SYLLABUS

For

M.Sc. CHEMISTRY PART II

(SEMESTER III & IV)

Academic Sessions

2026-27& 2027-28

PROGRAMME CODE: MCHE

Estd.1971

POST GRADUATE DEPARTMENT OF CHEMISTRY

GURU NANAK COLLEGE

BUDHALADA

(An Autonomous College)

NAAC Accredited 'A^{++} Grade

College with Potential for Excellence Status by

UGC, Star College Status-DBT

E-mail:gncbudhlada@yahoo.co.in

Website: www.https://www.gncbudhlada.org

Under Punjabi University, Patiala

SEMESTER-III

Paper Code	Title of Paper	Maximum Marks Pass Percentage 35%			Contact Hours			Credits	Time Allowed (Hours) Examination
		Total	External	Internal	L	T	P		
Core Subject									
MCHE 2301T	Analytical Chemistry	100	70	30	4	0	0	4	3hr
Elective Subjects: Inorganic Specialization									
MCHE 2302T	Ligand Field Theory	100	70	30	4	0	0	4	3hr
MCHE 2303T	Reaction Mechanism of Transition Metal Complexes	100	70	30	4	0	0	4	3hr
MCHE 2304T	Inorganic Spectroscopy-I	100	70	30	4	0	0	4	3hr
MCHE 2305P	Inorganic Chemistry Practical-I	100	70	30	0	0	6	3	6hr
MCHE 2306P	Inorganic Chemistry Practical-II	100	70	30	0	0	6	3	6hr
Elective Subjects: Organic Specialization									
MCHE 2307T	Photochemistry and Pericyclic Reactions	100	70	30	4	0	0	4	3hr
MCHE 2308T	Chemistry of Natural Products	100	70	30	4	0	0	4	3hr
MCHE 2309T	Heterocyclic Chemistry	100	70	30	4	0	0	4	3hr
MCHE 2310P	Organic Chemistry Practical-I	100	70	30	0	0	6	3	6hr
MCHE 2311P	Organic Chemistry Practical- II	100	70	30	0	0	6	3	6hr
Elective Subjects: Physical Specialization									
MCHE 2312T	Fundamentals of Spectroscopy	100	70	30	4	0	0	4	3hr
MCHE 2313T	Statistical Thermodynamics	100	70	30	4	0	0	4	3hr
MCHE 2314T	Fundamental and Atmospheric Photochemistry	100	70	30	4	0	0	4	3hr
MCHE 2315P	Instrumental Physical Chemistry Practical - I	100	70	30	0	0	6	3	6hr
MCHE 2316P	Physical Chemistry Practicals - I	100	70	30	0	0	6	3	6hr

SEMESTER-IV

Paper Code	Title of Paper	Maximum Marks Pass Percentage: 35%			Contact Hours			Credits	Time Allowed (Hours) for Examination
		Total	External	Internal	L	T	P		
Core Subject									
MCHE 2401T	Environmental Chemistry	100	70	30	4	0	0	4	3hr
Elective Subjects: Inorganic Specialization									
MCHE 2402T	Chemistry of Organometallic Compounds	100	70	30	4	0	0	4	3hr
MCHE 2403T	Advanced Topics in Inorganic Chemistry	100	70	30	4	0	0		3hr
MCHE 2404T	Inorganic Spectroscopy - II	100	70	30	4	0	0	4	3hr
MCHE 2405P	Inorganic Chemistry Practical -III	100	70	30	0	0	6	3	6hr
MCHE 2406P	Inorganic Chemistry Practicals -IV	100	70	30	0	0	6	3	6hr
Elective Subjects: Organic Specialization									
MCHE 2407T	Applications of Organic Molecular Spectroscopy	100	70	30	4	0	0	4	3hr
MCHE 2408T	Organic Synthesis	100	70	30	4	0	0	4	3hr
MCHE 2409T	Modern Synthetic Reactions and Rearrangements	100	70	30	4	0	0	4	3hr
MCHE 2410P	Organic Chemistry Practical -III	100	70	30	0	0	6	3	6hr
MCHE 2411P	Organic Chemistry Practical -IV	100	70	30	0	0	6	3	6hr
Elective Subjects: Physical Specialization									
MCHE 2412T	X-Ray Diffraction and other Techniques	100	70	30	4	0	0	4	3hr
MCHE 2413T	Biophysical Chemistry and Advanced Spectroscopy	100	70	30	4	0	0	4	3hr
MCHE 2414T	Polymers and Surface Chemistry	100	70	30	4	0	0	4	3hr
MCHE 2415P	Instrumental Physical Chemistry Practical - II	100	70	30	0	0	6	3	6hr
MCHE 2416P	Physical Chemistry Practical-II	100	70	30	0	0	6	3	6hr

Division of marks for internal Assessment:

Performance in minor Test/Mid Sem Test: 40%

Assignment/Project/Seminar : 40%

Attendance : 20%

ANALYTICAL CHEMISTRY
PAPER CODE - MCHE 2301T

Max Marks: 100 **Credits: 04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The objective of this course to acquire the fundamental concepts, principles, and techniques of modern analytical chemistry in order to equip them with an analytical mindset and the ability to solve a variety of analytical problems in an efficient and quantitative manner that emphasizes the importance of accuracy and precision in analytical results. The present syllabus has been framed as per the latest UGC NET syllabus

Course outcomes

Students will develop an understanding of the chemist's broad role in measurement and problem-solving for analytical tasks. The course will provide the concepts of various analytical techniques

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B, and C. Section A will have four questions carrying 12 marks each; Section B will also have four questions carrying 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. Questions should be evenly spread over the entire range of the syllabus. In no case, question should be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass

Marks: 35%

Section - A

1. **Sampling in analysis:** Theory of sampling, importance of selecting a representative sample, Criterion of a good sampling plan, Stratified sampling Vs. random sampling. Minimization of variation in stratified sampling, sampling plan for solids, liquids and gases.
2. **Reliability of analytical data:** Errors in chemical analysis, Classification of errors. Minimization of errors, accuracy and precision and detection limits. Improving accuracy

of analysis, correlation, Regression and calibration curves, linear regression. Analysis of variance and its application in analytical chemistry.

3. **Polarography:** Principle, residual, Migration, diffusion currents, polarographic maxima and method of suppression, advantages and disadvantages of D.M.E. Reversible & irreversible processes, fundamental equation of polar graphic wave. Derivation of Ilkovic equation, assumption & deviations, Quantitative technique & evaluation of quantitative results, Amperometric titrations & Biampometric titrations.
4. Basic Principles of related technique of Polarography, Alternating current, Square Wave, pulse (normal and Differential) Tensometry, radio frequency and computer controlled polarograph and its application.
5. **Chronopotentiometry** theory, circuit and applications & comparison with polarography.

Section - B

1. **Thermogravimetric analysis:** Introduction, Principle and Instrumentation, Factors affecting thermogravimetric results, applications of Thermogravimetry.
2. Differential Thermal analysis and differential scanning calorimetry on line analysis and their interpretation.
3. **Thermometric titrations:** Introduction, theory, and applications in acid-base precipitation and complexometric titrations.
4. **Spectrophotometry and Colorimetry**
   Theory of spectrophotometry and colorimetry, Beer's law, Deviation from Beer's law, absorptivity, Photometric accuracy. Spectrophotometric titrations, titration curves, and applications to quantitative analysis.
5. **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.

REFERENCE BOOKS

1. Chemical analysis by Lattinen Harris.
2. Modern Polarographic methods in Analytical Chemistry A. M. Bend.
3. Instrumental methods of analysis Willard, Merrit and Dean.
4. Vogel's Quantitative Inorganic analysis.
5. Vogel's Quantitative Chemical analysis.
6. Basic concepts of analytical Chemistry BY S. M. Khopkar.
7. Principles of Instrumental Analysis: Douglas A. Skoog, F. James Holler and Stanley R.
8. Analytical Chemistry – Gary D. Christian, Purnendu K. Dasgupta and Kevin A. Schug.

LIGAND FIELD THEORY
PAPER CODE - MCHE 2302T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

To understand the basic concepts of coordination chemistry and the limitations of crystal field theory and explain the bonding between metal ions and ligands using ligand field theory and molecular orbital concepts. To study the splitting of d-orbitals in different geometries such as octahedral, tetrahedral, and square planar complexes and interpret magnetic properties of coordination compounds using high-spin and low-spin configurations

Course learning outcomes:

Help in solving numerical and conceptual problems related to ligand field splitting, moments, and electronic transitions. Apply ligand field th eory concepts in bioinorganic chemistry, catalysis, and industrial applications. Explain the origin of color and electronic spectra of coordination compounds.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, each worth 02 marks. Questions should be evenly spread across the entire syllabus. In no case, question should be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass

Marks: 35%

Section - A

1. 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.

2. Quantitative Basis of the Crystal Fields.
(a) Crystal Field Theory.
(b) The Octahedral Crystal Field Potential, V_{oct}
(c) The Effect of V_{oct} on d Wave Functions.
(d) Evaluation of 10 Dq.
(e) The Tetrahedral Potential.

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

4. 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 term.

5. Thermodynamic Aspects of Crystal Fields
(a) Crystal Field Stabilization Energy.
(b) Lattice energy and C.F.S.E.

Section – B

1. 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.

2. Molecular orbital theory for complex ions.
(a) Elementary Molecular Orbital Theory.
(b) Bonding in octahedral complexes.
(c) Bonding in tetrahedral complexes.

3. 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.

(b) Charge transfer spectra

4. Spectral and Magnetic properties of Complexes of Non-Cubic Stereochemistry
   (a) General
   (b) Square Planar Complexes.
   (c) Square Pyramidal Complexes.
   (d) Dodecahedral Complexes

TEXT BOOKS

1. B. N. Figgis: Introduction to Ligand Fields.
2. F. A. Cotton: Chemical Applications of Group Theory.
3. Jaffe and Orchin: Symmetry in Chemistry.
4. Philips: Basic Quantum Chemistry.
5. A. B. P. Lever: Inorganic Electronic Spectroscopy
6. Gary L. Miessler, Paul J. Fischer, & Donald A. Tarr: Inorganic Chemistry
7. F. A. Cotton, Geoffrey Wilkinson, Carlos A. Murillo, and Manfred Bochmann: Advanced Inorganic Chemistry.
8. J. E. Huheey, E. A. Keiter, and R. L. Keiter: Inorganic Chemistry: Principles of Structure and Reactivity.

REACTION MECHANISM OF TRANSITION METAL COMPLEXES

PAPER CODE - MCHE 2303T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course on Reaction Mechanism of Transition Metal Complexes aims to develop an understanding of the fundamental principles governing the reactivity and mechanisms of coordination compounds. It focuses on substitution, electron transfer, and redox reactions of transition metal complexes, including associative, dissociative, and interchange mechanisms

Course Learning Outcomes

Explain the basic concepts and theories related to reaction mechanisms of transition metal complexes. Differentiate between substitution, redox, and electron transfer reactions in coordination compounds. Interpret kinetic data and apply rate laws to inorganic reaction mechanisms.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each. Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

(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.

(b) **Reaction of Square complexes**: mechanism of ligand displacement reactions, the trans effect, cis-effect.

(c) **Metal Carbonyl reactions**: Reactions of octahedral, reactions of binuclear carbonyl, associative reactions, species with 17 electrons.

(B) Electron transfer processes: Electron transfer theory, outer sphere reactions, Inner sphere reactions, bridged reactions, two-way two-electron exchange, two-electron transfer, non-complementary reactions, substitution through redox mechanism.

(C) Stereochemical labilities: Metal carbonyl reactivity, Fluxionality in organometallic compounds.

Section - B

a) 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.

b) Stability Constants of Metal complexes

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

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

(II) Factors affecting the stability constants

(i) Statistical effect

(ii) Electrostatic effect

(iii) Chelate effect

Course Learning Outcomes: Explain the basic concepts and theories related to reaction mechanisms of transition metal complexes. Differentiate between substitution, redox, and electron transfer reactions in coordination compounds. Interpret kinetic data and apply rate laws to inorganic reaction mechanisms.

RECOMMENDED BOOKS

1. Cotton and Wilkinson: Advanced Inorganic Chemistry, John Wiley 5th Edition.
2. Edwards: Inorganic Reactions Mechanism, An Introduction W. A. Benzamin, Inc. 1965
3. Shriver, Atkins and Longford: Inorganic Chemistry, Oxford University Press, 1990.
4. Jones and Jones: Elementary Coordination Chemistry.
5. Polarography of Metal Complexes by D.R. Crow
6. F. Basolo and R. G. Pearson: *Mechanisms of Inorganic Reactions: A Study of Metal Complexes in Solution.*
7. J. E. Huheey, E. A. Keiter, and R. L. Keiter: *Inorganic Chemistry: Principles of Structure and Reactivity.*
8. Keith F. Purcell and John C. Kotz: *Inorganic Chemistry.*

INORGANIC SPECTROSCOPY-I
PAPER CODE - MCHE 2504T

Max Marks: 100 Credits: 04
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

It focuses on the principles, instrumentation, and applications of various spectroscopic methods such as UV-Visible, Infrared (IR), Raman, and electronic spectroscopy. The course aims to develop an understanding of how electromagnetic radiation interacts with matter and how this interaction determines molecular structure, bonding, symmetry, and electronic transitions in inorganic systems. Students also learn to interpret spectral data for identifying functional groups, coordination modes, and geometrical features of metal complexes.

Course Learning Outcomes

After successful completion of Inorganic Spectroscopy- I, students will understand the fundamental principles and instrumentation of important spectroscopic techniques used in inorganic chemistry. They will be able to interpret UV-Visible, IR, Raman, and electronic spectra to characterize inorganic compounds and coordination complexes. Students will develop the ability to analyze molecular structure, bonding, symmetry, and electronic transitions using spectral data.

Medium of Instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, worth 02 marks each. Questions should be evenly spread over the entire range of the syllabus. In no case should a question be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. **General introduction to spectroscopy**
   Nature of radiation energies corresponding to various kinds of radiation, atomic and molecular transitions, selection rules & chemical processes affecting the natural line width of a spectral line, general applications; determinations of concentration, isobestic points, fingerprinting, Job's method of isomolar solutions.
2. **Mossbauer Spectroscopy**
   Introduction, interpretation of Isomer Shift, Quadrupole Interactions, Magnetic interactions, applications
3. **Nuclear Quadrupole Resonance Spectroscopy**

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

4. **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 Transition 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

5. **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.

6. **Vibration & Rotation Spectroscopy**

Introduction; harmonic and anharmonic vibrations; absorption of radiation by molecular vibrations; selection rules; force constant; vibrations in polyatomic molecules; effects giving rise to absorption bands; group vibrations; limitations of the group-vibration concept.

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

7. **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 fingerprinting, 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

RECOMMENDED BOOKS

1. R. S. Drago: Physical Methods for Chemists (2nd Edn.)
2. R. Chang: Basic Principles of Spectroscopy.
3. C.N.R. Rao: Chemical Application of Spectroscopy in Inorganic Chem.
4. Gary L. Miessler and Donald A. Tarr: Inorganic Chemistry
5. F. Albert Cotton: Chemical Applications of Group Theory
6. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis.*
7. John R. Ferraro, Kazuo Nakamoto, and Chris W. Brown: *Introductory Raman Spectroscopy.*
8. Kazuo Nakamoto: *Infrared and Raman Spectra of Inorganic and Coordination Compounds.*

Inorganic Chemistry Practical-I
PAPER CODE - MCHE 2305 P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

To provide students with advanced knowledge of the structure, bonding, reactivity, and properties of inorganic compounds and coordination complexes. The course aims to build a strong practical foundation in coordination chemistry, organometallic chemistry, inorganic spectroscopy, reaction mechanisms, and bioinorganic chemistry, while enhancing analytical and laboratory skills through practical training.

Course Learning Outcomes

The program develops practical laboratory competence, research methodology, scientific communication, and critical-thinking skills required to solve chemical problems. Students also gain the ability to apply inorganic chemistry concepts in research, industry, environmental studies, and interdisciplinary scientific fields, thereby preparing them for higher education, competitive examinations, teaching, and professional careers in chemistry

Preparation and Estimation

1. Preparation of $[Co(NH_3)_6]Cl_3$
2. Estimation of cobalt and chloride.
3. Preparation of $[Co(NH_3)_5\ NO_2]Cl_2$ and $[Co(NH_3)_5\ (ONO)]Cl_2$
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 diaquotetraacetatocopper(II).
11. Estimation of copper.
12. Preparation of Vanadyl acetylacetonate.
13. Preparation of $[Ni(NH_3)_6]Cl_2$
14. Estimation of Ni.

BOOKS RECOMMENDED:

1. W. L. Jolly: Synthesis and Characterization of Inorganic Compounds
2. Gurdeep Raj: Advanced Practical Inorganic Chemistry
3. Vogel's Textbook of Quantitative Chemical Analysis
4. G. Pass and H. Sutcliffe: *Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods.*
5. Marr and B. W. Rockett: *Practical Inorganic Chemistry.*
6. A. I. Vogel: *A Textbook of Macro and Semimicro Qualitative Inorganic Analysis.*
7. S. M. Khopkar: *Basic Concepts of Analytical Chemistry.*
8. F. A. Cotton, G. Wilkinson, C. A. Murillo, and M. Bochmann: *Advanced Inorganic Chemistry.*

INORGANIC PRACTICALS-II
PAPER CODE - MCHE2306P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objective

The program also promotes scientific thinking, research aptitude, problem-solving ability, and awareness of modern developments in inorganic chemistry so students can pursue careers in teaching, research, industry, and higher studies.

Course Learning Outcomes

After completion of the course, students learn spectrophotometric and conductometric determinations of various metal ion complexes. Students also learn various separations of metal ions by different chromatographic techniques

1. Chromatographic Separations

a. To Separate Hg (II), Pb (II), Cu (II) & Cd (II) ions by paper chromatography and to determine their R_f values.
b. To separate out Ni (II), Cu (II), & Zn (II) ions by paper chromatography and determination of their Rf values.
c. To separate out F, Cl, Br & I by paper Chromatography and determination of their R_f values.
d. To separate out Na (I) & K (I) by paper chromatography and determination of their R_f values.

2. Spectrophotometric Determinations

(a) Fe (II) with 1, 10-Phenanthroline
(b) Fe (III) with Pot. Thiocyanate

Ni with dimethylglyoxime

(iv) Cu (II) with Sodium diethyl dithiocarbamate
(i) Cr (VI) with 1,5-Diphenyl carbazide

3. Conductometry

(a) Determination of number of ions in
(i) $[Cr(urea)_6]CO_3$
(ii) $[Co(NH_3)_6]Cl_3$, $[Hg(NH_3)_2CO]$
(b) Titrations of mixture of acids.
(c) Precipitation titrations.

Books Recommended:

1. Vogel's Textbook of Quantitative Chemical Analysis by J. Mendham, R. C. Denney, J. D. Barnes, and M. J. K. Thomas.

2. Analytical Chemistry by Gary D. Christian, Purnendu K. Dasgupta, and Kevin A. Schug.
3. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch.
4. *Instrumental Methods of Chemical Analysis*: Gurdeep R. Chatwal and Sham K. Anand.
5. *Instrumental Methods of Analysis*: H. H. Willard, L. L. Merritt Jr., J. A. Dean, and F. A. Settle Jr.
6. *Basic Concepts of Analytical Chemistry*: S. M. Khopkar.
7. *Introduction to Chromatography*: V. K. Srivastava and K. K. Srivastava.
8. *Experimental Physical Chemistry*: Arthur M. Halpern and George C. McBane

PHOTOCHEMISTRY AND PERICYCLIC REACTIONS
PAPER CODE - MCHE 2307T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks:35%

Course Objectives

It is designed to provide students with a comprehensive understanding of the principles and mechanisms involved in photochemical and pericyclic reactions. The course aims to develop knowledge of the interaction of light with matter, electronic excitation, photophysical and photochemical processes, and the applications of photochemistry in organic synthesis and biological systems.

Course Learning Outcomes

After completing the course, students will be able to explain the behavior of molecules under light irradiation, interpret excited-state reactions, and analyze various photophysical and photochemical phenomena. They will gain the ability to predict the course and stereochemistry of pericyclic reactions using molecular orbital symmetry and Woodward–Hoffmann rules. The course also develops problem-solving skills, mechanistic reasoning, and the ability to apply these reactions in organic synthesis, research, and advanced chemical studies.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, worth 02 marks each. Questions should be evenly spread over the entire range of the syllabus. In no case should a question be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass

Marks: 35%

Section - A

1. **Photochemical Excitations & Photophysical Processes**
   Light absorption, electronic transitions/excitations, Singlet and Triplet states, "Forbidden" transitions, Types of excitations, Molecular orbital view of excitations.

Photochemical Processes:The Jablonski diagram, Intersystem crossing, Energy transfer.

2. **Study of Mechanism of Photochemical Reactions**

Detection of intermediates, Low temperature photochemistry, Quantum efficiency, Sensitization and Quenching.

3. **The Frontier Molecular Orbital Approach:**

a. Cycloadditions: Cheletropic reactions, Dipolar cycloadditions.

b. Sigmatropic reactions: Peripatetic cyclopropane bridge, Fluxional Molecules-Degenerate Cope rearrangements

c. Pericyclic Reactions Involving Ionic Transition States

i. Cycloaddition reactions
ii. Electrocyclic reactions
iii. Sigmatropic reactions
iv. Peripatetic cyclopropane bridge
v. Group transfers and Group eliminations

4. **The Perturbational Molecular Approach**

a. Aromatic and Antiaromatic Transition States, Evan's and Dewar's rules.

b. Applications of Evan's and Dewar's rules to Pericyclic Reactions

c. Pericyclic reactions involving ionic transition states: Cycloaddition reactions. Electrocyclic reactions, Sigmatropic reactions, Peripatetic cyclopropane bridge, Cheletropic reactions, 1,3 Dipolar cycloadditions, Group transfers and Group eliminations.

6. **Green Photochemistry and Applications**

- Introduction to green photochemical synthesis
- Introduction to environmental photochemistry
- Industrial applications of photochemistry

Section - B

7 **The Fate of Excited Molecules: Photochemical Processes**

Photoaddition and Substitution Reactions

a Photoreduction of carbonyl compounds-Linear addition initiated by hydrogen abstraction reaction.

b Synthetic applications of photochemical hydrogen abstraction reactions.

c Intramolecular hydrogen abstraction: The type-II family of reactions.

d Addition reactions of cyclic conjugated enones.

8 **Cycloadditions**

a Intermolecular [2+2] cycloadditons of alkenes and conjugated dienes.

b Photosensitised intermolecular cycloadditions of conjugated dienes.

c Photosensitised cyclodimerisation of 1,3-Dienes.

d. [2+2] photocycloaddition reactions of carbonyl compounds.

e. Oxetane formation by photoaddition of excited carbonyl compounds with "electron rich" substrates: alkenes and enol ethers.

f. Oxetane formation by photoaddition of excited carbonyl compounds with "electron poor" substrates: cyanoethylenes.

g. Photocyclodimerisation of aromatic compounds.

h. Photocycloaddition reactions of conjugated enones.

i. Synthetic applications of the [2+2] photochemical cycloadditons of enones.

9 **Isomerisations and Rearrangements**

a Photochemical cis-trans isomerisation of alkenes.

b Photochemical cis-trans isomerisation of conjugated dienes.

c cis-trans isomerisation of cycloalkenes.

d Photovalence isomerisation reactions of benzene: Photochemistry of benzene valence isomers.

e Photorearrangements of 2,4-cyclohexadienones.

f Sigmatropic isomerisations of β, γ -unsaturated enones.

10 Photofragmentation Processes

a Homolytic α-cleavage of ketones

b Photochemical reactions of cyclobutanones

c Sigmatropic rearrangements of β, γ - unsaturated ketones initiated by β, γ cleavage.

BOOKS RECOMMENDED

1. K. K. Rohatgi Mukherji, *Fundamentals of Photochemistry*, Reprint, Revised edition, New Age International (P) Ltd., Publishers, New Delhi, INDIA, 1997.
2. N. J. Turro, *Modern Molecular Photochemistry*, The Benjamin/ Cummings Co., Inc. California, USA, 1978.
3. Charles H. DePuy and Orville L. Chapman, *Molecular Reactions and Photochemistry*, Prentice Hall of India Private Ltd., New Delhi, INDIA, 1972.
4. S. M. Mukherji, *Pericyclic Reactions: A Mechanistic Study*, The MacMillan Co. of India Ltd., New Delhi, INDIA, 1979.
5. James Morrison Coxon and Brian Halton, *Organic Photochemistry*, Cambridge.
6. Ian Fleming: *Pericyclic Reactions*, Oxford University Press.
7. J. Singh and Jaya Singh: *Photochemistry and Pericyclic Reactions*, New Age International Publishers.
8. V. Ramamurthy and Kirk S. Schanze (Eds.): *Photochemistry: Volume 40* (Royal Society of Chemistry) / Selected chapters on modern organic photochemistry.

CHEMISTRY OF NATURAL PRODUCTS
PAPER CODE - MCHE 2308T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course aims to develop understanding of important classes of natural products such as alkaloids, terpenoids, steroids, flavonoids, carbohydrates, amino acids, and antibiotics, along with their biological significance and medicinal applications. It also emphasizes modern methods used for extraction, purification, structural elucidation, and stereochemical analysis of natural compounds through spectroscopic and chemical techniques.

Course Learning Outcomes

Students will develop the ability to interpret reaction mechanisms, biosynthetic pathways, and stereochemical features associated with natural compounds. Students will also learn modern techniques for extraction, purification, and structural characterization using spectroscopic and analytical methods. The course further enhances scientific reasoning, research skills, and the application of natural product chemistry in pharmaceuticals, medicinal chemistry, biotechnology, and related industrial and research fields.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, each worth 02 marks. Questions should be evenly spread over the entire range of the syllabus. In no case should a question be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. General methods and basic techniques used in structure determination
   Dehydrogenation: Dehydrogenation with high potential quinones, D.D.Q., mercuric acetate, selenium dioxide, and zinc distillation with suitable examples and mechanism.

Catalytic and Chemical Dehydrogenation: Dehydrogenation with S, Se, Pt, Pd-C as involved in C-H, C-C, C-O, C-N bonds codinine, Morphine to Apomorphine, Zinziberene, Himachalene, Cedrene, Santonin, Abietic acid, Cholesterol, Bile acids, Conessine, Yohimbine, Reserpine, Atisine, veatichin, kobusine, sangorine.

2. **Degradation of Carbon Skeleton:** Hoffmann degradation, mechanism, direction of elimination as involved in morphine group alkaloids, conessine, kobusine, narcotine, launadosine, hetisine, atisinium hydroxide.

   Von Braun Reaction: Fission of C-N bond in cocaine, dihydroatisin, morphine, thebaine, codeine; Emde degradation: Conessine, Thebaine, Quinoline.

   Alkalifusion: Alkalifusion of carboxylic function, alcohols, carbonyl functions, as illustrated in geraniol, mangostein, estradiol, estrone, querectine, terramycin formation α,β – apotcramycin.

3. **Oxidation Method:**
   (i) Oxidation by $KMnO_4$, Chromic acid, methinic H, allylic methylene, β-ionone, camphene
   (ii) Ozonolysis: Mechanism, α,β - unsaturated carbonyl compounds, aromatic, heterocyclic, fenchene, camphene, α -pinene, atisine veatichin, parasantoid codine and indoles.
   (iii) Indirect Oxidation:

(a) HNO_3 oxidation: Degradation of strychnine and determination of ring sizes A, B, C in steroids.

(b) Nitrous acid oxidation: Mechanism, cyclic ketone, ketocineoles, sangorine, methinic ketone, camphor, menthone.

(c) Hydroxylation with peracids. OsO_4, silver acetate and Iodine, oxidation with HIO_4, LTA, sodium bismuthate.

(d) Haloform reaction: Methyl ketone, ionone, cedrene, caryophyllene, and cholesterol.

4. Structure and synthesis of some natural products based on chemical and spectroscopic methods: α -pinene, camphor, Ascorbic Acid, and longifolene.

Section - B

5. **Terpenes and Carotenoids: Isoprene Rule,** MVA. Conversion to borneol, thujene and allied derivatives. Formation of farnesyl pyrophosphate (FPP) and geranylgeranyl pyrophosphate (GGPP) conversion to codinine, abietic acid, cambrene, farnesal, and Noralidols to cyclic sesquiterpenes, lanosterol, cholesterol.

   Biogenetic Approach: Acetate pathways bio-genesis of macrolide, erythromycin, muscone, muscopyridine, shikmic acid pathways biogenesis of coumarine, flavonoid isoflavones.

6. Structure elucidation of the following by chemical means and spectral studies, confirmation of structure by synthesis. Himachalene, Santonin, abietic acid, β-caryophyllene, cedrene, cedrol, α-terpene, menthol, β-carotene, vitamin A.

7. Structure elucidation with synthesis of the following:

I. **Alkaloids:** Quinine, Morphine.

II. **Steroids: Bile acids, cholesterol, androstene, testosterone, progesterone.**

III. **Antibiotic:** Penicillin, Cephalosporin and Mangostein (Structure elucidation Only).

8. Green Chemistry in Natural Product Synthesis

- Introduction of Green oxidation and reduction methods

- Introduction of Biocatalysis in natural product synthesis
- Introduction of Microwave- and ultrasound-assisted synthesis

BOOKS RECOMMENDED

1. I. L., Finar: *Organic Chemistry*, Vol.2.
2. R.O.C. Norman, J. M. Coxon: *Principles of Organic Synthesis*.
3. K. W., Bentley: *Elucidation of Organic Structure by Physical Methods*, Vol. I and II.
4. P. S. Kalsi: *Chemistry of Natural Products*.
5. Manske: Volumes 7, 11.
6. R. H. F. Manske (Ed.): *The Alkaloids* (Relevant Volumes).
7. O. P. Agarwal: *Chemistry of Organic Natural Products*, Vols. I & II.
8. Gurdeep R. Chatwal: *Organic Chemistry of Natural Products*, Vols. I & II.

HETEROCYCLIC CHEMISTRY
PAPER CODE - MCHE 2309T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

It focuses on important heterocyclic compounds of biological, pharmaceutical, and industrial significance. Through this course, students gain insight into modern synthetic methods, medicinal applications, and the role of heterocyclic compounds in natural products, dyes, agrochemicals, and advanced materials, thereby strengthening their analytical and research - oriented approach in organic chemistry.

Course Learning Outcomes

The course will also develop the ability to analyze the role of heterocyclic compounds in pharmaceuticals, agrochemicals, dyes, and biologically active natural products. Furthermore, learners will acquire problem-solving and research-oriented skills relevant to modern organic and medicinal chemistry.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, each worth 02 marks. Questions should be evenly spread over the entire range of the syllabus. In no case should a question be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. **Oxirane, aziridine, thirane** (Three-membered ring with one heteroatom): Introduction, synthetic methods, Direct insertion of heteroatom into carbon-carbon double bond, methylene insertion reaction, cyclization method, condensation reaction, nucleophilic and electrophilic ring opening. Reaction involving extrusion of the heteroatoms.
2. **Oxetane, oxetene, thiophenes, azetidines (Four-membered heterocyclics with one Heteroatom):** Introduction, synthetic methods, Cyclization reaction, Direct combination method, electrophilic and nucleophilic ring opening, and General chemical reactions.

3. **Pyrazole and imidazoles** (Five-membered heterocyclics with two heteroatoms): Introduction, Physical properties, Structure, synthetic methods, electrophilic and Nucleophilic reactions.
4. **Isoxazole and Oxazole:** Introduction, Physical and chemical properties of isoxazole and oxazole and their derivatives.

   Isothiazole and Thiazoles: Physical and chemical properties, synthetic reactions.

Section - B

5. **Pyridazine, Pyrimidine, Pyrazine** (Six-membered heterocyclic with two heteroatoms): Introduction, Synthetic approaches, Chemical reactions (electrophilic substitution, Nucleophilic substitution, Side chain reactivity).
6. **Molecular Rearrangement in some Heterocyclic compounds**

i. Ring Contraction:
   (a) Pyridine and Quinoline derivatives to pyrrole & indole.
   (b) Benzodiazepines to Quinoxalenes and Benzimidazole derivatives.
   (c) Quinoxaline to Benzimidazoles.
   (d) Dihydro flavonols to Benzyl and Benzylidene Coumaranone.
   (e) Dihydrofurans to cyclopropyl ketone.

ii. Ring Expansion:
   (a) Pyrrole to Pyridines.
   (b) Benzylidene Coumaranones to flavonones and flavonols.
   (c) Tetrahydro furfurylalcohol to Dihydropyran.

iii. 1, 2 Rearrangements in Heterocyclic system.
   (a) 1,2 - Rearrangement in catechin derivatives.
   (b) 1,2 - Rearrangement of indole derivatives.
   (c) 1,2 - Rearrangement during Clemmenson's Reduction.

iv. Aromatic Rearrangements
   (a) Jacobsen Rearrangement
   (b) Migration of Alkyl group during Fisher's Indole Synthesis
   (c) Rearrangement of N-substituted aniline, N-oxides
   (d) Rearrangement of Benzidine.

7. **Biological and Medicinal Importance of Heterocyclic Compounds**
   - Drug examples of each (Imidazole. Thiazole, Pyrimidine, Quinoline, Indole)
   - Pharmaceutical applications in brief
   - Brief Agrochemical applications
   - Structure–activity relationship (basic concept only)

BOOKS RECOMMENDED

1. R. M. Acheson: *Chemistry of Heterocyclics.*
2. A. R. Katrizky: *Handbook of Heterocyclics.*
3. Lee A. Paquette: *Principles of Modern Heterocyclic Chemistry.*
4. P-de-Mayo: *Molecular Rearrangement,* Vol.1.
5. John A. Joule and Keith Mills: Heterocyclic Chemistry
6. Thomas L. Gilchrist: Heterocyclic Chemistry
7. Jacques Mortier: Arene Chemistry: Reaction Mechanisms and Methods for Aromatic Compounds.
8. Jerry March: March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure.

ORGANIC CHEMISTRY PRACTICALS- I
PAPER CODE - MCHE 2310P

Max Marks: 100 **Credits: 03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course on Multistep Synthesis is designed to provide students with comprehensive knowledge of important organic name reactions and sequential synthetic transformations used to prepare industrially and biologically significant compounds. The course aims to develop understanding of reaction mechanisms, rearrangement reactions, and synthetic strategies through practical conversion of simple organic compounds into value-added products.

Course Learning Outcomes

Students will gain hands-on experience in reactions such as Beckmann Rearrangement, Benzilic Acid Rearrangement, and Fischer Indole Synthesis, including the synthesis of benzanilide, acetanilide, caprolactam, benzilic acid derivatives, maleimides, tetrahydrocarbazoles, and indole derivatives. The course also provides understanding on purification techniques, characterization of synthesized compounds, mechanistic interpretation, and development of laboratory skills required for advanced organic synthesis and research applications

(Multistep Synthesis)

1. **Beckman Rearrangement**
   - I. Benzophenone-Benzophenone Oxime-Benzanilide
   - II. Acetophenone-Acetophenone Oxime-Acetanilide.
   - III. Cyclohexanone-Cyclohexanone Oxime-Caprolactam.
2. **Benzillic acid Rearrangement**
   - I. Benzoin-Benzil-Benzillic-acid
   - II. Benzoin-Benzil-Benzil monohydrazone
3. **Fischer Indole Synthesis (from aryl hydrazines and ketones or aldehydes)**
   - I. N-aryl-Maleinilic acid-N-aryl-maleimide
   - II. 1, 2, 3, 4-tetrahydrocarbazole
   - III. 2-Phenyl-Indole from Phenyl-hydrazone

Note: Subject to the availability of chemicals, the experiments can be substituted by alternate experiment.

ORGANIC CHEMISTRY PRACTICALS-II
PAPER CODE - MCHE 2311P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course aims to provide students with hands-on experience in volumetric and redox analytical techniques used to estimate hydroxyl, amine, and carbonyl functional groups, as well as non-aqueous titrations using acetic perchloric acid. Students will learn methods for determining the purity and concentration of phenols, aniline, sulpha drugs, sugars, glucose, sucrose, alkaloids, sodium benzoate, sodium salicylate, ephedrine, and brucine through bromination, diazotization, Fehling's, Benedict's, and non-aqueous titration methods.

Course learning outcomes

The course also emphasizes accurate experimental procedures, preparation and standardization of solutions, calculation techniques, interpretation of analytical data, and development of laboratory competence required in chemical, pharmaceutical, and industrial analysis.

Quantitative Estimations

1. Hydroxyl group - (Phenolic)

Expt. 1: Determine the percentage purity of given phenols by brominating reagent.

2. Amine group

Expt. 2: Determine the amount of aniline per liter by substitution method.
Expt. 3: Determine the percentage purity of amine by diazotization method.
Expt. 4: Find the percentage purity of sulphadimidine by diazotization method.

3. Carbonyl group

Expt. 5: To standardize the given glucose solution by Fehling's method.
Expt. 6: Determine the percentage purity of the given sample of glucose.
Expt. 7: Determine the percentage purity of sugar by Fehling's method.
Expt. 8: To determine the amount of glucose in a given sample by Benedict's Solution.
Expt. 9: To determine the percentage purity of sucrose by Benedict's method.

4 Acetous Perchloric Acid

Expt. 10: To standardize acetous perchloric acid using primary standard potassium hydrogen phthalate.
Expt. 11: To determine percentage purity of sodium benzoate.
Expt. 12: To determine percentage purity of sodium salicylate.
Expt. 13: To determine percentage purity of given alkaloid (Ephedrin).
Expt. 14: To find percentage purity of Brucine.

Books recommended:

1. A. I. Vogel: *Vogel's Textbook of Quantitative Chemical Analysis.*
2. A. I. Vogel: *Vogel's Textbook of Practical Organic Chemistry.*
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, and A. R. Tatchell: *Vogel's Textbook of Practical Organic Chemistry* (5th Edition).
4. N. S. Gnanapragasam and G. Ramamurthy: *Organic Chemistry Laboratory Manual.*
5. Gurdeep R. Chatwal and Sham K. Anand: *Instrumental Methods of Chemical Analysis.*
6. S. M. Khopkar: *Basic Concepts of Analytical Chemistry.*
7. Gary D. Christian, Purnendu K. Dasgupta, and Kevin A. Schug: *Analytical Chemistry.*
8. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis.*

FUNDAMENTALS OF SPECTROSCOPY
PAPER CODE - MCHE 2312T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course is designed to provide students with a thorough understanding of the basic principles, theories, and applications of spectroscopic techniques used in chemical analysis and structure determination. The course aims to develop knowledge of the interaction of electromagnetic radiation with matter and the interpretation of spectral data obtained from UV-Visible, Infrared (IR), Nuclear Magnetic Resonance (NMR), and Mass Spectroscopy techniques

Course Learning Outcomes

Students will learn the fundamental concepts of absorption, emission, electronic transitions, molecular vibrations, magnetic properties, and fragmentation patterns that are essential for identifying and characterizing organic and inorganic compounds. The course provides learning the practical applications of spectroscopy in qualitative and quantitative analysis, molecular structure elucidation, and modern research in chemistry, thereby enhancing analytical, interpretative, and problem-solving skills required in academic, industrial, and research laboratories.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. Molecular Spectroscopy

Electromagnetic radiation, interaction of electromagnetic radiation with molecules, and quantization of different forms of energy in molecules. Regions of the electromagnetic spectrum and their analytical significance. Units of energy. Representations of spectra. Time-dependent Schrödinger equation. Induced quantum transition, derivation of an equation giving the rate of transition. Basis of selection rules.

2. Rotational Spectroscopy

Symmetry of molecules and angular momenta in three coordinates. Rigid rotor model, Intensities of spectral lines, Effect of isotopic substitution. Determination of moments of inertia and bond length. Non-rigid rotor model and centrifugal distortion. Application of rotational spectroscopy in molecular structure determination.

3. Vibrational Spectroscopy

Classical equation of vibration (Hook's law) of linear molecules, simple harmonic oscillator, vibrational energies of diatomic molecules, zero-point energy. Anharmonic oscillator. Vibrations of polyatomic molecules (H_2O and CO_2): fundamental frequencies, overtones, combination bands, and hot bands of polyatomic molecules.

Effect of Various Parameters on the Vibrational Frequency. Application of vibration spectra in elucidation of molecular structure from Vibration Frequency.

4. Vibrational-Rotation Spectroscopy

Selection rules and transitions for the rigid rotor - Harmonic oscillator model, P, Q, R branches of vibration-rotation spectra, relative intensities, coupling of rotation and vibrations.

5. Raman Spectroscopy

Classical and quantum theory of Raman effect. Stokes and anti-Stokes lines. Pure rotational spectra of linear molecules. O, Q and S branches of Vibrational Raman spectra. Rotational fine structure in the Vibrational Raman spectra.

Section - B

6. Nuclear Magnetic Resonance

Historical introduction to nuclear magnetic resonance, principle, instrumentation, nuclear precession, chemical shift and factors influencing chemical shift, shielding and deshielding effect. Equivalence and non-equivalence of protons (chemically and magnetically), Spin-Spin splitting and coupling constant, systems cont aining two interacting nuclei (A_2, AX & AB systems), systems containing three interacting nuclei (A_3, ABX, ABC), Karplus equation, interpretation of PMR spectra of some representative compounds like hydrocarbons, halogen compounds, hydroxy compounds, ethers, aldehydes, ketones, carboxylic acids, esters, amides and amines.

7. Electron spin resonance spectroscopy

Basis for resonance, experimental techniques, A block diagram of a typical ESR spectrometer, ESR of simple systems and of radical anion of aromatic hydrocarbons, mechanism of hyperfine interaction, McConnell's relation of electron delocalization, zero field splitting and Kramer's degeneracy, predicting the number of lines in E.S.R. spectra of radicals, factors affecting the Magnitude of the g value, some applications including biological structure determination, double resonance technique in ESR.

BOOKS

1. C.N. Banwell - *Molecular Spectroscopy*.
2. G.M. Barrow - *Molecular Spectroscopy*.
3. H.S. Randhawa – *Atomic and Molecular Spectroscopy*. (Pearson Education).

4. M. Chander - *Atomic Structure, Chemical bonding including Molecular Spectroscopy.*
5. *Organic spectroscopy: Principle and Applications* by Jagmohan (Narosa Publishing House).
6. *Spectroscopic methods in organic chemistry* by Dudley H. Williams and Ian Fleming (Tata McGraw Hill)
7. *Organic Spectroscopy* by William Kemp (MacMillan)
8. Chang R., *Basic Principles of Spectroscopy.*

STATISTICAL THERMODYNAMICS

PAPER CODE - MCHE 2313T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives: The course provides students with a fundamental understanding of the relationship between microscopic molecular behavior and the macroscopic thermodynamic properties of matter. The course aims to develop knowledge of statistical methods and probability concepts used to explain thermodynamic phenomena at the molecular level.

Course learning outcomes: Students will learn the principles of distribution laws, partition functions, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics, and their applications in evaluating thermodynamic properties such as energy, entropy, heat capacity, and free energy. The course also focuses on the statistical interpretation of the laws of thermodynamics, molecular motions, and equilibrium processes in gases, liquids, and solids.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, each worth 02 marks. Questions should be evenly spread over the entire range of the syllabus. In no case should a question be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. Quantum Statistics

Recapitulation of classical statistics and partition function, comparison between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, thermodynamic probability and statistical interpretation of entropy, statistics of monatomic ideal gas, principle of equipartition of energy, barometric equation, theory of Para magnetism, statistics of photon and electron gases, Maxwell distribution of molecular velocities, speed and energy distribution functions, thermionic emission.

2. Gaseous State

Classical and quantum mechanical treatments of specific heats of ideal diatomic gases, vibrational, rotational and electronic contributions to the specific heats of diatomic gases, fine

correction due to rotation-vibration coupling for diatomic gases, ortho and para hydrogens, polyatomic gases, gas mixture and entropy of mixing, non-ideal gases, equation of state of non-ideal gases, Lennard-Jones potential energy equation for compressed gases.

Section - B

3. Solid State

Classical treatment of specific heat of solids, Einstein and Debye theories of specific heats. Debye's T^3 law and low temperature behavior of solids, entropy of solids, equation of state of solids, order and disorder and the melting point and its factor affecting the melting behavior.

4. Chemical Systems

Law of mass action, chemical equilibrium, dissociation, equilibrium constants and their computation. Effect of temperature and pressure on equilibrium.

Fluctuations

Means distribution, mean square deviation, fluctuations in energy in a canonical ensemble, density fluctuation in a gas. Theory of Brownian motion and Brownian motion of galvanometer.

5. Irreversible Processes

Introduction, entropy production, coupled phenomena, transport parameters, thermoelectric phenomena, The Seebeck effect, Peltier effect and Thomson effect.

BOOKS RECOMMENDED

1. *Statistical Thermodynamics* by J.F. Lee, F. W. Sears and D.L. Turcotte.
2. *Introduction to Statistical Thermodynamics* by F.L. Hill.
3. *Statistical Thermodynamics* by M.C. Gupta.
4. *Molecular Driving Forces* by Ken Dill and Sarina Bromberg.
5. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma, and M.S. Pathania
6. Donald A. McQuarrie: *Statistical Mechanics.*
7. Keith J. Laidler, John H. Meiser, and Bryan C. Sanctuary: *Physical Chemistry.*
8. R. K. Pathria and Paul D. Beale: *Statistical Mechanics* (3rd Edition).

FUNDAMENTAL & ATMOSPHERIC PHOTOCHEMISTRY

PAPER CODE - MCHE 2314T

Max Marks: 100 Credits:04

End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course on is designed to provide students with a comprehensive understanding of the principles and applications of photochemical processes occurring in chemical and atmospheric systems. The course aims to develop knowledge of the interaction of light with matter, electronic excitation, photophysical and photochemical reactions, quantum yield, energy transfer, and reaction mechanisms of excited states.

Course learning outcomes

Students will learn the fundamental laws of photochemistry and how molecules behave under ultraviolet and visible radiation. The course also focuses on atmospheric photochemical processes such as ozone formation and depletion, photochemical smog, greenhouse effects, and the role of free radicals and pollutants in atmospheric chemistry. Through this study, students will gain analytical and environmental awareness along with the ability to apply photochemical concepts in research, environmental monitoring, and modern chemical sciences.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, and Section B will also have four questions carrying 12 marks each. Section C will consist of 11 short-answer type questions covering the entire syllabus, worth 02 marks each. Questions should be evenly spread over the entire range of the syllabus. In no case should a question be asked from outside the syllabus. Set the question paper strictly according to the instructions above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. Photochemical Reactions

Interaction of electromagnetic radiations with matter, types of excitations and excited states, Distinction of photoreactions from thermally initiated reactions and from high-energy radiation reactions, Basic laws of photochemistry; Grothus & Draper law, Stark-Einstein law (law of photochemical equivalence) and law of absorption (Lambert-Beer's law) and its limitations, Quantum yield and its determination by ferrioxalate actinometer.

2. Photochemistry of Atoms

Term symbols, Russell-Saunders coupling, selection rules, Excited states of Hg atoms ($^1P_1$, $^3P_1$ and metastable state, $^3P_0$), photosensitized reactions. Sensitized fluorescence, spin conservation rule and its application for energy transfer, Photophysical processes (fluorescence, phosphorescence, etc.), and photochemical degradation of excited states of Hg atoms, Hg-sensitized photoreactions of simple alkanes and alkenes.

3. Photochemistry of simple molecules

Different kinds of spectra; banded, continuous and diffuse spectra, Pre-dissociation, Photophysical processes of simple molecules like sulfur, halogens and oxygen.

4. Photochemistry of polyatomic molecules

Different types of molecular orbitals and electronic states, Jablonski diagram showing various photophysical processes like fluorescence, phosphorescence, ISC, IC, etc. Intensities and selection rules for spectral transitions, types of electronic transitions in organic molecules. Charge transfer transitions, excited-state lifetimes, and factors influencing photophysical processes.

5. Photochemical oxidation and reductions

Mechanistic features of photoreduction of benzophenone by alcohols, Photosensitized incorporations of molecular oxygen into organic compounds, Type I and II photoxygenation reactions, and applications of photo redox reactions in organic synthesis.

6. Industrial Applications of Photochemistry

Technical applications, including the use of luminescence phenomena for optical bleaching of textiles and paper. Rapid radiationless transition to ground state. Applications of electron and energy transfer processes, Photofragmentations used in photochemical synthesis of detergents and insecticides.

Section - B

7. Structure of the atmosphere, structure in terms of temperature, diffusion and ionization, characteristics and chemical composition.
8. Solar radiation, solar spectral distribution outside the earth's atmosphere, absorption by N_2, O_2, O_3 and distribution of solar energy on earth.
9. Chemistry of the upper atmosphere (chemistry of Nox and HOx species), features of odd oxygen and singlet oxygen, NO_2 and HO_2 species and other species like N_2O, NH_3, HNO_3 etc., in the atmosphere.
10. Meaning of Pollutant, different ways to express concentration of Pollutants (mass concentration, volume concentration, mass volume concentration & ppm) various pollutants like CO and CO_2, hydrocarbons, oxides of nitrogen, oxidants, halogenated, compounds, sulphur containing compounds and particulate matter monitoring and control of these pollutants.

11. Photochemical smog. Production of smog, hydrocarbon reactivities, conversion of NO to NO_2 oxidant dosage, reactions of O_3 and singlet O_2.
12. SO_2 Chemistry, Photolysis of SO_2, Photo-oxidation, free radical reactions, formation of acid rain.

BOOKS RECOMMENDED

1. Gilbert & Cundel: *Photochemistry*.
2. Calvert & Pits: *Photochemistry*.
3. *Atmoshperic Chemistry*, J. Heicklen, Academic Press, New York.
4. *Environmental Pollution Control Engineering*, C.S. Rao, New Age International (P) Limited Publishers.

SUPPLEMENTARY READINGS

1. K. K. Rohatgi-Mukherjee: *Photochemistry*.
2. Fifth International Symposium: *Photochemistry*.
3. Fifth International Symposium on Photochemistry (Selected Proceedings).
4. J. N. Pitts Jr. and J. G. Calvert: Selected papers on Atmospheric Photochemistry.

INSTRUMENTAL PHYSICAL CHEMISTRY PRACTICALS-I
PAPER CODE - MCHE 2315P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives: The course aims to develop understanding of the principles and applications of colorimetry, spectrophotometry, polarimetry, and polarographic measurements in chemical investigations. Students will learn to verify Lambert–Beer's law, determine concentrations of coloured compounds, study metal–ligand complexes, evaluate dissociation constants, determine molar extinction coefficients, and analyze complete absorption spect ra using spectrophotometric methods.

Course Learning outcomes: After successful completion of the course, students will be able to verify Lambert-Beer's law and apply Spectro-photometric methods for the quantitative determination of coloured compounds and mixtures. Students will gain the ability to study metal-ligand complex formation such as Cu^{2+}–EDTA complexes, determine pKa values of indicators like phenolphthalein, evaluate molar

1. Colorimetry and Spectro-photometry

1. Verification of Lambert-Beer's Law.
2. Determination of the concentration of colored compounds.
3. Study of Cu^{2+} -EDTA Complex.
4. Determination of the pKa of phenolphthalein.
5. Determination of the Composition of the mixtures.
6. Determination of the molar extinction coefficients.
7. Scanning of the complete spectra.

2. Polarimetry

1. To find the specific rotation and molar rotation of optically active substance.
2. To find the strength of the optically active substances in the given solution.
3. To find the order of the reaction and velocity constant for the inversion of cane sugar in acidic medium.
4. To compare the strength of hydrochloric acid and sulphuric acids.
5. To find the percentage of d-sugar and d-tatraric acid in the given solution polarimetrically.

3. Polarographic Measurements

1. Determination of $E_{1/2}$ of aqueous solution of Zn^{2+} and Cu^{2+}.
2. Determination of the concentration of the solution of zinc and cadmium salt.
3. Amperometric titration.

PHYSICAL CHEMISTRY PRACTICALS-I
PAPER CODE - MCHE 2316P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The objectives of this course are to develop an understanding of reaction kinetics through the study of reaction rates, order of reactions, catalytic effects, and determination of activation energy using systems such as potassium bromate–potassium iodide, hydrogen peroxide–hydroiodic acid clock reaction, and hydrolysis of tert-butyl chloride by conductance measurements.

Course Learning Outcomes

The course aims to familiarize students with the application of phase rule in studying ternary systems and determining the limits of homogeneity in systems involving benzene, chloroform, acetic acid, and water. It also seeks to impart practical skills in Thin Layer Chromatography (TLC) for separation, identification, and quantitative estimation of coloured and colourless organic compounds using chromatographic and spectrophotometric techniques.

1. CHEMICAL KINETICS

(I) Reaction between Potassium bromate and Potassium Iodide:
  (a) To study the kinetics of reaction between Potassium bromate and Potassium iodide catalyzed by H^+ ions at room temperature.
  (b) To study the kinetics of reaction between Potassium bromate and Potassium Iodide catalyzed by H^+ ions at least at three temperatures and hence to find out the activation energy of the reaction.

(II) To study the reaction between H_2O_2 and HI by the clock method at least at three temperatures and hence to find out the activation energy of the reaction.

(III) To study the kinetics of hydrolysis of tert-butyl chloride by conductance measurements.

2. PHASE RULE

Three component system.

(a) To study the limit of homogeniety of three components (i.e., benzene, acetic acid and water) system.

(b) To study the limit of homogeniety of three components (i.e., chloroform, acetic acid and water) system.

3. THIN LAYER CHROMATOGRAPHY

(I) To separate and identify the given mixtures of coloured compounds (azobenzene, hydroxyazobenzene, P-aminoazobenzene).

(II) To separate and identify the given mixture of colourless compounds (Diphenylamine, Benzophenone, Naphthalene, and biphenyl).

(III) To draw a calibration curve for different amounts of Azobenzene after separating on TLC plates, extracting with methanol, and

measuring with a spectrophotometer, and hence to find the amount of Azobenzene in its unknown sample.

4. Cryoscopy

1. To find the molecular weight of the given solute in water by depression in freezing point method.
2. To find the values of van't Hoff factor and degree of dissociation of weak electrolytes by cryoscopic method.
3. To determine the degree of association of benzoic acid in benzene by cryoscopic method.
4. To determine the mean activity coefficients of strong electrolytes.

5. Find the oscillator strength of the main band of diphenylamine in the ultraviolet region of the spectrum.

Books recommended:

1. Advanced Practical Physical Chemistry by J.B. Yadav
2. Senior Practical Physical Chemistry by B.D. Khosla, V.C. Garg, and A. Gulati
3. Practical Physical Chemistry by A.M. James and F.E. Prichard
4. Experimental Physical Chemistry by Carl W. Garland, Joseph W. Nibler, and David P. Shoemaker
5. Arthur M. Halpern and George C. McBane: *Experimental Physical Chemistry.*
6. Findlay's *Practical Physical Chemistry* (Revised by B. P. Levitt).
7. Peter Atkins and Julio de Paula: *Atkins' Physical Chemistry.*
8. S. Glasstone: *Textbook of Physical Chemistry.*

SEMESTER-IV

ENVIRONMENTAL CHEMISTRY
PAPER CODE - MCHE 2401T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The course aims to develop an understanding of the concept, scope, and significance of environmental chemistry, including environmental segments, pollutants, contaminants, sinks, receptors, greenhouse effect, global warming, and atmospheric chemical and photochemical reactions. Students are introduced to the causes, effects, and control of air pollution with emphasis on major air pollutants such as CO, NO_2, SO_2, hydrocarbons, suspended particulate matter, photochemical smog, acid rain.

Course Learning Outcomes

Students will acquire practical and theoretical expertise in modern environmental monitoring and analytical techniques such as Atomic Absorption Spectroscopy (AAS), Flame Photometry, Infrared Spectroscopy (FTIR and NDIR), Ion Selective Electrodes, High-Performance Liquid Chromatography (HPLC), Gas Chromatography (GC), and Anodic Stripping Analysis

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each. Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section – A

1. Concept, scope and importance of Environmental Chemistry, Environmental Pollution (sources and classification). Environmental Segments, Greenhouse effect, global warming and climate change, chemical and Photochemical reactions in the atmosphere, Pollutants, contaminants, sinks and receptor.
2. Air Pollution: Sources and classification, Air Pollutants (CO, NO_X, SO_2, HC, SPM) Photo chemical smog, Acid rain, particulates, Air Pollution accidents (TCDD (2, 3, 7, 8

tetra Chloro benzo - 10 dioxin), Bhopal, Chernobyl Air Pollution monitoring instruments, Monitoring of SO_2, NO-NOx, CO, CO_2 HC Ozone).

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

Section - B

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

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

6 Monitoring techniques for Pollution Analysis

(i) Atomic absorption spectroscopy and flame photometry theory, Instrument, Interferences and evaluation methods.

(ii) Infrared Spectroscopy Introduction, Instrumentation, Beer's – Lambert relationship. NDIR & FTIR.

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

8 HPLC (High-performance liquid chromatography) Principle and instrumentation, supports & types of detectors.

9. Gas chromatography: Apparatus, detector, working, column, and carrier gases.

10 Anodic Stripping Analysis: Principle, Apparatus and technique & advantages.

BOOKS

1. *Environmental Chemistry* by A. K. De.
2. *Environmental Pollution Analysis* S. M. Khopkar.
3. Vogel's text book of Quantitative Chemical Analyses.
4. *Environmental Chemistry* (11th Edition) by Stanley E. Manahan
5. *A Textbook of Environmental Chemistry and Pollution Control* by S.S. Dara and D.D. Mishra
6. Gary D. Christian, Purnendu K. Dasgupta, and Kevin A. Schug: *Analytical Chemistry*.
7. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis*.
8. Colin Baird and Michael Cann: *Environmental Chemistry*.

CHEMISTRY OF ORGANOMETALLIC COMPOUNDS
PAPER CODE - MCHE 2402T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives:
The course aims to develop knowledge of the classification, nomenclature, stability, and electronic structure of organometallic compounds of transition and non -transition metals, including metal carbonyls, π-complexes, sandwich compounds, and metal-alkyl and metal-aryl systems. The course also focuses on important reaction mechanisms such as oxidative addition, reductive elimination, migratory insertion, and ligand substitution, which govern organometallic transformations.

Course Learning Outcomes

Students will develop analytical and problem-solving skills related to reaction pathways, bonding patterns, and catalytic cycles of organometallic systems. Overall, the course will strengthen students' understanding of modern synthetic and industrial chemistry and prepare them for advanced studies and research in catalysis, inorganic chemistry, materials science, and related interdisciplinary fields.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each. Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. **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 behavior 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 Aluminohydrides.

2. **Compounds of Transition Metal with Alkenes, Alkynes and Delocalized Hydrocarbon Systems:** Alkene complexes, Types of Alkene Complexes, Synthesis & Reactions of Alkene complexes, Alkyne and Alkyne - Derived Compounds. Allyl and Related complexes: Allyls, Dienyl Compounds, trimethylenemethane Complexes. Carbocyclic-π-Complexes, Three-membered, four membered, five membered Rings: Di-η^5–cyclopentadienyls, Bridging cyclopentadienyls, Ionic cyclopentadienyls, monocyclopentadienyls, Reactions of C_5H_5 Ring, Metal compounds of Heterocycles, multidecker Sandwich Compounds.

Section - B

3. **Homogeneous Catalytic Synthesis of Organic Chemicals by Transition Metal complexes:** Introduction, Reactions of Carbon Monoxide and Hydrogen, Synthesis Gas and Water Gas, shift Reaction. Reduction of carbon monoxide by Hydrogen. The Fischer-Tropsch Synthesis. Synthesis of oxygenated compounds, Hydroformylation of Unsaturated Compounds. Reductive Carbonylation of Alcohols and other compounds, Carbonylation Reactions. Methanol and Methyl Acetate, Adipic Ester synthesis, other carbonylation Reaction. Decarbonylation Reactions. Catalytic Addition of Molecules to C-C Multiple Bonds. Homogeneous Hydrogenation of unsaturated compounds, Reversible cis-Dihydrido catalysis, Monohydrido complexes. Hydrogenation of unsaturated groups. transfer Hydrogenations. Hydrosilation of unsaturated compounds.

Other Aspects of Catalytic Reaction: Supported Homogeneous & Phase Transfer Catalysis.

Oxidation Reactions, Oxygen Transfer from Peroxo and Oxo Species. Oxygen Transfer from NO_2 group.

4. **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, Semibridging 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 RECOMMENDED

1. Cotton Wilkinson: *Advanced Inorganic*, John Wiley 5th & 6th Edition.
2. Shriver, Atkins and Longford: *Inorganic Chemistry*, Oxford University, Press, 1990.
3. *The Organometallic Chemistry of the Transition Metals* by Robert H. Crabtree
4. *Organometallic Chemistry* by Gary S. Spessard and Gary L. Miessler.
5. Elschenbroich, C.: *Organometallics*.

J. E. Huheey, E. A. Keiter, and R. L. Keiter: *Inorganic Chemistry: Principles of Structure and Reactivity.*

Hartwig, J. F.: *Organotransition Metal Chemistry: From Bonding to Catalysis.*

B. D. Gupta and A. J. Elias: *Basic Organometallic Chemistry: Concepts, Syntheses and Applications.*

ADVANCED TOPICS IN INORGANIC CHEMISTRY
PAPER CODE - MCHE 2403T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The course emphasizes the application of modern spectroscopic, electrochemical, and analytical techniques for the characterization of inorganic compounds. In addition, students are introduced to recent advances in inorganic chemistry related to nanomaterials, medicinal inorganic chemistry, environmental applications, and industrial processes.

Course Learning Outcomes

The course will enable students to apply modern spectroscopic, electrochemical, and analytical techniques for characterization and investigation of inorganic compounds and reaction systems. Students will gain insight into the applications of inorganic chemistry in catalysis, medicinal chemistry, environmental chemistry, nanoscience, and industrial processes

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. **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 a neutron flux, gamma transitions and isomerism & β decay, health and safety aspects in radiation protection, Analysis by Isotope dilution.

2. **Nano chemistry:** Introduction to nano chemistry, Nano and nature, nano the beginning, introduction to carbon Nanotubes; types, synthesis and purification.

ief introduction to self-assembled monolayers (SAMs), Monolayers on Gold, Preparation, ixed monolayers, SAMs and applications; Sensors, affinity biosensors, chemical sensors, rosion prevention, wetting control, molecular electronics

ocess of synthesis of Nano powders, Sol-Gel process, Electro-Deposition, Plasma enhanced apour decomposition, sputtering of Nano crystalline powders.

pplication of SEM, TEM and AFM to nanotechnology.

Section - B

3. **Metal to metal bonds and metal atom clusters:**

Introduction metal carbonyl Clusters, Isoelectronic and isolobal relationship, High uclearity Cabonyl Clusters (HNCCs) (Structural patterns, synthetic methods), hetero atoms n metal atom cluster: carbide and nitride containing clusters, electron counting schemes for INCCs, 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 lusters (M_6X_8 and M_6X_{12} types) chevral phases, triangular clusters and solid-state extended rrays. Compounds with M-M multiple bonds, Major structural types, quadruple bonds, other ond orders in the tetragonal context, relation of clusters to multiple bonds and one-limensional solids.

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

. **Polymers**

) 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

b) Sulfur polymers

1.10. Elementary sulfur: Crystalline:
1.10.1. Forms of sulfur
1.10.2. Molten sulfur
1.10.3. Sulfur vapour
1.11. Sulfanes (Hydrogen polysulfides) and their salts:
1.11.1 Free sulfanes

1.11.2. Salts of sulfanes

1.12. Alkyl and aryl Sulfanes :

1.12.1. Preparation

1.12.2. Properties and structure

c) 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 RECOMMENDED

1. Nuclear and Radiations Chemistry by Fiedelander and Kennedy.
2. Principles of Radio Chemistry, Indian Association of Nuclear Chemists and Allied Scientists. Editors D.D. Sood, N. Rama moorthy, A.V.R. Reddy.
3. Cotton Wilkinson; Advanced Inorganic, John Wiley 5th & 6th Edition.
4. Inorganic Polymers by Stone and Graham.
5. T. Pradeep, Nano: The Essentials; Understanding Nanoscience and Nanotechnology, Tata McGraw-Hill Education Pvt. Ltd., New Delhi.
6. A.K. Bandyopadhyay, Nano Materials, New Age International Publishers, New Delhi
7. C. N. R. Rao, A. Müller, and A. K. Cheetham (Eds.): *The Chemistry of Nanomaterials: Synthesis, Properties and Applications*.
8. Robert H. Crabtree: *The Organometallic Chemistry of the Transition Metals*.

INORGANIC SPECTROSCOPY-II
PAPER CODE - MCHE 2404T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The present syllabus has been framed as per the latest UGC NET syllabus. The objective of this paper is to understand the students with the wide knowledge of spectroscopy used in inorganic chemistry and organometallic chemistry. The subject will also develop a problem-solving approach in students through the concept of Nuclear Magnetic Resonance spectroscopy, Mass spectrometry, ESR, ORD and CD.

Course learning outcome

It empowers students to identify, analyze, and characterize complex inorganic and organometallic compounds using advanced physical and spectral techniques. After completing the course, the students will be able to understand and solve the problems of Nuclear magnetic spectrum, they also know about the applications of mass spectroscopy in structure determination

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. Nuclear Magnetic Resonance Spectroscopy

Introduction: Theory of NMR, behaviour 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 neighbour 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.

2. Application of NMR

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

3. 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

4. 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.

5. Mass Spectrometry

Instrument operation and presentation of spectral processes that can occur when a molecule

and a high-energy electron combine, fingerprint applications.

Interpretation of mass spectra, effect of isotope on appearance of mass spectrum, Molecular

weight determination: field ionisation techniques, evaluation of heat of sublimation and species in the vapor over high-melting solids. Appearance potential, and ionization potential.

6. ORD & CD

Theory of ORD & CD.

Measurement of optical Rotation.

Application of ORD & CD.

RECOMMENDED BOOKS

1. R. S. Drago: Physical Methods for Chemists (2nd Edn.)
2. C. A. Power: Mass-Spectroscopy.
3. R. Chnag: Basic Principles of Spectroscopy.
4. Willard Merritt Dean: Instrumental Methods of Analysis.
5. C. M. Banwell: Molecular Spectroscopy.
6. F. C. Gibb: Principles of Mossbauer Spectroscopy.
7. James Keeler: *Understanding NMR Spectroscopy* (3rd Edition).
8. Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James A. Vyvyan: *Introduction to Spectroscopy.*

Inorganic Chemistry Practical-III

PAPER CODE - MCHE 2405P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The course aims to develop experimental skills in the preparation of transition metal complexes involving chromium, cobalt, copper, iron, and nickel, and to familiarize students with the principles of coordination chemistry, stereochemistry, and redox behavior of metal ions.

Course Learning Outcomes

Students will develop laboratory skills related to water analysis and alloy composition analysis, enabling them to apply chemical principles to environmental and industrial samples. The course further strengthens scientific observation, data interpretation, laboratory safety practices, and technical reporting abilities essential for higher studies and research in inorganic chemistry.

1. Preparation of $[Cr(urea)_6]Cl_3$
2. Estimation of Cr and Cl.
3. Preparation of sodium diethyldithiocarbamate.
4. Preparation of nitroso bisdiethyldithiocarbamate iron (I).
5. Estimation of Iron.
6. Preparation of cis & trans dichlorobisethylenediammine cobalt (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 dichloropyridylcobalt(II)
11. Estimation of Cobalt.
12. Preparation of Sodium tetrathionate.
13. Estimation of Sodium tetrathionate using Potassium iodate.
14. Preparation of $[Ni(NH_3)_6]Cl_2$.
15. Estimation of Nickel.

14. Analysis of

(a) Water samples (hardness).
(b) Alloys (solder, brass, bronze, steel).

PAPER CODE - MCHE 2406P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

It seeks to familiarize students with the interpretation of IR spectra for identification of functional groups, bonding modes, and metal–ligand interactions in coordination compounds. The course also aims to impart practical knowledge of spectrophotometric methods such as Job's method and Mole-Ratio method for determining the stoichiometry and stability of metal complexes.

Course Learning Outcomes

Students will acquire practical expertise in the characterization of coordination complexes such as nickel ammine complexes, pyridine perchromate, chromium urea complexes, diethyldithiocarbamate derivatives, and sodium tetrathionate using spectroscopic techniques.

1. IR Spectroscopy

Study of the following complexes.

(i) $[Ni(NH_3)_6]Cl_2$
(ii) Pyridineperchromate
(iii) $[Cr(urea)_6]Cl_2$
(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).
   (c) Calculation of 10 Dq and for hexa aquo ion of Ni (II).
   (d) Verification of relative positions of following ligands in the spectrochemical series: H_2O, Py, NH_3, DMSO, Acetyl acetonate, ethylenediamine, acetate and urea.

4. Polarography

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

BOOKS RECOMMENDED

1. *Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A* by Kazuo Nakamoto
2. *Inorganic Chemistry* by Huheey, Keiter, and Keiter
3. *Vogel's Textbook of Quantitative Inorganic Analysis* by J. Mendham et al.
4. *Instrumental Methods of Analysis* by Willard, Merritt, Dean, and Settle
5. A. B. P. Lever: *Inorganic Electronic Spectroscopy.*
6. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis.*
7. H. H. Willard, L. L. Merritt Jr., J. A. Dean, and F. A. Settle Jr.: *Instrumental Methods of Analysis.*
8. C. N. Banwell and E. M. McCash: *Fundamentals of Molecular Spectroscopy.*

APPLICATIONS OF ORGANIC MOLECULAR SPECTROSCOPY
PAPER CODE - MCHE 2407T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The course aims to develop theoretical and practical knowledge of ultraviolet-visible (UV-Vis), infrared (IR), nuclear magnetic resonance (NMR), and mass spectrometry techniques, along with their applications in identifying functional groups, determining molecular structures, and analyzing stereochemical features of organic molecules.

Course Learning Outcomes

Students gain insight into molecular architecture and reaction mechanisms. In addition, the course aims to develop analytical thinking, instrumental knowledge, and data interpretation skills that are essential for advanced research, pharmaceutical analysis, chemical industries, and interdisciplinary applications of organic chemistry.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 12 marks each. Section C will consist of 11 short an swer type questions that will cover the entire syllabus and will be of 02 marks each. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. Ultraviolet and Visible Spectroscopy

Introduction, Colour and light absorption, the chromophore concept. Theory of electronic spectroscopy, orbitals involved and electronic transitions. Effect of solvent and conjugation on λ_{max}. Woodward Fieser, Fieser-Kuhn and Nelson's rules Spectral correlation with structure: conjugated dienes and polyenes: α, β-unsaturated carbonyl compounds; benzene, substituted benzenes and polynuclear aromatic hydrocarbons. Stereochemical factors in electronic spectroscopy:

biphenyls and binaphthyls, cis and trans isomers, angular distortion, cross conjugation and steric inhibition of resonance.

2. Infrared Spectroscopy

Molecular vibrations and modes of vibrations, factors influencing vibrational frequencies: vibrational coupling, hydrogen bonding, conjugation, inductive, mesomeric (resonance), field effects and bond angles, Application to identify functional groups: aliphatic, aromatic and aralkyl hydrocarbons, alcohols, phenols and ethers; aldehydes, ketones, carboxylic acids and esters; amines and amides; alkyl halides, aryl halides and aralkyl halides.

3. Mass spectrometry

Introduction. Mass spectrum and Metastable ion peak, Determination of molecular formula and recognition of molecular ion peak and the Nitrogen rule Molecular formula and index of Hydrogen deficiency, General rules of fragmentation and the McLafferty rearrangement . Fragmentations associated with functional groups: aliphatic, aromatic and aralkyl hydrocarbons, alcohols, phenols and ethers; aldehydes, ketones, carboxylic acids and esters; amines and amides; alkyl halides, aryl halides and aralkyl halides. Heteroaromatic compounds (pyrrole furan and thiophene) and amino acids.

4. Recent Advances in Spectroscopic Techniques

- Introduction of High-resolution mass spectrometry (HRMS).
- LC–MS and GC–MS (introductory concepts only).

Section - B

5. Nuclear magnetic resonance spectroscopy

Proton magnetic resonance spectroscopy: nuclear spin resonance, Chemical shift and its measurement, Relaxation processes, Chemical shift equivalence and magnetic equivalence, Factors influencing; chemical shift: Shielding, deshielding and anisotropic effects; effect of restricted rotation, concentration temperature and hydrogen bonding, Spin coupling (simple and complex), mechanism of coupling. Coupling constants, geminal coupling, vicinal coupling, virtual and long-range coupling. Factors influencing geminal and vicinal coupling, Non first order spectra, simplification of complex pmr spectra: increased strength, spin decoupling or double resonance and the use of chemical shift reagents,Variable temperature NMR spectroscopy: introduction and applications.

6. ^{13}C-NMR spectroscopy

Natural abundance of ^{13}C, resolution and multiplicity. The FT mode and rf pulse, Use of proton coupled, proton decoupled and off- resonance decoupling techniques; deuterium substitution and chemical shift equivalence in peak assignments, ^{13}C Chemical shift: effect of substituents on chemical shift position of alkanes, alkenes, alkynes and benzene. Spin coupling and ^{13}C - ^{1}H coupling constants

7. New dimensions in NMR spectroscopy

Nuclear overhauser effect and NOE difference spectra, Introduction to correlated spectroscopy (COSY). Homcor (^{1}H-^{1}H) and HETCOR (^{1}H-^{13}C) of menthol and geraniol, APT and DEPT techniques (menthol and geraniol), A brief introduction to Nuclear Overhauser Effect Spectroscopy (NOESY) with a suitable example

8. Integrated Spectral Interpretation

- Combined use of UV–Visible, IR, Mass and NMR spectroscopy.
- Brief introduction to solid-state NMR.

BOOKS RECOMMENDED

1. William Kemp, *Organic Spectroscopy*, P edition, ELKS, MacMillian, Hampshire, UK. 1991.
2. D. H. William and I. Fleming, *Spectroscopic Methods in Organic Chemistry*, TATA McGRAW-Hill Publishing Company Ltd., New Delhi, India, 1993.
3. R. M. Silverstein, G. C. Bassler and F. C. Morrill, *Spectrometric Identification of Organic Compounds*, 5th edition, John Wiley and Sons Inc., New York. USA, 1991.
4. Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James R. Vyvyan: *Introduction to Spectroscopy*.
5. James Keeler: *Understanding NMR Spectroscopy* (3rd Edition).
6. J. H. Simpson: *Organic Structure Determination Using 2-D NMR Spectroscopy: A Problem-Based Approach*.
7. Eberhard Breitmaier: *Structure Elucidation by NMR in Organic Chemistry: A Practical Guide*.
8. Dudley H. Williams and Ian Fleming: *Spectroscopic Methods in Organic Chemistry* (Latest Edition).

ORGANIC SYNTHESIS

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each. Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours

Max. Marks: 70

Pass Marks: 35%

Section - A

1. **Introduction to Organic Synthesis:** Concepts of synthesis and synthetic equivalents. General principles of the disconnection approach in retrosynthetic analysis. Importance of the order of synthetic events in organic synthesis. Introduction to one C–X and two C–X bond disconnections. Concept of polarity reversal (umpolung) and its significance in synthetic strategy.

   Protecting Groups: Principles of protecting alcohol, amino, carbonyl, and carboxylic functional groups using appropriate protecting groups, with suitable examples highlighting their importance and applications in organic synthesis.

One group C-C - disconnection: Disconnection of simple alcohols, of simple olefins. carbonyl compounds control in synthesis, friedal craft's type examples.

Two Group Disconnections 1,3-Difunctionalized compound α-hydroxy carbonyl compounds. α,β-unsaturated carbonyl compounds, 1,3-di carbonyl compounds. α,β unsaturated lactones, 1,5-dicarbonyl compounds michael disconnection, use of Mannich Reaction in disconnection, Robinson's annelation.

Diels Alder Reaction: General feature dienophile diene, intramolecular Diels Alder reaction stereochemistry and mechanisms, ene synthesis. Retro-Diels Alder's Reaction.

Section - B

5. Synthesis of alkene, β – elimination pyrolytic syn elimination, synthesis of allyl alcohol, sulphoxide sulphenate rearrangement, through phosphorous ylid, decarboxylation of α – lactum stereo selective synthesis of tri-tetra substituted alkenes through use of acetylenes. Fragmentation of sulphonates, oxidative decarboxylation of carboxylic acids. Decomposition of toulene p-sulphonylhydrazones, stereospecific synthesis from – 1,2-diols. Stereoselective route to γ, δ–carbonyl compounds.

6. **C-C bond formation:** Generation and importance of enolate ion, regioselectivity, stereoselectivity. Generation of dianion and their alkylation, alkylation of relatively acidic methylene groups. Hydrolysis and decarboxylation of alkylated product, O-Vs-C alkylation, C-alkylation of vinyl group, aryl group. Formation of enamines and alkylation. Alkylation of carbon by conjugate additions.

7. **Reaction of carbon nucleophiles with carbonyl group:** Condensation process favoured equilibrium by dehydration of aldol products, under acidic and basic conditions, Amine catalysed condensation, Mannich Reaction. Nucleoph ilic addition, Cyclisation process, Derzen, Perkin, Stobbe reaction. Sulphur slides, phosphorous ylides and related species as nucleophiles.

8. Modern Synthetic Strategies in Organic Synthesis

Principles of atom economy and green chemistry.
One-pot and multicomponent reactions.
Microwave-assisted organic synthesis.
Solvent-free organic synthesis.

BOOKS RECOMMENDED

1. W. Carruther: Some Modern Method of Organic Synthesis.
2. H. O. House: Modern Synthetic Reactions.
3. I. L. Finar: Organic Chemistry. Vol.2.
4. R.O.C. Norman; J.M. Coxon: Principles of Organic Synthesis.
5. Stuart Warren and Paul Wyatt: *Organic Synthesis: The Disconnection Approach.*
6. Michael B. Smith: *Organic Synthesis* (4th Edition or latest).
7. Francis A. Carey and Richard J. Sundberg: *Advanced Organic Chemistry, Part B: Reactions and Synthesis.*
8. Jie Jack Li: *Name Reactions: A Collection of Detailed Reaction Mechanisms.*

MODERN SYNTHETIC REACTIONS AND REARRANGEMENTS

PAPER CODE - CHEM 2409T

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours

Max. Marks: 70

Pass Marks: 35%

Section - A

1. **Functionalization of Non-Activated Carbon**
   Barton's reaction and related process mechanism, stereochemistry of transition state, photolysis of organic nitrites, N-Nitrosoamides, hypohalites. Reaction of monohydric alcohols with lead tetraacetate, olefinic alcohols from hydroperoxides, cyclobutanols from photolysis of ketones, applications to steroid nucleus.

2. (a) Hoffman Loeffler Ley Freytag Reaction using N-chloramine derivatives, mechanisitic approach and application.
   (b) Newer Chemical Techniques: Brief concept of crown ethers, phase transfer reagent, application in synthesis.
   (c) Use of compounds of Thallium (III), Palladium and Ruthenium oxide in organic synthesis.
3. **Applications of Organosilicon Compounds in Organic Synthesis:** Modern applications of organosilicon compounds in organic synthesis, including functional group protection, the use of trimethylsilyl cyanide (TMSCN), elimination reactions of α-hydroxysilanes, the Peterson olefination and related transformations, Annelation; alkenylsilanes and αβγδ-epoxysilanes, stabilisation of corbonium ions by α-silyl groups.
4. Allylic alkylation of alkenes; The dihydro 1,3-oxazine synthesis of aldehyde and ketones, coupling of organonickel and organocopper complexes. Reaction of lithium organocuparates, synthetic application of carbenes and carbenoids. Some photocyclisation reactions, acyclic conjugated trienes, stilbene, Anil, alkaloids and related processes.
5. **Modern Catalytic Methods in Organic Synthesis**
   - Introduction to transition-metal catalysis.
   - Palladium-catalyzed carbon-carbon bond-forming reactions (Suzuki–Miyaura, Heck and Sonogashira reactions).

Section - B

Molecular Rearrangements

6. **Rearrangements in Small Ring Compounds**
   (a) Introduction: Thermal rearrangements, Cyclopropane derivatives, Acid catalysed rearrangement involving carbonium ions, Base catalysed rearrangement, involving carbanians, Rearrangements involving free radicals and carbene intermediate.
   (b) Thermal rearrangements: Cyclobutane derivatives. Acid ctatalysed rearrangement involving carbonium ion, base catalysed rearrangement involving carbanions, Rearrangements involving free radical and carbene intermediate.

7. **Carbonium Ion Rearrangements in Bridged Bicyclic Systems:**

Study of Wagner–Meerwein, Pinacol, Nametkin, and Demjanov rearrangements, including their mechanisms, migratory aptitude, stereochemical consequences, and applications in organic synthesis.

8. **Rearrangement in Steroids**
   (a) Angular group migration, Rearrangement in C_{13}–CH_3, C_9, C_{11}, C_{19} methyl groups. Dienone phenol rearrangement.
   (b) Anthrasteroid Rearrangement.
   (c) Retro aldol phenomenon.
   (d) i-steroid transformation.
   (e) Ring expansion and contraction in A, B, C, D Rings.
   (f) Acyloin Rearrangement in D-homoannulation, Acyl group migration, Allylic transposition, Redistribution Reactions.

9. **Asymmetric and Sustainable Organic Synthesis**
   Introduction to stereoselective and asymmetric synthesis.
   Chiral auxiliaries and asymmetric catalysis (basic concepts).

BOOKS RECOMMENDED

1. K. W. Bentley: Elucidation of Organic Structure by Physical Method, Part-I, II.
2. P. S. Kalsi: Chemistry of Natural Products.
3. P. de-Mayo: Molecular Rearrangement, Vol. I & II.
4. H. O. House: Modem Synthetic Reaction.
5. W. Carruther: Some Modem Methods of Organic Synthesis.
6. Francis A. Carey and Richard J. Sundberg: *Advanced Organic Chemistry, Part B: Reactions and Synthesis.*
7. Jie Jack Li: *Name Reactions: A Collection of Detailed Reaction Mechanisms.*
8. Michael B. Smith: *Organic Synthesis* (4th Edition or latest).

ORGANIC CHEMISTRY PRACTICAL-III

PAPER CODE - MCHE 2410P

Max Marks: 100 **Credits:03**

End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The objective of this practical course is to provide students with comprehensive training in multistep organic synthesis and the application of modern synthetic methods in the preparation of industrially and biologically important organic compounds.

Course Learning Outcomes

Students are trained in the interpretation of IR and NMR spectra for structural characterization and confirmation of synthesized compounds. The practical exercises are intended to enhance laboratory techniques, analytical thinking, problem-solving ability, and understanding of reaction pathways, thereby preparing students for advanced studies, research, and applications in pharmaceutical, dye, and fine chemical industries.

Multi-step Synthesis

I. **Phenyl isothiocynate from Aniline**
   (i) To prepare Diphenyl thiourea (Thiocarbanilide) from Aniline.
   (ii) To prepare phenyl isothiocynate from thiocarbanilide.

II. **Cyclopentanone from cyclohexanone**
   (i) To prepare adipic acid from cyclohexanone (oxidation).
   (ii) To prepare cyclopentanone from adipic acid.

III. **α-Aminobenzenesulfonamide from acetanilide**
   (i) To prepare p-acetamidobenzene sulphonyl chloride from Acetanilide.
   (ii) To prepare p-acetamidobenzene sulphonamide from p- acetamidoienzene sulphonyl chloride.
   (iii) To prepare p-aminobenzene sulfonamide from p- acetamidobenzene sulphonamide.

IV. **Acridone from Anthranilic acid**
   (i) To prepare o-chlorobenzoic acid from anthranilic acid (Sandmeyer's Reaction).
   (ii) To prepare N-Phenylanthranilic acid from O-Chlorobenzoic acid (Ullman condensation).
   (iii) To prepare Acridone from N-Phenyl anthranilic acid (Cyclization).

V. **p-Bromo/ Nitro acetanilide from aniline**
   (i) To prepare Acetanilide from Aniline (Acetylation).
   (ii) To prepare p-bromoacetanilide from Acetanilide (Bromination).
   (iii) To prepare p-nitroacetanilide from Acetanilide (Nitration).

VI. **Preparation of chalcone**
   (i) To Preparation of chalcone from Aryl aldehyde and acetophenone.

VII. **Photochemical Reaction**

Benzophenone to Benzpinacol

VIII. Spectroscopy

Students are supposed to know the IR & NMR spectra of the prepared compounds.

NOTE: *Subject to the availability of Instrument/Chemicals, the experiments can be substituted by alternate experiments.*

ORGANIC CHEMISTRY PRACTICALS-IV
PAPER CODE - MCHE 2411P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

The objective of this practical course is to provide students with comprehensive knowledge and laboratory training in quantitative organic analysis using classical and instrumental techniques. The course aims to develop practical skills in the estimation and purity determination of organic compounds through extraction methods, non -aqueous titrations, addition reactions, oxidation methods, chromatographic separation, and spectrophotometric analysis

Course Learning Outcomes

The practical exercises are intended to strengthen analytical accuracy, instrumental handling, data interpretation, laboratory safety, and scientific reporting skills essential for advanced research, pharmaceutical analysis, quality control, and industrial applications in organic and analytical chemistry.

I. **Quantitative Estimation by Extraction Method**

Expt. 1: To determine percentage purity of sodium benzoate in the given sample by extraction method.

Expt. 2: To find percentage. purity of sodium salicylate by extraction method.

II. **Non-Aqueous determination. Potassium Methoxide**

Expt. 3: To standardize the given solution of potassium methoxide.

Expt. 4: To determine percentage of nitro-benzoic acid.

Expt. 5: To find the percentage of Barbitones.

Expt. 6: To determine percentage of succinimide in given sample.

III. **Olefinic bond**

Expt. 7: To determine percentage purity of allylacohol by addition method using brominating reagent.

Expt. 8: To find the amount of mesityl oxide using brominating reagent.

IV. **Diols**

Expt. 9: To determine the percentage purity of given sample of glycol using periodic acid.

Expt. 10: To determine the amount of glycerol per litre using periodic acid.

V. **Paper chromatography**

Separation and identification of alkaloids by paper chromatography and determination of

R_f values.

VI. **Spectrophotometeric (UV/VIS) Estimations**

1. Amino acids
2. Carbohydrate
3. Cholesterol
4. Ascorbic Acid
5. Asprin
6. Caffeine

NOTE: Subject to the availability of Instrument/chemicals, the experiments can be substituted by alternate experiments

X-RAY DIFFRACTION AND OTHER TECHNIQUES

PAPER CODE - MCHE 2412T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course objectives

It provides students with a comprehensive understanding of advanced analytical and characterization techniques used for determining the structural, physical, and chemical properties of materials and molecules. Emphasis is placed on understanding the relationship between molecular structure and material properties, interpretation of experimental data, and applications of modern characterization tools in research and industry

Course Learning Outcomes

After successful completion of the course students will be able to understand the fundamental principles of X-ray diffraction and interpret diffraction patterns for the determination of crystal structures and lattice parameters of crystalline materials. They will gain competency in sample preparation, data collection, spectral interpretation, and analysis of experimental results obtained from advanced instruments.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours
Max. Marks: 70

Pass Marks: 35%

Section - A

1. Crystallography And X-Rays

(i) Crystallography: Crystals, Crystal laitices, Unit Cell and Crystal systems. Bravias lattices and their classification, lattice, directions and lattice planes, Miller indices, derivation of spacing formula for cubic, tetragonal and orthorhombic crystals, stereographic projections, crystal structure of CsCl, NaCl Diamond, ZnS, CaF_2 etc.

Point defects, stoichiometric and non- stoichiometric crystal defects, thermodynamics of Schottky and Frenkel defects formation, colour centres, line defects and plane defects.

(ii) Nature of X-Rays: Introduction, the continuous spectrum, The characteristic spectra, absorption of X-Rays, filters, production and detection of X-Rays (Photographic method and counters)

2.X -Ray Diffraction

X-Ray diffraction and the directions of diffracted beam, X-ray spectroscopy, methods of X-ray diffraction - Bragg's method and Laue's method, Derivation of Bragg's law and Laue's diffraction equation. Rotating crystal method, Powder method, diffraction under non-ideal conditions. The intensities of diffracted beams scattered by an electron, atom and a unit cell. The structure factor calculations. The factors influencing the intensity of diffracted lines on the powder pattern. Determination of crystal structure, indexing patterns of cubic crystals, indexing patterns of non-cubic crystals. Electron diffraction scattering by gases. Wierl equation, measurement technique. Neutron diffraction: introduction, measurement technique, difference between neutron and X-ray diffraction.

Section - B

3. Circular Dichroism and Optical Rotatory Dispersion

Theory of polarised light, optical activity and optically active molecules, Cotton effects, CD and ORD, Octant Rule and its applications. Experimental Techniques, Applications: quantitative analysis, determination of absolute configuration, conformational studies, equilibrium studies and secondary and tertiary structural studies of biomolecules.

4. Nuclear Quadrupole Resonance Spectroscopy

Basic concepts, electric field gradient and quadrupole interactions, experimental techniques, Zeeman splitting of quadrupole spectra, quadrupole coupling in (i) atoms and (ii) molecules. Structural information obtainable from NQR spectra, nature of chemical bond and study of charge transfer compounds.

5. Mossbauer Spectroscopy

The Mossbauer effect, the Mossbauer active nuclei. Recoil free emission and absorption of gamma radiation, the spectral line width. The chemical isomer shift. The quadrupole splitting, magnetic hyperfine interactions. Measurement technique, elucidation of structure of ^{57}Fe, ^{119}Sn and ^{151}Eu complexes using Mossbauer data. Dynamic effect, Second-order Doppler shift and recoilless fraction. The Goldanskii-karyagin effect. Paramagnetic relaxation. Mossbauer spectroscopy of biological systems. Mossbauer spectroscopy applied to surface study, nature of chemical bond and structural determination, analytical applications.

BOOKS RECOMMENDED

1. R. Chang: Basic Principles of Spectroscopy.
2. R. S. Drago: Physical Methods in Chemistry.
3. B. D. Cullity: Elements of X-ray Diffraction.
4. T. C. GIBB: Principles of Mossbauer Spectroscopy.
5. Darassi: Optical Rotatory Dispersion.
6. C. N. Banwell and E. M. McCash: *Fundamentals of Molecular Spectroscopy.*
7. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis.*
8. B. E. Warren: *X-ray Diffraction.*

BIOPHYSICAL CHEMISTRY AND ADVANCED SPECTROSCOPY
PAPER CODE - MCHE 2413T

Max Marks: 100 **Credits:04**
End Semester Exam: 70
Internal Assessments: 30
Pass Marks: 35%

Course Objectives

The course aims to develop knowledge of biomolecular structure, molecular interactions, thermodynamics, kinetics, and the physicochemical behavior of biological macromolecules such as proteins, nucleic acids, and membranes. It is designed to familiarize students with modern spectroscopic methods including UV-Visible, infrared, fluorescence, Raman, NMR, ESR, mass spectrometry, and other advanced analytical techniques

Course Learning Outcomes

After completion of this course students will develop analytical thinking, experimental interpretation skills, and technical competence in handling sophisticated instruments, thereby preparing them for advanced research, interdisciplinary studies, and industrial applications in biophysical chemistry and molecular spectroscopy.

Medium of instruction: English

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours Max. Marks: 70 **Pass Marks: 35%**

Section - A

1. Biophysical Chemistry

Structure of water, Amino acids, Proteins and Polynucleic acids. The peptide bond and its significance. Isoelectric point. Conformations of polypeptide chains, primary, secondary and higher-order structures.

Factors affecting analyte structure and stability- pH Effects, Temperature Effects, Effect of solvent Polarity, and ionic strength.Biological relevance of chemical potential, Hydrophobic and hydrophilic interactions in biological systems.

Protein-Solvent Interactions-Preferential binding, hydration and exclusion. Protein denaturation models.

Thermodynamics of protein folding/stability by fluorescence, CD and calorimetric techniques (DSC and ITC), Hill equation and cooperative binding.

Binding of small ligands by biological macromolecules: Kinetics and energetics of protein-drug, protein-surfactant interaction by fluorescence, CD and calorimetric methods.

2. LASER And MASERS

Introduction, laser beam characteristics; directionality, intensity, monochromaticity and coherence, laser action; spontaneous and stimulated emission, amplification, population inversion, negative absorption. Pumping (optical, electrical etc.) Two level systems, possibility of amplification, Population inversion in three and four level systems. Masers; Two level maser system – ammonia maser (principle and working). Optical resonators. Solid laser – Ruby-laser, Gas lasers; Helium – Neon gas laser, Chemical lasers; HCl & HF lasers, Q - switching, Raman laser action, stimulated Raman scattering. Semiconductor lasers: Band model theory for metals Intrinsic and impurity semiconductors, p-n junctions, semiconductor diode laser. Applications of lasers and masers; projection of intense energy, absorption spectra, focussed beam, power transmission, communication, atmospheric optics, medical optics etc.

Section - B

3. Mass Spectrometry

Development with special reference to Dempster's mass spectrometer. Basic instrumentation: electron bombardment and photo ionization sources, magnetic, electrostatic and time of flight analyzers, ion detectors, (Vibrating reed electrometers and electron multipliers). Operation and representation of mass spectra, Types of ions in mass spectra. Energetics of electron impact process: appearance potential of positive and negative ion s, ionization efficiency curves. The Frank-Condon principle and the ionization and dissociation of molecules by electron impact. Molecular weight determination, evaluation of bond dissociation energies, heats of formation and electron affinities by mass spectrometric methods.

4. Photoelectron Spectroscopy (PES)

Basic principles of photoelectron spectroscopy; Introduction, photoelectron spectrum, block diagram of photoelectron spectrometer. Experimental techniques; light sources, spherical field analysers, deflection analysers, parallel plate mirror analyser, retarding field analyser, operational consideration; recording a spectrum, signal-to-noise ratio. Photoionization and atomization; Application of Frank - Condon principle to photoelectric spectra. Koopman's theorem.

Atomic photoelectron spectra of Ar, Kr and Xe and spin orbit coupling. Photoelectron spectra of halogen acids (HF, HCl, H Br, and HI) and spin orbit coupling, applications of PES in electronic structure determination.

BOOKS RECOMMENDED

1. S.F. Sun, Physical Chemistry of Macromolecules: Basic principles and Issues. Second Edition, A Wiley-Interscience Publication, JOHN WILEY & SONS, INC.
2. Allen Cooper, Biophysical Chemistry, 2nd Edition.
3. David Sheehan, Physical Biochemistry: Principles and applications. JOHN WILEY & SONS, INC.
4. C. Tanford, Physical Chemistry of Macromolecules.
5. C.R. Cantor and P.R. Schimmel, Biophysical Chemistry Part III: The Behavior of Biological Macromolecules.
6. K.E. van Holde, Physical Biochemistry
7. R.B. Gregory, ed., Protein-Solvent Interactions, Marcel Dekker, Inc. 1995
8. C. Branden and J. Tooze, Introduction to Protein structure, Garland Publishing, Inc., 1991
9. B. B. Laud : Lasers and non-linear optics.
10. B. A. Lengyel : Introduction to lasers.
11. Koichi Shimoda : Introduction to lasers.
12. R. Chang : Basic Principles of Spectroscopy.
13. R. S. Drago : Physical methods in Chemistry.
14. C. A. McDowell : Mass spectrometry.
15. D. Briggs (Editor) : Handbook of X-ray and UV photoelectron spectroscopy.
16. D. W. Turner : Photoelectron spectroscopy.

POLYMERS AND SURFACE CHEMISTRY

PAPER CODE - MCHE 2414T

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three Sections: A, B and C. Section A will have four questions carrying 12 marks each, Section B will have also four questions carrying 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. Questions should be evenly spread over the entire range of syllabus. In no case, question should be asked from outside the syllabus. The question paper should be set strictly according to the instructions mentioned above.

INSTRUCTIONS TO BE GIVEN IN THE QUESTION PAPER

1. Answer five questions in all, selecting at least two questions from each section. The question in section C is compulsory.
2. Questions in sections A and B carry 12 marks each. The questions in section C carry 2 marks each.

Time Allowed: 3 Hours

Max. Marks: 70

Pass Marks: 35%

Section - A

1. Introduction: Classification and nomenclature of polymers, structure, composition and polymerization mechanism (step growth and chain growth), types of monomers and polymers.
2. Step Polymerization: Reactivity of functional groups, basis for analysis of polymerization, kinetics of step polymerization, self catalysed polymerization, external catalysis of polymerization, step polymerization other than polyesterification non - equivalence of functional groups in polyfunctional reagents.
3. Radical chain ploymerization: Overall mechanism and kinetics of chain polymerization, initiation, thermal decomposition of initiators, types of initiators, kinetics of initiation and polymerization, dependence of polymerization rate on monomer concentration.
4. Co-polymerization and emulsion polymerization: Principle of copolymerization and emulsion polymerization, The composition of addition copolymers, kinetics of chain propagation in co-polymerization.
5. Molecular weight average and viscosity average molecular weight, polydispersity index, molecular weight determination by osmotic method, light scattering method, sedimentation method, diffusion constant, sedimentation equilibrium, viscosity method.
6. Statistics of Linear polymers Molecular weight, molecular weight distribution, polydispersity index. average and end to end distance, average radius of gyration.

Section - B

7. Adsorption: Adsorption, Adsorption of gases, influence of temperature and pressure, nature of adsorption (physical and chemical adsorption), and adsorbed gases, unimolecular layers. types of adsorptions, Langmuir adsorption isotherm and BET adsorption equation and their derivation, estimation of surface area of adsorption. Gibb's adsorption equation and its verification.
8. Kinetics of heterogeneous reaction at solid surfaces: Gas reaction on solids, single reacting gas, retardation of reaction products.
9. Catalysis: Catalysts and Criteria of catalysis and initiation of a reaction. Catalytic activity and its determination, salt effects (Primary and Secondary), (ho heterogeneous catalysis).

10. Spectroscopic methods like PES, AES, LEED to determine surface structure, important applications of surface chemistry, surfactant, wetting, micelles, detergency, surface tension, interfacial tension.

RECOMMENDED BOOKS

1. Principles of Polymerization by George Odian.
2. Principles of Polymer Chemistry by Paul J. Flory.
3. Text book of Physical Chemistry by Glastone.
4. Physical Chemistry of Macromolecules by Charles Tanford.
5. Physical Chemistry by G. M. Barrow.
6. The surface Chemistry of Solids by S. J. Gregg.
7. Physical Chemistry of Surfaces by Arthur W. Adamson, 4th Ed. John Wiley (New York).
8. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis*, Cengage Learning.

INSTRUMENTAL PHYSICAL CHEMISTRY PRACTICALS- II

PAPER CODE - MCHE 2415P

Max Marks: 100 **Credits:03**
End Semester Exam: 70
Internal Assessments: 30

Pass Marks: 35%

Course objectives

The objective of this practical course is to provide students with comprehensive training in electroanalytical and physicochemical techniques used for quantitative chemical analysis and the study of ionic equilibria.

Course Learning Outcomes

The course further enhances laboratory techniques, instrumental handling, quantitative data interpretation, analytical accuracy, scientific reasoning, and technical reporting skills required for higher studies, research, and industrial applications in physical and analytical chemistry.

I. **Conductance Measurements**

1. Acid-base Titrations
(a) Strong acid vs strong base.
(b) Weak acid vs strong base.
(c) Strong acid vs weak base.
(d) Mixture of strong acid and weak acid vs strong base.
(e) Mixture of strong acid, Weak acid and $CuSO_4$ vs strong base.
2. To determine the cell constant of the given conductivity cell.
3. Determination of the solubility of sparingly soluble salts.
4. Verification of Debye-Huckel-Onsagar equation.
5. Verification of Ostwald dilution law.
6. Transport number measurements by Hittorf's method.
7. Precipitation titrations.
8. Complexometric titrations.
9. Determination of the degree of hydrolysis of the salts.

II. **pH Measurements**

1. Acid-Base titrations.
   (a) Strong acid vs strong base.
   (b) Strong acid vs weak base.
   (c) Weak. acid vs strong base.
   (d) Mixture of a strong acid and weak acid vs strong base.
2. Determination of the dissociation constants of weak acids and weak bases.
3. Determinations of the degree of hydrolysis of the salts of weak acids and strong bases and that of strong acids and weak bases.
4. To determine the buffer capacity of the given buffer solution.

III. **E.M.F. Measurements (Potentiometry)**

1. Volumetric analysis.
   (a) Acid-base titrations.

(b) Precipitation titrations.

(c) Redox titrations.

2. Construction and determination of emf of the following cells:
   (a) Pt,Hg, Hg_2Cl_2, KCl (saturated) / Ag^+ (0.1N)/ Ag
   (b) Pt,Hg Hg_2Cl_2, KCl (0.1) / Ag^+ (0.1 N) / Ag
   (c) Ag / Ag^+ (0.01N)/Ag^+ (0.1N) Ag
   (d) Ag / Ag^+ (0.01N) / KCl (0.01N) AgCl / Ag
3. Determination of the solubility of the sparingly soluble salts.
4. Determination of the mean activity coefficients.
5. To determine the various thermodynamic functions for the following reaction:
   $Zn + Cu^{+2} \leftrightarrow Zn^{+2} + Cu$
6. To determine the equilibrium constant for the complex, $[Ag(NH_3)_4]^+$ formation.

IV. **Flame Photometry**

To determine the concentration of the ions like Na^+, K^+, Ca^{2+} in the given solution.

BOOKS RECOMMENDED:

1. Advanced Practical Physical Chemistry by J.B. Yadav
2. Practical Physical Chemistry by B. Viswanathan and P.S. Raghavan Practical Physical Chemistry
3. Textbook of Practical Physical Chemistry by K.K. Sharma and D.S. Sharma
4. Advanced Physical Chemistry Practical Guide
5. Arthur M. Halpern and George C. McBane: *Experimental Physical Chemistry.*
6. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch: *Principles of Instrumental Analysis.*
7. Peter Atkins and Julio de Paula: *Atkins' Physical Chemistry.*
8. J. N. Gurtu and R. Kapoor: *Advanced Experimental Chemistry, Vol. I: Physical Chemistry.*

PHYSICAL CHEMISTRY PRACTICALS – II

PAPER CODE - MCHE 2416P

Max Marks: 100 **Credits: 03**
End Semester Exam: 70
Internal Assessments: 30

Pass Marks: 35%

Course objectives

The objective of this practical course is to provide students with comprehensive knowledge and experimental training in photochemistry, phase equilibria, solution chemistry, and surface phenomena. The course aims to develop understanding of the fundamental principles of photochemical reactions, quantum yield measurements, and actinometry.

Course Learning Outcomes

The course further enhances laboratory skills, instrumental handling, quantitative an alysis, scientific interpretation, and problem-solving abilities essential for advanced research and industrial applications in physical chemistry and photochemistry.

1. PHOTOCHEMISTRY

(I) Intensity of the lamp/Quantum yield of the Reaction.

(a) To draw calibration curve for various concentrations of Ferrous sulphate/1,10-phenanthroline complex and hence to find the coefficient of its molar absorptivity.

(b) To find out the intensity of the lamp (visible light) by ferrioxalate actinometer.

(II) Methylene blue Sensitized photooxidation of Diphenylamine

(a) To study the rate of formation of the product in the above photochemical reaction with increasing quanta of light absorbed and to find the quantum yield of this reaction.

(b) To study the effect of following parameters on the above reaction

(1) Effect of dielectric constant of the medium.
(2) Effect of methylene blue concentration.
(3) Effect of diphenylamine concentrations.
(4) Effect of oxygen concentration.

2. TWO COMPONENT SYSTEMS

(a) To determine the critical solution temperature (CST) and critical solution concentration (CSC) for phenol/water system. .

(b) To find the Eutectic point for two component systems, i.e., Naphthalene/Benzoic acid and benzoic acid/ Cinnamic acid systems.

3. PARTIAL MOLAL VOLUMES

To find the partial molal volumes for urea, Glycine and ethanol in aqueous solutions.

4. LEAST SQUARE PLOT

To calculate the slope and intercept for a data of straight lines by least square method and to draw the line.

5. MICELLES FORMATION

(a) To determine the critical micelle conc. of sodium dodecyl sulphate from a study of the conductivity of aqueous solutions.

(b) To determine critical conc. for the formation of micelles from the spectral behaviour of a dye.

Books recommended:

1. Advanced Practical Physical Chemistry by J.N. Gurtu and Amit Gurtu
2. Senior Practical Physical Chemistry by B.D. Khosla, V.C. Garg, and Adarsh Gulati
3. Practical Physical Chemistry by B. Viswanathan and P.S. Raghavan
4. Arthur M. Halpern and George C. McBane: *Experimental Physical Chemistry.*
5. K. K. Rohatgi-Mukherjee: *Fundamentals of Photochemistry.*
6. Peter Atkins and Julio de Paula: *Atkins' Physical Chemistry.*
7. J. N. Gurtu and R. Kapoor: *Advanced Experimental Chemistry, Vol. I: Physical Chemistry.*
8. Carl W. Garland, Joseph W. Nibler, and David P. Shoemaker: *Experimental Physical Chemistry.*