanoparticles.
4. understand different properties and applications of inorganic materials.

Reference books:

[1] S. O. Pillai, Solid State Physics, Academic press (UNIT I, II)
[2] A. R. West, Solid State Chemistry, Wiley (UNIT I, II, III, IV)
[3] C. N. R. Rao, Solid State Chemistry, Dekker (UNIT II, III)
[4] S. K. Kulkarni, Nanotechnology: Principles and Practices, 3rd Edition, Capital Pubishing Company, 2014. (UNIT II, III, IV)
[5] T. Pradeep, Nano: The Essentials, McGraw Hill Education, 2007. (UNIT III, IV)
[6] K. K. Chattopadhyay, Introduction to Nanoscience and Nanotechnology, PHH Publisher. (UNIT III, IV)

Elective Course

MICT-404 A, Energy and Environmental chemistry

Course Objectives: Students will be able to

1. understand different energy conversion devices.
2. Study of control of air and water pollution.
3. study electrochemical and spectral methods of pollutant analysis.
4. understand monitoring, sampling and analysis of air and water pollutants.

Credits=4	SEMESTER-IV **MICT-404, Energy and Environmental chemistry**	No. of hours per unit/ credits
Credit –I UNIT I	**Energy Conversion 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	
Credit –1 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.	
Credit –1 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.	
Credit –1 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, CO_2, NO_2, SO_2, H_2S, analysis of	

	toxic heavy metals, Cd, Cr, Hg, As, Pb, Speciation Separation and analysis of Co, Cu, Mg, Mn, Fe, Al, analysis of anions SO_4^{2-}, PO_4^{3-}, NO_3^-, NO_2^-. 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.	

Course outcomes: Students should be able to

1. use of different energy conversion devices.
2. demonstrate how to control air and water pollution.
3. Use of electrochemical and spectral methods of pollutant analysis.
4. design methods of monitoring, sampling and analysis of pollutants.

Reference books:

[1] C. S. Rao, Environmental Pollution Engineering and Control, New Age International Publisher. (UNIT I, II)
[2] B. K. Sharma & H. Kaur, Environmental Pollution, Pragati Prakashan. (UNIT I, II, III, IV)
[3] S. M. Khopkar, Environmental Pollution Analysis, New age publisher. (UNIT I, II, IV)
[4] O. D. Tyagi, M. Mehre, A Text Book of Environmental Pollution, Anmol Publisher (UNIT III, IV)
[5] H. Kaur, Instrumental Methods of Chemical Analysis, Pragati Prakashan. (UNIT IV)

MICT-404 B , Radiation Chemistry

Course Objectives: Students will be able to

1. Study of isotopes, isotones and isobars and biological effect of radiation.
2. study radiochemical separation of isotopes.
3. understand tracer chemistry and its importance.
4. understand radiation detection and measurement process.

Credits=4	SEMESTER-IV **MICT-404 B, Radiation Chemistry**	No. of hours per unit/ credits
Credit –I UNIT I	**Isotopes and their biological effects**	**(15)**
	A] Isotopes Difference between Isotopes and Isobars, isotope separation, thermodynamic and kinetic isotope effects, isotope exchange reaction kinetics, determination of exchange rate constant, production and applications of radio isotopes. **B] Biological effects of Radiation** Introduction, genetic and somatic effect on human being, effect of radiation on plants and aquatic Environment.	
Credit –1	**Radiochemical Separation**	**(15)**

UNIT II		
	The need of radiochemical separation techniques, carrier techniques, isotope and nonisotopic carriers, coprecipitation and adsorption, ion exchange, solvent extraction, electrolytes behavior of carrier free tracer radionuclide.	
Credit –1 UNIT III	**Principle of tracer chemistry**	**(15)**
	Introduction to tracers, application of tracers in physiochemical studies, diffusion studies, isotopic and exchange reactions, tracer in the study of the mechanism of the inorganic chemical reaction, atom transfer and electron transfer mechanisms. Heterogeneous catalysis and surface area measurements, radio carbon dating, tracer studies with tritium, application in metallurgy and preservation of food, geochemical application and hot atom chemistry.	
Credit –1 UNIT IV	**Radiation detection and measurements**	**(15)**
	Ionization current measurements, multiplicative ion collector, methods not based on ion collection, auxiliary Instrumentation and health physical instruments and counting statistics. Working of Scintillation and Geiger Muller Counter.	

Course outcomes: Students should be able to

1. understand isotopes, isotones and isobars and biological effect of radiation.
2. differentiate radiochemical isotopes.
3. understand tracer chemistry and its importance.
4. differentiate radiation detection and measurement process.

Reference books:

[1] H. J. Arnikar, Essentials of Nuclear Chemistry, New age international publisher, (UNIT I, II)
[2] Friedlander, Kennedy and Miller, Nuclear and radio Chemistry, Wiley. (UNIT I, II, III, IV)
[3] D. C. Dayal, Nuclear physics, Himalaya Publishing House. (UNIT I, II, III, IV)
[4] B. G. Harvey, Introduction to Nuclear Physics and Chemistry, Literary Licensing, LLC. (UNIT II, IV)

Practical Course

MICP-405: Inorganic Chemistry Practical-VII: Lab VII

Course objective: Students will be able to
1) understand analysis of ore and alloy.
2) study different preparations of coordination complexes.
3) understand separation of mixtures by ion exchange technique.
4) understand different instrumentation techniques.

Credits=4	SEMESTER-IV **MICP-405: Inorganic Chemistry Practical-VII**	No. of hours (60)
	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	

(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.)

Course outcomes: Students should be able to
1) analyze different ore and alloy samples.
2) prepare coordination complexes.
3) understand separation of mixtures by ion exchange technique.
4) enlist different instrumentation techniques.

MICP-406: Inorganic Chemistry Practical- VIII : Lab VIII

Course objective: Students will be able to
1) understand X- ray diffraction analysis
2) understand interpretation of Mossbaur spectrum.
3) study IR and NMR spectroscopy for analysis of samples.
4) study interpretation of different spectrum.

Credits=4	SEMESTER-IV **MICP-406: Inorganic Chemistry Practical- VIII**	No. of hours (60)
Lab VIII	**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 jointly at the time of practical examination

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

Course outcomes: Students should be able to

1) analyze sample by X- ray diffraction.
2) understand interpretation of sample by Mossbaur spectroscopy.
3) interpret samples by IR and NMR spectroscopy.
4) understand interpretation of different spectrum.

Reference books:

[1] A. I. Vogel, J. Bassett 'Vogel's Textbook of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis', Longman Sc & Tech
[2] W. G. Palmer, "Experimental Inorganic Chemistry", Cambridge University Press
[3] H. Kaur, Instrumental Methods of Chemical Analysis, Pragati Prakashan.
[4] Gurudeep Raj, Advanced Practical Inorganic Chemistry, Krishna Prakashan.