(Semester III & IV)
M.Sc. Chemistry Part II
(Session: 2025-26)

Semester III									
Course code	Title of the Course	Credits			Total Credits	External Exams (hrs.)	Maximum Marks		
		L	T	P			IA	SE	Total
Core Subject:									
MCHEM2301T	Analytical Chemistry	4	0	0	4	3	30	70	100
Elective Subjects:									
Inorganic Specialization									
MCHEM2302T	Ligand Field Theory	4	0	0	4	3	30	70	100
MCHEM2303T	Reaction Mechanism of Transition Metal Complexes	4	0	0	4	3	30	70	100
MCHEM2304T	Inorganic Spectroscopy-I	4	0	0	4	3	30	70	100
MCHEM2305L	Inorganic Chemistry Practical-I	0	0	3	3	4	30	70	100
MCHEM2306L	Inorganic Chemistry Practical-II	0	0	3	3	4	30	70	100

Total Credits = 22; Total Marks = 600

Semester IV									
Course code	Title of the Course	Credits			Total Credits	External Exams (hrs.)	Maximum Marks		
		L	T	P			IA	SE	Total
Core Subject:									
MCHEM2401T	Environmental Chemistry	4	0	0	4	3	30	70	100
Elective Subjects:									
Inorganic Chemistry									
MCHEM2402T	Chemistry of Organometallic Compounds	4	0	0	4	3	30	70	100
MCHEM2403T	Advanced Topics in Inorganic Chemistry	4	0	0	4	3	30	70	100
MCHEM2404T	Inorganic Spectroscopy-II	4	0	0	4	3	30	70	100
MCHEM2405L	Inorganic Chemistry Practical-I	0	0	3	3	4	30	70	100
MCHEM2406L	Inorganic Chemistry Practical-II	0	0	3	3	4	30	70	100

Total Credits = 22; Total Marks = 600

(Semester-III)
M.Sc. Chemistry-II
ANALYTICAL CHEMISTRY
PAPER CODE: MCHEM2301T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry 12 marks each. Section C will consist of 11short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt four questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	This course will provide an insight into some of the fundamental concepts and principles that are very essential in the study of chemistry.
CO2	The students will understand the fundamental principle of various analytical techniques like chromatographic techniques, polarography and thermogravimetric analysis etc.
CO3	This course will suggest a suitable analytical method for a specific purpose, evaluate important sources of interferences and errors, and also suggest alternative analytical methods for quality assurance.
CO4	This course will develop skills in students like problems solving, critical thinking and analytical reasoning.

Section-A

Introduction to analytical chemistry: Methods of quantitative analysis, chemical analysis with its scale of operation, various steps in quantitative analysis.

Sampling in analysis, Theory of sampling importance of selecting a representative sample, criterion of a good sampling plan, stratified sampling V/s. random sampling. Minimization of variation in stratified sampling, sampling plan for solids, liquids and gases.

Reliability of analytical data, Errors in chemical analysis, classification of errors, Minimization of errors, accuracy and precision. Improving accuracy of analysis, correlation and Regression, linear regression. Analysis of variance.

Polarography: Principle, residual, Migration, diffusion currents, polarographic maximum, advantages and disadvantages of D.M.E. Reversible & irreversible processes, fundamental equation of polar graphic wave. Derivation of Ilkovic equation &.deviations, Quantitative technique & evaluation of quantitative results, Amperometric titrations & Biamperometric titrations.

Basic Principles of related technique of Polarography, Alternating current, Square Wave, pulse (normal and Differential) Tensometry, radiofrequency and computer controlled polarograph.

Chronoptentiometry theory, circuit and applications & comparison with polarography.

Section-B

Thermo Analytical Methods

Thermo gravimetric analysis, Introduction, Instrumentation, Factors affecting thermogravimetric results, Applications of Thermogravimetry.

Differential Thermal analysis and differential scanning calorimetry on line analysis.

Thermometric Titrations: Introduction theory and applications.

Spectrophotmetry and Colorimetry

Theory of spectrophotometry and colorimetry, Beer's law, Deviation from Beer's law, absorptivity, Photometric accuracy. Spectrophotometric titrations and titration curves and applications to quantitative analysis.

Solvent extraction: Distribution constant and distribution ratio and their importance in solvent extraction, synergistic extraction, extraction by solvation, Ion pair formation Methods of extraction and their applications in analytical chemistry.

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BOOKS PRESCRIBED:

1. Laitinen H.A., Harris, W.E. Chemical analysis. 2nd Edition, McGraw-Hill, New York (1975).
2. Bond, Alan Maxwell. Modern polarographic methods in analytical chemistry. CRC press, 2020.
3. Willard, H. H., Merritt Jr, L. L., Dean, J. A., & Settle Jr, F. A. Instrumental methods of analysis (1988).
4. Hall NF. A textbook of quantitative inorganic analysis (Vogel, Arthur I.).
5. Jeffery, G. H. "Vogel's Textbook of Quantitative Chemical Analysis 5th Ed." (2022).
6. Khopkar, Shripad Moreshwar. Basic concepts of analytical chemistry. New Age International, 1998.

(Semester-III)
M.Sc. Chemistry-II
LIGAND FIELD THEORY
PAPER CODE: MCHEM2302T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry 12 marks each. Section C will consist of 11 short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	A detailed overview of ligand field aspects used in chemistry with a particular focus on the most advanced topics addressed by surrounding ligands.
CO2	Detailed aspects of co-ordination complexes not only fulfil the need of it in the field of chemistry but also in medicine, food industry, drug analysis and environmental sample analysis.
CO3	Concept of ligand field enriches the students with the knowledge of wave functions and term symbols which elaborates the whole geometry and spectra of complexes.

Section-A

Introduction

(a) Concept of Ligand Field
(b) Scope of Ligand Field
(c) The d and other orbitals.
(d) Qualitative Demonstration of Ligand Field Effect.
(e) The Physical Properties Affected by Ligand Field.
(f) Ionic Model of Coordination compounds
(g) Crystal Fields and Ligand Fields.

Quantitative Basis of the Crystal Fields.

(a) Crystal Field Theory.
(b) The Octahedral Crystal Field Potentiel, V_{oct}
(c) The Effect of V_{oct} on d Wave Functions.
(d) Evaluation of 10Dq.
(e) TheTetrahedral Potential.

Atomic Spectroscopy

(a) The Free Ion
(b) Free Ion Terms
(c) Term Wave Functions
(d) Spin-Orbit Coupling

Free Ions in Weak Crystal fields

(a) The Effect of a Cubic Crystal Field on S and P terms.
(b) The effect of a Cubic Crystal Field on D terms.
(c) The effect of a Cubic Crystal Field on F terms.
(d) The effect of a Cubic Crystal Field on G, H and I terms.

Thermodynamic Aspects of Crystal Fields

(a) Crystal Field Stabilization Energy.
(b) Lattice energy and C.F.S.E.

Section-B

Free ions in medium and strong Crystal fields

(a) Strong field configuration.
(b) Transition from weak to strong crystal fields.
(c) Term energy level diagrams.
(d) Tanabe-Sugano diagrams.

Molecular orbital theory for complex ions.

(a) Elementary Molecular Orbital Theory.
(b) Bonding in octahedral complexes.
(c) Bonding in tetrahedral complexes

Electronic Spectra of complex ions

(a) Selection rules and band widths.
(b) Spectra of aqueous solutions of $[M(H_2O)_6]^{n+}$
(c) Spectra of spin free ML_6^{n+}
(d) Spectra of spin paired ML_6^{n+}
(e) Spectra of distorted octahedral complexes.
(f) Spectra of tetrahedral complexes
(g) The Spectrochemical and Nephelauxetic series.
(h) Charge transfer spectra

Spectral and Magnetic properties of Complexes of Non-Cubic Stereocheinistry

(h) General
(i) Square Planar Complexes.
(j) Square Pyramidal Complexes.
(k) Dodecahedral Complexes

BOOKS PRESCRIBED:

1. Figgis, Brian N. Introduction to Ligand Fields. Interscience Publications New York 1966.
2. Cotton, F. Albert. Chemical applications of group theory. John Wiley & Sons, 1991.
3. Jaffé, Hans H., and Milton Orchin. Symmetry in chemistry. Courier Corporation, 2002.
4. Leon F. Phillips Basic Quantum Chemistry. J. Wiley, Publisher, 1965.
5. B.R. Puri, L. R. Sharma, and K.C. Kalia .Principles of Inorganic Chemistry.(2008).
6. Miessler, Gary L., and Donald A. Tarr. Inorganic Chemistrv J.(2000).
7. Huheey, James E. Principles of structure and reactivity. Harper & Row, 1983.

(Semester-III)
M.Sc. Chemistry-II
REACTION MECHANISM OF TRANSITION METAL COMPLEXES
PAPER CODE: MCHEM2303T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry12 marks each. Section C will consist of 11short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONSFORTBECANDIDATES

Candidates are required to attempt five questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	The students will acquire the knowledge of Formation of octahedral and square planer complexes.
CO2	Reaction and mechanism of octahedral and square planer complexes and electron transfer reactions
CO3	Apply various methods to determine the stoichiometry and stability of complexes.

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Section-A

Ligand replacement reaction: Labile and inert complexes, crystal field stabilization, general aspects, dissociation or displacement, classification of mechanism, water exchange rates, formation of complexes from aqueous ions, equation and base hydrolysis, attack on ligands.
Reaction of Square complexes: mechanism of ligand displacement reactions, the Trans effect, Cis-effect.
Metal Carbonyl reactions: Reactions of octahedral, reactions of binuclear carbonyl, associative reactions, species with 17electrons.
Electron transfer processes: Electron transfer theory outer sphere reactions, ligand-bridged reactions, iron(II) iron(III) exchange, two electron transfer, non complementary reactions, and replacement through Redox mechanism.
Stereochemical non rigidity: Metal carbonyl scrambling, Fluxionality in organometallic compounds.

Section-B

Oxidative addition and migration (insertion) Reactions: General comments, the acid base behaviour of metal atom in complexes, Lewis acidity of complexes, oxidative addition: addition of specific molecules (hydrogen addition, HX additions, Organic halides, additions of some other molecules), reductive elimination, insertion reactions, insertion of carbon monoxide, insertions of alkenes and C-C unsaturated compounds, cleavage of C-H bonds; Alkane"activation", cyclometallation reactions.

(I) Stability Constants of Metal complexes

(a) (i) Slope ratio method (ii) Job's method of continuous variation
(iii) Solubility method (iv) Mole-Ratio method.

(b) General Methods: (a) Bjerrum's potentiometric method (b) Leden's method
(c) Ion Exchange method
(d) Polargraphic methods: Lingane's method, Deford & Hume's method.

(II) Factors affecting the stability constants

(i) Statistical effect
(ii) Electrostatic effect
(iii) Chelate effect

BOOKS PRESCRIBED:

1. Cotton, F. Albert, G. Wilkinson, Carlos A. Murillo, and M. Bochmann. Advanced inorganic chemistry. John Wiley & Sons, 5th Edition 1999.
2. Edwards: Inorganic Reactions Mechanism, An Introduction W. A. Benzainin, Inc.1965.
3. Shriver, Atkins and Longford: Inorganic Chemistry, Oxford University Press, 1990.
4. Gupta, B. D. Basic Organometallic Chemistry: Concepts, Syntheses and Applications. Universities Press, 2011.
5. Jones and Jones: Elementary Coordination Chemistry. Englewood Cliffs, N.J., Prentice-Hall 1965

(Semester-III)
M.Sc. Chemistry-II
INORGANIC SPECTROSCOPY-I
PAPER CODE -MCHEM2304T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3 hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry12 marks each. Section C will consist of 11short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt four questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	The students will know about the Utility of spectroscopic methods such as IR, Raman and Mossbauer techniques for the characterization of inorganic complexes.
CO2	Application of UV-Vis, FT-IR, Magnetic moment measurement to understand the inorganic compounds
CO3	Purification of different inorganic complexes.
CO4	Planning and generalization of the scheme for determining the structure of molecules using Electronic absorption spectroscopy, Microwave, IR spectroscopy, Raman spectroscopy, NQR spectroscopy, Mass spectroscopy so that they can propose a best solution to such problems.

Section-A

General Introduction to Spectroscopy

Nature of radiation energies corresponding to various kinds of radiations, atomic and molecular transitions, selection rules & chemical processes effecting the natural line width of a spectral line, general applications; determinations of concentration, isobestic points, finger printing, Job's method of Isomotal solutions.

Mossbauer Spectroscopy

Introduction Interpretation of Isomer Shift, Quadrupole Interactions, Magnetic interactions, applications.

Nuclear Quadrupole Resonance Spectroscopy

Introduction, energies of quardrupole transitions, effect of magnetic field on the spectra, relationship between electric field gradient and molecular structure, applications, interpretations of structural information from NQR spectra.

Electronic Absorption Spectroscopy

Vibrational and electronic energy levels in a diatomic molecule, relationship of Potential energy curves to electronic spectra. Nomenclature, Assignment of transitions, Spin-orbit coupling, criteria to aid in Bond assignment, Intensity of Electronic Transitions i) Oscillator Strengths, Transition moment Integral Derivation of some selection rules, spectrum of formaldehyde, Spin-Orbit & vibronic coupling contribution to Intensity, mixing of d & p orbitals in certain symmetries, higher state mixing, Intensity of electronic transitions, charge transfer transitions, polarized absorption spectra, Applications, fingerprinting, molecular addition compounds in Iodine, effect of solvent polarity on charge transfer spectra.

Section-B

Spectra of Transition Metal Complexes

Spectra of transition metal complexes: Selection rules and intensities of transition, nature of electronic transitions in complexes, use of Orgel diagrams.

Vibrational & Rotational Spectroscopy

Introduction, Harmonic and Anharmonic vibrations, absorption of radiation by molecular vibrations, selection rules, force constant, vibration in polyatomic molecules, effects giving rise to absorption bands, Group vibrations, limitation of group vibration concept.

Raman Spectroscopy: Introduction, selection rules, polarized and depolarised Raman lines, significance of nomenclature used to describe number of IR active and Raman active line. Symmetry requirements for coupling, combination bands and Fermi Resonance. Microwave Spectroscopy, measurement of bond angles and bond distance.

Application of Electronic Absorption and IR Spectroscopy

Calculations of Dq and β for octahedral Ni(II) complexes, structural evidence from electronic spectra. Miscellaneous applications of the principles related to electronic transitions. Applications of Infrared and Raman Spectroscopy: Procedure Finger printing, applications of Raman and Infrared selection rules to the determination of Inorganic structures, hydrogen bonding systems, change in spectra of donor molecules upon coordination, Change in the spectra accompanying change in symmetry upon coordination.

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BOOKS PRESCRIBED:

1. Drago, Russell S. Physical methods for chemists 2nd Edn.1992.
2. Barrante, James R. Basic Principles of Spectroscopy (Chang, Raymond).1972.
3. Rao, Chintamani Nagesa Ramachandra, Spectroscopy in Inorganic Chemistry. Vol. 1. Elsevier, 2012.
4. Kaur, H. Introduction to spectroscopy Pragati Prakashan 2021.
5. Cotton, F. Albert, Advanced inorganic chemistry. John Wiley & Sons, 1999.
6. Shriver, Atkins P. Atkins' inorganic chemistry. W H Freeman & Co.(2010).
7. Lee, John David. Concise inorganic chemistry. John Wiley & Sons, 2008.

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(Semester-III)
M.Sc. Chemistry-II
INORGANIC PRACTICALS-I
PAPER CODE-MCHEM2305L

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks

Credits: 03
Passing Marks: 35%

Preparation and Estimation

1. Preparation of $[Co(NH_3)_6]Cl_3$
2. Estimation of cobalt and chloride.
3. Preparation of $[CO(NH_3)_5NO_2]\ Cl_2$ and $[Co((NH_3)_6(ONO)]Cl_2$
4. Preparation of $[Pb(CH_3COO)_4]$
5. Estimation of Pb and acetate.
6. Preparation of Dipyridiniumhexachloroplumbate.
7. Estimation of Pb.
8. Preparation of $[I(py)_2NO_3]$
9. Estimation of Iodine.
10. Preparation of $[Cu_2(CH_3COO)_4(H_2O)_2]$.
11. Estimation of copper.
12. Preparation of Vanadyl acetylacetonate.
13. Preparation of $[Ni\ (NH_3)_6]Cl_2$
14. Estimation of Ni.

(Semester-III)
M.Sc. Chemistry-II
INORGANIC PRACTICALS-II
PAPER CODE: MCHEM2306L

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks

Credits: 03
Passing Marks: 35%

Chromatographic Separations

1. To Separate Hg(II), Pb(II), Cu(II) & Cd(II) ions by paper chromatography and to determine their R_f values.
2. To separate out Ni(II), Cu(II) & Zn(II) ions by paper chromatography and determination of their R_f values.
3. To separate out F, Cl, Br & I by paper Chromatography and determination of their R_f values.
4. To separate out Na(I) & K (I) by paper chromatography and determination of their R_f values.

Spectrophotometric Determinations.

(i) Fe(II) with 1,10-Phenonthroline
(ii) Fe(III) with Potassium thiocyanate
(iii) Ni with dimethylglyoxime
(iv) Cu(II) with Sodium diethyl dithiocarbamate
(v) Cr(V1) with 1,5-Diphenyl carbazide

Conductometry

Determination of number of ions in

(i) $[Cr(Urea)_6]Cl_3$
(ii) $[Co(NH_3)_6 Cl_3 [Hg(NH3)_2]Cl$
(iii) Titrations of mixture of acids.
(iv) Precipitation titrations.

(Semester-IV)
M.Sc. Chemistry-II
ENVIRONMENTAL CHEMISTRY
PAPER CODE: MCHEM2401T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3 hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry 12 marks each. Section C will consist of 11short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	The students will be able to Explain the theoretical principles and the main components of selected electro analytical and spectrometric/spectrophotometric methods.
CO2	Explain the theoretical principles of various separation techniques in chromatography and typical applications of chromatographic techniques.
CO3	Elaborate the Stratospheric chemistry, Ozone layer hole, ground level air pollution and health consequences.
CO4	Describe causes and effects of environmental pollution by energy industry and discuss some mitigation strategies.

Section-A

Concept and scope of Environmental Chemistry: Enviromiental Pollution, Environmental Segments, Green heuse effect and global warning, chemical and Photochemical reactions in the atmosphere, Pollutants, contaminants, sinks and receptor.

Air Pollution: Air Pollutants (CO, NO_2, SO_2, HCs, SPM) Photochemical smog, Acid rain, particulates), Air Pollution accidents [TCDD (2,3,7,8 tetraChlorobinzo-10dioxin), Bhopal, Chernobyl] Air Pollution monitoring instruments, Monitoring of, (SO_2NO-NOx,CO, CO_2HC Ozone).

Water Pollution: Water Pollutants, Drinking water standards, Investigation of water (Physical, Chemical and Biological) Important steps in water treatment (Coagulation, filtration) disinfection, Break point chlorination, lime soda ash process, corrison and scale formation, fluoridation, taste and color removal, water quality monitoring instruments.

Section-B

Industrial Effluent Analysis: Quality of Industrial effluents, Physical methods of classification, BOD, & COD of industrial effluents. Analysis of metal pollutants in effluents.

Chemical Toxicology: Toxic Pollutants in environment, Threshold limiting value, Biochemical effects of Hg, Cd, As, Pb, O_3, PAN, CN and pesticides.

Monitoring techniques for Pollution Analysis
Atomic absorption spectroscopy and flame photometry theory, Instrument, Interferences and evaluation methods. Infrared Spectroscopy Introduction, Instrumentation, Beer's-Lambert relationship, NDIR & FTIR.

Ion selective electrodes: working, construction, standardization different Ion selective electrodes.

HPLC (High performance liquid chromatography) Instrumentation, supports & detector.

Gas chromatography: Apparatus, detector and working.

Anodic Strapping Analysis: Principle, Apparatus, technique & advantages.

BOOKS PRESCRIBED:

1. De Anil, Kumar. Environmental chemistry. New Age International, 2003.
2. S.M. Khopkar. Environmental Pollution Analysis New Age International Pvt Ltd Publishers; 2nd Edn. 2020
3. J. Mendham.Vogel's textbook of Quantitative Chemical Analyses. Pearson Education 6th Edn. 2009.
4. Bhagi, Ajay Kumar, and Gurdeep R. Chatwal. Environmental chemistry. Himalaya Publishing House, 2010.
5. Chambers, Phoenix. Standard methods for the examination of water and wastewater. Scientific e-Resources, 2019.
6. Dezuane, John. Handbook of drinking water quality. John Wiley & Sons, 1997.
7. Lodge, James P. Methods of air sampling and analysis. Routledge, 2017.

(Semester-IV)
M.Sc. Chemistry-II
CHEMISTRYOF ORGANOMETALLIC COMPOUNDS
PAPER CODE-MCHEM2402T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3 hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry 12 marks each. Section C will consist of 11short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	The students will acquire the knowledge of Preparation of organometallic compounds and homogenous catalytic synthesis of organic chemicals.
CO2	Bonding and chemical properties of various compounds of transition metals with hydrocarbon systems.
CO3	Stability of organometallic compounds and clusters, and their applications as industrial catalysts.
CO4	Structure and bonding issues to understand the stability and reactivity of metal hydrides.

Section-A

Organometallic Compounds: Nomenclature of organometallic compounds, Classification of Ligands in organometallic compounds, inert gas rule.

Transition Metal compounds with Bonds to hydrogen: Characterization of Hydride complexes, Hydrogen Bridges. Synthetic methods, Chemical Behaviour of Hydrido Compounds, Mononuclear polyhydrides, homoleptic polyhydrido anions, Carbonyl hydride and Hydrido Anions, Molecular Hydrogen compounds, Metal- Hydrogen interactions with C-H groups,Complexes of Borohydrides and Alumino hydrides.

Compounds of Transition Metal with Alkenes, Alkyses and Delocalized Hydrocarbon Systems: Transition metal alkyl complexes: General methods of preparation, general characteristics, structure and bonding.Transition metal alkene complexes: Types of Alkene Complexes, Synthesis & Reactions of alkene complexes, Bonding involved.Transitionmetalalkynecomplexes: Preparation, bonding and properties. Transition metal allylcomplexes:Preparation,bonding and properties. Carbocyclic-π-Complexes π: Cyclobutadiene complexes, Cyclopentadienyl complexes, η^6_ arene complexes and trienyl complexes.

Section - B

Homogeneous Catalytic Synthesis of Organic Chemicals by Transition Metal complexes: Hydrogenation reactions: reversible cis-dihydrido catalysts, monohydride complexes, asymmetric hydrogenation, transfer hydrogenation; Alkene isomerization, hydrosilylation and hydroborationreactions;Reactionsofcarbonmonoxide and hydrogen: water gas shift reaction, Fisher Tropsch reaction; Hydroformylation of unsaturated compounds; Carbonylation reactions; decarbonylationreactions, Alkene oligomerization and polymerization: Zieglar Natta Polymerization, Alkene and alkyne metathesis, Oxidative carbonylations, supported homogeneous and phase transfercatalysis.

Transition Metal carbon Monoxide compounds: Preparation of Metal Carbonyls, Structures of Metal carbonyls Mononuclear, Binuclear, Trinuclear and Tetranuclear and larger Polynuclear carbonyls.

Additional structural and Bonding features: Fluxionality, Semi bridging CO groups, side on Bonding to CO, Oxygen to Metal Bonds, Vibrational Spectra of Metal carbonyls, Detection of Bridging CO groups. Molecular symmetry from the number of Bands, Bond Angles & Relative Intensities, Force constants, Prediction and Assignment of Spectra. Carbonylate Anions, Metal carbonyl, Hydrides, Reactions of Metal Carbonyls; Photochemical Reactions of Metal Carbonyls: Nucleophilic & electrophilic attacks on CO.

BOOKS PRESCRIBED:

1. Cotton, F. A., Wilkinson, G., Murillo, C. A., & Bochmann, M. Advanced Inorganic Chemistry. John Wiley & Sons. 1999.
2. Shriver, Atkins and Longford: Inorganic Chemistry, Oxford University, Press, 1990.
3. Gupta, B. D. *Basic* Organometallic Chemistry*: Concepts, Syntheses and Applications.* Universities Press, 2011.
4. Robert H. Crabtree The Organometallic Chemistry of the Transition Metals 6th Edn. 2014.
5. Verma, Dakeshwar Kumar, and Jeenat Aslam. Organometallic Compounds:Synthesis, Reactions, and Applications. John Wiley & Sons, 2023.

(Semester-IV)
M.Sc. Chemistry-II
ADVANCED TOPICS IN INORGANIC CHEMISTRY
PAPER CODE: MCHEM2403T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3 hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry 12 marks each. Section C will consist of 11 short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	The students will be able to gain advanced knowledge about spectroscopic terms and symbols
CO2	Learn about the radioactive activity and photonuclear reactions
CO3	Synthesis of high nuclearity carbonyl clusters and their structure

Section-A

Radiochemistry: Discovery of radioactivity, statistical aspect of radioactivity, radioactive decay and growth, naturally occurring radioactive substances, nuclear structure and properties, nuclear reactions, energetic of nuclear reactions, the Q-value of a reaction, Cross sections-partial reactions and total cross reaction. Bohr theory of nuclear reactions, types of reactions, Oppenheimer Phillips process, Photonuclear reactions, nuclear fission and fusion, fission products and fission yields, chain reaction at very high energies, nuclear transparency, high energy fission, slow neutron reactions Cross-section, equations of Radioactive decay and growth, equations of transformation in neutron flux, gamma transitions and isomerisin & β decay, health and safety aspects in radiation protection, Analysis by Isotope dilution.

Nanochemistry: Introduction to Nanoclirmistry, Nano and nature, nano the beginning, introduction to carbon nano tubes; types, synthesis and purification. Brief introduction to self assembled mono layers(SAMs), Monolayers on Gold, Preparation, Mixed monolayers, SAMs and applications; Sensors, affinity bio sensors, chemical sensors, corrosion prevention, wetting control, molecular electronics, Process of synthesis of Nano powders, Sol-Gel process, Electro-Deposition, Plasma enhanced vapour decomposition, sputtering of Nano crystalline powders. Application of SEM, TEM and AFM to nanotechnology.

Section-B

Metal to metal bonds and metal atom clusters: Introduction metal carbonyl Clusters, Isoelectronic and isolobal relationship, High nuclearity Cabonyl Clusters (HNCCs) (Structural patterns, synthetic methods), hetero atoms in metal atom cluster:carbide and nitride containing clusters, electron counting schemes for HNCCs,the capping rule, HNCCs of Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt etc. Lower halide and chalcogenide Clusters: Octahedral metal halide and chalcogenide clusters (M_6X_8 and M_6X_{12} types) chevral phases, triangular clusters and solid state extended arrays. Compounds with M-M multiple bonds. Major structural types, quadruple bonds, other bond orders in the tetragonal context, relation of clusters to multiple bonds and one dimensional solids.

Compounds with Transition Metal single, Double and Triple bonds to carbon: Compound Types, Synthetic methods for M-C Bonds, Decomposition Reactions Intramolecular Reductive Elimination, Other Reactions of M- C Bonds.

Polymers

a) Properties of Polymers

1.1. Linear polymer molecule
1.2. Size of linear polymer molecule
1.3. Shape of linear polymer molecule
1. 4. Crystalline and amorphous polymers
1.5. Polymer solubility
1.6. Solubility parameter
1.7. Glass-Transition temperature
1.8. Viscoelastic behaviour
1.9. Chemical flow and stress relaxation

Sulfur polymers: Elementary sulfur Crystalline, Forms of sulfur, Molten sulfur, Sulfur vapour, Sulfanes (Hydrogen polysulfides) and their salts, Free sulfanes, Salts of sulfanes, alkyl and aryl Sulfanes: Preparation, Properties and structure

Polymerization and oligomerization reaction: Ziegler Natta polymerization of ethylene and propylene, oligomerization and related reactions, reaction involving C-C bond cleavage, valence isomerization of strained hydrocarbons, alkene and alkyne metathesis.

BOOKS PRESCRIBED:

1. Friedlander, Gerhart, Joseph W. Kennedy, Edward S. Macias, and Julian M. Miller. Nuclear and radiochemistry. John Wiley & Sons, 1981.
2. Principles of Radio Chemistry, Indian Association of Nuclear Chemists and Allied Scientists. Editors D. D. Sood, N. Ramamoorthy, A.V.R. Reddy.
3. Cotton, F. Albert, Geoffrey Wilkinson, Carlos A. Murillo, and Manfred Bochmann. Advanced inorganic chemistry. John Wiley & Sons, 1999.
4. Inorganic Polymers by Stone and Graham 1962.
5. T. Pradeep, Nano : The Essentials; Understanding Nano science and Nanotechnology, Tata McGraw-Hill Education Pvt. Ltd., New Delhi, 2017.
6. A. K. Bandyopadhyay, Nano Materials, New Age International Publishers, New Delhi, 2008.
7. A.Katsuhiko, and Toyoki Kunitake. Supramolecular chemistry-fundamentals and applications: advanced textbook. Springer Science & Business Media, 2006.

(Semester-IV)
M.Sc. Chemistry-II
INORGANIC SPECTROSCOPY-II
PAPER CODE: MCHEM2404T

Max. Marks: 100
External Exam: 70 marks
Internal Assessment: 30 marks
Passing Marks: 35%

Credits: 04
Time allowed: 3 hrs

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective section of the syllabus and will carry 12 marks each. Section C will consist of 11 short answer type questions that will cover the entire syllabus and will be of 02 marks each. Use of scientific non-programmable calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions selecting two questions from each of A & B Sections. Section C is Compulsory.

COURSE OUTCOMES:

Sr. No.	On completing the course
CO1	The students will learn about Systematic qualitative analysis of inorganic compounds by using various spectroscopic techniques.
CO2	To understand the basic and advance applications of NMR and ESR for the characterization of coordination complexes
CO3	Summarize various concepts involved in various spectroscopy techniques and evaluate the spectroscopic data collected for structural elucidation.
CO4	Estimate the required technique for solving problems related to the structure, purity and concentration of chemicals and predict the desired outcomes based on which they can test the compatibility of process.

Section-A

Nuclear Magnetic Resonance Spectroscopy

Introduction: Theory of NMR, behavior of a bar magnet in magnetic field, rotating axis system magnetizing vectors and relaxation, NMR transition, NMR experiment, Chemical shift of some systems studied by NMR, Mechanism of electron shielding, remote shielding from neighbor anisotropy, interatomic ring currents, chemical shifts where the local diamagnetic term does not predominate, spin-spin splitting, Spin-Spin coupling mechanism for transmitting Nuclear Spins.

Application of NMR

Applications of Spin-Spin coupling to structure determination, Application involving the magnitude of coupling constants, complex spectra obtained when $J \sim \Delta$, Chemical exchange and other factors affecting the line width, effect of chemical exchange on spectra and the evaluation of reaction rates for fast reactions. Consequences of nuclei with quadrupole moment in NMR. Double resonance technique, exchange reactions between ligands and metal ions.

Nuclear Magnetic Resonance Spectra of Paramagnetic Transition Metal ion complexes

Introduction, Relaxation Processes, Average electron spin polarisation, Scalar or isotropic contact shifts in systems with isotropic tensor, pseudo contact shift, Semiqualitative interpretations of NMR spectra paramagnetic molecules, semi qualitative interpretation of contact shifts, applications of isotropic shifts.

Section-B

Electron Paramagnetic Resonance

Introduction, Principles, The hydrogen atom, Presentation of the spectrum, hyperfine splitting in isotropic systems involving more than one nucleus, contributions to the hyperfine coupling constant in isotropic systems. Anisotropic Effects: Anisotropy in the g-value, EPR of triplet states, nuclear quadrupole interaction, line widths, EPR applications.

Mass Spectrometery

Instrument operation and presentation of spectral processes that can occur when a molecule and a high energy electron combine, finger print applications. Interpretation of mass spectra, effect of isotope on appearance of mass spectrum, Molecular weight determination, field ionization techniques, evaluation of heat of sublimation and species in the vapour over high melting solids, Appearance potential and ionization potential.

ORD &CD: Theory of ORD & CD, Measurement of optical Rotation, Application of ORO & CD.

Varadha

BOOKS PRESCRIBED:

1. Drago, R.S., Physical Methods for Chemists 2nd Edn. Affiliated East West Press Pvt. Ltd., 2016.
2. Lubman, David M., ed. Lasers and mass spectrometry. Oxford University Press, 1990.
3. Chang, R., Basic Principles of Spectroscopy. McGraw-Hill Inc.,US, 1971.
4. Willard, Hobart Hurd, Lynne L. Merritt Jr, John Aurie Dean, and Frank A. Settle Jr., Instrumental methods of analysis,1988.
5. Mirabella, Francis M., ed. Modern techniques in applied molecular spectroscopy. John Wiley & Sons, 1998.
6. Gibb, Terence. Principles of Mössbauer spectroscopy. Springer Science & Business Media, 2012.

(Semester-IV)
M.Sc. Chemistry-II
INORGANIC CHEMISTRY PRACTICALS-I
PAPER CODE: MCHEM2405L

Max. Marks: 100 marks
External Exam: 70 marks
Internal Assessment: 30marks

Credits: 03
Passing Marks: 35%

List of Experiments:

1. Preparation of $[Cr(Urea)_6]Cl_3$
2. Estimation of Cr and Cl.
3. Preparation of sodium diethyldithiocarbamate.
4. Preparation of nitrosobisdiethyldithiocarbamate iron(I).
5. Estimation of Iron.
6. Preparation of cis &trans dichlorobisethylenediamminecobalt(III) chloride.
7. Preparation of bis(acetylacetonato)copper(II).
8. Estimation of copper.
9. Preparation of Pyridineperchromate.
10. Preparation of octahedral and tetrahedral complex of dichloropyridyl cobalt(II)
11. Estimation of Cobalt.
12. Preparation of Sodium tetrathionate.
13. Estimation of Sodium tetrathionate using Potassiumiodate.
14. Preparation of $[Ni(NH_3)_6]Cl_2$.
15. Estimation of Nickel.

(Semester-IV)
M.Sc. Chemistry-II
INORGANIC PRACTICALS-II
PAPER CODE: MCIIEM2406L

Max. Marks: 100 marks
External Exam: 70marks
Internal Assessment: 30marks

Credits: 03
Passing Marks: 35%

List of Experiments:

1. IR Spectroscopy: Study of the following complexes:
   (i) $[Ni(NH_3)_6]Cl_2$
   (ii) Pyridineperchromate
   (iii) $[Cr(Urea)_6]Cl_3$
   (iv) Na diethyldithiocarbamate.
   (v) Nitrosylbisdiethyldithiocarbamatoiron(I).
   (vi) Sodium tetrathionate

2. Determination of stoichiometry of complex of Fe-1,10-Phenanthroline and Cr-1,5-Diphenyl Carbazide
   (a) Job's method of continuous variation.
   (b) Mole-Ratio Method.

3. To find out oscillator strength and assignments of d-d bands to transitions hexaquo ions of Cr(III), Fe(II), Ce(III), Co(II) and Ni(II).
   (a) Calculation of 10Dq and β for $[Ni(H2O)6]^{2+}$
   (b) Verification of relative positions of following ligands in the spectrocheinical series: H_2O, Py, NHS, DMSO, Acetylacetonate, ethylenediamine, acetate and urea.

4. Polarography
   (a) Determination of half wave potential of lead and cadmium ion in 1M KCI.
   (b) Determination of cadmium ion in the given solution by standard addition method calibration plots.
   (c) Determination of lead & cadmium in alloys.