"Education through self-help is our motto."

Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara (Autonomous)

Lead College of
Karmaveer Bhaurao Patil University, Satara

Syllabus for

Master of Science

Part - II

CHEMISTRY

To be implemented from academic year 2024-25

(As Per NEP-2020 Guidelines)

Preamble

This syllabus is framed to give advanced knowledge of Chemistry to postgraduate students at second year of two years of M.Sc. degree course. The goal of the syllabus is to make the study of Chemistry popular, interesting and encouraging to the students for higher studies including research. The new syllabus is based on a basic and applied approach with vigor and depth. At the same time precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of industries and research. The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields. The units of the syllabus are well defined, taking into consideration the level and capacity of students

Credit Framework and Structure of Course for M.Sc. II

Semester – III

Level	Course Code	Course Title	No. of Lectures Per Week	Credits
	Discipline Specific Courses (DSC) (Mandatory)			
6.5	MICT 531	Coordination chemistry – I	4	4
	MICT 532	Nuclear chemistry	4	4
	MICT 533	Organometallic chemistry	4	4
	Discipline Specific Elective (DSE) (Choose Any one among two)			
	MICT 534 E-I MICT 534 E-II	E-I) Inorganic Chemical Spectroscopy E-II) Selected topics in Inorganic Chemistry	2	2
	MICT 535	Research Project (RP)	12	6
	MICT 536	LAB- III (based on MICT-531, 532 and 533)	4	2
Total				**22**

Semester –IV

Level	Course Code	Course Title	No. of Lectures Per Week	Credits
	Discipline Specific Courses (DSC) (Mandatory)			
6.5	MICT 541	Instrumental techniques	4	4
	MICT 542	Coordination chemistry-II	4	4
	MICT 543	Chemistry of Inorganic Materials	4	4
	Discipline Specific Elective (DSE) (Choose Any one among two)			
	MICT 544 E-I MICT 544 E-II	E-I) Energy and Environmental chemistry E-II) Radiation Chemistry	4	4
	MICT 545	On Job Training (OJT)	8	4
	MICT 546	LAB- IV (based on MICT-541, 542 and 543)	4	2
Total				**22**

M. Sc. Part – II (Semester – III)

Discipline Specific Course (DSC)

MICT-531, 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. learn magnetic properties of transition metal complexes
4. know the reactions of coordinated ligands.

Credits=4	Coordination chemistry – I	No. of hours
UNIT I	**Metal-ligand bonding**	**15**
	1.1. **Crystal Field Theory:** Splitting of d-orbital in tetragonal, square pyramidal, and trigonal bipyramid complexes. 1.2. CFSE-factors affecting the magnitude of 10 Dq-evidence for crystal field stabilization, 1.3. Tetragonal distortion from octahedral symmetry, John teller effect, 1.4. Nephelauxetic effect. 1.5. CFSE and their uses, factors affecting CFSE, 1.6. Limitations of crystal field theory. 1.7. **Molecular Orbital Theory:** Molecular orbital diagram for octahedral, tetrahedral and square planar complexes with and without π-bonding.	
UNIT II	**Electronic spectra of Transition Metal complexes**	**15**
	2.1. Determining the Energy terms, 2.2. Spin-orbit (L-S) coupling scheme, Hund's rule, 2.3. Determination of the term symbol for a d1 to d9 configuration, 2.4. Electronic spectra of transition metal complexes 2.5. Laporte 'orbital' selection rule, spin selection rule. 2.6. Orgel diagrams for octahedral metal complexes. 2.7. Racah parameters, calculations of 10 Dq, B and ⍰ parameters for octahedral complexes of cobalt and nickel, 2.8. Tanabe-Sugano diagrams for octahedral complexes, 2.9. Charge transfer spectra and Selection rule.	
UNIT III	**Magnetic properties of Transition metal complexes**	**15**
	3.1. Types of magnetic behavior, 3.2. Origin of paramagnetism, 3.3. Spin-orbit interaction, 3.4. Diamagnetism, Pascal constants, 3.5. Ferromagnetism and antiferromagnetism of metal complexes, 3.6. Temperature dependent paramagnetism,	

	3.7. Spin orbit coupling and magnetic moment, 3.8. Spins crossover phenomenon, 3.9. Determination of magnetic susceptibility.	
UNIT IV	**Reactions of coordinated ligand**	**15**
	4.1. 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) 4.2. Reactions of nondonor atoms (nucleophilic behaviour of the ligand, electrophilic bahaviour of the ligand) 4.3. 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) interpret the magnetic properties of transition metal complexes.
4) differentiate between reactions of coordinated ligand.

Reference books:

[1] Shriver D. F. Atkins P. W. Langford C. H. 1994, *Inorganic Chemistry,* 2nd Edition Oxoford.
[2] Gopalan R. and Ramlingam V.2001. *Concise Coordination Chemistry,* Vikas Publishing House.
[3] Messler and Tarr, 1984. *Inorganic Chemistry*, Pearson Publishers.
[4] Cotton F. A. & Wilkinson R. G. 2021. *Advanced Inorganic Chemistry,* Wiley.
[5] Huheey J. H. 1972. *Inorganic Chemistry Principles, structure and reactivity*., Harper and Row Publisher, Inc. New York.

MICT-532, Nuclear chemistry

Course Objectives: Students will be able to

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

Credits=4	Nuclear chemistry	No. of hours
UNIT I	**Systematics of alpha, beta and gamma decays**	**15**
	1.1. Alpha decay, energy curve, spectra of alpha particles 1.2. Giger-Nuttal law 1.3. Theory of alpha decay 1.4. Penetration of potential barrier 1.5. Beta decay 1.6. Range of energy relationship 1.7. Beta spectrum, Sergeants curve 1.8. Fermi theory of beta decay 1.9. Matrix elements 1.10. Allowed and forbidden transitions, curie plots 1.11. Gamma decay 1.12. Nuclear energy levels, Selection rule 1.13. Isomeric transitions, Internal conversion 1.14. Auger effect.	
UNIT II	**Nuclear Structure and Stability**	**15**
	2.1. Binding energy 2.2. Empirical mass equation 2.3. The nuclear models, the liquid drop model 2.4. Single particle shell model 2.5. Fermi gas model & collective/lunified nuclear model 2.6. Nuclear spin, parity & magnetic moments of odd mass number nuclei 2.7. Numericals.	
UNIT III	**Nuclear reactions**	**15**
	3.1. Introduction 3.2. Production of projectiles 3.3. Nuclear cross section, nuclear dynamics 3.4. Threshold energy of nuclear reaction 3.5. Coulomb scattering 3.6. Potential barrier, potential well 3.7. Formation of a compound nucleus 3.8. Nuclear reactions 3.9. Direct Nuclear reactions, 3.10. Heavy ion induced nuclear reactions 3.11. Photonuclear reactions	

	3.12. Symmetric and a symmetric fission 3.13. Decay chains and delayed neutrons.	
UNIT IV	**Reactor Theory and Applications of Radioactivity**	**15**
	4.1. Nuclear fission as a source of energy 4.2. Nuclear chain reacting systems 4.3. Critical size of a reaction 4.4. Research reactors, graphite moderated, enriched uranium reactors, light water moderated 4.5. Heterogeneous and homogeneous reactors 4.6. Thermonuclear reactors 4.7. Gamma interactions, shielding and health protection 4.8. Reactors in India. 4.9. Tracer technique in the field of analytical chemistry 4.10. structure determination elucidation of reaction mechanism 4.11. Isotopic dilution analysis 4.12. Neutron activation analysis 4.13. Applications in biological, medical, industrial fields 4.14. Age determination.	

Course outcomes: Students should be able to

1. explore different views for theoretical and applied background of Nuclear Chemistry.
2. demonstrate Nuclear structure and stability.
3. describe different nuclear reactions.
4. recognize different the Reactor Theories.

Reference books:

[1] Arnikar H. J. 1988. *Essentials of Nuclear Chemistry*, Wiley Eastern.
[2] Sharma B. K. 2000. *Nuclear and Radiation Chemistry,* Krishna Publication.
[3] Das A. K. and Das M. 2004 *Fundamental Concepts of Inorganic Chemistry*, Vol. 1 to Vol. 7, CBS Publishers.
[4] Friedlander G. Kennedy J. W. Macias E. S. and Miller J. M. 2012 *Nuclear and Radiochemistry,* Wiley.

MICT-533, Organometallic chemistry

Course Objectives: Students will be able to

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

Credits=4	Organometallic chemistry	No. of hours
UNIT I	**Transition metal- Carbon bond**	**15**
	1.1. Brief review of Stability of transition metal alkyls 1.2. Classification of σ-bonded hydrocarbyls, preparation, structure and bonding 1.3. General characteristics of metal alkyl and aryls 1.4. Organocopper compounds 1.5. Transition metal carbene complexes 1.6. Transition metal alkylidene complexes.	
UNIT II	**Transition Metal Pi-complexes**	**15**
	2.1. Carbon multiple bonds. 2.2. Nature of bonding, structural characteristics & synthesis 2.3. Properties of transition metal pi-Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, & arene complexes. 2.4. Application of transition metal, organometallic intermediates in oraganic synthesis relating to nucleophilic & electrophilic attack on ligands 2.5. Role in organic synthesis.	
UNIT III	**Metal Complexes in medicine**	**15**
	3.1. Medicinal use of metal complexes as antibacterial, anticancer 3.2. Use of cis-platin as antitumor drug 3.3. Antibiotics & related compounds 3.4. Metal used for diagnosis and chemotherapy with particular reference to anticancer drugs 3.5. Chelate therapy, 3.6. Chemotherapy with compounds of some non essential elements 3.7. Platinum complexes in cancer therapy 3.8. Antiviral activity of metal complexes.	
UNIT IV	**Oxygen transport and storage**	**15**
	4.1. Heme proteins & oxygen uptake 4.2. Structure and functions of haemoglobin, myoglobin, hemocyanins & hemerythrin 4.3. Oxygenation and deoxygenation 4.4. Oxygen adsorption isotherm and cooperativity 4.5. Physiological significance of haemoglobin	

	4.6. Role of globin chain in gaemoglobin 4.7. Cyanide poisoning and treatment.	

Course outcomes: Students should be able to

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

Reference books:

[1] Yamamoto A. 1986. *Organo Transition Metal Chemistry,* Wiley.

[2] Crabtree R. H. 2005. *The Organometallic Chemistry of the Transition Metals.* 4^{th} edn. John Wiley.

[3] Gopalan R. and Ramlingam V.2001. *Concise Coordination Chemistry,* Vikas Publishing House.

[4] Das A. K. and Das M. 2004 *Fundamental Concepts of Inorganic Chemistry*, Vol. 1 to Vol. 7, CBS Publishers.

[5] Shriver D. F. and Atkins P. W. 1999. *Inorganic Chemistry*. 3^{rd} edition. Oxford.

Discipline Specific Elective (DSE)

MICT-534 E-I: 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.

Credits=2	Inorganic Chemical Spectroscopy	No. of hours
UNIT I	**X-ray diffraction**	15
	1.1. X-ray Sources (X-ray tube and synchrotron sources with their principle of working characteristics of emission spectrum) 1.2. Bragg's law of diffraction 1.3. Methods of diffraction (powder and single crystal) 1.4. Powder diffraction: instrumentation, use of standards, characteristics of powder XRD pattern 1.5. Significance of peak intensities, systematic absences of reflections 1.6. Indexing of powder XRD pattern 1.7. Determination of lattice parameters and solving cubic crystal structure using powder XRD data 1.8. Qualitative (identification of the phases) and quantitative analysis (phase quantification) 1.9. Crystallite size determination 1.10. Determination of relative percentage crystallinity 1.11. Single crystal diffraction: Advantages of single crystal diffraction over powder diffraction 1.12. Introduction to Laue, rotation photograph and oscillation methods 1.13. Introduction to crystallographic database and file formats (raw, cif and pdf data files)	
UNIT II	**Infrared and Raman Spectroscopy**	15
	A) Infrared spectroscopy: 1.A.1. The vibrating diatomic molecule 1.A.2. The simple harmonic oscillator 1.A.3. The anharmonic oscillator 1.A.4. The diatomic vibrating rotator 1.A.5. Vibration– rotation spectrum of carbon monoxide 1.A.6. Breakdown of Born–Oppenheimur approximation 1.A.7. The vibration of polyatomic molecules 1.A.8. Overtones and combination frequencies 1.A.9. The influence of rotation of the spectra of polyatomic molecules 1.A.10.Techniques and Instrumentation, Applications. **B) Raman spectroscopy**: 1.B.1. Classical and Quantum theory 1.B.2. Outline of technique and instrumentation 1.B.3. Pure rotational Raman Spectra, vibrational Raman	

	spectra 1.B.4. Rule of mutual exclusion 1.B.5. Overtone and combination vibrations 1.B.6. Rotational fine structure 1.B.7. Applications	

Course Outcomes: Students should be able to
1. describe X-ray diffraction technique.
2. explain basic concepts of IR, and Raman spectroscopy.

Recommended books:

[1] Cotton F. A. 2003, C*chemical application of group theory*, Wiley eastern.
[2] Rao CNR 2012, *Spectroscopy in Inorganic Chemistry* Vol I, II, III Academic Press.
[3] Figgis B. N. and Hitachman M. A. 2000. *Ligand field theory and its application.* Wiely VCH publication.
[4] Kaur H. 2005, *Instrumental Methods of Chemical Analysis*, Pragati Prakashan.
[5] Chatwal G. R., Anand S. K. 2016. *Instrumental methods of chemical analysis*, Himalaya Publishing House.

MICT-534 E-II, Selected topics in Inorganic Chemistry

Course Objectives: Students will be able to
1. study of basic principles of Inorganic Catalysis Chemistry.
2. get knowledge about inorganic polymers and bonding.

Credits=2	Selected topics in Inorganic Chemistry	No. of hours
UNIT I	**Catalysis**	**15**
	1.1. Basic principles, thermodynamic and kinetic aspects, 1.2. industrial requirements, 1.3. Classification, theories of catalysis, 1.4. Homogeneous and heterogeneous catalysis. 1.5. Introduction, types & characteristics of substrate-catalyst interactions, 1.6. Kinetics and energetic aspects of catalysis, 1.7. Selectivity, stereochemistry, 1.8. Orbital symmetry and reactivity. 1.9. Catalytic reactions of coordination and Organometallic compounds.	
UNIT II	**Inorganic Polymers**	**15**
	2.1. Classification, types of Inorganic polymers 2.2. Chemistry of polymers like Silicones, silicates 2.3. Phosphonitric halides 2.4. Condensed phosphates 2.5. Coordinated polymers 2.6. Isopoly & heteropoly acids 2.7. Geopolymers as alternative cement materials.	

Course outcomes: Students should be able to

1. apply the basic principles of Inorganic Catalysis Chemistry.
2. explore about inorganic polymers and bonding.

Reference books:

[1] Chapman C., Hall V. 1981, *Homogeneous transition metal catalysis, A general art,* Masters, London.
[2] Bond G. C. 1987. *Heterogeneous catalysis,* Oxford science.
[3] Mark J. E., Allock H. R., West A. R. 2006, *Inorganic polymers*, Prentice hall.
[4] Simon A. L., 1975. *Energy Resources,* Pergamon.
[5] Sukhatme S. P. 1984. *Solar energy Principles of thermal collections and storage*, Tata Macgrow Hill, New Delhi.

Credits 6	MICP 535: Research Project (RP)	No. of hours (180 Hr)
• Students will undertake research in specific area of his Major/Core with an advisory supported by a teacher/Faculty member. Students are required to take 6 credit Research Project for semester III under the guidance of faculty members.		

Practical Course

MICP-536: Inorganic Chemistry Practical-III

Course objective: Students will be able to

1) learn about analysis of ore and alloy.
2) study different preparations of coordination complexes.
3) understand different instrumentation techniques.
4) acquire knowledge of inorganic quantitative analysis.

Credits=2	**Inorganic Chemistry Practical-III Lab III**	**No. of hours (60 Hr)**
	1) Ore and alloy Analysis Dolomite Ore Pyroluscite ore Brass Alloy Stainless steel	**30 Hr**
	2) Preparation of coordination complexes Ammoniumdiamminotetrathiocyanatochromate (III). Carbonatotetramminecobaltus (III) nitrate. Nitropentaminecobalt (III) chloride. Potassiumtransdi-aqua-oxalatochromate (III). Trans-di-chlorobisethylenediaminecobaltatechloride. Nickel ferrite. Zinc ferrite. Trisethylenediaminenickel (II) Sulphate. Trisethylenediaminenickel (II) thiosulphate. TristhioureacuprousSulphate.	**15 Hr**
	3) Instrumental techniques To determine the formula and stability constant of the complex between $CdSO_4$ and Na_2SO_3 conductometrically. To determine the normality of acetic acid and HCl conductometrically. To determine dissociation constant of ethylenediamine pH metrically. To study the titration of mixture of H_2SO_4 and CH_3COOH Vs NaOH pH metrically. Spectrophotometry Potentiometry Nephelometry Polarography *(Any other suitable experiments may be added when required)*	**15 Hr**

Course outcomes: Students should be able to

1) analyze different ore and alloy samples.
2) prepare coordination complexes.
3) enlist different instrumentation techniques.

4) describe inorganic quantitative analysis.

Reference books:

[1] Vogel A. I. 1980. *A text book of Quantitative Inorganic Analysis including elementary instrumental analysis*, Longman Sc & Tech.
[2] Palmer W. G. 1948. *Experimental Inorganic Chemistry.* Cambridge University Press.
[3] Kaur H. 2005, *Instrumental Methods of Chemical Analysis*, Pragati Prakashan.
[4] Raj Gurdeep 2009, *Advanced Practical Inorganic Chemistry*, Krishna Prakashan.

M. Sc. Part – II (Semester –IV)

Discipline Specific Course (DSC)

MICT-541, 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. learn instrumentation of Electron Spin Resonance Spectroscopy.
4. get knowledge of advanced instrumental tools for analysis of inorganic materials.

Credits=4	Instrumental techniques	No. of hours
UNIT I	**Thermal analysis**	**15**
	1.1.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 1.2.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. 1.3.c) Differential Scanning Calorimetry [DSC]; Defination; Comparison of DTA and DSC techniques; Instrumentation of DSC, Factors affecting to DSC curves. 1.4.d) Thermometric titrations: Theory, Instrumentation and applications. 1.5.e) Thermomechanical analysis: Theory, Instrumentation and applications	
UNIT II	**Mossbauer Spectroscopy**	**15**
	2.1. Principle of Mossbauer spectroscopy 2.2. Recoiless absorption and emission of gamma-rays, 2.3. Doppler shift 2.4. Instrumentation 2.5. Isomer shift and its factors affecting, Quadruple splitting, Temperature Dependence of MB parameters 2.6. Zeeman Splitting (Six fingered MB lines), MB spectra of iron and tin compounds 2.7. Applications 2.8. Numericals.	
UNIT III	**Electron Spin Resonance Spectroscopy**	**15**
	3.1. Principle of ESR Spectroscopy, Presentation of spectrum,	

	Hyperfine splitting in some proton systems 3.2. 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) 3.3. Superhyperfine splitting 3.4. Instrumentation 3.5. 'g' value and its factors affecting 3.6. Zero field splitting 3.7. Karmers's degeneracy 3.8. Applications 3.9. Numericals.	
UNIT IV	**Advanced Instrumental Tools for Analysis of Inorganic materials**	**15**
	4.1. Time resolved studies of chemical reactions such as material synthesis (solid state, hydrothermal, sol/gel, thin film growth etc.) 4.2. Cathode/anode materials in lithium ion batteries during charge/discharge cycles 4.3. In situ x-ray diffraction methods for thermal expansion/contraction studies 4.4. Structural studies as a function of temperature and pressure (XRD methods) 4.5. Temperature programmed techniques (temperature programme desorption/oxidation/reduction: TPD/TPR) 4.6. Methods of determination of surface acidity and basicity of solid catalysts 4.7. Computer softwares for plotting and analysis of the XRD data 4.8. Structure drawing softwares (VESTA).	

Course outcomes: Students should be able to

1. explain 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] Willard H. H. Merritt L. L. Dean J. A. Settle F. A. 2012. *Instrumental Methods of Analysis,* 7th edition CBS Publishers.
[2] Chatwal G. R., Anand S. K. 2016. *Instrumental methods of chemical analysis*, Himalaya Publishing House.

[3] Banwell C.N. McCash E.M. 2000. *Fundamentals of Molecular Spectroscopy,* 5th Edition McGraw Hill Publishers.
[4] Kaur H. 2005, *Instrumental Methods of Chemical Analysis*, Pragati Prakashan.
[5] Pavia D. L. Lampman G. M. Kriz G. S. Vyvyan J. R. 2012. *Introduction to Spectroscopy,* 5th edition, Cegate learning.
[6] Drago R. 2012. *Physical method in Inorganic Chemistry*, Affiliatedeast-West Press Pvt. Ltd.

MICT-542, Coordination chemistry-II

Course Objectives: Students will be able to

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

Credits=4	Coordination chemistry-II	No. of hours
UNIT I	**Reaction Mechanism of Transition Metal complexes**	15
	1.1. Classification of Inorganic reactions 1.2. Energy profile of reaction with terminology 1.3. Inert and labile complexes 1.4. VBT as well as CFT approaches for lability of complexes 1.5. Nucleophilic substitution reactions in octahedral complexes with their mechanism (associative and dissociative mechanism) 1.6. Types of intermediates involved acid hydrolysis 1.7. Acid hydrolysis and factors affecting acid hydrolysis 1.8. Base hydrolysis and its conjugate base mechanism 1.9. Direct & indirect evidences in favour of conjugate mechanism,	
UNIT II	**Substitution Reactions of Complexes**	15
	2.1. Substitution reaction, 2.2. reactions of Transition Metal complexes, 2.3. kinetics and mechanism of substitution reactions of octahedral complexes, 2.4. acid hydrolysis, base hydrolysis, kinetics and mechanism of substitution reaction. 2.5. Stereochemical aspects of substitution reaction of Octahedral Complexes 2.6. Stereochemical changes in dissociation (SN2) and displacement (SN2) mechanism through various geometries of coordination compounds. 2.7. Isomerization and racemization reactions in octahedral complexes.	
UNIT III	**Photochemistry**	15
	3.1. Absorption, excitation 3.2. Photochemical laws 3.3. Quantum yield 3.4. Electronically excited states of Metal complexes 3.5. Type of photochemical reactions 3.6. Substitutions reactions, rearrangement reactions, redox reaction 3.7. Photochemistry of Coordination compounds 3.8. Charge transfer spectra, charge transfer excitations	

	3.9. Methods for obtaining charge transfer spectra	
UNIT IV	**Applications of Coordination Compounds**	**15**
	4.1. Metal Complexes in Analytical Chemistry 4.2. Inorganic Qualitative Analysis, 'brown ring' test, 4.3. Complexometric Titrations, Complexes in Colourimetry, 4.4. Coordination Compounds in Gravimetry, 4.5. Stabilization of Oxidation States, 4.6. Complexes in Separation of Metals. 4.7. Metal Complexes in Medicinal Chemistry; Complexation in Food Poisoning, 4.8. Metal Complexes in Therapy. 4.9. Metal Complexes in Industrial Processes; Heavy Metals-protein Complexes in the Rasching Process, The Ziegler-Natta Catalyst, Metal complexes in alkene conversions, 4.10. Complexes and Electroplating, 4.11. Complexes in Metallurgy. Copper Metal dissolves in Aqueous Potassium Cyanide, 4.12. Complexes in water softening. 4.13. Metal complexes in Agriculture.	

Course outcomes: Students should be able to

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

Reference books:

[1] Puri B. R., Sharma L. R. and Kalia K. C. 2005. *Principals of Inorganic Chemistry*, India, Vishal Publishing company.

[2] Huheey J. H., Keiter E. A. and Keiter R. L. 1972. *Inorganic Chemistry Principles, structure and reactivity*., Harper and Row Publisher, Inc. New York.

[3] Das A. K. and Das M. 2004 *Fundamental Concepts of Inorganic Chemistry*, Vol. 1 to Vol. 7, CBS Publishers.

[4] Gopalan R. and Ramlingam V.2001. *Concise Coordination Chemistry,* Vikas Publishing House.

MICT-543, Chemistry of Inorganic Materials

Course Objectives: Students will be able to

1. acquire theoretical and applied background of Solid state materials.
2. know 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	Chemistry of Inorganic Materials	No. of hours
UNIT I	**Solid State Materials**	**15**
	1.1. Classification in crystals 1.2. Crystal systems and Bravais Lattice, Lattice planes and their designation 1.3. Metallic Crystal structures: Face-centered cubic (fcc), body-centered cubic (bcc), hexagonal close-packed (hcp) structure 1.4. Packing fraction 1.5. Radius ratio rule (2,3,4,6,8 co–ordinate structures) 1.6. octahedral and tetrahedral voids 1.7. Isomorphism and polymorphism 1.8. Structures of the followings crystal types: 1.9. AB type: NaCl, CsCl, Zincsulphide (sphalerite or cubic and hexagonal) 1.10. AB2 type: Fluorite (CaF_2), TiO_2(Rutile), $CdCl_2$, CdI_2 structures 1.11. AB_3 type: ReO_3, BiI_3, A_2B_3 type: Corundum Al_2O_3, α-Fe_2O_3 ,Mn_2O_3 1.12. ABO_3type: Perovskite Structures (Barium titanate, lead titanate, $CaTiO_3$, $FeTiO_3$) 1.13. AB_2O_4 type- Spinel structure, Normal & Inverse,Factors causing distortion in spinel 1.14. $A_2B_2O_7$ type: Pyrochlores ($La_2Sn_2O_7$)	
UNIT II	**Solid electrolytes**	**15**
	2.1. Typical ionic Crystals: Alkali metal halides (vacancy conduction), Silver chloride (interstitial conduction) 2.2. Solid Electrolytes – alumina, silver iodide, halide and oxide ion conductors 2.3. Applications of Solid Electrolytes 2.4. Fuel cells: electrochemical power generator (hydrogen-oxygen cell) 2.5. Solid state Galvanic cell 2.6. Thermoelectric Effects: Seebeck effects, Hall effect	
UNIT III	**Synthesis and Characterization of Nanomaterials**	**15**
	3.1. Introduction to Nanomaterials, Nanoscience and nanotechnology, History, Classifications 3.2. Metal nanoparticles: Reduction method 3.3. Semiconducting or composite nanomaterials:	

	Hydrothermal and Solvothermal method, Sol-gel, Arrested Precipitation, and other methods include) 3.4. Micelles-Microemulsions 3.5. Electron Microscopy (TEM & SEM) 3.6. Probe Microscopy (STM & AFM) 3.7. Diffraction Technique (XRD) 3.8. UV-Visible-NIR spectroscopy	
UNIT IV	**Properties and Applications of Nanomaterials**	**15**
	4.1. **Properties of Nanomaterials:** 4.2. Optical, Magnetic, Electrical, Mechanical, Structural properties 4.3. **Illustrative Nanomaterials:** 4.4. Carbon nanostructures (CNTs, Graphene and its derivatives, fullerenes 4.5. Metal oxides (TiO_2 and ZnO) & its composites 4.6. Quantum dots 4.7. Porous materials, Zeolites 4.8. **Applications in the various fields:** 4.9. Electronic devices 4.10. Energy generation and storage 4.11. Automobiles 4.12. Sports and toys 4.13. Textile Industries 4.14. Cosmetics Products 4.15. Domestic appliances 4.16. Sensors 4.17. Biotechnology and medical field 4.18. Space and Defense 4.19. Catalysis 4.20. 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. recognize different properties and applications of inorganic materials.

Reference books:

[1] Pillai S. O. 2005, *Solid State Physics*, 5th edition, Academic press.
[2] West A. R. 1999, *Solid State Chemistry*, 3rd edition, Wiley.
[3] Rao CNR 2012, *Spectroscopy in Inorganic Chemistry* Vol I, II, III Academic Press.
[4] Kulkarni S. K. 2014, *Nanotechnology: Principles and Practices,* 3rd Edition, Capital Pubishing Company.
[5] Pradeep T. 2007. *Nano The Essentials: Understanding Nanoscience and Nanotechnology*, Mc Graw Hill Education.

Discipline Specific Elective (DSE)

MICT-544 E-I, Energy and Environmental chemistry

Course Objectives: Students will be able to

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

Credits=4	Energy and Environmental chemistry	No. of hours
UNIT I	**Energy Conversion Devices**	**15**
	1.1. **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. 1.2. **Fuel Cells:** Working of Fuel Cells, Types of fuel cells, Current capabilities/uses, Fuel cell stacks and systems, Hydrogen as a fuel, 1.3. **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	**Control of Air and water pollutants**	**15**
	2.1. Method of control of air pollution 2.2. Electrostatic precipitation wet & dries scrubber, filters, 2.3. Gravity and cyclonic separation 2.4. Adsorption, absorption and condensation of gaseous effluent 2.5. Water and waste water treatment 2.6. Aerobic and anaerobic 2.7. Aeration of water 2.8. Principle of coagulation 2.9. Flocculation, softening, disinfection 2.10. Demineralization and fluoridation.	
UNIT III	**Electrochemical and spectral methods for pollutant analysis**	**15**
	3.1. Polarography: principle, instrumentation and applications 3.2. Cyclic Voltammetry, Anodic stripping voltammetry, 3.3. Amperometry 3.4. Coulometry, and conductance methods	

	3.5. Potentiometry 3.6. Ion selective electrodes 3.7. Atomic absorption spectroscopy 3.8. Atomic fluorescence spectrometry 3.9. Turbidimetry and Nephelometry 3.10. GC & HPLC.	
UNIT IV	**Monitoring, sampling and Analysis of Air and water pollutants**	**15**
	4.1. Methods of monitoring and sampling of gaseous, liquid and solid pollutants, 4.2. analysis of CO, CO_2, NO_2, SO_2 and H_2S, 4.3. analysis of toxic heavy metals, Cd, Cr, Hg, As, Pb, 4.4. Speciation Separation and analysis of Co, Cu, Mg, Mn, Fe, Al, 4.5. analysis of anions SO_4^{2-}, PO_4^{3-}, NO_3^-, NO_2^-. 4.6. Pesticide, residue analysis soil pollution, 4.7. Sources of pesticide residue in the Environment, 4.8. pesticide degradation by natural forces, 4.9. effect of pesticide residue on life, 4.10. 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. differentiate of electrochemical and spectral methods of pollutant analysis.
4. design methods of monitoring, sampling and analysis of pollutants.

Reference books:

[1] Rao C. S. 2009. *Environmental Pollution Engineering and Control,* New Age International Publisher.
[2] Sharma B. K. & Kaur H. 2000. *Environmental Pollution,* 3rd edition Pragati Prakashan.
[3] Khopkar S. M. 2012. *Environmental Pollution Analysis,* 5th edition New age publisher.
[4] Tyagi O. D. Mehre M. 2007. *A Text Book of Environmental Pollution,* Anmol Publisher.
[5] Kaur H. 2005, *Instrumental Methods of Chemical Analysis*, Pragati Prakashan.

MICT-544 E-II , Radiation Chemistry

Course Objectives: Students will be able to

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

Credits=4	Radiation Chemistry	No. of hours
UNIT I	**Isotopes and their biological effects**	**15**
	1.1. Difference between Isotopes and Isobars, isotope separation 1.2. Thermodynamic and kinetic isotope effects 1.3. Isotope exchange reaction kinetics 1.4. Determination of exchange rate constant 1.5. Production and applications of radio isotopes 1.6. **Biological effects of Radiation** 1.7. Genetic and somatic effect on human being 1.8. Effect of radiation on plants and aquatic Environment	
UNIT II	**Radiochemical Separation**	**15**
	2.1. The need of radiochemical separation techniques 2.2. Carrier techniques 2.3. Isotope and nonisotopic carriers 2.4. Coprecipitation and adsorption 2.5. Ion exchange 2.6. Solvent extraction 2.7. Electrolytes behavior of carrier free tracer radionuclide	
UNIT III	**Principle of tracer chemistry**	**15**
	3.1. Introduction to tracers, 3.2. Application of tracers in physiochemical studies, 3.3. Diffusion studies, isotopic and exchange reactions, 3.4. Tracer in the study of the mechanism of the inorganic chemical reaction, 3.5. Atom transfer and electron transfer mechanisms. 3.6. Heterogeneous catalysis and surface area measurements, 3.7. Radio carbon dating, 3.8. Tracer studies with tritium, 3.9. Application in metallurgy and preservation of food, 3.10. Geochemical application and hot atom chemistry.	
UNIT IV	**Radiation detection and measurements**	**15**
	4.1. Ionization current measurements, 4.2. Multiplicative ion collector, 4.3. Methods not based on ion collection,	

	4.4. Auxiliary Instrumentation and health physical instruments and counting statistics. 4.5. Working of Scintillation and Geiger Muller Counter.	

Course outcomes: Students should be able to

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

Reference books:

[1] Arnikar H. J. 1988. *Essentials of Nuclear Chemistry*, Wiley Eastern.
[2] Friedlander G. Kennedy J. W. Macias E. S. and Miller J. M. 2012 *Nuclear and Radiochemistry,* Wiley.
[3] Dayal D. C. 2011. *Nuclear physics,* 2nd edition Himalaya Publishing House.
[4] Harvey B. G. 2015. *Introduction to Nuclear Physics and Chemistry,* 4th edition Literary Licensing, LLC.

Credits 4	MICP 545: On Job Training (OJT)	No. of hours 120
OJT will provide the opportunities for internship with local/regional industries, business organization, health and allied areas, local government, etc. so that students may actively engaged with the employability opportunities. Students will undergo 4 credit work-based learning/OJT/internship.		

Practical Course

MICP-546: Inorganic Chemistry Practical-IV: Lab IV

Course objective: Students will be able to

1) learn about analysis of ore and alloy.
2) study different preparations of coordination complexes.
3) understand different instrumentation techniques.
4) acquire knowledge of interpretation of different spectrum.

Credits=2	**Inorganic Chemistry Practical-IV Lab IV**	**No. of hours perunit / Credit 60**
	1) Ore and alloy Analysis Bauxite Ore Fernico Alloy	15 Hr
	2) Preparation of coordination compounds Hexamminenickel (III) chloride. Aquachloroteratramminecobalt (III) chloride. SodiumHexanitrocobaltate. Tetraminecupricsulphate. Tristhiouracuprouschloride. Pentathioureadicuprousnitrate.	15 Hr
	3) Preparations of nanomaterials and characterization ZnO, Fe_2O_3	12 Hr
	4) pH Metry-2 Titration of mixture H_2SO_4 and CH_3COOH Vs NaOH pH metrically. To determine the dissociation constant of Carbonic acid by pH metrically. To determine the dissociation constant of Orthophosphoric acid pH metrically. To determine the PKa value of acetic acid pH metrically.	6 Hr
	5) Conductometry-2 To verify velocity of Onsaagar equation at low concentration for 1:1 type electrolyte conductometrically To titrate mixture of HNO_3 and H_2SO_4 or to determine the normality of HNO_3 and H_2SO_4 in mixture of given acid conductometrically.	6 Hr
	6) Spectral analysis X-ray powder diffraction analysis of compound, Determination of lattice parameters and Partial Size Calculation of band gap of semiconductors with the help of plots.	6 Hr

Course outcomes: Students should be able to

1) analyze different ore and alloy samples.
2) prepare coordination complexes.
3) enlist different instrumentation techniques.
4) describe interpretation of different spectrum

Reference books:

[1] Vogel A. I. 1980. *A text book of Quantitative Inorganic Analysis including elementary instrumental analysis*, Longman Sc & Tech.

[2] Palmer W. G. 1948. *Experimental Inorganic Chemistry.* Cambridge University Press.

[3] Kaur H. 2005, *Instrumental Methods of Chemical Analysis*, Pragati Prakashan.

[4] Raj Gurdeep 2009, *Advanced Practical Inorganic Chemistry*, Krishna Prakashan.