Savitribai Phule Pune University

(Formerly University of Pune)

Syllabus of

M.Sc. II Inorganic Chemistry

(According to NEP 2020)

for

Colleges Affiliated to Savitribai Phule Pune University

Approved by
Board of Studies in Chemistry

Implementation from Academic Year 2024 - 2025

Sr. No.	Course Name	Course Code	Major Core/ Major elective	Credits
Semester III				
1.	Organometallic and Homogeneous Catalysis	CHI-601 MJ	Major Core	4T
2.	Inorganic Reaction Mechanism	CHI-602 MJ	Major Core	4T
3.	Bioinorganic Chemistry	CHI-603 MJ	Major Core	2T
4.	Inorganic Analysis I (Volumetric and Gravimetric Analysis)	CHI-604 MJP	Major Core	2P
5.	Inorganic Analysis II (Inorganic Instrumental analysis and Interpretation of Inorganic compounds by spectral analysis)	CHI-610 MJP	Major Core	2P
6.	Inorganic Chemistry –IV Physical Methods of Inorganic Chemistry	CHI-610 (A) MJ	Major elective (Any One)	4T
	Inorganic Chemistry –IV Magneto Chemistry and Inorganic Polymers	CHI-610 (B) MJ		
7.	Research Project	CHI-631 RP	Research Project	4
Semester IV				
1.	Heterogeneous Catalysis and its applications	CHI-651MJ	Major Core	4T
2.	Solid state and Nanomaterials	CHI-652 MJ	Major Core	4T
3.	Inorganic Analysis-III (Synthesis of Nanomaterials and Inorganic Metal Complexes and Zeolites)	CHI-653 MJP	Major Core	2P
4.	Inorganic Analysis-IV (Modern Analysis techniques in Inorganic Chemistry)	CHI-654 MJP	Major Core	2P
5.	Industrial applications of Inorganic Chemistry	CHI-660 (A) MJ	Major elective (Any Two)	4T
	Inorganic Medicinal Chemistry	CHI-660 (B)MJ		
	Inorganic application of Biotechnology and	CHI-660 (C)MJ		

	Environmental Chemistry			
6.	Research Project (RP)	CHI-681 RP	Research Project	6

PROGRAM OUTCOMES (POs):

PO No.	PO Statement After completing the Programme Master of Science in Inorganic Chemistry, students will be able to	Knowledge and Skill
PO-1	Learn the terms, theories, assumptions, methods, principles, theory statements, and classification	Disciplinary knowledge
PO-2	Fixed out the problem and resolved it using theories and practical knowledge.	Critical thinking & Problem-solving
PO-3	Inculcate his knowledge for carrying projects and advanced research-related skills.	Research related skill
PO-4	Actively participate in the team on case studies and field-based situations.	Cooperation/Teamwork
PO-5	Analyse and interpret ideas, evidence, and experiences with learned scientific reasoning	Scientific reasoning
PO-6	Aware and implement the subject facts that can be applied to personal and social development	Reflective thinking
PO-7	Use digital literacy to retrieve and evaluate subject-related information	Information/Digitally literacy:
PO-8	Get moral and ethical values for society as well as in research	Moral and ethical awareness
PO-9	Give analytical reasoning to interpret research data.	Analytical Reasoning
PO-10	Improve their managerial skills and abilities in subject-related activities.	Leadership readiness/qualities
PO-11	Inculcate continuous learning habits through all available resources.	Lifelong readiness/qualities

PROGRAM SPECIFIC OUTCOMES (PSOs)

PO No.	PSO Statement After completing the Programme Master of Science in Inorganic Chemistry, students will be able to
PSO-1	Demonstrate proficiency in advanced terms, theories, principles, and techniques of chemistry through different courses, laboratory experiments, and research projects.
PSO-2	Develop a foundational understanding of research methodologies, including literature review, hypothesis formulation, experimental design, data analysis, and interpretation.
PSO-3	Acquire hands-on experience with advanced chemistry-related equipment.
PSO-4	Apply modern research techniques to investigate complex chemical phenomena and solve practical problems.
PSO-5	Demonstrate competence in quality assurance and quality control practices essential for industry.

Teaching Hours

a) Theory – Each credit of theory is equivalent to 15 teaching hours. For 1 credit of theory there will be 1 lecture of 1 hour per week. In case of theory paper consisting of sections, each section is of 2 credits and time allotted will be 30 hours teaching.

b) Practical – Each credit of practical is equivalent to 30 teaching hours. Each experiment will be allotted 5 h time.

2. Examination

Theory and practical courses carry 50 marks equivalent to 2 credits and 100 marks equivalent to 4 credits. Each course will be evaluated with Continuous Internal Evaluation (CIE) and University Assessment (UA) mechanism. Continuous Internal Evaluation shall be of 30% while university Evaluation shall be of 70%. To pass the course, a student has to secure 40% mark in CIE as well as university assessment. For CIE teacher must select variety of procedures for examination such as: i) Written test / Mid Semester test (not more than one for each course), ii) Term paper, iii) Viva-Voce, Project / survey / field visits iv) Tutorials v) Group discussion vi) Journal / Lecture / Library notes vii) Seminar presentation, viii) Short quiz ix) assignment x) research project by individual student or group of student xi) An open book test, etc. Each practical course will be extended over one semester and practical examination will be conducted at the end of every semester. The practical examination should involve one internal and two external examiners. All three examiners will evaluate the all practical courses.

Guidelines for Practicals and Project

- All experiments should be carried out on micro-scale and by considering stoichiometric quantities of reactants and reagents with the proper understanding of the mechanism.
- Post graduate departments should arrange at least **one study visit to relevant industry/national research laboratory/premier academic institute**.
- Students must read MSDS and should handle chemicals and reactions accordingly.
- The necessary reactions should be carried out in fume hood and appropriate safety measures should be taken during the laboratory experiments and projects.
- All reactions should be **monitored using alumina coated TLC plates**.

- Certified journals should be presented at the time of final examination.
- Students should choose a research project topic that aligns with their interests and career goals, but also consider its feasibility within the available resources and time frame.
- Consult with faculty members, advisors, or mentors to identify a research area that has potential for contribution to the field of chemistry.
- Students opting for the projects are encouraged to participate in AVISHKAR, national and international conferences and other project competitions.
- Teachers are encouraged to give the project ideas based on the societal needs.

Semester-III

CHI-601-MJ-Organometallic and Homogeneous Catalysis

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, student will be able to,

1. Identify organometallic complexes within coordination compounds.
2. Explain the structure and bonding principles in organometallic complexes.
3. Analyse the stability and reactivity patterns of simple organometallic complexes.
4. Evaluate modern characterization methods for organometallic compounds.
5. Apply organometallic compounds in synthesis processes.
6. Utilize organometallic compounds effectively as catalysts.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I: Organometallic Chemistry	
1	**Introduction:** **[03]** a) Recapitulation d-block metal carbonyls b) Scope of organometallic chemistry c) Valence electron Count d) 16-electron and 18-electron rule e) Effective atomic number f) Problem of counting electrons	**03**
2	**Transition block Carbonyl complexes:** a) Introduction to CO ligand b) Mode of Coordination c) Synthesis	**03**

	d) Reaction of CO e) Carbonyl Metallates	
3	**Sigma complexes:** a) Synthesis b) Bonding, properties and applications c) Hydrocarbonyl compounds	**04**
4	**Metal-Carbon multiple bonded compounds:** a) Carbene b) Carbynes	**04**
5	**Pi-complexes:** a) Introduction to Pi-complexes b) Synthesis of Alkenes di and polynes complexes	**04**
6	**Carbocyclic polyenes: $^{n}C_{n}R_{n}$:** Synthesis, bonding, properties and applications of Allyls, Cyclopentadienyls,	**04**
7	**Metal-metal bonds, Transition metal atom clusters and Carbonyl polymers**	**04**
8	**Fluxional Behaviour of organometallic compounds**	**02**
Section-II: Homogeneous Catalysis		
1	**Introduction to catalysis**: [4L] a) Basic principles b) Definition of activity & selectivity catalysis c) Homogeneous vs. Heterogeneous catalysis d) Importance of homogenous catalysis in synthesis of high value chemicals e) Importance of homogenous catalysis in synthesis of high value chemicals	**04**
2	**Catalytic reaction types with examples each:** a) Oxidative addition	**04**

	b) Reductive elimination c) Migratory insertion d) Elimination	
3	**Tollman catalytic cycles**	**02**
4	**Use of IR, NMR spectral techniques for identification of intermediates with examples**	**04**
5	**Reactions of olefins:** [10L] a) Polymerisation: Catalytic cycle for alkene Polymerisation, Metallocene catalysts-structure, special features advantages and mechanism of action. b) Oxidation and Epoxidation using homogeneous catalysis. c) C-C coupling (Cativa process, Heck, Suzuki, Negeshi reactions) d) Metathesis	**10**
6	**Asymmetric catalysis important and application**	**04**
7	**Catalyst product separation in homogeneous catalysis**	**02**

Reference Books:

1. Organ transition Metal Chemistry Anthony F. Hill, Royal Society of Chemistry, Tutorial
2. Chemistry Text, 2002.Chapters 1-7.
3. Organometallics: A concise Introduction, Ch. Elshebroicn and A. Salzer, VCH, chapters, 12-16
4. Organ Transition Metal Chemistry: Applications to Organic Synthesis, S.G. Davies, Permagaon 1982.
5. Inorganic Chemistry 3rd ed^{n} D.F. Shriver and P.W. Atkins, Oxford University Press, 1999, Chapter 16.
6. Organometallic Chemistry –R.C. Mehrotra and A. Singh, 1992, Wiley
7. Principles of Organometallic Chemistry, P. Powell, Chapman & Hall

8. Organometallic Compounds, Morries, Sijlirn, IVY Publication House
9. Organometallics in Organic Synthesis – Swan & Black
10. Organometallic Chemistry - E.J. Elias and Gupta
11. Homogeneous Catalysis - G.W.Parshall

CHI-602 MJ: Inorganic Reaction Mechanism and Photochemistry and reaction of coordinated ligands

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, student will be able to,

1. Understand mechanisms of inorganic reactions, covering substitution, addition, elimination, redox, and photochemical processes involving coordinated ligands.
2. Learn synthetic methods for the preparation of inorganic compounds and complexes.
3. Gain a deep comprehension of transition metal chemistry, including coordination complexes, ligand exchange reactions, and mechanisms.
4. Analyse experimental data and propose mechanisms for inorganic reactions based on kinetic and thermodynamic evidence.
5. Familiarize with spectroscopic and analytical techniques such as UV-Vis, NMR, IR spectroscopy, and mass spectrometry for studying reaction mechanisms.
6. Develop critical thinking skills by solving complex problems using knowledge of inorganic reaction mechanisms.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I: Inorganic Reaction Mechanism	
1	**Types of Mechanisms:** Basic concepts as stability and liability, stability constants; HSAB principle, chelate effect, Classification of inorganic reactions, Intimate and stoichiometric mechanism of ligand substitution.	**06**
2	**Ligand Substitution reactions:** ligand substitution. Substitution Reactions in Four- and Five-Coordinate Complexes Substitution in Td and square planar complexes: Trans effect, trans effect series, Theories, applications of trans effect. Factors influencing on substitution and stereochemistry	**04**

3	**Substitution in octahedral complexes:** S_N1, S_N2, S_N1CB mechanisms, steric effects on substitutions, Factors influencing substitution Isomerization and racemization in coordination compounds.	**08**
4	**Redox Reactions:** Electron Transfer reactions: Potential energy diagrams as a conceptual tool, Marcus equation, Types Electron Transfer reactions and factors affecting electron transfer reactions.	**08**
5	Inner and Outer sphere reactions, excited state outer sphere reactions & their applications	**04**
Section-II: Photochemistry and reaction of coordinated ligands		
1	**Photochemistry of metal complexes:** Photochemical reactions, Basic terminologies, Prompt and delayed reactions, quantum yield, recapitulation of fluorescence & phosphorescence, photochemical reactions irradiating at d-d and CT band Transitions in metal-metal bonded systems, photochemical reactions in Co (III), Cr(III), Rh(III) and Ru(II) complexes	**10**
2	**Reactions of coordinated ligand:** Non-chelate forming reactions Reaction of donor atoms (Halogenation of coordinated N atoms, Alkylation of coordinated S and N atoms, Solvolysis of coordinated phosphorus atoms). Reactions of non-donor atoms (nucleophilic behaviour of the ligand, electrophilic behaviour of the ligand). Chelate ring forming reactions: (reactions predominantly involving thermodynamic template effects, reactions predominantly involving kinetic effects).Chelate modifying reactions	**10**
3	**Reaction mechanisms of organometallic systems:** Ligand Substitution reactions, Oxidative addition reactions, Reductive elimination reactions, Methyl migration and CO insertion reactions, Reactions of alkenes	**10**

Reference Books:

1. Mechanism of Inorganic Reactions- C.F. Basselo, R.G. Pearson, Wiley,

2. Mechanism of Inorganic Reactions in Solution – An Introduction", D. Benson, McGraw–Hill Chapter 15, p.465, 1968.
3. Robert W. Hay, Reaction Mechanisms of Metal Complexes, Harwood Publishing Series in Chemical Science, Chichester, 2000, ISBN9781782420637.
4. Martin L. Tobe and John Burgess, Inorganic Reaction Mechanisms, Addison Wesley Longman Inc., 1999, ISBN-10: 0-85186-275-6
5. R. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems 3rd Edition, Oxford University Press 2007, Chapter 5, ISBN: 9780195301007
6. Inorganic Chemistry – D.F. Shriver, P.W. Atkins, C.H. Langford – Oxford, 2nd Edition, 1994.
7. "Inorganic Chemistry – Principles of Structure and Reactivity", J. E. Huheey, E. A. Keiter and R. L. Keiter, 4th edition. Harper Collins College Publ. New York, Chapt.13, p.537-76, 1993.
8. Inorganic Chemistry - Messler and Tarr - Pearson Publishers

CHI-603 MJ: Bioinorganic Chemistry

Course type: Major Core (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to,

1. Define metalloprotein and metalloenzymes, and explain the role of metals and ligands in biological systems.
2. Describe the role and structure of Zinc in Zinc Finger proteins, as well as different types of Zinc hydrolases and their functions.
3. Identify various types of Copper proteins, their structures, and functions, including model compounds of Blue and Non-Blue Proteins, oxidases, and superoxide dismutase (SOD).
4. Explain the function and structure of vitamin B12 coenzymes, detailing the actions of Cobalamines as coenzymes, such as Ribonucleotide reductase, and the significance of Methylcobalamin as a cofactor.
5. Discuss the function and structure of Fe-Mo cofactors and antagonism between Cu and Mo.
6. Apply the knowledge of metalloproteins, metalloenzymes, and cofactors to propose potential applications.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Introduction to Bioinorganic Chemistry:** Recapitulation of Biological roles of Metals and ligands Structure, function and biochemistry of enzymes containing the following metals: Zn, Cu, Co, Mn, Fe and Mo.	04
2	**Bioinorganic Chemistry of Metals:** **a. Zinc** Zinc Fingers, Carboxypeptidase, Carbonic anhydrase	04
	b. Copper:	06

	Type I, Type II, Type III, Blue Proteins Azurins, Plastocynins & Blue Oxidases, Model compounds of Blue copper proteins, Non-Blue Proteins Eg. Tyrosinase, Galactose oxidase, SOD	
	c. Cobalt: **[6L]** Vitamin B_{12} coenzymes & model compounds, Actions of Cobalamines, Adenosylcobalamine as a coenzyme, Ribonucleotide reductase, Methylcobalamine as cofactor	**06**
	d. Molybdenum: Mo-cofactors, xanthine oxidase, Antagonism between Cu & Mo, Hydroxylase	**04**
	i. Manganese	**03**
	j. Non-heme Iron	**03**

Reference Books:

1. Bioinorganic Chemistry: A Short Course Rosette M. Malone Wiley Interscience, 2002.
2. Biological Inorganic Chemistry-An Introduction, Robert Crichton, Elsevier Science, 2007.
3. The Biological Chemistry of the Elements:The Inorganic Chemistry of Life–J. J. R.

a. Fraustoda Silva and R. J. P. Williams. Clarendron Press, Oxford, 1991.

4. Bioinorganic Chemistry: Inorganic elements in the Chemistry of life., An Introduction and Guide-Wolfgang Kaim, Brigille Schwedrski John Wiley and sons, 1994.
5. Principles of Bioinorganic Chemistry – S.J. Lippard and J.M. Berg, University Science Books, 1994.
6. The Biological Chemistry of the Elements: The Inorganic Chemistry of Life– Silva, J.J. R. Fraustoda and R. J. P. Williams; 2nd Ed. Oxford University Press, 2012.

CHI-604 MJP: Inorganic Analysis I

[Volumetric and Gravimetric Analysis]

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to,

1. Understand fundamental analytical techniques such as volumetric and gravimetric analysis, displaying knowledge of key principles in quantitative analysis.
2. Comprehend concise techniques for metal estimation, showcasing a deep understanding of efficient methods for elemental analysis.
3. Analyse commercial samples like alloys, ores, and cement to precisely estimate the specific percentage of elements, demonstrating advanced analytical skills.
4. Apply volumetric analysis to determine the percentage of unknown and known solutions, demonstrating practical application of theoretical concepts.
5. Explain the sequential steps of gravimetric analysis, exhibiting a clear comprehension of the process involved in quantitative analysis.
6. Utilize gravimetric analytical techniques to calculate the percentage of unknown compounds, synthesizing analytical methods to solve complex problems.

Course Content

Inorganic Analysis I: [Volumetric and Gravimetric Analysis] **Any Twelve**

1. Stainless steel Alloy. [e.g. iron, chromium and nickel]
2. Ilmenite Ore [e.g. acid-insoluble matter (combined oxides), iron and titanium]
3. Analysis of Portland cement
4. Gravimetric Estimation of Si and Ca from Plaster of Paris sample
5. Pigment [e.g. Chromium from Zinc chrome] analysis
6. Estimation of Magnesium from tablet of Milk of magnesia
7. Estimation of calcium from calcium supplementary tablet
8. Estimation of Iron and Zinc from iron-zinc supplementary

a. (Multivitamin Tablet)

9. Consumer products: Estimation of Aluminium from alum sample
10. Estimation of Mn volumetrically from Tea leaves
11. Estimation of Cu and Ca from Bordeaux mixture
12. Estimation of Vitamin C from Lemon juice
13. Estimation of Phosphate from Fertilizer sample
14. Estimation of Total Hardness of Boring water
15. Estimation of Chemical oxygen demand (COD) from sewage/effluent sample

CHI-605 MJ: Inorganic Analysis II

[Inorganic Instrumental analysis and Interpretation of Inorganic compounds by spectral analysis]

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to,

1. Understand the magnetic properties of prepared complexes using the Magnetic susceptibility technique, distinguishing between paramagnetic, diamagnetic, and ferromagnetic behaviours.
2. Comprehend the basic mechanism of photocatalytic reactions, including degradation processes and the role of nanoparticle catalysts in environmental clean-up.
3. Interpret IR, ESR, XRD, CV, and NMR spectra of compounds through Table work study techniques, enabling structural investigation and analysis - Analysis.
4. Apply Kinetics of Aquation to determine reaction rate, order, and mechanism, aiding comprehension of reaction kinetics.
5. Gain insight into Metal-DNA interaction mechanisms using a spectrophotometer, understanding the basics of molecular interactions.
6. Investigate fragments responsible for weight loss and water molecule loss in Thermo gravimetric analysis, while studying the thermal stability of fabricated complexes.

Course Content

Part A: Inorganic Instrumental analysis (Any Six)

1. Magnetic Susceptibility - Two samples
2. Thermogravimetric studies - Two samples
3. Catalytic hydrogenation Kinetics of Aquation/Isomerisation - Two experiments
4. Photochemical reactions using Nanoparticles: any Two Metal oxide as catalysts
5. Metal DNA interactions (Viscosity and spectrophotometry)
6. Synthetic Copper Oxidase (Copper catalyzed oxidation of 2,6, disubstituted Phenols)
7. Cyclic Voltammetric study of i) Potassium ferricyanide ii) Ferrocene

Part B : Interpretation of Inorganic compounds by spectral analysis (Any Six)

1. Interpretation of IR spectrum of Inorganic compounds (Any Two Spectra)
2. Interpretation of ESR spectrum of Inorganic compounds (Any Two Spectra)
3. Interpretation of XRD spectrum of Inorganic compounds (Any Two Spectra)
4. Interpretation of CV spectrum of Inorganic compounds (Any Two Spectra)
5. Interpretation of NMR (19F, 31P) spectrum of Inorganic compounds (Any Two Spectra)
6. Interpretation of XPS spectrum of Inorganic compounds (Any Two Spectra)
7. Interpretation of UV-RDS spectrum of Inorganic compounds (Any Two Spectra)
8. Interpretation of DTA spectrum of Inorganic compounds (Any Two Spectra)
9. Interpretation of TGA spectrum of Inorganic compounds (Any Two Spectra)

CHI-610 (A) MJ: Physical methods in Inorganic Chemistry

Course type: Major Elective (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, student will be able to,

1. Recall and recognize various physical methods used in inorganic chemistry, such as spectroscopy techniques such as UV-DRS, NMR, EPR), X-ray crystallography, electron microscopy, and thermal analysis techniques.
2. Comprehend the principles behind interpreting spectra obtained from various techniques to determine structural and electronic properties of inorganic compounds.
3. Apply different physical methods to solve chemical problems, such as determining molecular structures, elucidating reaction mechanisms, and characterizing materials.
4. Develop skills in quantitative analysis using physical methods, including calibration, data processing, and error analysis.
5. Enhance critical thinking skills and the ability to solve complex chemical problems using physical methods through hands-on experience and theoretical discussions.
6. Understand the theoretical principles underlying each physical method and how they relate to the properties of inorganic compounds, fostering integration with theory.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I: Thermal and Spectroscopic techniques	
1	**Thermal techniques:** Principal, instrumentation, working and applications of following techniques: 1. TGA 2. DTA 3. DSC 4. TPD study	**12**
2	**Spectroscopic techniques:** Principal, instrumentation, working and applications of following spectroscopic techniques: 1. X-Ray diffraction	**18**

	2. NMR 3. ESR 4. FT-IR 5. Fluorescence **[18]**	
Section-II: Material Characterization techniques and analytical techniques		
1	**Material Characterization techniques:** Principal, instrumentation, working and applications of following techniques: 1. SEM and EDX 2. TEM 3. XPS 4. UV DRS 5. BET	**22**
2	**Analytical techniques:** Principal, instrumentation, working and applications of following techniques: 1. Cyclic voltammetry 2. Flame Photometer	**05**

Reference Books:

1. S. Butler and J. F. Harrod, Inorganic Chemistry – Principles and Applications, The Benjamin/Cummings Publishing Co., Inc., Redwood City, California (USA) (1989)
2. Ranald D. Archer, Inorganic and organometallic polymers, A John Wiley and Sons, Inc. publication (USA) 2001
3. N. H. Ray, Inorganic Polymers, Academic Press (1978).

CHI-610 (B) MJ: Magneto-chemistry and Inorganic Polymers

Course type: Major Elective (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, student will be able to,

1. Recognize the fundamentals of magnetic properties, including types, susceptibility, anisotropy, and experimental methods like the Gouy method, Faraday method, Evans method, and SQUID.
2. Grasp the practical application of the Van-Vleck susceptibility equation in analysing magnetic phenomena.
3. Utilize knowledge of magnetic properties to comprehend the behavior of transition metal complexes, encompassing concepts like low spin, high-spin crossover, and the magnetic characteristics of lanthanides and actinides.
4. Examine and assess anomalous magnetic moments within different symmetrical environments found in coordination complexes.
5. Assess the comprehension of magnetic properties concerning transition metal monoxides and halide salts.
6. Synthesize an understanding of soft and hard ferrites, as well as the real-world applications of magnetic materials, fostering the capacity for practical utilization.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I: Magneto-chemistry	
1	**Introduction:** Definition of magnetic properties and types of magnetic substances, magnetic susceptibility, anisotropy in magnetic susceptibility, experimental arrangements for determination of magnetic susceptibility: Gouy method, Faraday method, Evans method, SQUID.	**04**

2	**Paramagnetic Susceptibility:** Simplification and application of Van-Vleck susceptibility equation, temperature independent paramagnetism [4]	**04**
3	**Magnetic properties:** Magnetic properties of transition metal complexes in cubic and axially symmetric crystal fields, low spin, high-spin crossover, magnetic behavior of lanthanides and actinides, magnetic exchange interactions. **[6]**	**06**
4	**Anti-ferromagnetism:** Transition metal monoxides and halide salts of transition metals, ferrimagnetism (ferrites), magnetic anisotropy.	**04**
5	**Anomalous magnetic moments:** Anomalous magnetic moments in magnetically dilute and concentrated systems in various symmetrical environments of coordination complexes. Study of mixed valence compounds, their magnetic behavior	**06**
6	**Magnetic materials:** Soft and hard ferrites, i.e. structure and magnetic interactions in spinels, garnets, hexagonal ferrites. Application of magnetic materials, Molecular magnets, Single chain magnet, Photoinduced magnetism, Spin canting, Magnetic ordering.	**06**

Reference Books:

1. Elements of Magnetochemistry, 2nd Edn., R. L. Datta and A. Syamal (1993) Affiliation, East-Wiley Press (p) Ltd.
2. Introduction to Magnetochemistry, A. Earnshaw, Academic Press, (1968).
3. Magnetism and Transition Metal Complexes, F. E. Mabbs and D. J.
4. Machin (1973) Chapman and Hall, London.

Section-II: Inorganic Polymers

1	**Inorganic Polymers:** Overview and classification of polymers. Coordination Polymers: Homopolar and heteropolar inorganic polymers.Polyphosphazenes, Polysilanes, Polysiloxanes, Boron Polymers, Borazines, Phosphorous based polymer, polymeric compounds of sulphur, polythiazoles, silicates with reference to preparation, properties, structures, bonding and applications.	**12**

2	**Natural polymers:** Natural polymers and reactions yield coordination polymers. Synthesis of coordination polymers.	**04**
3	**Pre-ceramic Inorganic polymers:** Silicon carbide, Boron nitride, Aluminium nitride, Phosphorus nitride.	**05**
4	**Applications of Inorganic Polymers:** Metal containing polymer for medical purposes, Inorganic polymers as catalysts, Luminescent Inorganic polymers.	**08**

Reference Books:

1. S. Butler and J. F. Harrod, Inorganic Chemistry – Principles and Applications, The Benjamin/Cummings Publishing Co., Inc., Redwood City, California (USA) 1989 Chapter 15 to 17, pp 441-503.
2. Ranald D. Archer, Inorganic and organometallic polymers, A John Wiley and Sons, Inc. publication (USA) 2001
3. N. H. Ray, Inorganic Polymers, Academic Press 1978.

CHI-631 RP Research Project

Course type: Research Project **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to -

1. understand key concepts and principles relevant to the research topic.
2. learn diverse research methodologies proficiently.
3. write and communicate research findings persuasively through various mediums in the form of project report
4. analyze and synthesize scholarly literature effectively.
5. evaluate research findings and methodologies critically.
6. design and execute original research projects independently.

Following guidelines should be followed for the conduction and evaluation of research project.

- Each student will perform project separately.
- Project working hours should be 30 hours for each credit.
- Choose a topic that aligns with your interests and career goals, but also consider its feasibility within the available resources and time frame.
- Consult with faculty members, advisors, or mentors to identify a research area that has potential for contribution to the field of chemistry.
- Adhere to ethical principles and standards in all aspects of your research.
- Project report must be written systematically and presented in bound form: The project will consist of name page, certificate, content, summary of project followed by introduction, literature survey (recently published research papers must be included), experimental techniques, results and discussion, conclusions, Appendix consisting of i) references, ii) standard spectra / data if any and iii) safety precautions.
- If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. Systematic record of attendance of project students must be maintained by a mentor.

- Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.
- Students are encouraged to participate in national and international conferences and other project competitions.
- For conducting research study in M.Sc. Chemistry, it is highly recommended to follow the journals given below or any other journal from reputed publication.

1. **Journal of the American Chemical Society (JACS)**

   Publisher: American Chemical Society (ACS)

   Focus: Comprehensive coverage of all fields of chemistry, known for high-impact research.

2. **Angewandte Chemie International Edition**

   Publisher: Wiley-VCH on behalf of the German Chemical Society (GDCh)

   Focus: Broad coverage of all chemistry fields, emphasizing novel and significant research.

3. **Chemical Science**

   Publisher: Royal Society of Chemistry (RSC)

   Focus: Cutting-edge research across chemical sciences, open access.

4. **Nature Chemistry**

   Publisher: Nature Publishing Group

   Focus: Multidisciplinary and high-impact research across all areas of chemistry.

5. **Journal of Organic Chemistry (JOC)**

   Publisher: American Chemical Society (ACS)

   Focus: Specialized in organic chemistry, including synthesis and mechanisms.

6. **Inorganic Chemistry**

   Publisher: American Chemical Society (ACS)

   Focus: Research on inorganic and organometallic compounds.

7. **Analytical Chemistry**

Publisher: American Chemical Society (ACS)

Focus: Developments and applications in analytical techniques and methodologies.

8. **Physical Chemistry Chemical Physics (PCCP)**

   Publisher: Royal Society of Chemistry (RSC)

   Focus: Physical chemistry, chemical physics, and biophysical chemistry.

9. **Chemical Communications (ChemComm)**

   Publisher: Royal Society of Chemistry (RSC)

   Focus: Rapid publication of high-quality communications across all chemical sciences.

10. **Accounts of Chemical Research**

    Publisher: American Chemical Society (ACS)

    Focus: Comprehensive reviews and accounts of current research topics in chemistry.

11. **Chemical Society Reviews**

    Publisher: Royal Society of Chemistry (RSC)

    Focus: The journal publishes high-quality, authoritative, and state-of-the-art reviews across all areas of chemical science. It covers comprehensive and critical reviews on a broad range of topics in chemistry, including emerging and interdisciplinary fields.

Semester-IV

CHI-651-MJ: Heterogeneous Catalysis and its Application

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, student will be able to,

1. Define catalysts and their significance in chemical reactions.
2. Describe the differences between homogeneous and heterogeneous catalysis, including the role of organometallics.
3. Identify techniques used for characterizing heterogeneous catalysts, such as surface area analysis and spectroscopy.
4. Explain methods for preparing and modifying heterogeneous catalysts, such as impregnation and surface functionalization.
5. Analyse mechanisms of catalyst deactivation and evaluate strategies for regeneration.
6. Explore industrial applications of heterogeneous catalysis, including petroleum refining and environmental remediation.

Course Outcomes

Chapter No.	Title with Contents	No. of hours
	Section-I: Heterogeneous Catalysis	
1	**Introduction:** Principles of Heterogeneous Catalysis. a. Development of industrial heterogeneous catalysis, Important milestones. b. Quantitative aspects of adsorption /absorption on solid surfaces. c. Basic adsorption isotherms and their applications. d. Classification of heterogeneous catalysts: Metals, Bimetals, metal oxides supported metal catalysts.	**08**

	e. Factors Influencing Catalytic Action: Promoters and Poisons, Deactivation and Regeneration of catalyst	
2	**Preparation methods of Solid Catalysts:** Precipitation and co-precipitation, impregnation, a. High temperature fusion and alloy leaching b. Hydrothermal synthesis, vacuum pore impregnation, impregnation of porous support **c.** Post synthetic treatment: Drying, calcinations, activation and forming	**04**
3	**Characterization of Solid Catalysts:** a. BET surface area b. Temperature programmed techniques (TPD, TPR, TPS, TPO)	**08**
4	**Chemistry of Zeolites:** a. General Introduction, Nomenclature and classification of zeolites b. Hydrothermal synthesis Zeolite (eg. ZSM-5) and factors influencing zeolite synthesis. c. Zeolite framework structure and selected zeolite framework type such as Sodalite, LTA, FAU, MFI (ZSM-5),MEL(ZSM-11), BEA (zeolite beta). d. Zeolite characterization by powder XRD method.	**10**
Section-II: Applications of Heterogeneous catalysis		
1	**Application of Zeolites in catalysis:** a. Hydrocracking b. Shape selective catalysis c. Hydrogen transfer d. Catalytic reforming	**06**
2	**Catalyst used in industrial synthesis process:** a. The Fischer–Tropsch (FT) Synthesis Process b. Water Gas Shift Reaction c. Methanol Synthesis d. Alkylation of Aromatics e. Selective Hydrogenation of Hydrocarbons	**14**

	f. Semiconducting oxides w.r.t. Titanium Oxide as Photocatalysts g. Use of $BiMoO_4$ as Oxidation and Ammoxidation catalysts	
3	**Different heterogeneous catalyst for their application:** a. Conversion of biomass on solid catalysts b. MCM-41 as a catalyst c. Clays and Intercalated clays as catalyst	**06**
4	**Catalysis in Environmental Protection:** Automotive Exhaust catalysts: The catalytic converter, Perovskite and related oxides as Catalysts.	**04**

Reference Books:

1. Handbook of Heterogeneous Catalysis: Wiley International Wiley-VCH Verlag GmbH & Co. KGaA, 2008 .
2. Catalysis: Concepts and Green Applications: Gadi Rothenberg, WileyVCH; First edition, 2015 .
3. Heterogeneous catalysis by B.Viswanathan and D. K.Chakrabarty , New Age International Private Limited, 2007.
4. Heterogeneous Catalysis for the Synthetic Chemist By Robert L. Augustine, Marcel Dekker Inc.New York,1996.
5. Gerard, V. S.; Ferenc, N. Heterogeneous Catalysis in Organic Chemistry; Academic Press; New York. First edition, 2006.

CHI-652MJ: Solid State Chemistry and Nanomaterials

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to,

1. Define defects and categorize them into different types.
2. Identify various types of magnetic materials, describe their properties, and explain their applications.
3. Explain the phenomenon of superconductivity and discuss its practical uses.
4. Differentiate between biomaterials and ceramic materials, and analyse their respective applications.
5. Describe cementations materials and outline their practical applications.
6. Discuss the principles of nanomaterial and nanotechnology, and explore their diverse applications.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I: Solid State Chemistry	
1	**Crystal defects and Non-stoichiometry:** Diffusion in solids, phase transformation in solids, solid state reactions and crystal growth. Preparation methods of solids.	**02**
2	**Magnetic Materials:** Atomic magnetism and solids, type of magnetic materials, exchange interactions, hysteresis loop and their classification, calculation of magnetic moment from saturation magnetisation, magnetic domains, examples of magnetic materials, soft and hard ferrites, structure and magnetic interactions in spinel, garnet hexagonal ferrites, application of magnetic materials	**06**
3	**Superconducting materials:**	**06**

	Definition, superconductivity, critical temperature, critical field, BCS theory, properties and classification of superconductors, high Tc superconductors, examples with structure and applications, fullerenes, intermetallic superconductors, synthesis, applications	
4	**Ceramic Materials:** Classification of ceramics, dielectric properties and polarization properties of ceramics, piezo-, pyro- and ferro-electric effect of ceramics, sol-gel processing of ceramics. Examples and application of ceramics: oxides, carbides, borides, nitrides.	**05**
5	**Composite Materials:** Definition, glass transition temperature, fibers for reinforced plastic composite materials (i.e. glass fibers, carbon fibres, and aramid fibers); concrets and asphalt materials. Application of composite material	**05**
6	**Cementitious Materials:** Difference between Blended and Non-Portland cements; Non-portland cements; high alumina cements, calcium sulfoaluminate cements, phosphate cements.Chemicals in cement hydration; hydration process, set retarders and accelerators, plasticizers, slip-casting processing. Application of cementitious materials.	**06**
7	**Bio-materials:** Definition of biomaterials and biocompatibility;, Type of bio-materials: Metallic materials, Biopolymeric materials, Bioceramic materials (dense hydroxyapatite ceramics, bioactive glasses, and bioactive composites); Application of Biomaterials	**02**

Reference books:

1. Solid state Chemistry: An Introduction – L.E. Smart & E.A. Moore, CRC, Taylor &
2. Materials Science and Engineering – V. Raghavan, 2nd Edn.
3. Introduction to Solids – L.V. Azarroff, 2nd Edn. 1980
4. Elements of materials science and engineering – Van Vleck, 5th Edn.
5. Insight to Speciality Inorganic Chemicals – D. Thompson, Royal Society of Chemistry, 1995.

Section-II: Nanomaterials		
1	**Nanoscience and Nanotechnology:** a. Introduction to nanoscience and nanotechnology b. Natural and artificial nanoparticles c. Ancient Nanotechnology d. Stalwarts of nanotechnology- Feynman, Drexler and Taniguchi e. Moore's law f. asics of nano-photonics	**04**
2	**Synthetic methods of nanomaterials:** **[6L]** Physical and Chemical methods for synthesis of nanomaterials	**06**
3	**Effects of making into small:** i. Size dependence of material properties ii. Special properties a. Structural properties b. Thermal properties c. Chemical properties d. Mechanical properties e. Magnetic properties f. Optical properties g. Electronic properties h. iological properties	**06**
4	**Classification of nanotechnology:** i. Classification of nanomaterials ii. Classification of Nanotechnology a. Wet nanotechnology b. Dry nanotechnology c. Computational nanotechnology iii. Concept of 0 D,1 D, 2 D and 3 D nanostructures.	**06**

5	**Applications of nanomaterials:** a. Carbon nanomaterials b. Nanocomposites include metal nanomaterials such as single particles as well as core shell nanomaterials. c. Polymer Nanotechnology d. Organic Electronics e. Nanotribology f. anobiotechnology	**06**

Reference books:

1. The Chemistry of Nanomaterials edited by C.N.R.Rao, A.Muller, A.K.Cheetham Wiley-VCH Verlag GmbH & co. Volumes 1&2.
2. Nanomaterials by Dr. Sulbha Kulkarni.
3. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012
4. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2008
5. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano.

CHI-653 MJP: Inorganic Analysis-III

Synthesis of Nanomaterials, Inorganic Metal Complexes and Zeolites

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to,

1. Describe the techniques used for synthesizing nanomaterials and solid-state materials, such as co-precipitation, sol-gel, and hydrothermal methods.
2. Analyze the structural investigations of solid-state materials to understand their applicability as catalysts.
3. Explain important concepts like precipitation and aging in the context of material synthesis.
4. Understand research-based fabrication techniques for materials, including sol-gel and hydrothermal methods.
5. Discuss green synthesis methods for nanomaterials and their significance.
6. Apply knowledge of complex synthesis, stoichiometric ratios, and M-L ratios to understand material fabrication challenges.

Course Content

Part I: Synthesis of Nanomaterials [Any Six]

1. Synthesis of Zinc oxide (ZnO) nanomaterial by Co-precipitation method
2. Synthesis of Nickel oxide (NiO) nanomaterial by Hydrothermal method
3. Synthesis of Bismuth oxide (Bi_2O_3) nanomaterial by Sol-gel method
4. Synthesis of Silver nanoparticles by Green synthesis method using plant extract
5. Synthesis of Nickel Ferrite materials
6. Synthesis of Ferroso-ferric oxide (Fe_3O_4) by Co-precipitation method
7. Synthesis of Cobalt oxide (Co_3O_4) nanomaterial by Hydrothermal method
8. Synthesis of Lanthanum Ferric Oxide ($LaFeO_3$) nanomaterial by Sol-gel method
9. Synthesis of Cerium Oxide (CeO_2) by Green synthesis method using plant extract
10. Synthesis of Titanium Oxide (TiO_2) by Co-precipitation method

Part II: Synthesis of Inorganic Metal complexes and Zeolites [Any Six)

1. Trans-dichloro-bis(ethylene diamine) Cobalt (III) chloride
2. $Mn(acac)_3$
3. $Hg[Co(SCN)_4]$
4. $Cu(o\text{-}phen)_2$
5. Hexa thiocyanato chromate
6. Tris- triphenylphosphine Nickel (II) sulphate.
7. Chloroaquo tetraamino cobaltic sulphate.
8. $Fe(DTC)_3$
9. Synthesis of ZSM-5 (Zeolite) by Hydrothermal or Co-precipitation method
10. Synthesis of MCM-41(Mesoporous material) by Hydrothermal or Co-precipitation method

CHI-654 MJP: Inorganic Analysis-IV

[Modern Analysis Techniques in Inorganic Chemistry]

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to,

1. Describe various modern analysis techniques to comprehend their principles and applications.
2. Explain instrumentation-based analysis methods to understand their role in analytical chemistry.
3. Analyse sophisticated instrumentation techniques like spectrophotometry and flame photometry to understand their mechanisms.
4. Apply knowledge of polymer-based resin separation techniques to understand the process of mixture separation.
5. Evaluate the kinetics of reactions to understand the rate and mechanism of chemical transformations.
6. Interpret the analysis of heavy metals using Atomic Absorption Spectroscopy (AAS) to understand its principles and applications.

Course Content

Modern Analysis techniques in Inorganic Chemistry [Any Twelve]

1. Photometric Titrations Cu Vs. EDTA, Fe Vs. EDTA using salicylic acid.
2. Photochemistry of ferrioxalate a) Preparation b) Photochemistry
3. Preparation of complex and Kinetics by conductometry
4. Preparation of complex and Kinetics by spectrophotometry
5. To study metal-DNA interaction spectrophotometrically
6. Flame photometry: determination of the percentage of sodium, Lithium, Potassium, Magnesium and calcium in the water sample
7. Determination of phosphate in detergent by spectrophotometry
8. Atomic absorption spectrophotometer (AAS): Demonstration and determination of amount of iron from tap water sample

9. Ion exchange chromatography [separation and estimation of mixture of zinc (II) and magnesium (II)]
10. Determination of Residual pesticide of fruit/Vegetable sample by GCMS analysis
11. Table work report: Literature survey and Plagiarism study of given topic
12. Preparation and Purity of complex with DMG [Any two Transition metals: Cu, Ni, Fe, Cr and Mn]
13. Preparation and Purity of complex with 8-hydroxyquinoline [Any two Transition metals: Cu, Ni, Fe ,Cr and Mn]
14. Preparation and Purity of complex with Thiourea [Any two Transition metals: Cu, Ni, Fe, Cr and Mn]

CHI-660 (A) MJ : Industrial applications of Inorganic Chemistry

Course type: Major Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to,

1. Describe corrosion inhibition principles and their practical applications.
2. Analyze industrial gas separation techniques and their uses.
3. Evaluate properties and handling of chemical explosives and propellants.
4. Discuss metal finishing processes and their environmental impacts.
5. Assess safety measures in chemical industries for hazard control.
6. Explain the principles of green chemistry and its significance in sustainability.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Inorganic Chemicals as metallic Corrosion Inhibitors:** Introduction, Principles of corrosion inhibitors, corrosion as an electrochemical process, Practical aspects of corrosion inhibition, Anion inhibitor properties in neutral electrolytes, some application of corrosion inhibitors (cooling water circulation-once through and open systems, engine radiation & cooling systems, central heating system, refrigeration plants and high chloride systems, water for steam raising, corrosion inhibitors for paint coating).	06
2	**Industrial gases:** Introduction, Separation of gases from air, Hydrogen, Carbon dioxide, Carbon monoxide, Oxygen, Acetylene, Sulphur dioxide, Nitrous oxides.	04
3	**Chemical explosives and propellants:** Introduction, Potential energy of explosives , Properties of explosives, Manufacture of explosives, Explosives made by nitration, Dynamite, Commercial high explosives containing no nitroglycerine,	06

	Initiating devices, Sporting and military explosives , Disruptive explosives for military use, Handling and storage of explosives.	
4	**Metal finishing technology:** Fundamental considerations, Electrodepositions of Copper, Nickel, Gold, Silver, Tin and Tin alloys for Lead free solder, Electrodeposition of Chromium, Electrodeposition of semiconductors, Electrodeposition deposition of Copper and Nickel, Environmental aspects of electrodeposition, Ionic Liquid treatments for enhanced corrosion resistance of Magnesium based substrates.	**04**
5	**Safety consideration in chemical process industries:** Introduction, Concern for chemical safety, Hazards and their control in petrochemical industries, Hazards and their control in petroleum refineries and LPG boiling plants, Hazards in storage, Handling and use of chemicals, Chemical storage- safety issues, Observations related to safety aspects, Specific recommendation for hazard control and improved plant safety, Chemical plant safety- from concept to decommissioning.	**06**
6	**Green Chemistry:** Introduction, Designing a Green synthesis, Basic Principles of Green Chemistry, Green Chemistry in Day-to- Day life, Green Chemistry in sustainable development.	**4**

Reference Books:

1. Handbook of Industrial Chemistry,Vol.1, by K.H.Davis,F.S.Berner, Edited by S.C. Bhatia (CBS Publishers, Bangalore,2004.
2. Industrial inorganic chemistry, Karl Heinz Buchel, Hans-Heinrich Moretto, Peter woditsch
3. Modern Electroplating , By M. Schlesinger and M. Paunovic (John Wiley and sons, Hoboken , New Jersey, 5th Edition 2010.
4. Insight into Specialty Inorganic Chemicals-David Thompson (The Royal Society of Chemistry,1995)- Chapter 15.
5. New Trends in Green Chemistry (2nd Edition)-V.K.Ahluwalia and M.Kidwai (Anamaya Publishers, 2007.

CHI-660 (B) MJ: Inorganic Medicinal Chemistry

Course type: Major Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to,

1. Understand metal ions' roles in disease and how chelating agents, metalloproteins, and metal-based drugs can modulate them.
2. Analyse how cisplatin-based anticancer agents work clinically, including their DNA interactions and resistance mechanisms.
3. Evaluate transition metal complexes' interaction with DNA as potential chemical nucleases, focusing on their activity and reactions.
4. Discuss lithium's biomedical uses, covering its chemistry, distribution, isotopic studies, and biochemistry for therapeutic understanding.
5. Examine bismuth's medicinal properties, including compounds, biomolecule binding, and enzyme inhibition, for medical comprehension.
6. Investigate gold complexes' anti-arthritic, anti-tumor, and anti-HIV activities, including their chemistry, biochemistry, and pharmacology for therapeutic insights.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Overview:** Introduction, Metal Ions in Disease, Use of chelating agents, Metalloproteins as Drug Targets, Matrix Metallopreteinases, Modulation of Cellular responses by Metal-Containing, Drugs Metal-Based Chemotherapeutic, Drugs Metal Complexes as Diagnostic Agents.	02
2	**Cisplatin-based Anticancer Agents:** Introduction, Clinical Properties, Cisplatin carboplatin, Iproplatin, Determination of Platinum Drug Levels and Pharmacokinetics, Platinum Chemistry Mechanism of Action, Structure-Specific Damage-Recognition Proteins, Mechanisms of Resistance to	04

	Cisplatin/Carboplatin, Circumvention of Tumor Resistance to Cisplatin, Development of New Platinum Drugs, Dose Intensification of Cisplatin/Carboplatin, Modulation of Platinum Resistance Mechanisms, Dinuclear and Trinuclear Platinum Complexes as Anticancer Agents.	
3	**Transition Metal Complexes as Chemical Nucleases:** Interaction of Metal Complexes with DNA, Reactions of Metal Complexes with DNA, Nuclease activity of $[Cu(phen)_2]^+$	**04**
4	**Biomedical Uses of Lithium:** Chemistry of Lithium, Distribution of Lithium in the body and in Cells, Studies using Lithium isotopes, Biochemistry of Lithium	**03**
5	**Bismuth in Medicine:** The Chemistry of Bismuth, Properties of the element, Bi(III) Compounds, Bi(V) Compounds Bismuth in Medicine, Helicobacter Pylori bacterium, Methods for the study of Bi, Bismuth Citrate Complexes, Bismuth Complexes with Biomolecules, Bismuth binding to oxygen-containing molecules, Bismuth Complexes with thiolate ligands, Bismuth(III) complexes with Metallothionein and Transferrin, Enzyme Inhibition	**04**
6	**Gold Complexes with Anti-arthritic, anti-tumor and Anti-HIV activity:** Introduction, Chrysotherapy, History of Medicinal Uses, Gold Chemistry, Oxidation states, Gold(I) complexes, Gold(III) Complexes, Oxidation-Reduction Potentials, Gold Biochemistry and Pharmacology In-vivo metabolism and ligand displacement, Anti-tumor Activity, Anti-HIV activity.	**04**
7	**Vanadium Compounds as Possible Insulin Modifiers:** Introduction, Characterization of Vanadium's Insulin-mimetic Effects, Sites of Action of Vanadium, Animal Studies and Human Trials, Toxicological Considerations, Improved Tissue Uptake with Metal Chelation.	**03**

8	**Therapeutic Radiopharmaceuticals:** Introduction, Therapeutic radionuclides, β- Particle emitting radionuclides, α- Particle emitting radionuclides, Low energy electron emitters, Therapeutic radiopharmaceuticals for routine medical use, 131I–sodium iodide, Intra-cavity and Intra-arterial radiopharmaceuticals, Radio-therapeutic agents for bone cancer treatment 89Sr-chloride, 153Sm- EDTMP	**08**

Reference Books:

1. Uses of Inorganic Chemistry in Medicine Ed. by Nicholas P. Farrell
2. Transition Metal Complexes as Drugs and Chemotherapeutic Agents by Nicholas Farrell
3. Metal Complexes as Enzyme inhibitors A.Y. Louie and Thomas Meade Chem. Rev., 1999, 99, 2711.
4. Metals in Medicine by James C. Dabrowiak, DOI:10.1002/9780470684986, Print ISBN:9780470681961 | Online ISBN:9780470684986,
5. Metallodrugs in Medicinal Inorganic Chemistry, Katja Dralle Mjos and Chris Orvi, Chem. Rev. 2014, 114, 8, 4540–4563.

CHI-660 (C) MJ: Inorganic Chemistry Applications in Environment

Course type: Major Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to,

1. List the components of wastewater treatment processes, including screening, grit removal, and biological treatment units.
2. Explain the different types of water pollutants, their sources, and the regulations governing water quality.
3. Utilize biotechnology methods for treating various wastewater components like high-strength waste, sludge, and specific contaminants such as phenol and cyanide.
4. Evaluate future energy sources like solar, biomass, geothermal, water, tidal power, and fuel cells for their potential impact on sustainable energy production.
5. Assess the effectiveness of different wastewater treatment technologies and biotechnological applications in removing pollutants and improving water quality.
6. Propose innovative solutions for addressing wastewater treatment challenges and transitioning to sustainable energy sources for the future.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Introduction to wastewater Analysis:** Specification of treated wastewater for disposal into surface water, Screening chamber, Grit Chamber, Oil & Grease removal, designing of biological unit- stabilization pond, Aerated lagoon, Trickling filters, Anaerobic treatment.	10
2	**Water Pollutants:** Types, Disease-causing agents, oxygen-consuming waste, suspended solids and sediments, Dissolved solids, Regulation of water quality, Analysis of solids by different techniques.	04
3	**Applications of Biotechnology for the treatment of wastewater:**	08

	Introduction, Role of microorganism for the treatment of wastewater, Application of biotechnology for a. high strength waste. b. Primary and secondary sludge c. Phenol & cyanide removal d. Solid phase extraction.	
4	**Energy sources for future:** a. Solar Energy-Solar heating for homes and other buildings, electricity from solar thermal power collectors, electricity from photovoltaic cells. b. Energy from biomass- Production of biomass, biofuels, biodiesel. c. Geothermal energy d. water power e. Tidal power f. uel Cells-Polymer electrolyte membrane fuel cells, Phosphoric acid fuel cell, Direct methanol fuel cell, Alkaline fuel cell, Regenerative(reversible) fuel cell, Clean cars for the future, Energy sources for the twenty first century.	**08**

Reference Books:

1. Environmental Chemistry by A. K. Bagio.
2. Principles of Environmental Chemistry by James Girard Bartlett Publishers.
3. Waste Water Engineering by Calf& Eddy.
4. Waste Water treatment for pollution control by Arceivala.
5. Principles of water quality Control by T. H. Y Tebbut.
6. Manual on Sewage &Sewage treatment, Ministry of Works, New Delhi.

CHI-681 RP Research Project

Course type: Research Project **No. of Credits: 6**

Course Outcomes

At the end of the course, students will be able to -

1. understand key concepts and principles relevant to the research topic.
2. learn diverse research methodologies proficiently.
3. write and communicate research findings persuasively through various mediums in the form of project report
4. analyze and synthesize scholarly literature effectively.
5. evaluate research findings and methodologies critically.
6. design and execute original research projects independently.

Following guidelines should be followed for the conduction and evaluation of research project.

- Each student will perform project separately.
- Project working hours should be 30 hours for each credit.
- Choose a topic that aligns with your interests and career goals, but also consider its feasibility within the available resources and time frame.
- Consult with faculty members, advisors, or mentors to identify a research area that has potential for contribution to the field of chemistry.
- Adhere to ethical principles and standards in all aspects of your research.
- Project report must be written systematically and presented in bound form: The project will consist of name page, certificate, content, summary of project followed by introduction, literature survey (recently published research papers must be included), experimental techniques, results and discussion, conclusions, Appendix consisting of i) references, ii) standard spectra / data if any and iii) safety precautions.
- If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. Systematic record of attendance of project students must be maintained by a mentor.
- Project will be evaluated jointly by three examiners and there will not be any practical

performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

- Students are encouraged to participate in national and international conferences and other project competitions.
- For conducting research study in M.Sc. Chemistry, it is highly recommended to follow the journals given below or any other journal from reputed publication.

1. Journal of the American Chemical Society (JACS)

Publisher: American Chemical Society (ACS)

Focus: Comprehensive coverage of all fields of chemistry, known for high-impact research.

12. Angewandte Chemie International Edition

Publisher: Wiley-VCH on behalf of the German Chemical Society (GDCh)

Focus: Broad coverage of all chemistry fields, emphasizing novel and significant research.

13. Chemical Science

Publisher: Royal Society of Chemistry (RSC)

Focus: Cutting-edge research across chemical sciences, open access.

14. Nature Chemistry

Publisher: Nature Publishing Group

Focus: Multidisciplinary and high-impact research across all areas of chemistry.

15. Journal of Organic Chemistry (JOC)

Publisher: American Chemical Society (ACS)

Focus: Specialized in organic chemistry, including synthesis and mechanisms.

16. Inorganic Chemistry

Publisher: American Chemical Society (ACS)

Focus: Research on inorganic and organometallic compounds.

17. Analytical Chemistry

Publisher: American Chemical Society (ACS)

Focus: Developments and applications in analytical techniques and methodologies.

18. Physical Chemistry Chemical Physics (PCCP)

Publisher: Royal Society of Chemistry (RSC)

Focus: Physical chemistry, chemical physics, and biophysical chemistry.

19. Chemical Communications (ChemComm)

Publisher: Royal Society of Chemistry (RSC)

Focus: Rapid publication of high-quality communications across all chemical sciences.

20. Accounts of Chemical Research

Publisher: American Chemical Society (ACS)

Focus: Comprehensive reviews and accounts of current research topics in chemistry.

21. Chemical Society Reviews

Publisher: Royal Society of Chemistry (RSC)

Focus: The journal publishes high-quality, authoritative, and state-of-the-art reviews across all areas of chemical science. It covers comprehensive and critical reviews on a broad range of topics in chemistry, including emerging and interdisciplinary fields.