



DEPARTMENT OF CHEMISTRY
UNIVERSITY OF LUCKNOW
M.Sc. Chemistry Two Year Postgraduate Course Structure
For students admitted in session 2025-26 onwards
Semester II

Semester II						
Paper	Paper Title	Type	Credits	Internal Assessment	Univ Exam	Total Marks
CHMCC-201	Inorganic Chemistry 2	Core Course 6	4	30	70	100
CHMCC-202	Organic Chemistry 2	Core Course 7	4	30	70	100
CHMCC-203	Physical Chemistry 2	Core Course 8	4	30	70	100
CHMCC-204	Advance Chemistry Practical 2	Core Course 9	4	-	100	100
CHMCC-205	Project and Seminar Presentation	Core Course 10	2	-	100	100
CHMID-206	Concepts of Chemistry	Interdepartmental	2	30	70	100
			20			600



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Unit IV

• **Infrared spectroscopy:**

- Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strength, vibration of polyatomic molecules, selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factor affecting the band position and intensities, Far IR region metal ligand vibrations, normal coordinate analysis.

Unit V

• **Raman spectroscopy:**

- Classical theories of Raman effect. Pure vibrational, vibrational-rotational Raman spectra, selection rule, mutual exclusion principle. Resonance Raman spectroscopy, Coherent Anti Stokes Raman spectroscopy (CARS).

• **Microwave spectroscopy:**

- Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequency, intensities, non-rigid rotor. Stark effect, nuclear and electron spin interaction and effect of external field applications.

Recommended Books:

1. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw Hill.
2. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
3. Theory and Applications of UV Spectroscopy, H. H. Jaffe and M. Orchin, IBH- Oxford.
4. Introduction to Magnetic Resonance, A. Carrington and A..D. MacLachalan, Harper & Row.
5. Physical Methods for Chemistry, R. S. Drago, Saunders Company.
6. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
7. Organometallic Chemistry: A Unified Approach by R. C. Mehrotra and A. K. Singh



DEPARTMENT OF CHEMISTRY
UNIVERSITY OF LUCKNOW
M.Sc. Chemistry Two Year Postgraduate Course Structure
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Semester II

Organic Chemistry 2 (Core Course 7)
Paper Code CHMCC-202 **Marks (70 + 30) = 100**

Credits 4

Course Objective:

- The objective of this course is to provide students coming in the first year of Masters program new and advance understanding mechanistic approaches in organic chemistry and basic characterization of organic compounds into electronic and IR spectroscopy.

Course Outcome:

After the completion of the course the students will acquire knowledge of:

- CO-1:** what are aromatic electrophilic and nucleophilic substitutions and their mechanism with the help of suitable examples.
- CO-2:** free radical reactions, their mechanism and also the reactivity towards aliphatic and aromatic substrates.
- CO-3:** addition reactions between carbon- carbon multiple bonds and hetero atom and carbon multiple bonds and mechanism of some specific name reactions.
- CO-4:** elimination reactions and rules used to study elimination reactions with the help of specific examples of elimination reactions.
- CO-5:** how to determine the structure of organic molecules using UV and IR spectroscopic techniques, λ_{\max} for polyenes and α , β -unsaturated carbonyl compounds, IR range for functional groups, solving structural problems based on UV-Vis, IR spectral data.

Unit I

- Aromatic Electrophilic substitution**
 - The arenium ion mechanism, Orientation and reactivity, energy profile diagram. The ortho / para ratio, ipso attack, orientation in other ring system. Diazonium coupling, Vilsmeier reaction, Gatterman-Koch reaction.
- Aromatic Nucleophilic substitution**
 - The S_NAr , S_N1 , benzyne and $S_{RN}1$ mechanisms. Reactivity-effect of substrates structure, leaving group and attacking nucleophile. The Von Richter, Sommelet-Hauser and Smiles rearrangements.

Unit II

- Free Radical Reactions**
 - Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighboring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Alicyclic halogenation (NBS), oxidation of aldehyde to carboxylic acid, auto-oxidation, coupling of alkynes. Sandmeyer reaction. Hunsdiecker reaction.
- Addition to Carbon – Carbon multiple bonds**
 - Mechanistic and stereochemical aspects of addition reaction involving electrophiles. Nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, Michael's reaction.

Unit III

- Addition to Carbon – Hetero multiple bonds**
 - Wittig reaction. Mechanism of condensation reaction involving enolates-aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Sotobbe reaction. Hydrolysis



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of ester and amides, ammonolysis of esters.

- **Elimination Reactions**

- The E2, E1 and E1cB mechanism. Reactivity-effects of substrates structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

Unit IV

- **Infrared Spectroscopy**

- Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. FTIR.

Unit V

- **Ultraviolet and Visible Spectroscopy**

- Various electronic transitions (185-800 nm), Beer-Lambert Law, effect of solvent on electronic transitions, ultraviolet bands for unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and unsaturated carbonyl compounds. Steric effect in biphenyls.

- **Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)**

- Definition, deduction of absolute configuration, octant rule for ketones.

Recommended books:

1. Silverstein and Bassler, Spectrometric Identification of Organic Compounds, Wiley.
2. Organic Spectroscopy, P.S. Kalsi, New Age International (P) Limited.
3. Spectroscopy of Organic Compounds, Pavia, Mery Finch Publication.
4. Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press.)
5. Organic Spectroscopy, I Fleming, McGraw-Hill Inc., US.
6. H.O. House, Synthetic Organic Chemistry.



DEPARTMENT OF CHEMISTRY
UNIVERSITY OF LUCKNOW
M.Sc. Chemistry (Regular Seats and Self-Financed Seats)
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Credits 4

Physical Chemistry 2 (Core Course 8)
Paper Code CHMCC-203

Marks (70 + 30) = 100

Course Objective:

- The objective of this course is to provide students coming in the first year of Masters program new and advance understanding into classical/statistical thermodynamics and quantum mechanics.

Course Outcome:

Students will recognize the importance of:

- **CO-1.** the limitation of classical thermodynamics, Statistical thermodynamics and Non equilibrium thermodynamics.
- **CO-2.** the difference between the classical and quantum mechanics.
- **CO-3.** the connections between common approximation methods and standard chemical frame works (e.g. Born Oppenheimer approximation, molecular orbital theory).

Unit I

• **Unifying Principal:**

- Electromagnetic radiation, interaction of electromagnetic radiation with matter-absorption, emission, transmission, reflection, refraction, dispersion, polarization and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, transition moment, selection rules, intensity of spectral line.

• **Quantum Chemistry and its introduction to Quantum mechanical results:**

- Discussion of solution of the Schrodinger equation to the same model system viz. particle in a 3D box, the harmonic oscillator, the two-particle rigid rotor, the hydrogen atom (with derivation).

Unit II

• **Approximate methods:**

- The variation theorem, linear variation principle. Perturbation theory (first order and non-degenerate). Simple application of variation method in perturbation theory, Results of the time dependent perturbation theory, Comparison of the variation and perturbation methods with example.

• **Molecular Orbital Theory:**

- Huckel theory of conjugated system, bond order and charge density calculation. Application to ethylene, butadiene etc. Introduction to extended Huckel theory.

Unit III

Angular Momentum:

Ordinary angular momentum, eigen functions for angular momentum, eigen values of angular momentum.

Electronic structure of atom:

Electronic configuration, Russell-Saunders term and coupling schemes, Slater-Condon parameter, term separation energy of p^n configuration, term separation energy for the d^n configuration, magnetic effects: spin-orbit coupling and Zeeman splitting.



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M.Sc. Chemistry (Regular Seats and Self-Financed Seats)

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Unit IV

- **Classical Thermodynamics:**
 - Partial molar quantities and their physical significance. Concepts of fugacity and determination of fugacity.
- **Phase transition:**
 - Phase transition of first order and second order, Relation between heat of neutralization and their standard boiling point (thermodynamically)
- **Non-Equilibrium Thermodynamics:**
 - Thermodynamic criteria for non – equilibrium state, entropy production and entropy flow, entropy balance equation for different irreversible processes (e.g. heat flow, chemical reaction etc.) transformation of generalized fluxes and forces, non-equilibrium stationary states, phenomenological equation, microscopic reversibility and Onsager's reciprocity relation, electrokinetic phenomena, diffusion, electric conduction.

Unit V

- **Statistical Thermodynamics:**
 - System, assembly, ensemble averaging. Canonical, grand canonical and microcanonical ensembles. Thermodynamic probability and most probable distribution (Boltzman distribution law) and its mathematical derivation.
 - Partition functions- translational, rotational, vibrational and electronic partition function, calculation of thermodynamic properties in the term of partition function. Application of partition function in equilibrium constant and heat capacity of solids.

Recommended Books:

1. P.W. Atkins, Physical Chemistry, Oxford University Press, New York.
2. S. Glasston, Physical Chemistry, Nostrand
3. Advance Physical Chemistry (Vol-1,2,3,4), K.L. Kapoor, Mac Millan, India
4. Puri Sharma Pathania, Advance Physical Chemistry.
5. J.O.M. Bockris and A.K.N. Reddy, Modern Electrochemistry, Vol.2, Plenum Press, New York
6. Statistical Thermodynamics, Second Edition, New Age International Limited Publisher, India by M.C. Gupta
7. Introductory Quantum chemistry by A.K Chandra, Second Edition, Tata Mc Graw-Hill publishing company Limited, India
8. Quantum chemistry Through problems and solution by R.K Prasad, New age International Pvt Ltd, Publishers
9. Molecular quantum Mechanics By P.W. Atkins Oxford University Press, Oxford New York
10. Physical Chemistry by Ira N. Levine



DEPARTMENT OF CHEMISTRY
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M.Sc. Chemistry (Regular Seats and Self-Financed Seats)
Two Year Postgraduate Course Structure
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Semester II

Credits 4

Advance Chemistry Practical 2 (Core Course 9)
Paper Code CHMCC-204

Marks 100

Course Objective:

- The objective of this course is to provide students coming in the first year and second semester of Master's program about the new quantitative analyses and syntheses of some typical coordination complexes and organic compounds and their relevant spectroscopic characterization as well as the use of spectrophotometer and electrochemical set-ups.

Course Outcome:

In order to make students understand the theories taught to them in M.Sc. semester (II) indifferent branches of chemistry e.g. Inorganic, Organic and Physical, the following practical experiments are introduced. Students will learn:

- **CO-1.** Qualitative analysis and determination of two metal ions volumetrically and gravimetrically.
- **CO-2.** The preparation of selected inorganic compounds and their characterization by spectroscopic method.
- **CO-3.** Two steps synthesis involving different name reactions.
- **CO-4.** The basic knowledge like preparation of solution, standardization of secondary solution, dilution, calibration, and handling of some sophisticated electronic related to the practical syllabus.
- **CO-5.** The basic knowledge of conductance measurement, Ostwald dilution law, solubility of sparingly soluble substance, potentiometry, pH- metery, order of reaction, saponification of an ester, phase diagram of three component system, inversion of cane sugar by polarimetry and kinetics using Visible spectrophotometer.
- **CO-6.** To focus their aim for future prospects of Ph.D. programme and pharmaceutical industry.

INORGANIC CHEMISTRY

- **Quantitative analysis**
 - Separation and determination of two metal ion Cu-Ni, Cu-Zn., Cu-Fe etc. involving volumetric and gravimetric methods.
- **Inorganic preparation in aqueous and organic medium:**
 - Preparation and complete analysis of $K_3[Fe(C_2O_4)_3] \cdot 3H_2O$
 - Preparation and separation of **cis** and **trans** $-[Co(en)Cl_2]$
 - Preparation of $CuCl_2$. DMSO and Copper glycine complex.
 - Preparation of Ph_3P and its complexes.
 - Preparation and reactions of ferrocene.
 - Preparation of $Mn(gly)_3$

ORGANIC CHEMISTRY

- **Two steps synthesis involving-**
 - Acetylation
 - Oxidation
 - Grignard reaction
 - Aldol condensation



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- Sandmeyer reaction
- Acetoacetic ester Condensation
- Cannizzaro reaction
- Friedel Craft reaction
- Aromatic Electrophilic Substitution

PHYSICAL CHEMISTRY

- **Conductance measurements**
 - Determine the equivalent conductance of a weak electrolyte at different concentration and hence test the validity of Ostwald's dilution Law. Determine the dissociation constant K_a/K_b of the weak electrolyte.
- **Potentiometry-Electrochemistry (EMF – Measurements)**
 - Determine the EMF of a given a concentration cell by potentiometer and find out the effect of dilution on the EMF of cell.
 - Determine the pH a given buffer solution using given quinhydrone electrode.
- **Kinetics Experiments**
 - Study reaction kinetics between KI and $K_2S_2O_8$ by fractional change method and find out its order of reaction at a given temperature.
 - Study reaction kinetics between acetone and iodine by isolation method and determine its order of reaction at a given temperature.
- **Phase Equilibria**
 - Construct the phase diagram for three component system (eg. Ethanol, benzene and water or chloroform, acetic acid and water).
- **Spectrophotometer**
 - Study the kinetics of decomposition of the complex formed between sodium sulphide and sodium nitroprusside spectrophotometrically, and also find the order and rate constant of the reaction.

Distribution of Marks

Branch	Experiment	Viva	Class Record	Total
Inorganic	23	6	4	33
Organic	23	6	4	33
Physical	24	6	4	34
Total Marks				100

Recommended Book:

1. Vogels Text book of Quantitative Analysis revised, J. Bessett, R.C. Denney, G.H. Jellery and J.Mendhan ELBS
2. Experimental Inorganic Chemistry by Mounir A, Malati, Horwood series in Chemical Science(Horwood publishing Chichester) 1999.
3. Inorganic Experiments, J. Derexwoolings VCH
4. Microscale Inorganic Chemistry, Z. Scafran, R.M. Pike and M.M. Singh Wiley.
5. Practical Inorganic Chemistry, G. Marrant, B.W. Rockett, Van Nostrand.
6. The systematic Identification of Organic Compounds, R.L. Shringer and D.Y. Curlin.
7. Qualitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
8. Basic concept of Analysis chemistry, S.M. Chopkar, Wiley Bastern.
9. Synthesis and characterization of Inorganic compounds, W.L. Jolly, Prentice Hall.
10. Systematic Qualitative Organic Analysis, H. Middeton, AdwardArnoid.



**DEPARTMENT OF CHEMISTRY
UNIVERSITY OF LUCKNOW**

M.Sc. Chemistry (Regular Seats and Self-Financed Seats)

Two Year Postgraduate Course Structure

For students admitted in session 2025-26 onwards

Semester II

11. Handbook of Organic Analysis Qualitative and Quantitative, H. Clark, Edward Ar.
12. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
13. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
14. Findley's Practical Physical Chemistry revised, B.P. Levitt, Longman.
15. Experimental Physical Chemistry, R.C. Das and Bebera, Tata Mc Grawhill.
16. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Barg (R. Chand and Co., Delhi)
17. Experimental Physical Chemistry by D.P. Shoemaker Mc Grawhill, 7th Edition 2003.
18. Experiments in Chemistry, D.V. Jahagirdar, Himalaya Publishing House.
19. Practical Physical Chemistry, B. Vishwanathan and P.S. Raghwan, Viva Books.
20. General Chemistry Experiments, Anil J Elias, University Press (2002)
21. Experimental Physical Chemistry, V.D. Athawale, Parul Mathur, New Age International (P)Limited.
22. Systematic Experiment in chemistry, Arun Sethi, New Age International (P) Limited.
23. Experiments in Physical chemistry, J.C. Ghosh, Bharati Bhavan.
24. Advanced Practical Physical Chemistry, JB Yadav.
25. Practical Organic Chemistry, Mann and Saunders.



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Credits 2

Project and Seminar Presentation (Core Course 10)
Paper Code CHPR-201

Marks = 100

Course Objective:

- To inculcate in students the art of public speaking, presentation and discussion of seminars.

Course Outcome:

- CO-1. students should be able demonstrate ability to plan and strategize a scientific problem, and implement it within a reasonable time frame.
- CO-2. It is expected that after completing this project dissertation, students will learn to work independently and how to keep accurate/readable record of assigned project.
- CO-3. In addition, students will be able to know the library search and handle the data in a meaningful way.
- CO-4. Also, students will be able to interpret the spectral data independently.
- CO-5. Subsequently, the students should be able to critically examine research articles, and improve their scientific writing/communication skills and power point presentation.

For project work and seminar presentation, the area of the work would be to be decided by the advisor/mentor based on syllabus of the current semester. On completion of the project work, students have to submit the work in the form of seminar followed by oral presentation.

Distribution of Marks

Class	Report	Viva	Presentation	Total
Internship	60	20	20	100



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Semester II

Credits 2

Concepts of Chemistry (Interdepartmental)
Paper Code CHMID-206

Marks (70 + 30) = 100

Course Objective:

- After successful completion of the first year of Masters, students coming in third semester/second year and the objectives of this course are to provide knowledge to the students from other faculties about the fundamental of chemistry.

Course Outcome:

After the completion of the course the students will acquire the knowledge of:

- **CO-1.** Use of arrow notations in Organic reactions mechanism, different kinds of polymer and their importance, different techniques of polymerization, each quantum number represents and how to obtain quantum numbers for any electron in an atom and determine the number of protons, neutrons, electrons and nuclei in elements and compounds.
- **CO-2.** Periodic properties of all the elements, electronegativity and whether a bond is metallic, ionic, covalent or polar covalent.
- **CO-3.** Predict atomic structure, chemical bonding or molecular geometry based on accepted models.
- **CO-4.** Electronic effects operates in covalent bonds, Types of Reactions and different types of Intermediates formed during the reactions
- **CO-5.** Appropriate method of solution for a variety of Mathematic problems, basic physical quantities and various gas Laws for observation of behaviour of gas and Kinetic molecular model.

Unit I

- **Types of arrows used in Organic Reaction Mechanism —**
 - Curved arrow, half-headed and double-headed arrows
- **Introduction of Polymers,**
 - natural and synthetic polymers, properties of polymers, Biomedical polymers and their importance
- **Basic Concepts**
 - Quantum numbers. Zeeman effect. Pauli's exclusion principle. Aufbau principle. Effective nuclear charge, screening effect, Slater's rule- applications and limitations

Unit II

- **Classification of Elements and Periodicity of Properties,**
 - Noble gases and s, p, d and f- block elements. Modern periodic table. Position of hydrogen in the periodic table. Horizontal, vertical and diagonal relationships in the periodic table. Scales of electronegativity- Pauling, Mulliken and Allred Rochow scale.
- **Ionic bond**
 - factors influencing the formation of ionic compounds – ionization energy, electron affinity and lattice energy; inert pair effect, Fajan's rules. Covalent bond – polarity of covalent bond.

Unit III

- **Valence bond theory (VBT) –**
 - Sigma and pi bonds, hybridization, valence shell electron pair repulsion (VSEPR) theory and geometries of molecules – BeCl_2 , H_2O , BF_3 , NH_3 , XeF_4 ,



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Semester II

BrF_3 , PCl_5 , SF_6 and IF_7 . Molecularorbital theory (MOT) – bonding and antibonding orbitals, bond order, applications of MOT to H_2 , He_2 , N_2 , O_2 , O_2^+ , O_2^- , HF and CO. Comparison between VBT and MOT.

Unit IV

- **Effects**
 - Resonance and Inductive effect
- **Reaction Intermediates –**
 - Homolytic and Heterolytic bond breaking (carbonium ion, carbanion and free radical)
- **Types of Reactions –**
 - Addition, Elimination, Substitution and Rearrangement Reactions.

Unit V

- **Mathematical concepts:**
 - Logarithm, anti-logarithm, functions, integrations and differentiation, partial differentiation, trigonometric functions, exponential functions, binary and decimal numbers.
- **Basics of physical chemistry:**
 - Physical quantities- moles, mole fraction, normality, molality, molarity, formality, equivalent weight, molecular weight and their determination, SI units and derived units.
- **Kinetic molecular theory:**
 - Ideal and non-ideal gases, laws of gases, the kinetic molecular model, expressions for the pressure of gas, molecular velocities and their relations, mean free path, collision diameter, collision number.

Recommended Books:

1. Inorganic Chemistry, Puri, Sharma, Kalia and Kaushal.
2. Pradeep's Inorganic Chemistry, K. K. Bhasin, Pradeep Publication.
3. Chemistry for Degree Students, R. L. Madan, S. Chand Publishing.
4. Organic Chemistry, M. K. Jain, Shoban Lal & Co.
5. Pradeep's Organic Chemistry, S. N. Dhawan, Pradeep Publication.
6. Physical Chemistry, Puri Sharma & Pathania.
7. Pradeep Physical Chemistry, Khetrpal, Pradeep Publication.