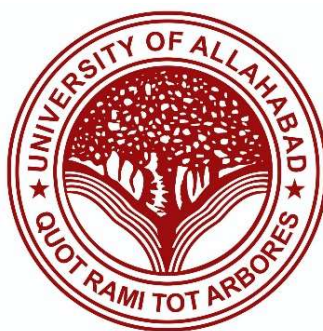




Syllabus for M.Sc. Chemistry
(2 years/4 semesters) Programme
Based on
CHOICE BASED CREDIT SYSTEM
(C.B.C.S.)
(2024 onwards)



Department of Chemistry
Faculty of Science
University of Allahabad
Allahabad – 211002



The Master of Science in Chemistry course is a Two-Year Full-Time Course consisting of four semesters to be known as Semester I, Semester II, Semester I, Semester III and Semester IV.

PROGRAMME STRUCTURE

Part I	First Year	Semester I	Semester II
Part II	Second Year	Semester III	Semester IV

COURSE STRUCTURE

Semester	Core Course			Specialized Course			Elective Course			Total Credits
	No. of papers	Credits (L+T/P)	Total Credits	No. of papers	Credits (L+T/P)	Total Credits	No. of papers	Credits (L+T/P)	Total Credits	
Semester I	4 + 4 (P)	12+8(P)	20	0	0	0	0	0	0	20
Semester II	4 + 4 (P)	12+8(P)	20	0	0	0	0	0	0	20
Semester III	0	0	0	3 + 1(P)	09+10(P)	19	1	3	3	22
Semester IV	0	0	0	3 + 1(P)	09+10(P)	19	1	3	3	22
Total credits for the course			40			38			6	84

N.B. : 78 credits as core/specialized courses and 6 credits as elective courses are compulsory to obtain the M. Sc. degree.

Skill development: Students have to take up their dissertation work through which they will be trained to take up research problems and solve them. Through the project work they can acquire the basic and essential knowledge to take up research as a career. Also training acquired on handling instrument/scientific equipment makes them suitable for any industrial job.

Value added course: All the core course and specialized course syllabi are framed to enrich the students for attempting competitive exams. Elective courses are provided to enhance students' awareness of the current job opportunities and motivate them to do high-quality research.



SEMESTER-WISE COURSE DETAILS

SEMESTER-I

Serial No.	Paper	Course Code	Course Title	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-501	Inorganic Chemistry	03	40+60
2	Paper-III (L/T)	CHE-502	Organic Chemistry	03	40+60
3	Paper-II (L/T)	CHE-503	Physical Chemistry	03	40+60
4	Paper-IV (L/T)	CHE-504	Analytical Chemistry	03	40+60
5	(P)	CHE 533	Practical	08	40+60
Total				20	500



SEMESTER-II

Serial No.	Paper	Course Code	Course Title	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-505	Inorganic Chemistry	03	40+60
2	Paper-III (L/T)	CHE-506	Organic Chemistry	03	40+60
3	Paper-II (L/T)	CHE-507	Physical Chemistry	03	40+60
4	Paper-IV (L/T)	CHE-508	Analytical Chemistry	03	40+60
5	(P)	CHE 534	Practical	08	40+60
Total				20	500



SEMESTER-III

INORGANIC CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Course Code	Course Title	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-509	Bio-inorganic Chemistry	03	40+60
2	Paper-II (L/T)	CHE-510	Organometallic Chemistry	03	40+60
3	Paper-III (L/T)	CHE-511	Coordination Polymers, Cages, Clusters, and Nanostructures	03	40+60
4	Paper-IV (L/T) (Elective-A)	CHE-551	Nuclear Chemistry	03	40+60
5	(P)	CHE-535	Practical	10	40+60
Total				22	500



SEMESTER-III

ORGANIC CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100)
					40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-512	Rearrangements and Photochemistry	03	40+60
2	Paper-II (L/T)	CHE-513	Oxidation, Reduction, and Organometallic-Reagents	03	40+60
3	Paper-III (L/T)	CHE-514	Strategies in Organic Synthesis and Heterocyclic Chemistry	03	40+60
4	Paper-IV (L/T) (Elective-B)	CHE-552	Spectroscopy of Organic Compounds	03	40+60
5	(P)	CHE-536	Practical	10	40+60
Total			22		500



SEMESTER-III

PHYSICAL CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-515	States of Matter	03	40+60
2	Paper-II (L/T)	CHE-516	Advanced Spectroscopy & Magnetochemistry	03	40+60
3	Paper-III (L/T)	CHE-517	Advanced Chemical Kinetics & Catalysis	03	40+60
4	Paper-IV (L/T) (Elective-C)	CHE-553	Chemistry of Nanomaterials	03	40+60
5	(P)	CHE-537	Practical	10	40+60
Total				22	500



SEMESTER-III

ANALYTICAL CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100)
					40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-518	Theoretical Aspects of Analytical Chemistry	03	40+60
2	Paper-II (L/T)	CHE-519	Separation Techniques	03	40+60
3	Paper-III (L/T)	CHE-520	Spectrochemical Methods	03	40+60
4	Paper-IV (L/T) (Elective-D)	CHE-554	Environmental Monitoring	03	40+60
5	(P)	CHE-538	Practical	10	40+60
Total				22	500



SEMESTER-IV

INORGANIC CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-521	Advanced Spectroscopic Techniques in Chemical Analysis	03	40+60
2	Paper-II (L/T)	CHE-522	Structural Methods in Inorganic Chemistry	03	40+60
3	Paper-III (L/T)	CHE-523	Selected Topics in Inorganic Chemistry	03	40+60
4	Paper-IV (Elective-A) (L/T)	CHE-555	Industrial chemistry	03	40+60
5	(P)	CHE-539	Practical + Project work	10	40+60
Total				22	500



SEMESTER-IV

ORGANIC CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100)
					40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I (L/T)	CHE-524	Biosynthesis and Chemistry of Natural Products	03	40+60
2	Paper-II (L/T)	CHE-525	Stereoselective Synthesis	03	40+60
3	Paper-III (L/T)	CHE-526	Biomolecules & Bioactive Compounds	03	40+60
4	Paper-IV (Elective-B) (L/T)	CHE-556	Reagents and Reactions	03	40+60
5	(P)	CHE-540	Practical + Project work	10	40+60
Total				22	500



SEMESTER-IV

PHYSICAL CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I	CHE-527	Chemical Bonding, & Statistical Mechanics	03	40+60
2	Paper-II	CHE-528	Photo & Colloidal Chemistry	03	40+60
3	Paper-III	CHE-529	Advanced Thermodynamics & Electrochemistry	03	40+60
4	Paper-IV (Elective-C)	CHE-557	Industrial Polymer Chemistry	03	40+60
5	(P)	CHE-541	Practical + Project work	10	40+60
Total				22	500



SEMESTER-IV

ANALYTICAL CHEMISTRY (SPECIALIZATION)

Serial No.	Paper	Code	Description	Credits	Max. Marks (100) 40 (Internal Assessment) + 60 (End semester Exam)
1	Paper-I	CHE-530	Electroanalytical Method	03	40+60
2	Paper-II	CHE-531	Analytical Characterization Techniques	03	40+60
3	Paper-III	CHE-532	Analytical Methods	03	40+60
4	Paper-IV (Elective-D)	CHE-558	Environmental Chemistry	03	40+60
5	(P)	CHE-542	Practical + Project work	10	40+60
Total				22	500



Programme Outcomes (PO) of Master of Science (M.Sc.)

PO1: Critical Thinking:

Inculcate critical thinking to carry out scientific investigation objectively. Formulate coherent arguments; critically evaluate practices, policies, and theories by following scientific approach to knowledge development. Critically evaluate ideas, evidence and experiences from an open- minded and reasoned perspective.

PO2: Knowledge Skill:

Equip the student with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof. Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge.

PO3: Scientific Communication Skills:

Imbibe effective scientific and / or technical communication in both oral and writing. Ability to show the importance of the subject as precursor to various scientific developments since the beginning of the civilization.

PO4: Ethics:

Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in the subject concerned. Ability to identify unethical behavior such as fabrication, falsification or misrepresentation of data and adoptive objective, unbiased and truthful actions in all aspects.

PO5: Enlightened Citizenship:

Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges.

PO 6: Analytical Reasoning:

Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyze and synthesize data from a variety of sources; draw valid conclusions and support them with evidence and examples and addressing opposing viewpoints.



PO 7: Multicultural Competence:

Development of a set of competencies in order to enhance and promote the growth of multicultural sensitivity within universities. Integrating multicultural awareness such as race, gender, physical ability, age, income and other social variables, and by creating an environment that is , “welcoming for all students” .

PO 8: Lifelong Learning:

Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning throughout life, through self- paced and self- directed learning aimed at personal development, and adapting to changing academic demands of work place through knowledge/ skill development/ reskilling.

PO9: Leadership Qualities:

Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination in a smooth and efficient way.

PO 10: Research Skills:

Prepare students for pursuing research or careers in industry in concerned subject and allied fields. Capability to use appropriate software to solve various problems and to apply programming concepts of C++ and Mathematica/ MATLAB to various scientific investigations, problem solving and interpretation.



Program Specific Outcomes (PSOs) of MSc Chemistry

PSO No.	Programme Specific Outcomes (POs) Upon completion of our MSc chemistry programme, students will be able to learn the following.
PSO1	Academic competence: (i) Understand fundamental principles and advanced concepts of organic, inorganic, analytical, and physical chemistry. (ii) Demonstrate understanding of various types of reactions, reaction mechanisms, stereochemistry, photochemistry, electrochemistry, rearrangements, heterocyclic, medicinal chemistry, and advanced materials systems. (iii) Interpret analytical data for structure elucidation obtained using NMR, IR, UV and Mass spectroscopy.
PSO2	Personal and Professional Competence: (i) Develop analytical skills such as synthesizing, separating, characterizing chemical compounds and chemical reaction with the help of sophisticated instruments. (ii) Evaluate results obtained, observations and conclusion of experiments. Documentation of results. (iii) Formulate ideas, scientific writing and authentic reporting, effective presentation, and communication skills.
PSO3	Research Competence: (i) Develop research skills through dissertation/Project work in different fields of chemistry such as organic, nanoscience, analytical, physical etc. (ii) Review scientific literature and findings in systematic manner and processing of information obtained to understand scope for novelty. (iii) Design novel synthetic routes using a retrosynthetic approach for development of elegant, economic and eco-friendly schemes.
PSO4	Entrepreneurial and Social competence: (i) Demonstrate importance of industrial applications of organic chemistry in various fields. (ii) Devise chemical processes with a green approach having advantage in safe operations.

SYLLABUS
For M.Sc. CHEMISTRY (Inorganic)
(THEORY & PRACTICAL)
CHOICE BASED CREDIT SYSTEM
(C.B.C.S)
(2024 onwards)



Department of Chemistry
Faculty of Science
University of Allahabad
Allahabad – 211002

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 501 – INORGANIC CHEMISTRY PAPER-I	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand the concept of Metal – Ligand Bonding in transition metal complexes	
CO 2	Understand the Molecular orbital theory and apply their knowledge to analyze transition metal complexes	
CO 3	Identify the elements of symmetry, symmetry operations and point groups of molecules	
CO 4	Explain molecular structure by the use of character tables. Specify and correlate the application of symmetry to spectroscopy to find out which modes are IR and Raman active	
CO 5	Describe the concept of Molecular Luminescence	

The following section provides the mapping of Course Outcomes (COs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) for the M.Sc. Chemistry (Inorganic Chemistry Specialization) program. Correlation is represented on a scale of 1 to 3:

3 – High correlation

2 – Medium correlation

1 – Low correlation.

CHE 501 – Inorganic Chemistry (Sem I)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand the concept of Metal–Ligand Bonding in transition metal complexes	PO1(3) PO2(2) PO10(2)	PSO1(3), PSO2(2)
CO2: Apply Molecular Orbital Theory to analyze transition metal complexes	PO2(3) PO6(2)	PSO1(3)
CO3: Identify symmetry elements and point groups of molecules	PO1(2) PO6(3)	PSO1(2)
CO4: Correlate molecular symmetry with spectroscopy	PO2(3) PO10(2)	PSO1(3)
CO5: Describe Molecular Luminescence phenomena	PO3(2) PO10(2)	PSO1(2)

CHE 505 – Inorganic Chemistry (Sem II)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Explain reaction mechanisms of transition metal complexes	PO1(3) PO2(3)	PSO1(3)
CO2: Understand substitution reactions and trans effect in square planar complexes	PO2(3) PO6(2)	PSO1(3)
CO3: Analyze redox and electron transfer mechanisms	PO2(3) PO10(3)	PSO1(3), PSO3(2)
CO4: Predict spectroscopic ground states and microstates	PO2(3) PO10(3)	PSO1(3)
CO5: Describe Electronic Spectra of transition metal complexes	PO3(2) PO10(2)	PSO1(3)

CHE 509 – Bio-inorganic Chemistry (Sem III)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: List functions and fate of metals in biological systems	PO1(2), PO8(2)	PSO1(2), PSO3(3)
CO2: Explain structures of biologically important metal complexes	PO1(3), PO2(3)	PSO1(3)

CO3: Describe structures and functions of metalloproteins and iron-sulphur proteins	PO1(3), PO10(2)	PSO3(3)
CO4: Explain structure and function of metalloenzymes	PO2(3), PO10(2)	PSO3(3)
CO5: Understand copper-containing enzymes and SOD mechanisms	PO2(3), PO10(3)	PSO3(3)

CHE 521 – Advanced Spectroscopic Techniques (Sem IV)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Describe principles of Mass, NMR, and ESR spectroscopy	PO2(3), PO10(3)	PSO1(3), PSO2(3)
CO2: Explain multinuclear NMR and applications to metal nuclei	PO2(3), PO10(3)	PSO1(3)
CO3: Elucidate structures from spectroscopic data	PO2(3) PO6(3)	PSO1(3), PSO2(3)
CO4: Interpret Raman and IR spectra	PO2(3), PO10(3)	PSO1(3)
CO5: Solve numerical problems based on spectroscopic data	PO2(3) PO6(2)	PSO2(3)

SEMESTER I –THEORY PAPER

COURSE CODE: CHE 501 – INORGANIC CHEMISTRY

Paper – I

Course Credit = 03 (45 Lectures)

No. of Lectures

UNIT-I (Crystal Field Theory)

09

Valence bond theory: inner and outer orbital complexes; Crystal field theory: crystal field splitting diagrams in octahedral, tetrahedral, square planar, square pyramidal, and trigonal bipyramidal complexes, Jahn-teller distortion; Application of CFSE; Metal-metal multiple bond.

UNIT-II (Molecular Orbital Theory)

09

Ligand field theory; Molecular orbital theory: sigma bonding, sigma plus pi bonding in octahedral (*e.g.*: $[\text{Ti}(\text{H}_2\text{O})_6]^{+3}$, $[\text{Co}(\text{NH}_3)_6]^{+3}$, $[\text{CoF}_6]^{-3}$, $[\text{FeF}_6]^{-3}$, $[\text{Fe}(\text{CN})_6]^{-3}$), tetrahedral and square planar complexes; Effect of pi bonding on the value of Δ_o and its applications to metal complexes.

UNIT-III (Molecular Symmetry and Character Tables)

09

Symmetry elements and symmetry operations: symmetry groups, defining properties of a group, inversion center, proper axes, proper rotation, symmetry point group, great orthogonality theorem; Character tables and its application.

UNIT-IV (Application of Symmetry)

09

Symmetry and symmetry consideration in simple inorganic (NH_3 , BF_3 , PF_5 , SF_6 , B_2H_6) and coordination compounds (*e.g.* ferrocene, ML_6 , ML_5X , ML_4X_2 , ML_3X_3 , ML_4).

UNIT-V (Molecular Luminescence)

09

Basic principles of fluorescence emission: characteristics of fluorescence emission (Jablonski diagram: fluorescence and phosphorescence, delayed fluorescence); General properties of fluorescence

emission; Parameters of fluorescence: fluorescence intensity, fluorescence average lifetime, fluorescence quantum yield and emission maxima; Solvatochromism: effect of solvent polarity on emission spectra, steady state and time resolved fluorescence; Fluorescence quenching: basic idea of fluorescence resonance energy transfer (FRET); Photoluminescence in transition metal complexes (3d series) and zinc(II); Molecular fluorescence as an analytical tool (applications).

Recommended Books

1. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity, (Fourth edition), Published by Pearson Education, Inc.
2. Malik, Tuli, and Madan, Selected Topics in Inorganic Chemistry, S. Chand Publishing Co.
3. F. A. Cotton, Chemical Applications of Group Theory, Wiley Publication.
4. David M. Bishop, Group Theory and Chemistry, Dover Publications, New York.
5. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, (Third Edition), Springer Science.
6. Molecular Fluorescence: Principle and Applications by B. Valeur, 2001.
7. Fundamental of Photochemistry by K. K. Rohatgi – Mukhrejee.
8. Modern Molecular Photochemistry by N. J. Turro.

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE-533- INORGANIC CHEMISTRY LAB COURSE CODE	Number of Credits: 02
On completion of the course, the students will be able to:		
CO 1	Understand the basics behind Qualitative Analysis	
CO 2	Develop analytical skills to analyze the Qualitative mixture of seven radicals including two rare elements. (Mo, W, Ti, Zr, Th, Ce, V) in cationic and anionic forms.	
CO 3	Develop analytical skills to separate quantitatively mixture of ions and understand the gravimetric and volumetric methods	

SEMESTER – I

INORGANIC CHEMISTRY LAB COURSE

LAB COURSE CODE CHE 533

Course Credit = 02 (45 hrs)

1. Qualitative Analysis

Qualitative mixture analysis for seven radicals including two rare elements. (Mo, W, Ti, Zr, Th, Ce, V) in cationic and anionic forms.

2. Quantitative separation and determination of the following pairs of metal ions using gravimetric and volumetric methods

- (i) Ni^{2+} (gravimetrically) and Cu^{2+} (Volumetrically)
- (ii) Ba^{2+} (gravimetrically) and Cu^{2+} (Volumetrically)
- (iii) Fe^{3+} (gravimetrically) and Ca^{2+} (Volumetrically)
- (iv) Mg^{2+} (gravimetrically) and Ca^{2+} (Volumetrically)

Recommended Books

1. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 505 – INORGANIC CHEMISTRY	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Explain the reaction mechanism of different Transition metal complexes	
CO 2	Understand Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction	
CO 3	Understand Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions	
CO 4	Predict the spectroscopic ground states, microstates	
CO 5	Describe Electronic Spectra of Transition Metal Complexes	

SEMESTER II - THEORY PAPER
COURSE CODE: CHE 505 – INORGANIC CHEMISTRY
PAPER – I

Course Credit = 03 (45 lectures)

No. of Lectures

UNIT-I (Reaction Mechanism in Octahedral Complexes) 09

Thermodynamic and kinetic stability of metal complexes; Reaction mechanism of transition metal complexes: inert and labile complexes; Mechanism of octahedral substitution: Acid hydrolysis and factors affecting acid hydrolysis, base hydrolysis and conjugate base mechanism, direct-indirect evidence in favor of conjugate base mechanisms.

UNIT-II (Reaction Mechanism in Square planar Complexes) 09

Anation reactions; Reactions without metal ligand bond cleavage; Substitution reactions in square planar complexes: mechanism of the substitution reaction, trans effect, and theories of trans effect.

UNIT-III (Electron Transfer Reaction) 09

Electron transfer reaction: oxidation-reduction reactions; Electron transfer and law of conservation of energy; Factors effecting rate of electron transfer; Mechanism of electron transfer: outer sphere mechanism and inner sphere mechanism; Complementary and non-complementary reactions; Electron transfer in mixed valence complexes; Marcus theory and Marcus inverted region; Electron transfer and electron tunneling.

UNIT-IV (Electron Spectroscopy-I) 09

Basic principles of electronic spectroscopy; Frank–Condon principle; Spin and Laporte selection rules; Band intensities and band-width; Number of microstates and term symbols for gaseous atoms/ions; Spin-orbit coupling and energies of J levels.

UNIT-V (Electron Spectroscopy-II) 09

Interpretation of electronic spectra: Orgel diagram for 3d transition metal complexes; Tanabe – Sugano diagram for transition metal complexes; Calculations of crystal field and ligand field parameters: Dq (crystal-field splitting parameter), B (Racah parameter) and β (nephelauxetic parameters); Nephelauxetic series and charge transfer spectra; Magnetic properties of transition metal complexes.

Recommended Books

1. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity.
2. Keith F. Purcell and John C. Kotz, Inorganic Chemistry.

3. Gary Wulfsberg, Inorganic Chemistry, Viva Student Edition.
4. W. H. Malik, G. D. Tuli, and R. D. Madan, Selected Topics in Inorganic Chemistry, S. Chand and Company Limited
5. J. D. Lee, Inorganic Chemistry.
6. S. K. Aggarwal and Keemti Lal, UGC Advanced Inorganic Chemistry, Pragati Prakashan.

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 532-INORGANIC CHEMISTRY LAB COURSE	Number of Credits: 02
On completion of the course, the students will be able to:		
CO 1	Develop skills for the Preparation of Coordination Complexes and their Characterization by m.p, elemental Analysis and molar conductivity measurements	
CO 2	Develop skills for the Recording and analysis of UV-visible and IR spectra of coordination compounds	

SEMESTER – II
INORGANIC CHEMISTRY LAB COURSE

LAB COURSE CODE CHE 532

Course Credit = 02 (45 hrs)

1. Preparation of Coordination Complexes and their Characterization by m.p, elemental Analysis and molar conductivity measurements.

- a) $\text{VO}(\text{acac})_2$
- b) $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3] \cdot 3\text{H}_2\text{O}$
- c) $\text{Na}[\text{Cr}(\text{NH}_3)_2(\text{SCN})_4]$
- d) $\text{Mn}(\text{acac})_3$
- e) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$
- f) $\text{Hg}[\text{Co}(\text{SCN})_4]$
- g) $[\text{Co}(\text{Py})_2\text{Cl}_2]$
- h) $[\text{Ni}(\text{NH})_6]\text{Cl}_2$

2. Study of recorded UV-visible and IR of above prepared coordination compounds.

Recommended Books

- 1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
- 2. Marr & Rockett Inorganic Preparations, 2002.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 509 – INORGANIC CHEMISTRY PAPER – I (Bio-inorganic Chemistry)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	List out the functions and fate of metals in biological systems and understand photosystem	
CO 2	Explain the structure of biological important complexes like hemoglobin, hemocyanin, metal phthalocyanine	
CO 3	Describe the Structure and function of metalloproteins and iron-sulphur proteins	
CO 4	Describe the Structure and function of metalloenzymes	
CO 5	Understand the structure and function of Copper – containing Enzymes, Superoxide dismutase (SOD), Bovine Superoxide dismutase (BOD)	

SEMESTER III - THEORY PAPER COURSE

COURSE CODE - CHE 509

PAPER – I

(Bio-inorganic Chemistry)

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Role of Metal Ions in Biological Systems) 09

Role of metal ions in biological systems; Na^+/K^+ pump; Photosystems: Oxygen Evolving Complex; Nitrogen fixation.

UNIT-II (Complexes of Biological Importance) 09

Complexes of biological significance: Metal complexes of porphyrins and phthalocyanin; Vitamin B12 and B6; Chlorophylls; Plastocyanin and related pigments.

UNIT-III (Metalloproteins) 09

Oxygen carrying metalloproteins: haemoglobin (features of heme and apoprotein, oxygenated and deoxygenated form, T and R State, mechanism of heme oxidation, role of proximal and distal histidine, nature of heme-oxygen binding, cooperativity effect, Bohr's effect, Hill coefficient), myoglobin, hemerythrins and hemocyanin; Electron transport protein (Iron-Sulfur Proteins): rubredoxin, ferredoxins, cytochromes (types a, b and c); Some synthetic oxygen carriers: Vaska's complex, Collman's compound and Cobalt(II)-schiff base complexes.

UNIT-IV (Metalloenzymes-I) 09

Molybdenum (Mo) containing metalloenzymes: nitrogenase, xanthine oxidase, sulphite oxidase and nitrate reductase; Iron (Fe) containing metalloenzymes: cytochrome oxidase, catalases, peroxidases, cytochrome P450.

UNIT-V (Metalloenzymes-II) 09

Copper (Cu) containing enzymes: superoxide dismutase (SOD), ascorbic acid oxidase; Zinc (Zn) containing enzymes: carboxypeptidase A and B, carbonic anhydrase and urease.

Recommended Books

1. Keith F. Purcell and John C. Kotz, Inorganic Chemistry.
2. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity.

3. A. K. Das, Bioinorganic Chemistry, Books and Allied (P) Ltd.
4. K. Hussain Reddy, Bioinorganic Chemistry.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 510 – INORGANIC CHEMISTRY PAPER – II (Organometallic Chemistry)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand the basics and classifications of organometallic compounds	
CO 2	Use knowledge about structure and bonding issues to understand the stability and reactivity of simple organometallic complexes	
CO 3	Understand fundamental reaction types and mechanisms and how to combine these to understand efficient catalytic processes	
CO 4	Understand the concept of Fluxionality in Organometallic Compounds	
CO 5	Know important applications of organometallic homogeneous catalysis in the production of large-scale (bulk) and smaller-scale (fine chemicals) production	

SEMESTER III - THEORY PAPER COURSE

COURSE CODE - CHE 510

PAPER – II

(Organometallic Chemistry)

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Organometallics-I)

09

Classification of organometallic compounds based on hapticity and polarity of M-C bond; EAN and 18 electron rule with limitations; Electron counting in reactions: oxidation state, coordination number and geometry; Effects of complexation; Nomenclature and general characteristics.

UNIT-II (Organometallics-II)

09

Complexes of σ - and π - donor organic ligands; Transition metal with alkenyls, alkynyls, carbenes, carbynes; Preparation, bonding and structure of alkene, alkyne, allyl, dienyl and arene complexes with metal; Metallocenes; Important reactions: oxidative addition, reductive elimination, olefin insertion and β -hydride elimination.

UNIT-III (Homogeneous and Heterogeneous Catalysis)

09

Transition metal compounds in homogeneous catalysis and compounds with M-H bond; Catalytic cycle; Hydrogenation; Alkene hydrosilylation and hydroboration; Alkene hydrocyanation; Hydroformylation; Coupling reactions; Heterogeneous catalysis: Fischer-Tropsch reaction and Zeigler-Natta polymerization of olefins.

UNIT-IV (Catalytic Cycle)

09

Wacker Process; The Monsanto process; Cativa Process; Hydrocarbonylation of olefins; Oxopalladation reactions; Activation of C-H bond; Metal hydrides (classical and non-classical); Dihydrogen complexes; Agostic interaction.

UNIT-V (Fluxionality)

09

Fluxional organometallic compounds and fluxionality; Dynamic equilibria in compounds such as n^2 -olefins and n^3 -allyl and dienyl complexes; Applications: alkene metathesis, dimerization, oligomerization and polymerization of alkenes, and activation of CO and CO₂.

Recommended Books

1. Dirk Steinborn, Fundamentals of Organometallic Catalysis, 2012, Wiley-VCH, ISBN: 978-3-527-32717-1.
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals.
3. A. Yamamoto, Organotransition Metal Chemistry: Fundamental Concept and Applications, John Wiley, 1986.
4. B. D. Gupta and A. J. Elias, Basic Organometallic Chemistry: Concepts, Synthesis and Application, 2013, ISBN: 978-81-7371-709-3.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 511 – INORGANIC CHEMISTRY PAPER – III (Coordination Polymers, Cages, Clusters and Nanostructures)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Learn and design Metal organic framework	
CO 2	Describe structure and bonding in metal carbonyls and related Compounds	
CO 3	Compare the structure and bonding in Boranes, Carboranes, metal clusters	
CO 4	Comprehend the types, properties and applications of nanomaterials and design innovative routes for nanomaterial synthesis and its application	
CO 5	Understand the structural aspects of various types of metal alkoxides, their properties and industrial applications	

SEMESTER III - THEORY PAPER COURSE

COURSE CODE - CHE 511

PAPER – III

(Coordination Polymers, Cages, Clusters and Nanostructures)

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Metal-organic Frameworks)

09

Metal-organic frameworks (MOFs): history, discovery, nomenclature and terminology; Difference between metal-organic frameworks (MOFs) and covalent-organic frameworks (COFs); Classification of MOFs; Synthetic strategies of MOFs: different high temperature and ambient temperature synthetic methods and post synthetic modification of the MOFs; Characterization of MOFs using spectroscopic and physical characterization techniques; Applications of MOFs for gas storage and capturing, separation, heterogeneous catalysis, water purifications and in advanced fields.

UNIT-II (Metal Carbonyls)

09

Metal carbonyls and related compounds: preparation, structure and properties; Bonding in metal carbonyls; Symmetry of metal carbonyls; Variants of CO bridging vibrational spectra of metal carbonyls; Principle reaction types of metal carbonyls and metal nitrosyl.

UNIT-III (Boron Chemistry)

09

Molecular orbital diagram of diborane; Polyhedral boranes: structure and bonding in higher boranes, carboranes, metallo-boranes, metallo-carboranes; Wade's and Jemmis' Rules; STYX code.

UNIT-IV (Nanoparticles)

09

Nanoparticles: introduction, classification, methods of preparation: physical and chemical methods viz. sol-gel; wet chemical synthesis; GVD; CVD and applications (medical and electrical) in chemistry.

UNIT-V (Metal-Alkoxides)

09

Metal-Alkoxides: properties, structural and catalytic aspects; Industrial applications of various types of metal-alkoxides.

Recommended Books

1. Stefan Kaskel, The Chemistry of Metal–Organic Frameworks: Synthesis, Characterization, and Applications (Volume 1), Wiley-VCH Verlag GmbH & Co. KGaA

2. Ali Morsali and Sayed Ali Akbar Razavi, Functional Metal-Organic Frameworks: Structure, Properties and Applications, Scrivener Publishing- Wiley.
3. Omar M. Yaghi, Markus J. Kalmutzki and Christian S. Diercks, Metal-Organic Frameworks and Covalent Organic Frameworks: Synthesis, Characterization, and Applications, Wiley-VCH Verlag GmbH & Co. KGaA.
4. Stuart R. Batten, Suzanne M. Neville and David R. Turner, Coordination Polymers: Design, Analysis and Application, 2009.
5. Glen E. Rodgers, Inorganic Chemistry.
6. J. E. Huheey, Ellen A. Keiter, and Richard L. Keiter, Inorganic Chemistry, Principle of Structure and Reactivity, 4th edition, Published by Pearson Education, Inc.
7. J. D. Lee, Inorganic Chemistry.
8. S. Shanmugam, Nanotechnology, MJP Publishers, Chennai.
9. Patrick Salomon, A Handbook on Nanochemistry, Dominant Publishers and Distributors, New Delhi.
10. S. Balaji, Nanobiotechnology, MJP Publishers, Chennai.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CODE CHE 535- INORGANIC CHEMISTRY LAB COURSE	Number of Credits: 10
On completion of the course, the students will be able to:		
CO 1	Learn basics of different chromatographic techniques	
CO 2	Develop analytical skills to separate mixture of Cations/Anions by Paper Chromatographic Technique using Aqueous Media	
CO 3	Develop analytical skills to separate mixture of Cations/Anions by Paper Chromatographic Technique using Non-aqueous Media	
CO 4	Learn ion-exchange method of separation	
CO 5	Develop analytical skills to separate mixture of ions using ion-exchange methods	

SEMESTER III
INORGANIC CHEMISTRY LAB COURSE
COURSE CODE-PHYSICAL CHE- 535
(In addition to CHE CODE - 509, 510 & 511)
Course Credit = 10 (160 hrs.)

1. Separation of a Mixture of Cations/Anions by Paper Chromatographic Technique Using Aqueous/Non-aqueous Media:

- a) Pb^{2+} and Ag^+ (aqueous and non-aqueous media)
- b) Co^{2+} and Cu^{2+} (non aqueous media)
- c) Cl^- and I^- (aqueous – acetone media)
- d) Br^- and I^- (aqueous – acetone media)

2. Ion-exchange Method of Separation

- a) Separation of Zn^{2+} and Mg^{2+} on an anion exchanger
- b) Separation of Co^{2+} and Ni^{2+} on an anion exchanger

Recommended Books

- 1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
- 2. Marr & Rockett Inorganic Preparations, 2002

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 551 – ELECTIVE PAPER (Nuclear Chemistry)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understanding Nuclear Fundamentals	
CO 2	Radioactive Dating and Radiation Analysis	
CO 3	Nuclear Reactions and Reactor Technology	
CO 4	Comparison of Chemical and Nuclear Reactions	
CO 5	Isotope Separation and Radioisotope Applications	

MSc III Semester - Elective Papers

COURSE CODE - CHE 551

PAPER – IV

(Nuclear Chemistry)

Course Credit = 03 (45 Lectures)

No of Lectures

Unit-I (Fundamentals of Nuclear Chemistry) 09

Fundamentals of nuclear chemistry and properties of nucleus; α , β , γ decay; Beth's notation; Meson theory and n/p ratio; Binding energy and mass defect; Threshold energy; Q-value; Packing fraction;

Nuclear models: shell and liquid drop; Magic numbers; Isotopes; Isobars; Isotones; Isoelectronic; Isosteres; Isodiaphers; Nuclear isomers; Mirror nuclei; Group displacement law; Radioactive disintegration series; Law of radioactive decay.

Unit-II (Nuclear Chemistry) 09

Radioactive dating methods: carbon dating, potassium-argon dating, uranium-lead dating; Neutron Activation Analysis (NAA); Radio release methods; Radiometric titrations; Dilution analysis; Units of radiation energy; Radiation dosimetry; Radiolysis of water and aqueous solutions; Interactions of radiations with matter: photoelectric effect, Compton effect, pair production; Interaction of neutron with matter.

Unit-III (Nuclear Reactions-I) 09

Nuclear reactions: basic principle of fission and fusion, energy released in fission chain reactions, controlled release of fission energy and use of moderators; Classification of nuclear reactors including breeder reactors; Reactor safety; Nuclear waste management; Principle of atomic, hydrogen, plutonium and cobalt bomb; Nuclear fuels; Fuel cycle and fuel reprocessing; Nuclear transmutation and artificial radioactivity; The 4-factor formula.

Unit-IV (Nuclear Reactions-II) 09

Comparison of chemical and nuclear reaction; Nuclear reactions: capture, particle-particle, spallation, fragmentation, stripping, photonuclear, thermonuclear, proton-induced, deuteron-induced, alpha-induced, neutron-induced; Solar energy; Exoergic and endoergic nuclear reactions; Applications of atomic energy; Contribution of nuclear energy in progress of India.

Unit-V (Radioactivity) 09

Methods of separation of isotopes: thermal diffusion, distillation, fractional distillation, chemical exchange method; Measurement of radioactivity: GM counter, scintillation counter, proportional counter; Statistical

analysis of radioactivity; Application of radioisotopes: medical and agricultural applications, determination of chemical pathways and structure *etc.*

Recommended Books

1. H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Revised Ed., New Age International (P) Limited.
2. Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry. 2nd ED. Pearson Education Limited, Essex, 2005, ISBN: 0130-39913-2.
3. S. K. Aggarwal and Keemti Lal, UGC Advanced Inorganic Chemistry, Pragati Prakashan.
4. L. R. Madan, Physical Chemistry, McGraw Hill Education (India) Private Limited, New Delhi, India, 2015, ISBN: 1-259-06254-6.
5. R. L. Dutta and G. S. De, Inorganic Chemistry, Part - I, Chemical Elements and their Compounds.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 521 – INORGANIC CHEMISTRY PAPER – I (Advanced Spectroscopic Techniques in Chemical Analysis)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Describe the working principles of Mass Spectrometry, nuclear magnetic resonance (NMR), and electron spin resonance (ESR)	
CO 2	Understand the basics and utility of Multinuclear NMR of Metal nuclei	
CO 3	Elucidate structure of inorganic and Organic compounds from nuclear magnetic and electron spin resonance spectroscopy data	
CO 4	Interpret Raman and IR spectroscopy and describe application to chemical analysis	
CO 5	Solve and work with numerical based on spectroscopic data. Interpret different types of molecular spectra and structure to evaluate valuable data from it	

SEMESTER IV - THEORY PAPER

CORE COURSE CODE – CHE 521

PAPER –I

(Advanced Spectroscopic Techniques in Chemical Analysis)

Course Credit= 03 (45 Lectures)

No of Lectures

UNIT- I (NMR Spectroscopy)

09

NMR spectroscopy: basic principles; Chemical environment and chemical shifts; Coupling constant: mechanism of coupling, one, two, three and long range coupling; Molecular relaxation processes; Double resonance; Decoupling phenomenon; Cross polarization-NOE; Off resonance; DEPT spectra and its structural applications in ^{13}C NMR; Use of chemicals as NMR auxiliary reagents (shift and relaxation reagents); Dynamic processes in NMR: NMR due to proton exchange- (i) proton on oxygen-alcohols (ii) proton on nitrogen-amines (iii) solvent effect; ^1H NMR of paramagnetic substances.

UNIT-II (Multinuclei NMR)

09

NMR spectroscopy of the multinuclei: ^{19}F , ^{31}P , ^{77}Se , ^{107}Ag , ^{195}Pt , ^{119}Sn , and ^{11}B .

UNIT- III (EPR Spectroscopy)

09

Electron spin resonance spectroscopy: basic principle, hyperfine splitting (isotropic systems); g value and the factors affecting the g value; Interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); Electron-electron interactions, Anisotropic effects (the g value and the hyperfine couplings); Structural applications to transition metal complexes.

UNIT IV (IR and Raman Spectroscopy)

09

Infrared spectroscopy: basic principle, selection rule for harmonic and anharmonic oscillator, fundamental vibrations, overtones and combination frequencies; Functional group vibrations; Factors affecting CO, CN, NO, NO₂ stretching frequencies in their corresponding transition metal complexes; Mode of bonding of ambidentate ligands.

Raman spectroscopy: Rayleigh scattering, Raman scattering (Stokes and Anti-Stokes line); Classical and quantum theory of Raman effect; Raman activity of vibration for H₂O and CO₂ molecules; Rule of mutual exclusion; Combined use of Raman and infra-red spectroscopy to determine the shapes of simple AB₂, AB₃, and AB₄ molecules.

Mass spectrometry: basic principle and measurement of m/z ; Various types of ions; Ionization techniques: electron ionization, chemical ionization, fast atom bombardment, and electrospray ionization (ESI); Charge deconvolution in ESI; Mass analyzers: magnetic sector (single focusing), time of flight, quadrupole mass analyzer; Detectors: Faraday cup and electron multiplier; Different types of masses; $[M+1]$ and $[M+2]$ masses; Isotopes and its natural abundance and pattern in mass spectrum; Calculation of isotopic distributions (binomial approach); Mass accuracy; Resolution and high resolution mass spectrometry (HRMS); Nitrogen rule; Rule of thirteen; Even-electron rule; Hydrogen density index (HDI) or double bond equivalence (DBE); Stevenson's rule; McLafferty rearrangement; Fragmentation in mass spectrometry.

Recommended Books

1. D. L. Pavia, G. M. Lampman, G. S. Kriz, and J. R. Vyvyan, Introduction to Spectroscopy.
2. C. N. Banwel and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw-Hill Publishing Company Limited.
3. K. Das and M. Das, Fundamental Concepts of Inorganic chemistry, Volume 7, CBS Publishers and Distributors Pvt. Ltd.
4. H. H. Willard, L. L. Merritt, J. A. Dean, and F. A. Settle, Instrumental Methods of Analysis.
5. D. A. Skoog, F. J. Holler, and S. R. Crouch, Instrumental Analysis.
6. J. Mendham, R. C. denney, J. D. Barnes, M. Thomas, and B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis.
7. Jurgen H. Cross, Mass Spectrometry: A Text Book.
8. Edmond de Hoffmann and Vincent Stroobant, Mass Spectrometry: Principles and Applications.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 522 – INORGANIC CHEMISTRY PAPER – II (Structural Methods in Inorganic Chemistry)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand and predict the magnetic properties of any material	
CO 2	Describe the working principles of Mossbauer Spectroscopy, UV-Visible Spectroscopy, and Photoelectron Spectroscopy	
CO 3	Understand the theory and principle behind X-Ray Spectroscopy	
CO 4	Interpret and analyze absorption spectra	
CO 5	Determine the hyperfine parameters, recoil energy, quadrupole splitting and chemical shift / isomer shift by using mossbauer spectroscopy	

SEMESTER IV - THEORY PAPER

CORE COURSE CODE – CHE 522

PAPER –II

(Structural Methods in Inorganic Chemistry)

Course Credit= 03 (45 Lectures)

No. of Lectures

UNIT- I (Magnetic Properties)

09

Magnetic properties; Magnetic behaviors: single molecule magnet and single chain magnet; Recent methods of magnetic susceptibility measurements; Anomalous magnetic properties of transition metal complexes; Spin cross-over phenomena; Magnetic properties of binuclear metal complexes involving metal-metal exchange interaction (Bleaney-Bower equation).

UNIT- II (Electron Spectroscopy)

09

X-ray photoelectron spectroscopy (XPS); Auger electron spectroscopy (AES); Ultraviolet photoelectron spectroscopy (UPS): instrumentation, basic principles, spectral features, chemical shifts, depth profiling and its utilization to structure determination of inorganic molecules and metal complexes leading to their implementation in catalysis.

UNIT- III (X-ray Spectroscopy)

09

X-Ray spectroscopy: X-ray sources, scattering and absorption, refraction and reflection from interfaces, refractive index, X-ray optics, scattering from non-crystalline material, small angle X-ray scattering (SAXS); Scattering from crystalline material: X-ray diffraction (XRD), X-ray absorption spectroscopy (XAS), X-ray absorption fine structure spectroscopy (EXAFS), X-ray absorption near edge spectroscopy (XANES) with synchrotron radiation techniques, X-ray fluorescence (XRF), emission spectroscopy, scanning X-ray fluorescence spectroscopy (XRF), X-ray detectors, X-ray imaging: scanning transmission, tomography.

UNIT- IV (UV Visible Spectroscopy)

09

UV Visible Spectroscopy: basic principle and instrumentation; Type of transitions: charge transfer spectra, d-d transition; Selection rules; Electronic spectra of complexes: $[\text{V}(\text{H}_2\text{O})_6]^{3+}$, $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$, $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$.

UNIT- V (Mossbauer Spectroscopy)

09

Mossbauer Spectroscopy: basic principle; Conditions for Mossbauer spectroscopy; Spectral parameters: isomer shift, electric quadrupole interactions, magnetic interactions; Structural deductions for important complexes.

Nuclear Quadrupole Resonance (NQR): Theory and its applications.

Recommended Books

1. R. L. Dutta and G. S. De, Inorganic Chemistry Part I, The New Book Stall
2. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley and Sons, 2008.
3. S. Zhang, Lin Li, and A. Kumar, Materials Characterization Techniques, CRC press, 2008.
4. Jeroen A. Van Bokhoven, X-Ray Absorption and X-Ray Emission Spectroscopy, John Wiley and Sons, Ltd, 2016.
5. Introduction to XAFS, Cambridge University Press, 2011.
6. H. H. Willard, L. L. Merritt, J. A. Dean, and F. A. Settle, Instrumental Methods of Analysis.
7. D. A. Skoog, F. J. Holler, and S. R. Crouch, Instrumental Analysis.
8. J. Mendham, R. C. denney, J. D. Barnes, M. Thomas, and B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis.
9. Leopold May, An Introduction to Mossbauer Spectroscopy.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 523 – INORGANIC CHEMISTRY PAPER – III (Selected Topics in Inorganic Chemistry)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Describe the working principles of Electron Microscopy	
CO 2	Learn application of Electron Microscopy viz. Electron Microscope, AFM (Atomic force microscopy), STM (Surface tunnelling microscopy)	
CO 3	Explain Photochemistry of Transition Metal complexes	
CO 4	Understand the physical and chemical significance of electrodes, electrochemical methods and techniques	
CO 5	Understand and apply different voltammetric techniques	

SEMESTER IV - THEORY PAPER

CORE COURSE CODE – CHE 523

PAPER –II

(Selected Topics in Inorganic Chemistry))

Course Credit= 03 (45 Lectures)

No. of Lectures

UNIT- I (Electron Microscopy)

09

Electron microscopy: Historical overview of electron microscopy; Comparison between light microscopy and electron microscopy; Scanning Electron Microscopy (SEM): Working principles; Electron beam-sample interactions; Sample preparation techniques for SEM; Transmission Electron Microscopy (TEM): Introduction to TEM; Electron diffraction and imaging.

UNIT- II (Microscopic Techniques)

09

Overview of microscopy techniques, Basic principles of scanning probe microscopy, Comparison between AFM and STM, Atomic force microscopy (AFM): Working principles of AFM; Modes of operation: contact mode, tapping mode, non-contact mode; Probe-sample interactions; Surface tunneling microscopy (STM): Introduction to STM; Quantum tunneling phenomenon; Tunneling current and tip-sample interactions.

UNIT – III (Photochemistry)

09

Principles of photochemistry in metal complexes (electronic excitation, singlet, and triplet states, Franck-Condon principle, excimers, and exciplexes, quantum yields, and reactions of excited states). Photoreactions of first-row transition metals like chromium(III), cobalt(III), copper(I)/(II), and manganese-based photosystems. Photoreactions of dimeric, multimetallic complexes, and various reactions involving $\text{Ru}(\text{bpy})^{3+}$ and related complexes, including catalytic processes and chemiluminescence.

UNIT- IV (Cyclic Voltammetry-I)

09

Linear sweep voltammetry and cyclic voltammetry: Working principle and its application; Instrumentation; Analysis of Cyclic voltammetry curve for $\text{K}_3\text{Fe}(\text{CN})_6$ and LiFePO_4 .

UNIT- V (Cyclic Voltammetry-II)

09

Types of voltammetry: Differential pulse voltammetry (principle and application), anodic stripping voltammetry (principle and application), chronoamperometry (principle and application), Coulometry: working principle; Types of Coulometry, Instrumentation and Application.

Recommended Books

1. R.F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AFM.
2. Brent Fultz and James M. Howe, Transmission Electron Microscopy and Diffractometry of Materials.
3. D. M. Roundhill, Photochemistry and Photophysics of Metal Complexes.
4. Philip H. Rieger, Electrochemistry, Brown University, 1986, ISBN No: 0-13-249138-9.
5. Valentin Mirceski, Sebojka Komorsky-Lovric, and Milivoj Lovric, Theory and Application: Square-Wave Voltammetry, 2007, ISBN: 9783540737407.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 539- INORGANIC CHEMISTRY LAB COURSE	Number of Credits:10
On completion of the course, the students will be able to:		
CO 1	Learn the basics and working of spectrophotometer	
CO 2	Learn basics of spectroscopic determinations	
CO 3	Analyze the spectra to determine the composition of analyte	
CO 4	Develop analytical skills to work in team based work	

SEMESTER IV
INORGANIC CHEMISTRY LAB COURSE
COURSE CODE-PHYSICAL CHE- 539
(In addition to CHE CODE - 521, 522 & 523)
Course Credit = 10 (160 hrs)

1. Spectroscopic Determinations
 - (a) Mn/Cr/V in steel Sample.
 - (b) Ni/Mo/W/V/U/ by extractive spectrophotometric method.
 - (c) Fluoride/ nitrite / Phosphate.
 - (d) Iron – phenanthroline complex: Job’s method.
 - (e) Zirconium – Alizarin Red-S complexes: Mole-ratio method.
 - (f) Copper-Ethylene diamine complexes: Slope-ratio method.
 - (g) Iron-thiocyanate complex-Ionophoric method
2. Atomic Absorption Spectroscopy
 - Estimation of metal ions.
3. Project Work

Recommended Books

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
2. Marr & Rockett Inorganic Preparations, 2002

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 555 – ELECTIVE PAPER INDUSTRIAL CHEMISTRY	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand Fuel Classification and Properties	
CO 2	Understand Glass Industry and Specialized Glass Manufacturing	
CO 3	Understand Cement Industry and Concrete Manufacturing	
CO 4	Gain knowledge about Soap and Synthetic Detergent Production	
CO 5	Gain knowledge about Sugar Industry and Sugar Substitutes	

MSc IV Semester - Elective Papers

COURSE CODE - CHE 555

PAPER – IV

(Industrial Chemistry)

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT I (Fuels)

09

Classification of fuels: solid, liquid and gaseous

Solid fuels: Coal – Types (sub-bituminous, bituminous, anthracite and lignite), properties and uses; Cooking and non-cooking coal.

Liquid fuels: refining of crude petroleum and uses of fractions; hydrodesulphurization; Cracking: thermal and catalytic (fixed bed and fluidised bed cataylsis); Octane number.

Gaseous fuels: Natural gas and gobar gas: production, composition and uses; Gobar electric cell.

Calorific value of fuels and its determination; Energy sources: renewable and non-renewable.

Unit II (Glass Industry)

09

Glass Industry: introduction and classification of glass; Manufacturing: raw materials and methods; Special glasses: optical, coloured, fibre, laminate, safety, photosensitive, photochromatic, lead, borosilicate and glass wool.

Unit III (Cement Industry)

09

Cement Industry: types of cement; Composition, setting and hardening of cement; Mortars and concrete; Gypsum; Plaster of Paris; Manufacture of Portland cement; Estimation of silica, alumina, calcium oxide and sulphates in Portland cement.

Unit IV (Soap)

09

Soap: manufacture of soap; Types of soaps.

Synthetic detergents: manufacture of detergent; Types of detergents: anionic, cationic, nonionic and amphoteric.

Unit V (Sugar Industry)

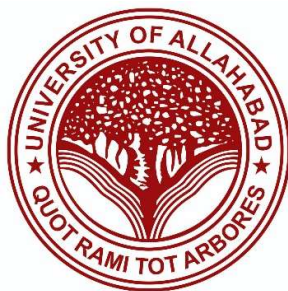
09

Sugar industry: Double sulphitation process; Refining and grading of sugar; Saccharin and aspartame: synthesis and use as a sugar substitute; Ethanol: manufacture from molasses by fermentation.

Recommended Books

1. B. K. Sharma, Industrial Chemistry, Goel Publishing house Meerut.
2. P. C. Jain and M. Jain, Engineering chemistry, 10th ed.; Dhanpat Rai and sons, 1993.
3. P. Kamaraj, R. Jeyalakshmi, and V. Narayanan, Chemistry in engineering and technology Sudhandhira publications, 2001.

SYLLABUS
For M.Sc. CHEMISTRY (Organic)
(THEORY & PRACTICAL)
CHOICE BASED CREDIT SYSTEM
(C.B.C.S)
(2024 onwards)



Department of Chemistry
Faculty of Science
University of Allahabad
Allahabad – 211002

The following section provides the mapping of Course Outcomes (COs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) for the M.Sc. Chemistry (Inorganic Chemistry Specialization) program. Correlation is represented on a scale of 1 to 3:

3 – High correlation

2 – Medium correlation

1 – Low correlation.

CHE 502 – Organic Chemistry (Sem I)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand chemical bonding, reactivity, acidity/basicity, aromaticity	PO1(3) PO2(3)	PSO1(3)
CO2: Determine reaction mechanisms and intermediates	PO2(3) PO6(2)	PSO1(3)
CO3: Apply stereochemistry concepts to organic systems	PO2(3) PO3(2)	PSO1(3)
CO4: Analyze nucleophilic substitution and rearrangements	PO2(3) PO6(2)	PSO2(3)
CO5: Identify and evaluate reaction intermediates (carbanions, carbenes, etc.)	PO6(3) PO2(2)	PSO2(3)

CHE 533 – Organic Practical (Sem I)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Perform separation and identification of binary organic mixtures	PO2(3) PO3(2)	PSO2(3)
CO2: Troubleshoot and optimize separation procedures	PO6(3) PO2(2)	PSO2(3)
CO3: Estimate functional groups quantitatively	PO2(3) PO10(2)	PSO2(3)
CO4: Use chemical methods for estimation of organic compounds	PO2(3) PO6(2)	PSO2(3)

CHE 506 – Organic Chemistry (Sem II)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand free radical chemistry and mechanisms	PO1(3) PO2(3)	PSO1(3)
CO2: Apply addition reactions to C=C and C≡C systems	PO2(3) PO6(2)	PSO2(3)
CO3: Analyze elimination reactions and orientations	PO2(3) PO6(2)	PSO2(3)
CO4: Predict pericyclic reaction outcomes using	PO2(3)	PSO1(3)

symmetry rules	PO10(3)	
CO5: Design stereochemically controlled synthetic routes	PO10(3) PO9(2)	PSO3(3)

CHE 534 – Organic Practical (Sem II)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Practice safe lab techniques and proper handling of reagents	PO4(3) PO3(2)	PSO2(3)
CO2: Synthesize multi-step organic compounds	PO2(3) PO10(2)	PSO3(3)
CO3: Analyze compounds using spectrophotometry and chemical methods	PO2(3) PO6(2)	PSO2(3)

CHE 510 – Pericyclic & Photochemistry (Sem III)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Explain molecular orbital symmetry and pericyclic reactions	PO1(3) PO2(3)	PSO1(3)
CO2: Apply Woodward–Hoffmann rules to predict stereochemistry	PO2(3) PO6(2)	PSO1(3)
CO3: Analyze photochemical reaction pathways and excited states	PO2(3) PO10(3)	PSO2(3)
CO4: Design photochemical strategies in synthesis	PO10(3) PO9(2)	PSO3(3)
CO5: Solve problems on pericyclic reaction stereochemistry	PO6(3) PO2(2)	PSO2(3)

CHE 511 – Spectroscopy (Sem III)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand IR, NMR, UV-Vis and Mass spectroscopy principles	PO2(3) PO10(3)	PSO1(3)
CO2: Apply spectroscopy for structural elucidation of organic molecules	PO2(3) PO6(3)	PSO2(3)
CO3: Interpret complex NMR patterns and mass fragmentation	PO2(3) PO6(3)	PSO2(3)
CO4: Correlate spectral features with functional groups	PO2(3) PO10(2)	PSO1(3)
CO5: Confirm molecular structures using combined spectroscopic data	PO10(3) PO6(3)	PSO2(3)

CHE 512 – Strategies in Organic Synthesis & Heterocyclic Chemistry (Sem III)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand strategies for organic synthesis and heterocycle construction	PO1(3) PO2(3)	PSO1(3)
CO2: Apply retrosynthetic analysis for complex targets	PO2(3) PO10(3)	PSO3(3)
CO3: Analyze reagent selection and protecting group strategies	PO2(3) PO6(3)	PSO2(3)
CO4: Design synthetic routes for heterocycles and natural product fragments	PO10(3) PO9(2)	PSO3(3)

CHE 522 – Biosynthesis & Chemistry of Natural Products (Sem IV)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand biosynthetic pathways and structures of natural products	PO1(3) PO2(3)	PSO1(3)
CO2: Apply synthetic methods to natural product frameworks	PO2(3) PO10(2)	PSO3(3)
CO3: Analyze stereochemical and regiochemical issues in biosynthesis	PO2(3) PO6(2)	PSO2(3)
CO4: Design syntheses of complex natural products	PO10(3) PO9(2)	PSO3(3)

CHE 525 – Stereoselective Synthesis (Sem IV)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand principles of stereoselective and asymmetric synthesis	PO1(3) PO2(3)	PSO1(3)
CO2: Apply chiral reagents and catalysts to achieve stereocontrol	PO2(3) PO10(3)	PSO3(3)
CO3: Analyze stereochemical outcomes and methods for enantioselectivity	PO6(3) PO2(3)	PSO2(3)
CO4: Design stereoselective routes for target molecules	PO10(3) PO9(3)	PSO3(3)

CHE 526 – Biomolecules & Bioactive Compounds (Sem IV)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand structure and function of biomolecules and bioactives	PO1(3) PO2(3)	PSO1(3)
CO2: Apply analytical and synthetic approaches to bioactive molecules	PO2(3) PO10(2)	PSO2(3)
CO3: Analyze mode of action and SAR (structure-activity relationships)	PO6(3) PO2(2)	PSO3(3)
CO4: Design bioactive analogues using medicinal	PO10(3)	PSO3(3)

chemistry principles	PO9(2)	
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CHE 524/556 – Electives & Advanced Topics (Sem IV) (Reagents & Reactions / Reagents and Reactions)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand modern reagents and their mechanistic roles	PO2(3) PO10(3)	PSO1(3)
CO2: Apply reagents in targeted synthetic transformations	PO2(3) PO6(3)	PSO2(3)
CO3: Analyze reagent compatibility and reaction scope	PO6(3) PO2(3)	PSO2(3)
CO4: Design reagent-based synthetic solutions for complex problems	PO10(3) PO9(2)	PSO3(3)

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 502 ORGANIC CHEMISTRY PAPER-II	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	understand chemical bonding and reactivity, various effects in organic molecules, Acidity and Basicity as well as aromaticity.	
CO 2	gain knowledge on methods of determination of reaction mechanism, various reaction intermediates	
CO 3	understand concepts of stereochemistry and will be able to stereochemical aspects in organic chemistry	
CO 4	develop knowledge of nucleophilic substitution (aliphatic and aromatic reactions and related rearrangements, considering substrate structure and nucleophilic attack	
CO 5	identify and evaluate Reaction Intermediates, including carbanions, non-classical carbocations, and reactive species like carbenes and nitrenes.	

Syllabus:

UNIT – I

π -Molecular Orbitals of Conjugated Systems and Aromaticity:

Qualitative description of molecular orbitals of simple acyclic and monocyclic systems: Huckel and Perturbation molecular orbital theory. Aromaticity in benzenoid, non-benzenoid compounds and metallocenes, Huckels rule, energy of pi-molecular orbitals, annulenes, anti-aromaticity, homo-aromaticity.

Reaction Mechanism: Structure and Reactivity

A review of reaction mechanisms including methods of determination. Linear free energy relationships and their applications (Hammett equation and modifications). Hard and soft Nucleophiles.

UNIT – II

Stereochemistry

Elements of symmetry, chirality, molecules with more than one chiral centre, threo and erythro isomers, optical purity, Topicity and Prostereoisomerism: Topicity of ligands and faces-homotopic, enantiotopic and Cram's rule/diastereotopic ligands and faces. Optical activity in the absence of chiral carbon: Stereochemistry and configuration of allenes, spiranes, alkylidene cycloalkanes, adamantanes, catenanes, biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes.

UNIT – III

Conformational Analysis

Factors responsible for the stability of conformation: Torsional strain, steric strain, Dipole-dipole interaction, Hydrogen bonding, angle strain, hyperconjugation, and anomeric effect. *Cyclostereoisomerism*: Configurations, conformations and stability of cyclohexanes (mono-, di-, and trisubstituted), cyclohexenes, cyclohexanones, halocyclohexanones, decalins, decalols and decalones and conformational effect on reactivity including- Cieplak's Model. Conformation of saturated heterocycles, stereoelectronics requirement for their formation and reactions- Baldwin's rules.

UNIT – IV

Aliphatic Nucleophilic Substitution

The S_N2 , S_N1 , mixed S_N2 , S_N1 , S_Ni and SET mechanisms, The neighboring group mechanism, neighboring group participation by P and S bonds, anchimeric assistance. Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis, ambident nucleophile and regioselectivity.

UNIT – V

Reaction intermediate:

Generation, structure, stability, and reactivity of carbene (electrophilic and nucleophilic), nitrene, carbanion (enolate ion), non-classical carbocations- phenonium ions, norbornyl system, common carbocation rearrangement.

Aromatic Nucleophilic Substitution:

The ArS_N1 , ArS_N2 , and benzyne mechanisms, Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, Smiles rearrangements and Bucherer Reaction.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002.
2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
3. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Prentice Hall, 2011.
4. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
5. Ernest L Eliel, Samuel H. Wilen, Stereochemistry of organic compounds, Wiley India Edition, 2008.
6. March, J. *Advanced Organic Chemistry* John Wiley & Sons (1992).
7. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
8. Carey, F.A. & Sundberg, R. J. *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
9. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
10. Advanced Organic Chemistry by Prof. J. Singh & Prof. L.D.S. Yadav.

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 533 PRACTICAL (ORGANIC CHEMISTRY)	Number of Credits: 02 Number of Lectures: 45 (hrs)
students will be able to:		
CO 1	acquire knowledge and skill on the qualitative analysis of separation of binary mixture of organic compounds and identification techniques.	
CO 2	Develop skills in troubleshooting and optimizing separation procedures for efficient isolation of target compounds.	
CO 3	understand quantitative analysis and develop experimental skills for chemical estimation of functional groups.	
CO 4	understand analysis and develop experimental skills for estimation of organic compounds using chemical methods.	

Syllabus:

- (a) Separation and identification of organic compounds using chemical methods from binary mixtures.
- (b) Estimation of carbohydrate and carbonyl compounds, or any other possible estimations by chemical methods.

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 506 ORGANIC CHEMISTRY PAPER-II	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	gain knowledge on chemistry of organic reaction mediated free radical and mechanistic aspects of various free radical reactions.	
CO 2	understand fundamental aspects of various addition reactions to carbon-carbon and carbon-heteroatom multiple bonds including their mechanistic aspects and applications in organic synthesis.	
CO 3	get an idea about the mechanistic pathway of various elimination reactions including pyrolytic eliminations	
CO 4	acquire knowledge of molecular orbital symmetry and possibility of thermally and photochemically pericyclic reactions	
CO 5	predict course of a given pericyclic reaction using the theoretical concept and apply knowledge of stereochemical output in a reaction.	

Syllabus:

UNIT-I

Free Radical Reactions

Generation, structure, stability and reactions of free radicals- Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes, Free radical rearrangement, Hunsdiecker reaction. Cage effects; radical-cations & radical-anions, $S_{RN}1$ substitution processes.

Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspect of addition reaction involving electrophiles, nucleophiles and free radicals. Regio and chemoselectivity reactivity and stereochemical orientation with following reactions: Addition to cyclopropane ring. addition reactions on alkenes including cyclooxene such as-Hydroboration, epoxidation, hydroxylation, Michael reaction, Hydrogenation.

UNIT-II

Addition to Carbon-Hetero Atom Multiple Bonds

Generation of enolate ions and their synthetic applications including stereochemical aspect. Stereochemistry of Wittig, Aldol condensation reactions (Zimmerman-Traxler model). Stobbe Condensation reaction, Reaction mechanism of Hydrolysis of esters.

Elimination Reactions

The E2, E1 and E1cB mechanisms and their stereochemistry and orientation. Reactivity- effects of substrates, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination and Peterson elimination.

UNIT-III

Pericyclic Reactions I:

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1,3,5- hexatriene and allyl system, Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO and PMO approach, Electrocyclic reactions-conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl systems.

UNIT-IV

Pericyclic Reactions II:

Cycloadditions-antrafacial and suprafacial additions, $4n$ and $4n+2$ systems, $2+2$ addition of ketenes, 1,3-dipolar cycloadditions and cheletropic reactions.

UNIT-V

Pericyclic Reactions III:

Sigmatropic rearrangement-Suprafacial and antarafacial shift of Hydrogen, sigmatropic shifts involving carbon moieties, retention and inversion of configuration, (3,3) and (5,5) sigmatropic rearrangements, detailed treatment of Claisen and Cope-rearrangements. Fluxional tautomerism, Aza-Cope rearrangements. Problems on pericyclic reactions.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002
2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
3. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Prentice Hall, 2011.
4. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
5. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
6. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
7. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
8. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999).
9. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
10. Advanced Organic Chemistry by Prof. J. Singh & Prof. L.D.S. Yadav.
11. Photochemistry and Pericyclic Reactions, Prof. Jagdamba Singh and Dr. J. Singh.

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 534 PRACTICAL (ORGANIC CHEMISTRY)	Number of Credits: 02 Number of Lectures: 45 (hrs)
students will be able to:		
CO 1	acquire knowledge of: Safe laboratory practices by handling laboratory glassware, equipment, and chemical reagents	
CO 2	demonstrate proficiency in the synthesis of various organic compounds through multi-step reactions, thereby acquiring practical skills in synthetic organic chemistry	
CO 3	understand analysis and develop experimental skills for estimation of organic compounds using spectrophotometer as well as chemical methods.	

Syllabus:

1. Preparation of various organic compounds involving two or three steps employing different reactions viz. Aldol Condensation, reactions of enolate ions, oxidation reactions, Cannizzarro reaction, Molecular rearrangement reactions etc. with a view to give the student sufficient synthetic training in synthetic organic chemistry.
2. Estimation of ester and formaldehyde or any other suitable estimations by chemical or spectrometric methods.

Course Outcomes (COs)		
M.Sc. Semester III (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 512 <i>Rearrangements and Photochemistry</i> (PAPER-I)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	understand fundamental aspects of Molecular Rearrangements including their mechanistic aspects.	
CO 2	gain knowledge on applications Molecular Rearrangements in organic synthesis.	
CO 3	understand the concept of organic photochemistry with different processes and terminologies	
CO 4	get an idea about the photochemical reactions of various classes of compounds like olefins, carbonyl compounds, aromatic compounds	
CO 5	understand applications of organic photochemistry.	

Syllabus:

UNIT-I

Molecular Rearrangements I: Migration to electron deficient carbon atom-Pinacole-Pinacolone rearrangement, Wagner-Meerwein rearrangement, Tiffeneau-Demjanov ring expansion, Dienone-Phenol rearrangement, Wolf rearrangement, Benzil Benzilic acid rearrangement, Favorski rearrangement, Wittig Rearrangement.

UNIT-II

Molecular Rearrangements II: Migration to electron deficient nitrogen atom-Hofmann, Curtius, Losen, Schmidt, Beckmann rearrangement. Migration to electron deficient oxygen atom- Baeyer-Villiger rearrangement, Hydroperoxide rearrangement, Dakin reaction. Miscellaneous: Nazarov rearrangement

UNIT-III

Photochemistry I: Absorption of light by organic molecules, properties of excited states, mechanism of excited state processes and methods of preparative photochemistry, Photochemistry of Carbonyl Compounds: cleavage reaction, addition reaction, reduction & oxidation, hydrogen abstraction.

UNIT-IV

Photochemistry II: Rearrangements of, ketones, dienone, α , β - unsaturated ketones and cyclohexadienones, photochemistry of p-benzoquinones.

UNIT-V

Photochemistry III: Photochemistry of unsaturated system

Olefins, cis-trans isomerisation, dimerisation, hydrogen abstraction and additions. Acetylenes-dimerisation, Dienes-photochemistry of 1, 3-butadiene (2+2) additions leading to cage structures, photochemistry of cyclohexadienes, Photochemistry of aromatic compounds-excited state of benzene and its 1,2 and 1, 3-shifts, Photo-Fries rearrangement, Photo-Fries reaction of anilides, photosubstitution reaction of benzene derivatives.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
4. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
5. N. J. Turro, J. C. Scaiano, and V. Ramamurthy, Modern Molecular Photochemistry of Organic Molecules, University Science Books, 2010.
6. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
7. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
8. Horspool, W. M. *Aspects of Organic Photochemistry* Academic Press (1976).
9. Photochemistry and Pericyclic Reactions, by Prof Jagdamba Singh and Dr. J. Singh,

Course Outcomes (COs)		
M.Sc. Semester III (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 513 <i>Oxidation, Reduction, and Organometallic- Reagents (PAPER-II)</i>	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	understand fundamental aspects of oxidation and reduction reactions including their mechanistic aspects	
CO 2	gain the knowledge on applications of various oxidizing and reducing agents in organic synthesis	
CO 3	understand fundamental aspects of Organometallic Reagents used in organic synthesis.	
CO 4	gain knowledge on various palladium catalyzed coupling reactions and their applications in organic synthesis	

Syllabus:

UNIT-I

Oxidation I: Oxidation of Hydrocarbons-alkenes-including oxidative functionalization, aromatic rings, saturated, C-H groups (activated and unactivated), alcohols, diols.

UNIT- II

Oxidation II: Oxidation of Aldehydes, ketones and carboxylic acids, amines, hydrazines and sulphides. Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium (III) nitrate.

UNIT-III

Reduction: Reduction of Hydrocarbons-alkenes, alkynes and aromatic rings, Carbonyl Compounds: aldehydes, ketones, acids and their derivatives, Epoxides, nitro, nitroso, azo compounds, Hydrogenolysis,

UNIT-IV

Organometallic Reagents I: Prominent Synthetic applications of organometallic compounds with mechanistic and stereochemical details of following metals-Hg, Cd, Ce, Zn, In, Ni, Fe, Co, Rh, Cr, Ru and Ti.

UNIT- V

Organometallic Reagents II: Application of Pd(o) and Pd(II) complexes in organic synthesis – Stille, Suzuki and Sonogashira coupling, Heck reaction and Negishi coupling and their stereochemistry.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
4. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
5. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
6. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed.
7. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.
8. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.
9. P. R. Jenkins, Organometallic Reagents in Synthesis, Oxford science Publ., Oxford (1992).

Course Outcomes (COs)		
M.Sc. Semester III (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 514 <i>Strategies in Organic Synthesis and Heterocyclic Chemistry</i> (PAPER-III)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	independently design and present a synthetic plan or strategy for synthesizing organic molecules	
CO 2	explain the concepts of umpolung, synthons, synthetic equivalents, and stereocontrol and use them in planning organic syntheses	
CO 3	describe the basic principles of retrosynthetic analysis and apply them to designing synthetic strategies.	
CO 4	design protecting group strategies for synthesis of organic molecules and understand use of protecting groups in organic synthesis.	
CO 5	demonstrate proficiency in the nomenclature, reactivity, and synthesis of various heterocyclic compounds.	

Syllabus:

UNIT-I

Disconnection Approach: General introduction to synthons and Synthetic equivalents, Disconnections, (C-C, C-S, C-O, C-N bonds).

UNIT-II

Functional group interconversion: chemo selectivity, Umpolung, cyclisation reaction choosing synthetic route for small- and large-scale synthesis.

UNIT-III

Synthetic Strategies: (i). For formation of carbon-carbon bond. (ii). For formation of carbon-nitrogen bond. (iii). For formation of carbon-halogen bond. (iv). For Ring Synthesis (v). For Multistep Synthesis e.g. Complex molecules- Camphor, Reserpine and Vitamin D.

UNIT-IV

Protecting Groups: The Concept of Protecting Functional Groups: protection of alcoholic, amino, carbonyl and carboxylic groups.

UNIT-V

Heterocyclic Chemistry: General Introduction, Nomenclature (including fused heterocycles), spectral characteristics, reactivity and aromaticity. Synthesis and reactivity of pyrazole, imidazole, oxazole, thiazole, isooxazole and their applications in organic synthesis. Reactivity and synthesis of pyrimidine, pyridazines, pyrazines, purines, pteridines with and without oxygen and/or sulfur atoms, and their role in biological systems.

Reference Books:

1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
2. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
3. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
4. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
5. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed.
6. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.
7. A. R. Katritzky and A. F. Pozharskii, Handbook of Heterocyclic Chemistry, Elsevier, 2000.
8. J. A. Joule, K. Mills, G. F. Smith, Heterocyclic chemistry, 3rd Edition, Stanley Thornes Publishers Ltd, 1995.
9. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
10. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.

Course Outcomes (COs)		
M.Sc. Semester III (Elective B-Organic)		
Course Code and Title of the Course	CHE 552 <i>Spectroscopy of Organic Compounds</i> (PAPER-IV)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	Demonstrate comprehensive understanding of Nuclear Magnetic Resonance (NMR) Spectroscopy and analyze complex spectra and solve structural problems using NMR spectroscopy.	
CO 2	Apply advanced concepts such as virtual coupling, Stereochemistry, and Karplus curve to interpret NMR spectra effectively.	
CO 3	Interpret Carbon-13 NMR spectra, including chemical shift, coupling constants, and various techniques such as DEPT, INEPT, and APT and apply two-dimensional NMR spectroscopy techniques (COSY, NOESY, INADEQUATE) to solve complex structural problems.	
CO 4	Understand the principles and applications of Mass Spectrometry (MS), and analyze mass spectra of organic compounds to determine molecular structures.	
CO 5	Utilize joint application of UV, IR, NMR (¹ H & ¹³ C), and mass spectroscopy for solving structural problems in organic compounds.	

Syllabus:

UNIT-I

Nuclear Magnetic Resonance Spectroscopy I: PMR Spectroscopy chemical exchange, effect of deuteration, complex spin-spin interaction between two, three four and five nuclei (first order spectra).

UNIT-II

Nuclear Magnetic Resonance Spectroscopy II: Virtual coupling, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contract shift reagents, solvent effects. Fourier transform technique, Nuclear Overhauser Effect (NOE)-NOESY, HOESY, ROESY. Resonance of other nuclei: F, P, N. Structural problems based on PMR.

UNIT-III

Nuclear Magnetic Resonance Spectroscopy III: Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Off- resonance decoupling , DEPT, INEPT, APT techniques. Two-dimension, NMR spectroscopy: COSY, HMBC, HMQC, TOCSY and INADEQUATE techniques. Structural problem based on ¹³C NMR.

UNIT-IV

Mass Spectrometry: Introduction, ion production-EI, CI, FAB, ESI, APCI, MALDI;; factors affecting fragmentation, ion analysis, ion abundance, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Isotopic peaks. Mc-Lafferty rearrangement, Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect of their structure determination.

UNIT-V

Structural problems by joint application of UV, IR, NMR (^1H & ^{13}C) and mass spectroscopy.

Reference Books:

1. Organic Spectroscopy, Prof L. D. S. Yadva, Springer (2005).
2. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Brooks Cole, 5th Ed., 2015.
3. R.M. Silverstein, F. X. Webster, Spectrometric Identification of Organic compounds, John Wiley & Sons Inc., 7th Ed., 2011.
4. D.H Williams & I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata Mcgraw Hill Education, 6th Ed., 2011.
5. W. Kemp, Organic Spectroscopy, Palgrave Macmillan, 3rd Ed., 1991.
6. L. D. Field, H. L. Li., A. M. Magill, Organic Structures from 2D NMR Spectra, Wiley, 2015.
7. L. D. Field, S. Sternhell and J R Kalman, Organic Structures from spectra; John Wiley & Sons Ltd., 2007.

Course Outcomes (COs)		
M.Sc. Semester III (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 536 Practical + Project work	Number of Credits: 10 Number of Lectures: 160 (hrs)
students will be able to:		
CO 1	acquire knowledge and skill on the qualitative analysis of separation of ternary mixture of organic compounds and identification techniques.	
CO 2	acquire knowledge of multi-step synthetic procedures specially through green chemistry approach: aqueous workup, distillation, reflux, separation, isolation, and crystallization.	
CO 3	acquire knowledge of Starting materials, functional groups, mechanism, and typical reaction conditions.	
CO 4	develop analytical skill on the qualitative analysis of biologically and pharmaceutically relevant organic compounds using spectrometric techniques	
CO 5	Integrate theoretical knowledge with practical skills gained throughout the course, demonstrating their ability to design and execute experiments, analyse data, and communicate findings effectively through the preparation of a project report	

Syllabus:

1. Separation and identification of organic compounds using chemical methods from organic mixtures containing up to three components.
2. Preparation of organic compounds involving several stages (Green protocol may also be used including Multi-component reactions).
3. Verification of Lambert Beer's Law and estimation of carbohydrates, protein, amino acids, ascorbic acid, blood cholesterol and aspirin/paracetamol in APC tablets or any other suitable compound by UV-Visible spectrophotometric method.

Course Outcomes (COs)		
M.Sc. Semester IV (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 524 <i>Biosynthesis and Chemistry of Natural Products</i> (PAPER-I)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	Understand the classification and importance of various natural products, including terpenes, steroids, alkaloids, polyphenols, plant pigments, and prostaglandins.	
CO 2	Learn the total synthesis of various natural products and their biosynthesis pathways.	
CO 3	Gain proficiency in the synthesis and characterization of various natural products commonly found in daily life.	
CO 4	Develop skills in predicting the pathway for structure elucidation of unknown naturally occurring organic compounds	

Syllabus:

UNIT- I

Bio-synthesis of Natural Products:

- The acetate hypothesis, poly β -Ketoacids, Biosynthesis, Biogenesis Primary and Secondary reactions involved in biosynthesis. Biosynthesis of poly- β -ketoacid.
- Isoprene rule, mevalonic acid from acetyl Co-enzyme A. Biosynthesis of mono, sesqui, di and triterpenes.
- Shikimic acid pathway for biosynthesis of aromatic ring.
- General biosynthesis of alkaloids.

UNIT- II

Terpenoids and Carotenoids: Classification, isoprene rule. Structure determination, stereochemistry, synthesis of the following representative molecules: citral, α -terpenol, menthol, farnesol, abietic acid and β - carotene. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible. Introduction of Camphor and α -pinene.

UNIT- III

Alkaloids: Classification, General methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, Structure, stereochemistry and synthesis of the following: Ephedrine, (+) nicotine, quinine and morphine. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

UNIT- IV

Steroids: Basic skeleton Diel's hydrocarbon and stereochemistry, structure determination and synthesis of cholesterol, testosterone, estrone and progesterone. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible. Introduction of adrenal cortical hormones.

UNIT- V

Prostaglandins: Occurrence, nomenclature, classification. Synthesis of PGE₂ and PGF_{2a}

Plant Pigments: General methods of structure determination, synthesis of Apigenin, Quercetin Cyanidin, Hirsutin. Quercetin-3-glucoside, Diazein and cyanidine-7-glucoside. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
2. Mann, J. Secondary Metabolites, Oxford University Press, Oxford, UK, (1980).
3. K. Nakanishi, Natural Product Chemistry, Academic Press, 2013.
4. D. R. Dalton, The Alkaloids. New York: M. Dekker, 1979
5. Barton and Ollis, Comprehensive Organic Chemistry, Pergamon, 1979.
6. D. Paul, Medicinal Natural Products: A Biosynthetic Approach, John Wiley and Sons, 2002.
7. M. Paolo, Biosynthesis of Natural Products, Wiley, 2010.
8. Jagdamba Singh, S. M. Ali & J. Singh, Natural Products Chemistry, Pragati Prakashan.

Course Outcomes (COs)		
M.Sc. Semester IV (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 525 <i>Stereoselective Synthesis</i> (PAPER-II)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on competition of the courses, students will be able to:		
CO 1	Understand the importance of the configuration of chiral organic compounds, particularly in the pharmaceutical industry where chemists work on stereoselective synthesis of compounds.	
CO 2	Explore approaches in asymmetric synthesis.	
CO 3	Familiarize themselves with different techniques of asymmetric synthesis.	
CO 4	Acquire knowledge of stereoselective synthesis of various industrially and pharmaceutically relevant compounds	

Syllabus:

UNIT- I

Stereoselective reactions of cyclic compounds: Introduction: Stereoselectivity and stereospecificity. Regioselectivity and regiospecificity. Reactions of four, five and six-membered rings including bicyclic, fused & spirocyclic compounds-conformational control & stereoselectivity. Stereoselective reactions via formation of cyclic intermediate/transition state.

UNIT- II

Diastereoselective: π - facial addition of nucleophilic to chiral carbonyl compounds: Chiral substrate with α -stereocentres- Cram's model, Felkin-Anh model, Cram's Chelate model, Prelog's rule. Addition of nucleophilic to chiral carbonyl compounds Chiral substrate with β - stereocentres. Diastereoselective epoxidation and hydroboration of Chiral alkene-Houk Model.

UNIT- III

Asymmetric Synthesis I : The principle of asymmetric synthesis. Asymmetric synthesis using: (i) Chiral pool (chiron approach) (ii). Chiral auxiliary: Oxazolidinone, nor/pseudo-ephedrine & Oppolzer sultam-based chiral auxiliary controlled Diels-Alder reaction, alkylation of chiral enolates and aldol reaction, Alkylation using SAMP and RAMP.

UNIT IV

Asymmetric Synthesis II: Asymmetric synthesis using: Chiral reagents: Use of (-)-sparteine and Brown's chiral Ipc reagents (ii) Chiral catalysts: CBS catalyst, Ruthenium catalyzed chiral reductions of ketones, Catalytic asymmetric hydrogenation of alkenes, Asymmetric epoxidation (Sharpless and Jacobson), Sharpless asymmetric dihydroxylation reaction, Organocatalyzed aldol reaction & Mannich Reaction (Use of proline), Conjugate addition (Use of imidazolidinones). Self-generation chirality, Enzyme catalysis.

UNIT- V

Stereochemistry of some reaction: (i). Mc-Murry reaction. (ii). Corey-Winter reaction. (iii). Fragmentation reaction. (iv). Peterson, Julia & Tebbe olefination (vi) Diastereoselective radical cyclization reactions.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
2. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
4. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
5. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
6. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed.
7. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.
8. Stereochemistry with applications to organic reactions by Prof. J. Singh, Prof. L.D.S. Yadav, Dr. J. Singh & Dr. S. Singh.
9. Advanced Organic Chemistry by Prof. J. Singh & Prof. L.D.S. Yadav.

Course Outcomes (COs)		
M.Sc. Semester IV (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 526 <i>Biomolecules & Bioactive Compounds</i> (PAPER-III)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	Understand the historical perspective and remarkable properties of enzymes.	
CO 2	Grasp the detailed structures of DNA/RNA and the stabilizing forces involved, as well as learn sequencing methods and solid-phase synthesis techniques for DNA/RNA.	
CO 3	Learn about the types of naturally occurring sugars, lipids, and their derivatives.	
CO 4	Understand the structures, functions, and applications of selected vitamins, antibiotics, pyrethroids, rotenones, and pheromones, enabling them to apply this knowledge in various scientific and industrial contexts	

Syllabus:

UNIT-I

Enzymes

Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Fisher's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetic, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition, regulatory enzymes, Enzyme immobilization.

UNIT- II

Nucleic Acids: Secondary and Tertiary structure of DNA/RNA and stabilizing forces, polymorphic nature of DNA, Sequencing, solid phase synthesis; trimester, phosphoramidite and phosphonate methods, Purification : HPLC and gel electrophoresis. Peptide nucleic acid (PNA).

UNIT- III

Carbohydrates and Lipids: Basic structure and type of sugars. Protection and deprotection. Deoxy-sugars, amino sugars, glycolic sugars and their synthetic aspects. Introduction to industrially important polysaccharides. Classification and biological importance of fatty acids and lipids, stereochemical notation in lipids Chemistry Structure and role of carbolipids, phospholipids and sphingolipids.

UNIT- IV

Vitamins and Antibiotics: Structure elucidation and synthesis of Vitamins B1 and E. Biological role of Vitamin B6 and Vitamin H. Synthesis of Penicillin G, Chloramphenicol and Cephalosporin. Biological role of tetracycline and streptomycin.

UNIT- V

Pyrethroids and Rotenones, Pheromones: Synthesis and reactions of Pyrethroids and Rotenones. (For structure elucidation, emphasis is to be placed on the use of parameters wherever possible). Classification of pheromones their synthesis.

Reference Books:

1. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
2. Lehninger Principles of Biochemistry, by Nelson, David L., and Michael M. Cox. 7th ed., W.H. Freeman, 2017.
3. Saenger, W. *Principles of Nucleic Acid Structure* Springer-Verlag (1984).
4. Bioorganic Chemistry - A Chemical Approach to Enzyme Action, by H. Dugas, 3rd Ed. Springer, 1999.
5. Stryer, L. *Biochemistry* 4th Ed., W. H. Freeman & Co. (1995).
6. Sinden, R. P. *DNA Structure and Function* Academic Press (1994).
7. R. F. Doerge, J. B. Lippincott, Wilson & Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, 8th Ed, Philadelphia, USA, 2010
8. Lednicer and Mitscher, Organic Chemistry of Drug Synthesis, Vols I and II, John Wiley, 1980.
9. G. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, Oxford, 1998.
10. D. J. Abraham, Burgers Medicinal Chemistry and Drug Discovery, Vol. I, 6th Ed., John Wiley and Sons, New Jersey, 2003.

Course Outcomes (COs)		
M.Sc. Semester IV (Elective B-Organic)		
Course Code and Title of the Course	CHE 556 <i>Reagents and Reactions</i> (PAPER-IV)	Number of Credits: 03 Number of Lectures: 45 (hrs)
on completion of the courses, students will be able to:		
CO 1	Learn the application of modern synthetic reactions and reagents in organic synthesis.	
CO 2	Be equipped with the knowledge and skills necessary for utilizing a wide array of reagents in organic synthesis, understanding stereochemistry in transformations, and performing selective organic reactions.	
CO 3	Gain understanding of green chemistry principles for sustainable synthesis practices and organic reactions involving green chemistry.	
CO 4	Familiarize themselves with atom-economical organic name reactions along with their synthetic applications	

Syllabus:

UNIT: I

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible) Complex metal hydrides – NaBH₄, Sodium cyanoborohydride, LiAlH₄ (LAH), Alkoxy substituted LAH, DIBAL, diborane, Selectride, diisooamylborne, hexylborane, 9-BBN, isopinocampheyl and diisopinocampheylborane, catechoborane Gilman's reagent, SmI₂, Lithium diisopropyl amide (LDA).

UNIT: II

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): Dicyclohexylcarbodiimide (DCC), DEAD, 1, 3-Dithiane (Reactivity Umpolung), Trimethylsilyl iodide, Tri n-butyltin hydride, PCC, Dess-Martin and related reagents

UNIT: III

Use of following reagents in organic synthesis and function group transformation (including stereochemistry where possible): DDQ & SeO₂, Hydrazine, phenylhydrazine & p-Toluenesulfonyl hydrazide, nucleophilic heterocyclic carbenes (NHC), Organo silicon, Nitrogen, Sulphur and Phosphorus Ylides-preparation and their synthetic applications.

UNIT: IV

Selective Organic Reaction and their Synthetic Application: Stork Enamine reaction, Ene and related reactions, Reaction at inactivated C-H bonds-Barton Reaction & Hofmann-Löffler-Freytag reaction. Olefine Ring Closing Metathesis .

UNIT: V

Green Chemistry: Introduction of green chemistry basic principles of green chemistry, Green protocol for benzoin condensation, bromination and acylation, organic synthesis using visible light and ionic liquid. Selective Organic name reaction and their Synthetic Application in reference to Green Chemistry: Baylis-Hillman Reaction, Stetter Reaction, Passerinin and Ugi Reactions.

Reference Books:

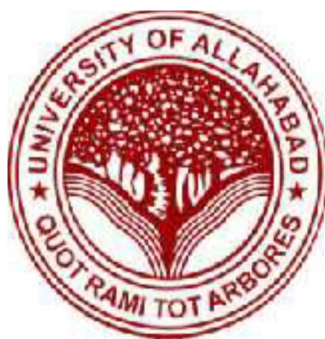
1. I.L. Finar, Organic Chemistry, Vol I, 6th Edition, Pearson Education, 2002.
2. I.L. Finar, Organic Chemistry, Vol II, 5th Edition, Pearson Education India, 2002.
3. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001.
4. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
5. F.A. Carey, & R. J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
6. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
7. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed.
8. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.
9. P. T. Anastas and T. C. Williamson, Green Chemistry: Frontiers in benign chemical synthesis and processes, Oxford University Press, Oxford, Ed. 1998.
10. Organic Synthesis by Prof. J. Singh & Prof. L.D.S. Yadav.

Course Outcomes (COs)		
M.Sc. Semester IV (Organic Chemistry Specialization)		
Course Code and Title of the Course	CHE 540 Practical + Project work	Number of Credits: 10 Number of Lectures: 160 (hrs)
students will be able to:		
CO 1	Demonstrate proficiency in measuring optical rotation values, calculating ee/de ratios, and determining specific rotation using suitable chiral compounds.	
CO 2	Resolve suitable racemic mixtures, developing a strong understanding of stereochemistry and analytical techniques.	
CO 3	Demonstrate competence in isolating and identifying natural products, gaining practical experience in handling natural product extracts, and employing various chromatography techniques.	
CO 4	interpret spectra effectively and deduce molecular structures, enhancing their analytical skills in chemical characterization through applying NMR spectroscopy, UV spectroscopy, IR spectroscopy, and Mass Spectrometry Integrate theoretical knowledge with practical skills gained throughout the course, demonstrating their ability to design and execute experiments, analyse data, and communicate findings effectively through the preparation of a project report	
CO 5		

Syllabus:

1. Measurement of optical rotation values, calculation of ee/de ratios and determination of specific rotation with suitable chiral compounds.
2. Isolation of Caffeine from tea leaves; casein from milk, or any other possible isolation from natural product. Chromatography: Paper, Analytical and Preparative.
3. Applications of NMR spectroscopy UV, IR and Mass Spectroscopy in structure determination of organic and biologically important compounds.
4. Project

SYLLABUS
For M.Sc. CHEMISTRY (Physical)
(THEORY & PRACTICAL)
CHOICE BASED CREDIT SYSTEM
(C.B.C.S)
(2024 onwards)



Department of Chemistry
Faculty of Science
University of Allahabad
Allahabad – 211002

The following section provides the mapping of Course Outcomes (COs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) for the M.Sc. Chemistry (Physical Chemistry Specialization) program. Correlation is represented on a scale of 1 to 3:

3 – High correlation

2 – Medium correlation

1 – Low correlation.

Mapping of Cos with Pos and PSOs for CHE 503 – Physical Chemistry (Sem I)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand the principles of thermodynamics and their chemical applications	PO1(3), PO2(3)	PSO1(3)
CO2: Apply kinetics to determine reaction mechanisms and rate laws	PO2(3), PO6(2)	PSO2(3)
CO3: Interpret molecular behavior using quantum mechanics concepts	PO1(3), PO2(3)	PSO1(3), PSO3(2)
CO4: Relate macroscopic properties with molecular systems through statistical thermodynamics	PO2(3), PO6(3)	PSO1(3)
CO5: Develop problem-solving skills using thermodynamics and kinetics	PO6(3), PO10(2)	PSO2(3)

Mapping of Cos with Pos and PSOs for CHE 507 – Physical Chemistry (Sem II)

Course Outcomes (COs)	POs Mapped (1–3)	PSOs Mapped (1–3)
CO1: Understand concepts of quantum chemistry and wave mechanics	PO1(3), PO2(3)	PSO1(3)
CO2: Apply Schrödinger equation to chemical systems	PO2(3), PO10(3)	PSO1(3), PSO2(2)
CO3: Analyze molecular structure and spectra using theoretical models	PO2(3), PO10(3)	PSO1(3), PSO2(3)
CO4: Explain chemical bonding and molecular interactions through computational models	PO2(3), PO6(2)	PSO1(3), PSO3(3)
CO5: Evaluate the limitations of classical models and	PO1(3),	PSO3(3)

propose improvements	P02(3)	
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Mapping of Cos with Pos and PSOs for CHE 515 – States of Matter (Sem III)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand gaseous and condensed states and their properties	P02(3), P010(2)	PS01(3)
CO2: Apply concepts of intermolecular forces and equations of state	P02(3), P010(2)	PS01(3), PS02(2)
CO3: Explain surface and colloidal phenomena	P01(3), P010(2)	PS01(3)
CO4: Analyze phase transitions and critical phenomena	P02(3), P06(3)	PS01(3)
CO5: Correlate physical properties with industrial and research applications	P010(3), P08(2)	PS04(3)

Mapping of Cos with Pos and PSOs for CHE 516 – Advanced Spectroscopy & Magnetochemistry (Sem III)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand theoretical principles of advanced spectroscopy	P02(3), P010(3)	PS01(3)
CO2: Explain types of spectroscopy including ESR and NMR	P02(3), P010(3)	PS01(3), PS02(3)
CO3: Apply spectroscopic data to analyze molecular structure	P02(3), P06(3)	PS02(3)
CO4: Evaluate magnetic properties of molecules	P06(3), P010(3)	PS02(3)
CO5: Interpret spectra to determine bonding and electronic configuration	P02(3), P010(3)	PS01(3), PS02(3)

Mapping of Cos with Pos and PSOs for CHE 517 – Advanced Chemical Kinetics & Catalysis (Sem III)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand chemical kinetics and rate laws for complex reactions	PO1(3), PO2(3)	PSO1(3)
CO2: Apply catalysis principles to industrial and biological systems	PO2(3), PO10(3)	PSO4(3)
CO3: Analyze reaction mechanisms and energy profiles	PO2(3), PO6(3)	PSO2(3)
CO4: Evaluate kinetic data to determine reaction parameters	PO6(3), PO10(3)	PSO2(3)
CO5: Design catalytic systems for sustainable chemistry	PO10(3), PO8(2)	PSO3(3)

Mapping of Cos with Pos and PSOs for CHE 527 – Chemical Bonding & Statistical Mechanics (Sem IV)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand theories of bonding in molecules and solids	PO1(3), PO2(3)	PSO1(3)
CO2: Explain applications of statistical mechanics in thermodynamics	PO2(3), PO10(2)	PSO1(3), PSO2(2)
CO3: Apply partition function to calculate thermodynamic parameters	PO2(3), PO6(3)	PSO1(3), PSO2(3)
CO4: Analyze quantum mechanical models of molecular bonding	PO2(3), PO10(3)	PSO1(3)
CO5: Evaluate molecular models for predicting physical properties	PO6(3), PO10(3)	PSO2(3)

Mapping of Cos with Pos and PSOs for CHE 528 – Photo & Colloidal Chemistry (Sem IV)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand principles of photochemistry and radiation chemistry	PO2(3), PO10(2)	PSO1(3)
CO2: Apply photochemical principles in materials and biological systems	PO2(3), PO10(3)	PSO3(3)
CO3: Explain mechanisms of colloidal systems and emulsions	PO2(3), PO10(2)	PSO1(3)
CO4: Analyze kinetics of photophysical and photochemical processes	PO2(3), PO6(3)	PSO2(3)
CO5: Design photoactive and colloidal materials for industrial applications	PO10(3), PO8(2)	PSO4(3)

Mapping of Cos with Pos and PSOs for CHE 529 – Advanced Thermodynamics & Electrochemistry (Sem IV)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand classical and modern thermodynamics concepts	PO1(3), PO2(3)	PSO1(3)
CO2: Apply thermodynamic relations to chemical and physical systems	PO2(3), PO6(2)	PSO1(3), PSO2(2)
CO3: Explain electrochemical cells and electrode potentials	PO2(3), PO10(2)	PSO1(3)
CO4: Analyze electrochemical data to determine thermodynamic quantities	PO2(3), PO10(3)	PSO2(3)
CO5: Evaluate efficiency of thermodynamic cycles and electrochemical systems	PO6(3), PO10(3)	PSO2(3), PSO4(3)

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 503 – PHYSICAL CHEMISTRY PAPER-III	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Analyze and compare calorimetric and spectroscopic entropies, demonstrating a comprehensive understanding of entropy determination methods and their application.	
CO 2	Apply the Le Chatelier principle in thermodynamic systems and analyze the thermodynamic functions of mixing. They will demonstrate the ability to determine fugacity and its variation with temperature and pressure in both ideal and real gas mixtures	
CO 3	Understand the fundamental concepts of the Debye-Huckel Theory and its applications and also evaluate the triumphs and limitations of the Debye-Huckel theory in describing activity coefficients across different concentration regimes.	
CO 4	Demonstrate a comprehensive understanding of molecular spectroscopy, including the classification of spectra and characterization of electromagnetic radiations and apply principles of rotational (microwave) spectroscopy, including the interpretation of relative intensities of spectral lines	
CO 5	Analyze vibrational motion in molecules, including the interpretation of energy levels, force constants, and bond strengths in simple harmonic oscillators.	

SEMESTER I –THEORY PAPER

COURSE CODE: CHE 503 – PHYSICAL CHEMISTRY

Paper – III

Course Credit = 03 (45 Lectures)

No. of Lectures

UNIT – I (Advanced Thermodynamics-I)

09

Statements of the Third Law of Thermodynamics, Nernst Heat Theorem and its application to non-condensed systems, Determination of entropy from the Third Law using the correction due to gas imperfections. Calorimetric entropy, Spectroscopic entropy, Comparison of calorimetric and Spectroscopic entropies, Raoult's laws, Henry's law, solubility behaviour of ideal solutions

UNIT – II (Advanced Thermodynamics-II)

09

Le Chatelier principle and its thermodynamic derivation, fugacity of gases and mixture of ideal and real gases, determination of fugacity and its variation with temperature and pressure, thermodynamic functions of mixing. Degree of advancement of reaction, De Donder's treatment of chemical equilibria, variation of equilibrium constant with temperature and pressure.

UNIT-III (Electrochemistry)

09

Debye- Huckel Theory of the structure of dilute ionic solution, charge density and electrical potential, Properties of ionic cloud, activity coefficients from Debye-Huckel theory, Limiting law and its verification, Debye-Huckel Theory to more concentrated solutions, The triumph and limitations of Debye-Huckel theory of activity coefficients, Electrical potential and mean activity coefficient in the case of ionic clouds with finite sized ions.

UNIT-IV (Spectroscopy-I)

09

Molecular Spectra- Basic concepts of molecular spectroscopy, Classification of spectra, Characterization of electromagnetic radiations, Regions of the spectrum.

Rotational (Microwave) Spectroscopy

Principal moment of inertia, classification of rotors: rigid rotor and non-rigid rotor, selection rule (rigid rotor), effect of isotopic substitution frequencies, linear polyatomic molecules, non-linear polyatomic molecules, asymmetric Top molecules, relative intensities of spectral lines, stark effect, instrumentation and application.

UNIT-IV (Spectroscopy-II)

09

Vibrational Spectroscopy

Energy levels of simple harmonic oscillator, vibrational motion of a diatomic molecule, zero-point energy Force constant and bond strengths, Anharmonic oscillator, Morse potential energy diagram, Hot bands, selection rules, Vibration-rotation spectroscopy, vibrational –rotational spectra of a diatomic molecule and poly atomic molecule PQR Branches, Normal Modes of molecular vibrations.

Recommended Books

1. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press.
2. Castellan, G.W., Physical Chemistry 3rd Ed., USA, Addison-Wesley Publishing Company.
3. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry 1 (Ionics), Springer.
4. Banwell, C.N., & Mc Cash, Elaine M., Fundamental of molecular spectroscopy 3rd Ed., UK. Mc Graw-Hill Companies.
5. Barrow, G.M., Introduction to molecular spectroscopy. USA, Mc Graw-Hill Companies.
6. Hollas, J.M., Modern spectroscopy 4th Ed., USA, John Wiley & Sons Ltd.
7. Brown, J. M., Rotational spectroscopy of diatomic molecules, UK, Cambridge University Press.
8. Donald A Mc Quarrie and John D Simon, Physical Chemistry: A molecular approach, University Science Books Sausalito, California.

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 533- PHYSICAL CHEMISTRY LAB COURSE	Number of Credits: 02
On completion of the course, the students will be able to:		
CO 1	Outline and recall basic knowledge of fundamentals and application of physical chemistry through chemical and scientific theories.	
CO2	Apply and justify the principles of chemical kinetics and thermodynamics through experiments.	
CO3	Perform the experiment and tabulate the observations. Justify the steps to prepare and standardize different solutions.	
CO4	Use of safety responsibilities residing in working with chemicals. Illustrate safety measures related to experiments carried out.	

SEMESTER – I

PHYSICAL CHEMISTRY LAB COURSE

LAB COURSE CODE CHE 533

Course Credit = 02 (45 hrs)

1. Kinetics of oxidation of reducing sugars by potassium ferricyanide/ copper (II) in presence of ammonium hydroxide or sodium hydroxide.
2. Kinetics of oxidation of alcohols/diols by aqueous alkaline hexacyanoferrate (III) ions.
3. Conductometric titration of weak/strong acid and strong /weak base.
4. Potentiometric titration of weak/strong acid and strong /weak base.
5. Determine the concentration or percentage of one or two optically active substances in the given solution polarimetrically.
6. Determination of congruent composition and temperature of a binary system (diphenylamine-benzophenone system).
7. To construct the phase diagram for three component system (chloroform-acetic acid-water).

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 507 – PHYSICAL CHEMISTRY	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	demonstrate a comprehensive understanding of the postulates of quantum mechanics and their application in solving the Schrödinger equation for various systems.	
CO 2	understand the statistical behavior of quantum states, calculate partition functions for different degrees of freedom in gaseous systems, and relate them to thermodynamic quantities.	
CO 3	analyze and interpret complex reaction kinetics, determine reaction mechanisms, and compare different theories of chemical reaction rates such as collision theory and transition state theory.	
CO 4	Understand the fundamentals of solid-state chemistry, including crystal structures, symmetry, and bonding in solids, and analyze X-ray diffraction patterns using Bragg's equation.	
CO 5	classify different types of polymers and understand the kinetics of step polymerization. and calculate molecular weight averages using different methods.	

SEMESTER II –THEORY PAPER

COURSE CODE: CHE 507 – PHYSICAL CHEMISTRY

Paper – III

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Quantum Chemistry)

09

Postulates of quantum mechanics, Eigen functions and eigen values, Normalization and Orthogonality conditions, Operators, one dimensional and 3-dimensional particle in box, Tunnel effect, one dimensional harmonic oscillator, Rigid rotor, Schrodinger equation for hydrogen atom, shapes of s, p, d and f- orbitals. Approximate methods: Variational principle; and its application to ground state H-atom, Radial and Angular distribution curves for H-atom, Perturbation theory (first order and non-degenerate), Application of Perturbation theory for hydrogen atom.

UNIT-II (Statistical Mechanics-I)

09

Quantum states and complexions, The combinatory rule, System with definite total energy, Degeneracy of energy levels, Probability and most probable distribution, Indistinguishability, Maxwell-Boltzmann statistics, partition function, Translational, rotational, vibrational, nuclear and electronic partition functions, partition functions and their relation to thermodynamic quantities, Maxwell-Boltzmann law for gaseous system, Thermodynamic functions for gaseous systems.

UNIT-III (Chemical Kinetics-I)

09

Empirical rate laws and temperature dependence; kinetics of complex reactions; equilibrium state and steady state approximation; determination of reaction mechanisms; theories of chemical reaction rates: collision theory, transition state theory, comparison of collision and absolute reaction rate theory, transition state theory in solution.

UNIT-IV (Solid State-I)

09

Classification, Crystal structures, Symmetry, Bonding in solids, Miller indices, Cohesive energy of ionic crystal, Lattice energy of crystals (Born-Landé equation), Bragg's equation, The Debye Scherrer method, X-ray analysis of NaCl crystal, Defects in crystal (Schottky, Frenkel, Metal Excess, and Metal Deficiency defects).

UNIT-V (Polymer chemistry-I)

09

Introduction of type of polymers, Step polymerization, Kinetics of step polymerization, Molecular weight distribution in linear polycondensation (Derivation of size distribution), Molecular weight averages, Method of determining the molecular weight by osmotic pressure, Light scattering, Sedimentation and Viscosity methods.

Recommended Books

1. McQuarrie, D. A. Statistical Mechanics, Viva Books Pvt. Ltd.: New Delhi.
2. Bagchi B. Statistical Mechanics for Chemistry and Material Science, CRC Press.
3. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd Ed.
4. Laidler, K. J. Chemical Kinetics 3rd Ed., Benjamin Cummings.
5. Billmeyer, F. W. Textbook of Polymer Science 3rd Ed. Wiley-Interscience: New York.
6. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press.
7. McQuarrie, D. A. & Simon, J. D. Physical Chemistry: A Molecular Approach 3rd Ed., Univ. Science.
8. Levine, I. N., Quantum Chemistry 7th Ed., USA, Pearson Education.
9. West, A. R. Solid State Chemistry and its Applications 2nd Ed., John Wiley & Sons Ltd.
10. Gowarikar, V.R., Vishwanathan, N.V., & Sridhar, J. Introduction to polymer science, New York, John Wiley & Sons.
11. C.W. Bunn. Chemical Crystallography. Oxford at the Clarendon Press.

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 534-PHYSICAL CHEMISTRY LAB COURSE	Number of Credits: 02
On completion of the course, the students will be able to:		
CO 1	Understand the fundamentals and application of chemical kinetics in the oxidation of organic compounds such as cyclic ketones, diols.	
CO2	Demonstrate the behaviour of different electrolytic solutions using Conductometer and Potentiometer.	
CO3	Apply the fundamental theories of Chemical kinetics and electrochemistry.	

SEMESTER – II

PHYSICAL CHEMISTRY LAB COURSE

LAB COURSE CODE CHE 534

Course Credit = 02 (45 hrs)

1. Uncatalyzed oxidation of cyclic ketones by alkaline hexacyanoferrate (III).
2. Kinetics of oxidation of diols by cerium (IV) sulphate in aqueous sulphuric acid medium.
3. Determination of solubility and solubility product of sparingly soluble salts (e.g., PbSO_4 , BaSO_4) conductometrically.
4. Determination of the strength of strong and weak acids in a given mixture conductometrically.
5. To determine the degree of dissociation of weak acid by conductometrically. And verify the Ostwald dilution law.
6. Conductometric/potentiometric titration of mixture of acids; KCl , KI and KBr .
7. Determination of density of refractive index of binary mixtures of acetone + CCl_4 at different compositions and calculation of partial molar volumes.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 515 – PHYSICAL CHEMISTRY PAPER – I (States of Matter)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand Maxwell's law of distribution of velocity and Gaussian density function and its applications to gaseous systems.	
CO 2	Relate viscosity to mean free path and analyze its variation with temperature and pressure and understand the law of equipartition of energy, degrees of freedom, and the molecular basis of heat capacities.	
CO 3	Understand surface tension and viscosity of liquids, including their determination and the effects of temperature and pressure, and analyze the equation of state and partition function, as well as theories of liquid viscosity.	
CO 4	Understand the Free Electron Theory, Fermi-gas Theory, and Band Theory of solids and analyze the behavior of metals, semiconductors, and insulators.	

SEMESTER III - THEORY PAPER COURSE

COURSE CODE - CHE 515

PAPER – I

(States of Matter)

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Gaseous State-I)

09

Distribution law (Barometric formula), Maxwell's law of distribution of velocity and energy, Maxwell's law and Gaussian density function, R, M, S, Mean and Most probable velocities, Collision frequency, Collision between like and unlike molecules.

UNIT-II (Gaseous State -II)**09**

Kinetic theory of thermal conductivity and diffusion coefficient of gases (quantitative treatment), viscosity of gases and its relation to mean free path, variation of viscosity with temperature and pressure. Law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

UNIT-III (Liquid State-I)**09**

Surface tension, Viscosity of liquid and its determination, effect of temperature and pressure on viscosity and surface tension. Internal pressure and its determination, nature of intermolecular forces, oscillating dipoles, dipole-induced dipoles, London theory of dispersion forces, Various contributions of intermolecular forces, hydrogen bonding.

UNIT-IV (Liquid State-II)**09**

Liquids as dense gas and solids, Qualitative structural analysis of liquids by spectroscopic and computational techniques, Radial distribution function method. Equation of state and partition function, Eyring's vacancy theory and free volume theory of liquid viscosity, effect of temp and pressure on viscosity, thermodynamic correlation and determination of free volume. L-J potential, Lennard-Jones and Devonshire cell model.

UNIT-V (Solid State-II)**09**

Free electron theory, Fermi-gas theory and band theory of solids, Metals, semi-conductors and insulators, Intrinsic extrinsic p-type and n-type semi-conductors, Superconductivity, Effect of temperature on superconductivity.

Recommended Books

1. P.A. Egeistaff. An Introduction to Liquid State, Academic Press.
2. A.F.M. Barton, Longman. The Dynamic Liquid State, London Longman Group Ltd.
3. J.A. Pryde. The Liquid State, Hutchinson University Library.
4. H. Eyring and M.S. John. Significant Liquid Structures, John Wiley & Sons Inc.
5. Walter J. Moore, Prentice-Hall. Physical Chemistry, Prentice-Hall.
6. K. Laidler and J.H. Meiser. Physical Chemistry, Publisher Houghton Mifflin.
7. G K Vemulapalli. Physical Chemistry, Prentice Hall of India, New Delhi.
8. David Ball, Physical Chemistry, Cengage India Private Limited.
9. West, A. R. Solid State Chemistry and its Applications 2nd Ed., John Wiley & Sons Ltd.
10. C.W. Bunn. Chemical Crystallography. Oxford at the Clarendon Press.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 516 – PHYSICAL CHEMISTRY PAPER – II (Advanced Spectroscopy & Magnetochemistry)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Analyze the principles of electronic spectra of molecules, and apply the Born-Oppenheimer approximation and Franck-Condon principle to interpret rotational fine structure and predissociation spectra	
CO 2	Understand the fundamentals Raman spectroscopy, and apply rotational-vibrational Raman spectroscopy for structure determination.	
CO 3	Understand the fundamentals and applications of NMR, ESR, Mossbauer spectroscopy and photoelectron spectroscopy.	
CO 4	Understand the origin of magnetic moment and its types. and gain knowledge of Pascal's law and Langevin's theory of paramagnetism and Curie's law.	

SEMESTER III - THEORY PAPER
CORE COURSE CODE –CHE 516
PAPER – II
(Advanced Spectroscopy & Magnetochemistry)
Course Credit = 03 (45 Lectures)

UNIT-I (Advanced Spectroscopy-I)	No. of Lectures
	09

Orbital and spin moments, Electrons and multielectron systems, Magnetic property of complex compound in relation to their structure, Bohr magneton, L-S and J-J couplings. Electronic spectra of molecules, Born-Oppenheimer approximation, Franck-Condon principle, Rotational fine structure of Electronic-Vibration transitions, Predissociation spectra.

UNIT-II (Advanced Spectroscopy-II)	09
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Raman Spectroscopy

Raman Effect, theory of Raman Effect (quantum mechanical and classical), rotational Raman spectra, vibrational Raman spectra, rotational-vibrational Raman spectroscopy, rule of mutual exclusion and structure determination, instrumentation and Application of Raman spectroscopy.

UNIT-III (Advanced Spectroscopy-III)

09

NMR Spectroscopy

Theory of NMR, relaxation process and chemical shift, The coupling constant, nuclear spin interaction, Application of NMR spectroscopy.

ESR spectroscopy: Principle of ESR, Magnetic moment of electron and splitting factor, Hyper-fine splitting and double resonance in ESR, Application of ESR spectroscopy.

UNIT-IV (Advanced Spectroscopy-IV)

09

Mossbauer spectroscopy: Principle of Mossbauer spectroscopy, Origin of line width, Isomer shift, Quadrupole effects, Application of Mossbauer.

Photo Electron Spectroscopy (PES)

Principles of photoelectron spectroscopy, Koopman's theorem, types of PES, photo ionization constant, chemical shift in Electron Spectroscopy for Chemical Analysis (ESCA), instrumentation, techniques of PES, application of ESCA.

UNIT-V (Magnetochemistry)

09

Origin of magnetic moment, paramagnetic-, diamagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetism. Pascal's law and its applications. Magnetic susceptibility and its determination, susceptibility equivalents, Diamagnetism of elements, Compounds and its ions, Langevin's theory of paramagnetism, Curie's law, Weiss molecular field theory of paramagnetism, Curie- Weiss law, Determination of Curie point.

Recommended Books

1. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press.
2. Banwell, C.N., & Mc Cash, Elaine M., Fundamental of molecular spectroscopy 3rd Ed., UK. Mc Graw-Hill Companies.
3. Barrow, G.M., Introduction to molecular spectroscopy. USA, Mc Graw-Hill Companies.
4. Ira n. Lavine Molecular Spectroscopy Publisher: New York, Wiley.
5. Hollas, J.M., Modern spectroscopy 4th Ed., USA, John Wiley & Sons Ltd.
6. Brown, J. M., Rotational spectroscopy of diatomic molecules, UK, Cambridge University Press.
7. H. E. White, Atomic Spectroscopy, USA, Mc Graw-Hill Companies.
8. Selwood, P.W., Magneto chemistry, Swin burne Press.
9. Donald A Mc Quarrie and John D Simon, Physical Chemistry: A molecular approach, University Science Books Sausalito, California.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 517 – PHYSICAL CHEMISTRY PAPER – III (Advanced Chemical Kinetics & Catalysis)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand the Kinetics mechanism of fast reactions and different techniques of study of fast reactions and understand and apply various theories of unimolecular reactions, such as Lindemann, Hinshelwood, RRK, and RRKM theories.	
CO 2	develop a comprehensive understanding of catalysis, including characteristics and theories of catalysis.	
CO 3	demonstrate proficiency in understanding the mechanism of heterogeneous catalysis and the role of surfaces in catalytic reactions and analyze nano-catalysis and enzyme catalysis, as well as industrial catalysts.	

SEMESTER III - THEORY PAPER
CORE COURSE CODE - CHE 517
PAPER –III
(Advanced Chemical Kinetics & Catalysis)
Course Credit = 03 (45 Lectures)

UNIT-I (Advanced Chemical Kinetics -I)	No. of Lectures
	09

Absolute rate theory in terms of partition function, Salt effects: primary and secondary salt effects in the light of mechanistic tests; Influence of ionic strength and dielectric constant. Unimolecular reactions: treatment of Lindemann, Hinshelwood, Rice-Ramsperger- Kassel (RRK), and Rice-Ramsperger-Kassel-Marcus (RRKM) theories; thermodynamic formulation of rate constant; transmission co-efficient.

UNIT-II (Advanced Chemical Kinetics-II)	09
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Study of equilibrium constant and steady state treatment for Arrhenius and Vant Hoff's complexes, Influence of substituents on reaction rates (inductive and electrometric effects), Linear free energy relationship, Taft equation.

UNIT-III (Advanced Chemical Kinetics-III)**09**

Fast reactions: Techniques to study fast reactions, flow method (i.e. stop-flow method), relaxation method (i.e. T-jump method), flash photolysis and magnetic resonance method; kinetics of fast reactions. Oscillatory reactions: Kinetics of oscillatory reactions with special reference to Belousov–Zhabotinsky mechanism (B-Z mechanism)

UNIT-IV (Catalysis-I)**09**

Characteristics of catalysis; Theories of catalysis: Intermediate compound formation theory, adsorption theory for heterogeneous catalysis; Homogeneous catalysis: Kinetics of the homogeneous and acid-base catalysis, catalytic coefficients, effect of pH on reaction velocity; Kinetics of Rh(III) catalysed oxidation of cyclopentanol by $\text{K}_3\text{Fe}(\text{CN})_6$ in alkaline medium.

UNIT-V (Catalysis-II)**09**

Heterogeneous catalysis: Mechanism of heterogeneous catalysis, role of surfaces in heterogeneous catalysis; Nano catalysis; Enzyme catalysis; Industrial Catalysts: Catalyst poisons, inhibitor, carrier, promoter, Kinetics of Ir(III) catalysed oxidation of cyclohexanone by Ce(IV) in acidic medium.

Recommended Books

1. Reaction Kinetics, M. J. Pilling and A.P.W, Seakins, Oxford Science Publication, New York
2. Chemical Kinetics, 3rd Ed., K.J. Laidler, Harper & Row Publishers, New York.
3. Theories of Molecular Reaction Dynamics: The Microscopic Foundation of Chemical Kinetics, N. E. Henriksen, F. Y. Hansen, Oxford University Press Inc., New York
4. Theory of Unimolecular Reactions, W. Forst, Academic Press Inc., New York
5. Physical Chemistry, K.J. Laidler, J.H. Meiser, CBS Publishers & Distributors.
6. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press.
7. Rajaraman, J., Kuriacose, J. C., Kinetics and Mechanism of Chemical Transformations, India, Macmillan Publishers India Limited

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 537-PHYSICAL CHEMISTRY LAB COURSE	Number of Credits: 10
On completion of the course, the students will be able to:		
CO 1	Apply the different aspects of chemical dynamics through the experiments of Oxidation of diols, ketones, oxidation of arsenic (III).	
CO 2	Illustrate the concept of viscosity and density through its determination for aqueous solution of glucose/sucrose/urea at different temperatures	

SEMESTER III
PHYSICAL CHEMISTRY LAB COURSE
COURSE CODE-PHYSICAL CHE- 537
(In addition to CHE CODE - 515, 516 & 517)
Course Credit = 10 (160 hrs.)

1. Oxidation of diols by cerium (IV) sulphate in acidic medium catalysed by rhodium (III) chloride.
2. Kinetics of oxidation of ketones by cerium (IV) sulphate in acidic medium catalysed by Ir(III) chloride .
3. Uncatalyzed and/or iridium (III) catalysed oxidation of arsenic (III) with alkaline hexacyanoferrate (III).
4. Determination of viscosity and density of aqueous solution of glucose/sucrose/urea at different temperatures and to calculate apparent and partial molar volume.
5. Titrate a mixture of copper sulphate, acetic acid and sulphuric acid with sodium hydroxide by conductometrically.
6. Titrate phosphoric acid potentiometrically against sodium hydroxide.
7. Determine the dissociation constant (p^{K_a}) of a weak acid using p^H meter.
8. To verify the Debye-Huckel-Onsager law for strong electrolytes by conductometrically.
9. To draw the mutual solubility curve of two immiscible liquid and find out the critical solution temperature of phenol-water system.
10. To obtain the phase diagram of water–ethanol-benzene system at room temperature.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 553 – PHYSICAL CHEMISTRY ELECTIVE-C PAPER (Chemistry of Nanomaterials)	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand the Classification, fundamental Properties, synthesis process, and applications of Nanomaterials.	

MSc III Semester – Elective-C Papers

CHE 553 Chemistry of Nanomaterials

Paper-IV

Course Credit= 03 (45 Lectures)

No of Lectures

UNIT-1` (Fundamentals of Nanomaterials) 09

Introduction of nanomaterials, properties of nanomaterials, classification (On the basis of materials and dimension) of nanomaterials, quantum dots, core-shell nanostructures and nano composites materials (Classification, Properties and application). Advanced nanomaterials (nanowires, nanorods, carbon nanotubes, graphene and fullerenes) Synthesis, properties and application.

UNIT-2 (Fabrication of Nanomaterials) 09

Bottom-up approaches: Chemical reduction method, sol-gel process and chemical vapor deposition, and top-down approaches: ball milling, and lithography.

UNIT-3 (Stability of Nanomaterials) 09

Surface energy, surface area and surface area to volume ratio, Stabilisation of nanoparticles: electrostatic stabilization with special reference to DLVO theory, steric stabilization and electrostatic stabilization.

UNIT-4 (Characterization Techniques of Nanomaterials) 09

Principle and instrumentation of X-ray diffraction, Scattering, field emission scanning electron microscopy, transmission electron microscopy, surface area analyser.

UNIT-5 (Applications of Nanomaterials: Representative Examples)

09

In the field of health and medicine, environment, energy, catalysis and agriculture.

Recommended Books

1. Cao, G. Nanostructures and nanomaterials: synthesis, properties and application. Empirical College Press.
2. Geoffrey, A. Ozin, Nano chemistry: A chemical approaches to nanomaterials. Royal Society of Chemistry.
3. Gabor, L. H., Harry, F. T., Dutta, J., Moore, J.J. Introduction to nanoscience & nanotechnology. CRC Press Taylor & Francic group.
4. Guozhong, C. Nano structure & nanomaterials synthesis, properties & application. Imperial College Press.
5. Pradeep, T. Nano: The essentials. McGraw Hill Pvt. Ltd.
6. Shah, M.A., Shah, K.A. Nanotechnology: The science of small. Wiley Publication.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 527 – PHYSICAL CHEMISTRY PAPER – I Chemical Bonding, & Statistical Mechanics	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Gain an understanding of Huckel molecular orbital theory of simple molecules, calculation of delocalization energy, and interpretation of the physical significance of charge density and bond order.	
CO 2	Develop proficiency in perturbation methods in LCAO-MO theory and extended Huckel molecular orbital theory, including SCF-MO method calculations.	
CO 3	Analyze the heat capacity of hydrogen and monoatomic crystals at low temperatures using the Einstein model and Debye's theory of solids.	
CO 4	Understand Bose-Einstein statistics and Fermi-Dirac statistics, including a comparison with Maxwell-Boltzmann statistics.	

SEMESTER IV - THEORY PAPER
CORE COURSE CODE - CHE 527
PAPER –I
(Chemical Bonding, & Statistical Mechanics)
Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Chemical Bonding: Molecular Quantum Mechanics-I)

09

Huckel molecular orbital theory and its application to hybridization systems (ethylene, butadiene, allyls and benzene), Calculation of delocalization energy, Physical significance of charge density and bond order, Calculation of bond length, Pauling and Wheland's modification in HMO theory and its application to heteromolecules (pyrimidine).

UNIT-II (Chemical Bonding: Molecular Quantum Mechanics-II)

09

Perturbation methods in LCAO-MO theory, Extended Huckel molecular orbital theory and SCF-

MO method calculations, applications on ethylene, butadiene, cyclopropenyl radical, cyclobutadiene and benzene; introduction to extended Huckel theory.

UNIT- III (Statistical Mechanics-II)

09

Heat capacity of hydrogen at low temperatures, Heat capacities of monoatomic crystals, The Einstein model, Debye's theory of solid, Heat capacities of crystals at very low temperatures. Expression of equilibrium constant in terms of partition functions,

UNIT-IV (Statistical Mechanics-III)

09

Bose-Einstein statistics, Fermi Dirac Statistics, Comparison of M-B, B-E and F-D statistics, Fermi-Dirac gas (Electron gas in metals)- Bose —Einstein gas (liquid Helium). Statistical thermodynamics of ortho and para hydrogen.

UNIT V (Polymer chemistry-II)

09

Kinetic of initiation retardation, chain polymerization and ionic polymerization (anionic and cationic), Copolymerisation, Coordination polymerization, Degradation of polymers (oxidative, chemical and photolytic), Liquid crystalline polymers, conducting polymers.

Recommended Books

1. Pauling and Wilson, Introduction to Quantum Mechanics, Dover Publications Inc.
2. Ira N. Levine Advanced Quantum Chemistry, Pearson publisher.
3. Cohen-Tannoudji, Claude; Diu, Bernard; Laloë, Franck. Quantum Mechanics, Publisher Wiley-VCH.
4. JJ Sakurai, J. Napolitano. Modern Quantum Mechanics 2nd Ed., Pearson publisher.
5. McQuarrie, Donald A. Statistical Mechanics, University Science Books.
6. Pathria, R. K.; Beale, Paul. Statistical Mechanics, Elsevier Publication.
7. Stowe, Keith. Introduction to Statistical Mechanics and Thermodynamics, Cambridge University Press.
8. Chandler, David. Introduction to Modern Statistical Mechanics, Oxford University Press, New York.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 528– PHYSICAL CHEMISTRY PAPER – II Photo & Colloidal Chemistry	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Gain the knowledge of photochemistry and photochemical reactions, and analyze photolysis and radiolysis reactions and understand the role of photochemical processes	
CO 2	Understand the classification and characterization of colloids and analyze the forces between colloidal particles, and mechanisms of stabilization.	
CO 3	Understand the fundamentals of surface chemistry, and applications of the Gibbs adsorption isotherm and the BET theory.	

SEMESTER IV - THEORY PAPER
CORE COURSE CODE - CHE 528
PAPER –II
(Photo & Colloidal Chemistry)
Course Credit = 03 (45 Lectures)

No of Lectures
09

UNIT-I (Photochemistry and Chain Reactions -I)

Light absorption: Laws of absorption; Laws of photochemistry: Primary and secondary processes in photochemistry, fate and properties of excited states; Photoluminescence and photo stationary state, Photosensitization, Rice-Herzfeld mechanisms. Photochemical chain reactions (hydrogen and chlorine, hydrogen and bromine).

UNIT-II (Photochemistry and Chain Reactions -II)

09

Non-chain photochemical reactions (formation of phosgene, decomposition of H_2O_2 in presence of CO); Photolysis and radiolysis reactions; Photochemical life processes: photosynthesis and vision.

Chain reactions: types, examples and characteristics of chain reactions, kinetics of chain reactions, polymerization reaction kinetics, nuclear fission as a chain reaction or explosive reactions.

UNIT-III (Colloids Chemistry-I)

09

Types of colloids, forces between colloidal particles, characterization of colloids, charge stabilization, steric stabilization, effect of polymer on colloid stability, kinetic properties, sols, gels, clays, foams, emulsions, food colloids, concentrated colloidal dispersions,

UNIT-IV (Colloids Chemistry-II)

09

Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization, phase separation and mass action models, reverse micelles, solubilization.

UNIT-V (Surface Chemistry)

09

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapor pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET theory, mathematical derivation of BET equation, surface films on liquids (Electro-kinetic phenomenon).

Recommended Books:

1. Fundamentals of photo chemistry, K.K. Rothagi-Mukheriji, 3rd Ed., New Age Publishers.
2. Essentials of Molecular Photochemistry, A Gilbert and J. Baggott, Blackwell Scientific.
3. Molecular Photochemistry, N. J. Turro, University Science Books.
4. Introductory Photochemistry, A. Cox and t. Camp, McGraw Hill.
5. Hiemenz, Paul C., Raj Rajagopalan, Principles of colloid and Surface Chemistry 3rd Ed., Marcel Dekker, Inc.
6. Shaw, D. J. Introduction to Colloid and Surface Chemistry 2nd Ed. Butterworths.
7. Brian Wardle, Principles and Applications of Photochemistry, Manchester Metropolitan, University, Manchester, UK
8. Marco Montalti, Alberto Credi, Luca Prodi, M. Teresa Gandolfi. Hand Book of Photo Chemistry 3rd Ed., CRC Press.
9. Adamson, A. W. & Gast, A. P. Physical Chemistry of Surfaces 6th Ed., Wiley.
10. Gabor, A., Somorjai, Yimin L. Introduction to Surface Chemistry & Catalysis, New York, John Wiley & Sons.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 529 – PHYSICAL CHEMISTRY PAPER – III Advanced Thermodynamics & Electrochemistry	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Differentiate between of ideal and non-ideal solutions, including thermodynamic functions of mixing for non-ideal solutions, and calculate Molar Properties and excess thermodynamic function.	
CO 2	Understand the fundamentals non-equilibrium thermodynamics and analyze linear laws and the Gibbs equation, as well as thermodynamic criteria for non-equilibrium states	
CO 3	Examine the triumph and limitations of the Debye-Huckel theory of activity coefficients, and its extension to realistic systems and determine the structure of electrified interfaces double layer:	

SEMESTER IV - THEORY PAPER
CORE COURSE CODE – CHE 529
PAPER –III
(Advanced Thermodynamics & Electrochemistry)
Course Credit= 03 (45 Lectures)

No of Lectures

UNIT-I (Advanced Thermodynamics-III)

09

Ideal and non-ideal solutions, Thermodynamic functions of mixing of non-ideal solutions, Gibbs-Duhem-Margules equation and its applications, Activity and activity coefficients, Activity coefficients from excess thermodynamic function, Partial molar properties, Determination of Partial Molar Properties, Excess thermodynamic function and determination of excess function.

UNIT-II (Non-Equilibrium Thermodynamics-I)

09

Thermodynamic functions for non-equilibrium states, Postulates and methodology, Linear laws, Gibbs equation, Thermodynamic criteria for non-equilibrium states, entropy production, entropy production in heat flow and matter flow, entropy production in chemical reaction. entropy production in open system. Entropy production due to flow of current in electrical conductor, The phenomenological law.

UNIT-III (Non-Equilibrium Thermodynamics-II)

09

Microscopic reversibility and Onsager's reciprocity relations transformations properties of the generalized fluxes and forces, non-equilibrium stationary states (Prigogine's principle of minimum entropy production), electro kinetic phenomena, diffusion. electrical conductor.

UNIT-IV (Advanced Electrochemistry-I)

09

Asymmetry and electrophoretic effects, Stoke's law and Walden product, Debye-Huckel- Onsager equation, Conductance ratio and the Onsager slope, Verification of Debye- Huckel Onsager equation, Modifications of Debye-Huckel-Onsager equation, Fuoss-Onsager and other equations.

UNIT-V (Advanced Electrochemistry-II)

09

Lippmann equations (surface excess), determination of surface excess, structure of electrified interfaces double layer: parallel-plate condenser model (Helmholtz-Perrin theory), Guoy Chapman model, Stern model, exchange current density, derivation of Butler-Volmer equation, Overpotential, The current-potential relation, The Tafel equation, Hydrogen overvoltage and decomposition potential, H₂-Evolution mechanism.

Recommended Books

1. Atkin's, P., Julio, P. D., Physical Chemistry 10th Ed., U. K., Oxford University Press.
2. Castellan, G.W., Physical Chemistry 3rd Ed., USA, Addison-Wesley Publishing Company.
3. Groot, SR. de., Mazur, P., Non- Equilibrium Thermodynamics, Amsterdam, North-Holland Publishing Company.
4. E. N. Yereimin. Fundamentals of Chemical Thermodynamics, MIR Publishers, Moscow.
5. IRAN. Levine. Physical Chemistry, Mc Graw Hill.
6. Bard, A. J., Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications, 2nd Ed., New York, John Wiley & Sons.
7. Bockris, J. O' M., Reddy, A. K. N. Modern Electrochemistry 1: Ionics 2nd Ed., USA, Springer.
8. Bockris, J. O' M., Reddy, A. K. N. & Gamboa-Aldeco, M. E. Modern Electrochemistry 2-A: Fundamentals of Electrodics 2nd Ed., USA Springer.
9. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2-B: Electrodics in Chemistry, Engineering, Biology and Environmental Science 2nd Ed., USA, Springer.
10. Brett, C. M. A. & Brett, A. M. O. Electrochemistry-Principle, methods and application, UK, Oxford University Press.
11. Koryta, J., Dvorak, J. & Kavan, L. Principles of Electrochemistry, New York, John Wiley & Sons.
12. Glasstone, Samuel, An Introduction to Electrochemistry, East-West Press Pvt. Ltd.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 541- PHYSICAL CHEMISTRY LAB COURSE	Number of Credits: 10
On completion of the course, the students will be able to:		
CO 1	Demonstrate the theoretical aspects through experiments.	
CO2	Get understanding of kinetics of iridium (III), and Ru(III)catalysed oxidation of aliphatic/cyclic alcohols/glycols.	

SEMESTER IV
PHYSICAL CHEMISTRY LAB COURSE
COURSE CODE-PHYSICAL CHE- 541
(In addition to CHE CODE - 527, 528 & 529)
Course Credit = 10 (160 hrs)

1. Study of the oxidation of cyclic alcohols by cerium (IV) sulphate in acidic medium in presence of Iridium (III) chloride.
2. Kinetics of iridium (III) catalysed oxidation of aromatic aldehydes/aromatic alcohols/hydrocarbons by cerium (IV) in aqueous acidic medium.
3. Kinetics of Ru (III) catalysed oxidation of alcohols/diols by Ce(IV) sulphate in acidic medium.
4. Kinetics of oxidation of aliphatic/cyclic alcohols/glycols by alkaline hexacyanoferrate (III) catalysed by ruthenium (III) chloride.
5. Determine the Hammett constant of a given substituted benzoic acid by pH measurement.
6. Determine the acidic and basic dissociation constant of an amino acid and the isoelectric point of an acid.
7. Adsorption of acetic acid on charcoal to verify Freundlich and Langmuir's isotherm.
8. To study the adsorption of oxalic acid on charcoal and to prove the validity of Freundlich and Langmuir's isotherm.
9. To find out the dimerization constant of benzoic acid in benzene.
10. To find the formula of complex copper ammonium ion or study the complex formation between copper sulphate and ammonia solution.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 557 – Elective-C Papers Industrial Polymer Chemistry	Number of Credits: 03
On completion of the course, the students will be able to:		
CO 1	Understand the fundamentals of polymers such as classification, types, synthesis, isolation, purification techniques and mechanisms of the polymerization process.	
CO 2	Develop proficiency in understanding industrial polymers, including plastics, fibers, rubber (elastomers), coatings, and adhesives and various industrial applications.	

MSc IV Semester – Elective-C Papers
CHE 557 Industrial Polymer Chemistry
Paper-IV
Course Credit= 03 (45 Lectures)

No of Lectures

UNIT-1 (Fundamental of Polymers)	09
Introduction, classification of polymers, types and mechanisms of polymerization: condensation polymerization, radical chain polymerization, ionic chain polymerization and copolymerization; molecular weight determination: principle, advantages and limitations; properties and applications of polymers.	
UNIT-2 (Industrial Polymers)	09
Plastics, Fibers, Rubber (elastomers), Coating and adhesives, Rheology of polymeric materials, Deformation behaviour of polymeric materials.	
UNIT-3 (Conducting Polymers)	09
Introduction and classification, polyacetylene, polyaniline, PEDOT, photo conducting polymers.	
UNIT-4 (Experimental Methods)	09
Polymer synthesis, Isolation and purification of polymers, Polymerfractionation	

Degradation, Types of degradation: Thermal degradation, Mechanical degradation, Degradation by Ultrasonic waves, Photodegradation, Degradation by high-energy radiation, Oxidative degradation, Hydrolytic degradation.

Recommended Books

1. Gowarikar, V.R., Vishwanathan, N.V., & Sridhar, J. Introduction to polymer science, New York, John Wiley & Sons.
2. Malcolm P. Stevens, Polymer Chemistry, Oxford University Press, New York.
3. Hiemenz, Paul C., Timothy P. Lodge Polymer chemistry 2nd Edition. CRC Press.
4. Billmeyer, F. W. Textbook of Polymer Science 3rd Ed. Wiley-Interscience: New York.
5. Charles E. Carraher Jr. Introduction to Polymer chemistry, CRC Press.
6. Fred W. Billmeyer, Text book of Polymer Science, John Wiley & Sons.

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(THEORY & PRACTICAL)
CHOICE BASED CREDIT SYSTEM
(C.B.C.S)
(2024 onwards)



Department of Chemistry
Faculty of Science
University of Allahabad
Allahabad – 211002

The following section provides the mapping of Course Outcomes (COs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) for the M.Sc. Chemistry (Analytical Chemistry Specialization) program. Correlation is represented on a scale of 1 to 3:

3 – High correlation

2 – Medium correlation

1 – Low correlation.

Mapping of Cos with Pos and PSOs for CHE 504 – Analytical Chemistry (Sem I)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand basic principles and scope of analytical chemistry	PO1(3) PO2(2)	PSO1(3)
CO2: Explain various analytical techniques and their applications	PO2(3) PO10(2)	PSO1(3)
CO3: Apply instrumental methods for qualitative and quantitative analysis	PO2(3) PO10(3)	PSO2(3)
CO4: Interpret analytical data to determine chemical composition	PO2(3) PO6(3)	PSO1(3) PSO2(3)
CO5: Develop analytical problem-solving skills for research and industry	PO10(3) PO8(2)	PSO3(3) PSO4(2)

Mapping of Cos with Pos and PSOs for CHE 508 – Analytical Chemistry (Sem II)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand the principles of analytical separation and purification techniques	PO2(3) PO10(2)	PSO1(3)
CO2: Describe theoretical and practical aspects of analytical calibration	PO2(2) PO3(2)	PSO1(3) PSO2(2)
CO3: Apply chromatographic and spectroscopic methods to chemical systems	PO2(3) PO6(2)	PSO1(3) PSO2(3)
CO4: Evaluate data for error minimization and precision	PO6(3)	PSO2(3)

in analysis	PO10(3)	
CO5: Develop awareness on analytical applications in industry and environment	PO5(3) PO8(2)	PS04(3)

Mapping of Cos with Pos and PSOs for CHE 518 – Theoretical Aspects of Analytical Chemistry (Sem III)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Explain the theoretical background of analytical chemistry and chemical equilibrium	PO1(3) PO2(3)	PS01(3)
CO2: Understand concepts of gravimetry, titrimetry and electroanalytical methods	PO2(3) PO10(2)	PS01(3) PS02(3)
CO3: Apply concepts to select appropriate analytical methods for specific samples	PO2(3) PO6(2)	PS02(3)
CO4: Evaluate results of quantitative analysis with statistical tools	PO6(3) PO10(3)	PS02(3)
CO5: Correlate theory with laboratory experiments	PO2(3) PO10(2)	PS01(3) PS02(3)

Mapping of Cos with Pos and PSOs for CHE 519 – Separation Techniques (Sem III)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand the principles of separation and purification techniques	PO2(3) PO10(2)	PS01(3)
CO2: Explain working of chromatographic methods like TLC, HPLC, GC	PO2(3) PO10(2)	PS01(3)
CO3: Apply ion-exchange and solvent extraction methods for analysis	PO2(3) PO6(2)	PS02(3)
CO4: Evaluate the efficiency and resolution of separation methods	PO6(3) PO10(3)	PS02(3)

C05: Design analytical procedures integrating multiple separation methods	P02(3) P010(3)	PS03(3)
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**Mapping of Cos with Pos and PSOs for CHE 520 – Spectrochemical Methods
(Sem III)**

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
C01: Understand fundamentals of spectrochemical techniques	P02(3) P010(3)	PS01(3)
C02: Explain absorption and emission spectroscopy principles	P02(3) P010(3)	PS01(3)
C03: Apply UV-Vis, IR, and AAS for qualitative and quantitative analysis	P02(3) P010(3)	PS02(3)
C04: Interpret spectral data to deduce chemical composition	P06(3) P010(3)	PS02(3)
C05: Evaluate instrument performance and analytical accuracy	P06(3) P010(3)	PS02(3) PS03(2)

**Mapping of Cos with Pos and PSOs for CHE 530 – Electroanalytical Methods
(Sem IV)**

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
C01: Explain principles of electrochemical analysis and electrode processes	P02(3) P010(3)	PS01(3)
C02: Apply potentiometric and voltammetric methods to chemical systems	P02(3) P010(3)	PS02(3)
C03: Analyze data obtained from electrochemical measurements	P02(3) P06(3)	PS02(3)
C04: Evaluate electroanalytical results and discuss accuracy and limitations	P06(3) P010(3)	PS02(3)
C05: Design electroanalytical experiments for research	P010(3)	PS03(3)

and industry	PO9(2)	
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Mapping of Cos with Pos and PSOs for CHE 531 – Analytical Characterization Techniques (Sem IV)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Understand advanced analytical characterization techniques	PO2(3) PO10(3)	PSO1(3)
CO2: Explain principles of NMR, ESR, and Mass spectrometry	PO2(3) PO10(3)	PSO1(3) PSO2(3)
CO3: Apply instrumental methods to characterize unknown compounds	PO2(3) PO6(2)	PSO2(3)
CO4: Analyze and interpret analytical data for structure elucidation	PO6(3) PO10(3)	PSO2(3)
CO5: Develop analytical research capability using advanced instruments	PO10(3) PO8(2)	PSO3(3)

Mapping of Cos with Pos and PSOs for CHE 532 – Analytical Methods (Sem IV)

Course Outcomes (COs)	POs Mapped (1-3)	PSOs Mapped (1-3)
CO1: Describe different analytical methodologies and validation processes	PO2(3) PO10(3)	PSO1(3)
CO2: Apply analytical techniques in environmental and industrial analysis	PO2(3) PO8(2)	PSO4(3)
CO3: Evaluate accuracy, precision and sensitivity of methods	PO6(3) PO10(3)	PSO2(3)
CO4: Correlate analytical findings with real-world chemical problems	PO2(3) PO10(3)	PSO2(3), PSO4(3)
CO5: Design and validate new analytical protocols	PO10(3), PO9(2)	PSO3(3)

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 504 – ANALYTICAL CHEMISTRY PAPER IV	Number of Credits: 03
On completion of the course, students will be able to:		
CO 1	Understand fundamentals of chemical analysis including qualitative and quantitative methods of analyses.	
CO 2	Understand and analyse data in analytical chemistry such as accuracy, precision, errors, significant figures and Standard deviation relevant to experiments.	
CO 3	Develop understanding of volumetric methods of analysis via acid-base, redox, precipitation, complexometric and chelatometric titrations.	
CO 4	Gain knowledge on weight relationships, principles and scope of gravimetric methods, role of organic and inorganic precipitants in gravimetric analysis.	
CO 5	Understand fundamentals of atomic and molecular Spectroscopy (UV-Vis and IR).	

SEMESTER I –THEORY PAPER

COURSE CODE: CHE 504 – ANALYTICAL CHEMISTRY

Paper – IV

Course Credit = 03 (45 Lectures)

No. of Lectures

UNIT – I (Fundamentals of Chemical Analysis) 09

Analytical chemistry and chemical analysis, Classification of analytical methods, Method selection, Sampling, Qualitative and Quantitative Analysis, Sensitivity and Selectivity of Analytical Methods, Sampling; Buffer solutions, Equilibrium constants in analysis.

UNIT – II (Data Handling in Analytical Chemistry) 09

Accuracy and Precision; Determinate and Indeterminate errors; Significant figures, Rounding off figures; Standard deviation; Propagation of errors, Regression analysis; Detection limit evaluation.

UNIT-III (Volumetric methods of analysis) 09

Standard solutions; Acid-base, redox, precipitation, complexometric and chelatometric titrations; conductometric titration, Theory of Indicators – Mixed Indicators and Fluorescent Indicators.

UNIT-IV (Gravimetric Methods of Analysis) 09

Weight relationships; Principles and scope of gravimetric methods; Conditions of Impurities in precipitates – Coprecipitation and post precipitation; Washing, filtering and drying of precipitates; Role of organic precipitants in gravimetric analysis, important organic precipitants: Dimethylglyoxime, cupferron, 8- Hydroxyquinoline, salicylaldoxime, 1-nitroso 2-naphthol, Anthranic acid, α - benzoinoxime (Cupron), Sodium tetraphenylboron.

UNIT-IV (Spectrochemical Methods) 09

Atomic and Molecular Spectroscopy, Instrumentation and working of UV-Vis spectroscopy, Absorption by Isolated chromophores and conjugated chromophores, Spectral shifts, Absorption due to metal complex formation (*d-d* transition, charge transfer processes). Job's method of continuous variation, mole ratio and slope ratio analysis, Beer-Lambert law, Its limitations and applications, Infrared spectroscopy, Structural analysis using UV-Vis and FT-IR spectroscopy.

Raman Spectroscopy: Basic theory and applications. Complementarity of IR and Raman spectra (Mutual exclusion principle).

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. G. D. Christian, *Analytical Chemistry*, 5th Edition (1994), John Wiley & Sons, New York.
3. A.J. Bard and L.R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2nd Edition (2000), Wiley, New York.
4. Spectroscopy of Organic Compounds by P. S. Kalsi.

Course Outcomes (COs)		
M.Sc. Semester I		
Course Code and Title of the Course	CHE 533-ANALYTICAL CHEMISTRY LAB COURSE	Number of Credits: 02
On completion of the course, students will be able to:		
CO 1	Get hands on training on volumetric titrations for the determination of replaceable hydrogen in acid by titration with bases.	
CO 2	Apply CO1 for the determination of bicarbonate.	
CO 3	Apply the understanding of volumetric titrations for the determination of water hardness by complexometric titration with ethylenediamine tetraacetic acid as ligand and Eriochrome black T as indicator.	
CO 4	Apply the understanding of precipitation titration for the determination of Silver by Volhard's method and Fajan's method.	
CO 5	Estimate the active oxidant concentration present in the commercial hypochlorite or hydrogen peroxide solution by iodometric titration.	

SEMESTER – I
ANALYTICAL CHEMISTRY LAB COURSE

LAB COURSE CODE CHE 533

Course Credit = 02 (45 hrs)

1. Acid-base titrations using suitable pH indicators
 - (a) Strong acid vs. strong base
 - (b) Weak acid vs. strong base
2. Determination of Bicarbonate
3. Complexometric titrations:
 - (a) Determination of hardness water using EDTA
 - (b) Determination of the concentration of calcium in milk powder using EDTA
4. Precipitation titrations:
 - (a) Determination of Silver by Volhard's method
 - (b) Determination of Chloride by Fajan's method
5. Analysis of commercial hypochlorite or peroxide solution by iodometric titration

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 508 – ANALYTICAL CHEMISTRY PAPER IV	Number of Credits: 03
On completion of the course, students will get:		
CO 1	Basic understanding of separation techniques used in Analytical Chemistry such as Solvent extraction, TLC, Column chromatography, Ion exchange chromatography, GC, HPLC.	
CO 2	Exposure to fundamental electrochemistry with special reference to potentiometry including redox, reference, glass electrodes, potentiometric titrations, and their applications	
CO 3	Basic understanding of Electro-analytical methods such as coulometry and its applications in titrations and electrodeposition methods.	
CO 4	Basic understanding of NMR and mass spectrometry	
CO 5	Exposure to the semimicro analysis of elements and functional groups in organic compounds.	

SEMESTER II –THEORY PAPER

COURSE CODE: CHE 508 – ANALYTICAL CHEMISTRY

Paper – IV

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I (Fundamentals of separation techniques) 09

Solvent extraction, Chromatography separation: Principle and classifications of chromatography, Basics about Paper chromatography, Thin layer chromatography (TLC), Column chromatography, Ion exchange chromatography, GC, HPLC.

UNIT-II (Potentiometry) 09

Potentiometric Electrodes: Metal Electrodes, Metal – Metal Electrodes, Metal- Metal Salt Electrodes for measuring the Salt's Anion, Redox Electrodes, Reference Electrodes, Potentiometric titrations, Potentiometers and pH meter, Glass pH Electrode and its applications; Alkaline Error and Acid Error.

UNIT-III (Fundamentals of electroanalytical and electrocatalytic processes) 09

Introduction to Electroanalytical methods: Nernst Equation, Origin of EMF of a galvanic cell, Polarizable and non-polarizable electrodes, The concept of overpotential, Electrochemical reactions under mass transfer control, Electrochemical reactions under charge transfer control. Electrogravimetry & electrodeposition. Electrocatalytic processes: oxygen reduction reactions, oxygen evolution reactions, hydrogen evolution reactions, and CO₂ reduction.

UNIT-IV (Spectroscopic analysis of compounds) 09

Nuclear magnetic resonance (NMR) spectroscopy of compounds (¹H and ¹³C NMR): Chemical shift, Shielding and deshielding effect, Mass spectrometry, Molecular ion peak, base peak and isotopic peaks, Fragmentation modes and rearrangement of ions. McLafferty rearrangement, Mass spectra of certain chemical classes. Identification of organic compounds using a combination of spectral data.

Spot tests for elements present in organic compounds, spot tests for metal ions. Spot tests for identification of functional groups – hydroxy, aldehyde, ketone, carboxylic, nitro and amino.

Determination of elements in organic compounds: Semimicro determination of carbon, hydrogen, oxygen, Halogen and nitrogen.

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
3. Spectroscopy of Organic Compounds by P. S. Kalsi.
4. J.M. Hollas, *Modern Spectroscopy*, 3rd Edition (1996), John Wiley, New York.

Course Outcomes (COs)		
M.Sc. Semester II		
Course Code and Title of the Course	CHE 534–ANALYTICAL CHEMISTRY LAB COURSE	Number of Credits: 02
On completion of the course, students will be able to:		
CO 1	Apply the theoretical knowledge of volumetric titrations for the estimation of soda ash.	
CO 2	Determine the concentrations of various metal ions in solutions by using spectrophotometric methods of analysis.	
CO 3	Execute experiments for acid base neutralization by using conductometric and potentiometric titrations	

SEMESTER – II

ANALYTICAL CHEMISTRY LAB COURSE

LAB COURSE CODE CHE 534

Course Credit = 02 (45 hrs)

1. pH-metric titration
2. Spectrophotometric determination of iron
3. Determination of nitrate in water by spectrophotometry
4. Spectrophotometric determination of manganese and chromium in mixture
5. Conductometric titration
6. Potentiometric titration

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 518 – ANALYTICAL CHEMISTRY PAPER – I (Theoretical Aspects of Analytical Chemistry)	Number of Credits: 03
On completion of the course, students will be able to:		
CO 1	Understand theoretical aspects of Statistics including distribution of random numbers, Gaussian distribution, testing hypothesis-comparison of a mean with a true value, comparison of two means.	
CO 2	Understand Least Squares plot; standard deviations of the slope and intercept; Correlation coefficient and coefficient of determination.	
CO 3	Interpret the different ways of representing equilibrium data in graphs such as pH-pC diagram, predominance diagrams, titration curves and fractionation diagrams.	
CO 4	Understand Kinetic analysis applied to Enzymes and homogeneous catalysts, properties of enzymes, Enzyme Inhibitors and Activators.	
CO 5	Analyze forensic data forensic related to a crime-scene investigation, analysis of petroleum products, narcotics and beverages	

SEMESTER III - THEORY PAPER COURSE

(Specialization in Analytical Chemistry)

COURSE CODE - CHE 518

PAPER – I

(Theoretical Aspects of Analytical Chemistry)

Course Credit = 03 (45 Lectures)

	No of Lectures
UNIT-I (Statistical methods in analytical chemistry)	09
(a) Descriptive Statistics: Distribution of random numbers, Gaussian distribution, other distributions, Location parameters – Arithmetic, Geometric and Harmonic means, Median, Quartile; Confidence level and Confidence interval	
(b) Statistical Testing: F-test, T-test, rejection of results – Dixon's Q test	
(c) Statistics of Sampling:	
UNIT-II (Linear least squares)	09
Least Squares plot; standard deviations of the slope and intercept; Correlation coefficient and coefficient of determination.	
UNIT-III (Graphic presentation of equilibrium data)	09
Predominance diagrams, Fractionation curves and <i>pH-pC</i> diagrams for acids and bases, Construction of titration curves for acid-bases neutralization, precipitation and complex formation reactions.	
UNIT-IV (Kinetic methods of analysis)	09
Enzyme catalysis – Enzyme kinetics, properties of enzymes, Enzyme Inhibitors and Activators; The Michaelis constant Determination of enzymes and Example of Enzymatic Analysis.	
UNIT-V (Introduction to forensic analysis)	09
Profile of a forensic laboratory, Forensic Scientists' role and quality control, Crime-scene investigation, Collection and preserving physical evidences and evidentiary documentation, Future	

prospects of forensic analysis, Analysis of petroleum products, standard methods of analysis of petroleum products. Analysis of drugs, narcotics and beverages.

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
3. W.J. Welcher (Ed.), *Scott's Standard Methods of Chemical Analysis*, Vol. III A, 6th Edition (1966), and vol. III B, 5th Edition (1975), Van Nostrand Reinhold Co. London.
4. Peter Fordham, *Non-destructive Testing Techniques*, 1st edition (1968), London Business Publications Ltd., London

Course Outcomes (SCOs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 519–ANALYTICAL CHEMISTRY PAPER - II (Separation Techniques)	Number of Credits: 03
On completion of the course, students will be able to get:		
CO 1	Fundamental knowledge of principles and applications of solvent extraction, solvent extraction of metals and analytical separations.	
CO 2	Understanding of synthesis and characteristics of ion-exchange resins, mechanism of ion exchange using ion exchange resins, factors affecting the selectivity of ion exchange resin, ion exchange capacity and their applications.	
CO 3	Understanding of ion chromatography as a separation tool, instrumentation and analytical applications.	
CO 4	Understanding of partition chromatography, principle of liquid – liquid partition chromatography.	
CO 5	Basic knowledge of principles, types, instrumentation and applications of electrophoresis in inorganic chemistry and molecular biology.	

SEMESTER III - THEORY PAPER

CORE COURSE CODE –CHE 519

PAPER – II

(Separation Techniques)

Course Credit = 03 (45 Lectures)

	No. of Lectures
UNIT-I	09
Principles and applications of solvent extraction: Nernst's Distribution law, distribution ratio and percentage of extraction, quantitative treatments of extraction equilibria, solvent extraction of metals, analytical separation, multiple batch extraction, counter current distribution, synergistic extraction. Solid –phase extraction, Supramolecules in solvent extraction.	
UNIT-II	09
Ion exchange Resins – Mechanism of ion exchange, synthesis and characteristics of ion-exchange resins, Factors affecting the selectivity of ion exchange resin, Ion exchange capacity, Techniques in ion exchange methods and analytical applications.	
UNIT-III	09
Ion Chromatography – Ion chromatography as a separation tool, Instrumentation in Ion chromatography; Analytical Applications of Ion chromatography Adsorption chromatography:– Principle and application of adsorption chromatography, Column chromatography & its experimental setup, Applications of column chromatography .	
UNIT-IV	09
Partition Chromatography- Principle of Liquid – Liquid partition chromatography Reversed Phase Partition chromatography, Application of Extraction Chromatography, Paper, Thin Layer and Ion-pair chromatography.	

Electrophoresis – Principles of Electrophoresis – Classification of Electrophoresis Methods, Techniques of Electrophoresis and Instrumentation, Applications in Inorganic Chemistry, Separation of Biological Products.

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. G.H. and H. Freiser, *Solvent Extraction in Analytical Chemistry*, 1st Edition (1958), John Wiley, New York.
3. B.L. Karger, L.R. Snyder and C. Howarth, *An Introduction to Separation Science*, 2nd Edition (1973), John Wiley, New York.
4. E.W. Berg, *Chemical Methods of Separation*, 1st Edition (1963), McGraw Hill, New York.

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 520 – ANALYTICAL CHEMISTRY PAPER - III (Spectrochemical Methods)	Number of Credits: 03
On completion of the course, students will be able to understand:		
CO 1	The theory, instrumentation and analytical applications involved in ESR.	
CO 2	The principles of turbidimetry, nephelometry, fluorimetry and their applications and Fluorescence Spectroscopy.	
CO 3	The basics of atomic spectroscopy (FES and AAS), their principal and applications related to estimation of alkaline and alkaline earth metal ions.	
CO 4	The working principles of inductively coupled plasma in atomic emission spectroscopy (ICP-AES), instrumentation and advantages of ICP-AES Instrumentation over conventional flame photometry.	
CO 5	Principle behind electron spectroscopy and microscopy, their instrumentation and applications including XPS, AFM, SEM and TEM.	

SEMESTER III - THEORY PAPER

CORE COURSE CODE - CHE 520

PAPER –III

(Spectrochemical Methods)

Course Credit = 03 (45 Lectures)

	No. of Lectures
UNIT-I	09
Electron Spin and its Magnetism; 'g'-Factor; ESR Spectral Phenomenon, Instrumentation and Important analytical applications.	
UNIT-II	09
Turbidimetry and Nephelometry, instrumentation and applications.	
Fluorescence Spectroscopy: Principle of Fluorescence, Structural effects on Fluorescence, Fluorescence Quenching, Fluorescence Quantum Yield, Instrumentation and applications of fluorescence spectroscopy	
UNIT-III	09
Flame Emission Spectroscopy (FES) and Atomic Absorption Spectroscopy (AAS), Principles, Instrumentation, detectors, Quantitative Evaluation Methods in FES and AAS, Sensitivity and Detection Limits in Analysis, Graphite Furnace in AAS, Applications of FES and AAS in the analysis of alkali and alkaline earth metal ions.	
UNIT-IV	09
Principles of plasma spectroscopy, Direct and inductively coupled plasma sources, Instrumentation and applications of ICP-AES, Inductively coupled plasma Mass spectrometry (ICP-MS), Instrumentation and Applications, quadrupole mass spectrometers, analysis methods for solids and liquids.	

Principle, instrumentation and applications of Electron spectroscopy (XPS and Auger), Atomic force microscopy (AFM), Scanning electron microscopy SEM), and Transmission electron microscopy (TEM).

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
3. J.M. Hollas, *Modern Spectroscopy*, 3rd Edition (1996), John Wiley, New York.
4. D.C. Garratt, *the Quantitative Analysis of Drugs*, 2nd Edition (1992), Chapman and Hall Ltd., London.
5. Rajaraman, J., Kuriacose, J. C., *Kinetics and Mechanism of Chemical Transformations*, India, Macmillan Publishers India Limited

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 538–ANALYTICAL CHEMISTRY LAB COURSE	Number of Credits: 10
On completion of the course, students will get hands-on training on:		
CO 1	Separation of metal ions such as Zn^{2+} & Mg^{2+} Co^{2+} & Ni^{2+} using anion exchange resin and EDTA.	
CO 2	Determination of pK_a of weak acids and pH of Hair shampoos using a pH meter.	
CO 3	Spectrophotometric determination of Fe(III), Aspirin, Phenacetin and Caffeine in APC tablets using solvent extraction.	
CO 4	Paper and thin layer chromatography for the separation of organic compounds and amino acids.	
CO 5	Infrared spectroscopic determination of a mixture of Xylene isomers / APC tablet.	
CO 6	Flame emission photometric determination of sodium.	

SEMESTER III

ANALYTICAL CHEMISTRY LAB COURSE

COURSE CODE-ANALYTICAL CHE- 538

(In addition to CHE CODE - 518, 519 & 520)

Course Credit = 10 (160 hrs.)

1. Separation of $\text{Zn}^{2+} + \text{Mg}^{2+}$ present in a sample using anion exchange resin and estimation of each metal ion thus separated by E.D.T.A. titration.
2. Separation of $\text{Co}^{2+} + \text{Ni}^{2+}$ present in a sample using anion exchange resin and estimation of each metal ion thus separated by E.D.T.A. titration.
3. Determination of the pH of Hair shampoos.
4. Determination of the pk value of weak organic acid by pH titration.
5. U.V. Spectrophotometric determination of Aspirin, Phenacetin and Caffeine in APC tablets using solvent extraction Determination of Fe(III) by chloride extraction in ether
6. Separation of amino acids using paper chromatography
7. Electrophoresis
8. Flame emission photometric determination of sodium
9. Infrared determination of a mixture of Xylene isomers / APC tablet
10. Thin – Layer chromatography, Separation of Amino acids.
11. Water analysis

Course Outcomes (COs)		
M.Sc. Semester III		
Course Code and Title of the Course	CHE 554-ANALYTICAL CHEMISTRY ELECTIVE-D PAPER (Environmental Monitoring)	Number of Credits: 03
On completion of the course, students will gain:		
CO 1	Basic knowledge of monitoring water quality standards such as dissolved oxygen content, biological oxygen demand, chemical oxygen demand, total organic count, pH, total dissolved solids, hardness etc.	
CO 2	Understanding of the various ways of removal of heavy metals and dyes from polluted water.	
CO 3	Knowledge of analysis of waste water.	
CO 4	Understanding of monitoring particulate emissions using X-ray fluorescence spectrometry.	
CO 5	Knowledge of monitoring and causes of diseases, various microbiological tests for coliform.	

SEMESTER III – ELECTIVE-D PAPER

COURSE CODE - CHE 554

Paper-IV

(Environmental Monitoring)

Course Credit= 03 (45 Lectures)

No of Lectures

UNIT-I **09**

Water quality standards; Sampling and measurements of parameters like DO, BOD, COD, TOC, pH, Total Suspended Solids, Total Dissolved Solids, Hardness, Amount of Organic Matters, pE Determination of Inorganic ions, Plant Nutrients, NKP.

UNIT-II **09**

Methods of removal of Heavy Metals and Dyes from the polluted water:

Heavy Metals: Membrane filtration, Electrochemical Method, Ion exchange method, Chemical Precipitation

Dyes: Advanced Oxidation process, Photocatalytic degradation, Nanoparticle treatment, Coagulation – Flocculation method, Biological treatment.

UNIT-III **09**

Wastewater, Wastewater treatment, Soaps, Detergents and Pesticides, Monitoring automobile Emissions, Monitoring Emissions from Stationary Sources.

UNIT-IV **09**

Monitoring Particulate Emissions (High – Volume sampling, Separation of Particles by size, XRF Spectrometry).

UNIT-V **09**

Monitoring of Disease – Causing Agents, Microbiological tests for coliform, Multiple – Tube Fermentation Technique, Membrane Filtration Technique Ortho – nitrophenyl – β – D – galactopyranoside (ONPG) Test.

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
3. G.W. Vanloon, S.J. Duffer, *Environmental Chemistry - A Global Perspective*, Oxford University Press (2000).
4. F.W. Fifield and W.P.J. Hairens, *Environmental Analytical Chemistry*, 2nd Edition (2000), Black Well Science Ltd.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 530 – ANALYTICAL CHEMISTRY PAPER -I (Electroanalytical Methods)	Number of Credits: 03
On completion of the course, students will be able to:		
CO 1	Understand principles of voltammetry including the voltammetric cell, the current voltage curve, the stepwise reduction or oxidation supporting electrolyte chemicals modified electrodes.	
CO 2	Gain knowledge on the principles of polarography including dropping mercury electrode, concepts of half wave potential.	
CO 3	Develop basic knowledge on anodic stripping voltammetry, cyclic voltammetry square wave polarography, and chronopotentiometry.	
CO 4	Get exposure to various chemical sensors and their classification, their principle of working including sensitivity and limit of detection.	
CO 5	Get exposure to various biosensors based on enzyme electrodes.	

SEMESTER IV - THEORY PAPER

CORE COURSE CODE - CHE 530

PAPER –I

(Electroanalytical Methods)

Course Credit = 03 (45 Lectures)

	No of Lectures
UNIT-I	09
Voltammetry: The voltammetric cell, the current-voltage curve, types of potential-excitation signals, Linear sweep voltammetry, Cyclic voltammetry, Electrical double layer, Faradaic and non-faradaic processes, Factors affecting electrode reaction rate and current, supporting electrolyte.	
UNIT-II	09
Polarography, The dropping mercury electrode, the Ilkovic equation, Inorganic and organic polarography. Impedance, analysis and application in electrochemical systems (impedimetric sensors and battery).	
UNIT- III	09
Stepwise reduction and oxidation, Anodic stripping voltammetry, Chronopotentiometry, Chronoamperometry, Differential pulse voltammetry, Chemically modified electrodes.	
UNIT-IV	09
Chemical Sensors classification, sensitivity and limit of detection, potentiometric sensors Ion selective Electrodes (ISEs), types of electrodes, selectivity and applications of ISEs., Gas sensors, voltammetric sensors, FET based sensors.	
UNIT-V	09
Biosensors–Definition, concept, types, applications, The enzyme electrode, applications of enzyme electrodes; biosensors based on Ion-Selective electrodes, Lateral Flow Biosensors- (Pregnancy, COVID, Malaria).	

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. A.J. Bard and L.R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2nd Edition (2000), Wiley, New York.
3. I.M. Kolthoff and J.J. Lingane, *Polarography*, 2nd Edition (1952), Wiley Intersciences, New York.
4. C.W.C. Milner and G. Phillips, *Coulometry in Analytical Chemistry*, Pergamon Press, New York (1967).

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 531 – ANALYTICAL CHEMISTRY PAPER -II (Analytical Characterization Techniques)	Number of Credits: 03
On completion of the course, students will be able to:		
CO 1	Understand the effect of temperature and atmosphere on the stability of compounds, composites under the course headline of Thermal and calorimetric methods of Analysis.	
CO 2	Understand the working principle of X-ray Emission Spectrometry and their applications.	
CO 3	Get exposure to various instrumental techniques for characterisation of compounds related to mass spectrometry, gas chromatography and high Performance liquid chromatography.	
CO 4	Understanding of polarimetry and related methods including optical rotatory dispersion (ORD) and circular dichroism (CD) and their instrumentation.	
CO 5	Get understanding of the usage of computers and microprocessors in Analytical Chemistry including instrument optimizations, data recording and storage and analysis.	

SEMESTER IV - THEORY PAPER

CORE COURSE CODE - CHE 531

PAPER –II

(Analytical Characterization Techniques)

Course Credit = 03 (45 Lectures)

No of Lectures

UNIT-I **09**

Thermal and calorimetric methods of Analysis : Thermogravimetric Analysis (TGA) – Principle, apparatus and applications; Differential Thermal analysis (DTA) – Principle and apparatus; Derivative thermogravimetry – principle and apparatus, Interpretation of TGA and DTA curves. Thermometric titrations; Differential scanning calorimetry (DSC) - Instrumentation and Applications.

UNIT-II **09**

X-ray processes (Theory, Instrumentation and applications), X-ray Diffraction, Bragg's Law, X-ray absorption, emission and fluorescence methods.

UNIT-III **09**

Mass spectrometry : Principles, instrumentation and applications

Gas chromatography and High Performance Liquid Chromatography : Principle, Instrumentation and Applications.

UNIT-IV **09**

Polarimetry and Related methods: Polarised Light, Applications of Polarimetry, Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD), Instrumentation for ORD and CD.

UNIT-V **09**

The role of computers and microprocessors in Analytical Chemistry- Instrument optimizations, Data recording and storage, Data processing and data analysis (Chemometry), The scope of microprocessor Control and computers in analytical laboratories.

Recommended Books:

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition (2000), Wiley, New York.
3. J.M. Hollas, Modern Spectroscopy, 3rd Edition (1996), John Wiley, New York.
4. H.A. Strobel, Chemical Instrumentation – A Systematic Approach, 2nd Edition (1973), Addison Wesley, Mass.
5. D.C. Garratt, the Quantitative Analysis of Drugs, 2nd Edition (1992), Chapman and Hall Ltd., London.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 532 – ANALYTICAL CHEMISTRY PAPER -III (Analytical Methods)	Number of Credits: 03
On completion of the course, students will be able to:		
CO 1	Understand moisture analysis for foods and chemicals by using Karl Fischer titration. They will also estimate the amount of active hydrogen by Zerwintinoff's method.	
CO 2	Understand volumetric methods of gas analysis for the determination of H ₂ O ₂ and available active chlorine in bleaching powder.	
CO 3	Gain knowledge on the importance of analysis of oils and fats.	
CO 4	Understand the importance of biochemical microanalysis of carbohydrates, amino acids, estimation of protein in egg albumin, estimation of blood cholesterol etc.	
CO 5	Understand various diagnostic methods especially the immunoassays (ELISA, Western blots, RIA).	

SEMESTER IV - THEORY PAPER

CORE COURSE CODE – CHE 532

PAPER –III

(Analytical Methods)

Course Credit= 03 (45 Lectures)

No of Lectures

UNIT-I (Moisture and active hydrogen analysis) 09

Importance of moisture analysis (Food, chemicals and inert atmosphere reactions), Estimation of moisture by Karl Fischer Titration (KFT), Reagents for KFT, Volumetric and Coulometric KFTs, Interferences in KFT, Determination of active hydrogen by Zerewitinoff's method and its applications.

UNIT-II (Gas Analysis) 09

Gas Analysis: Volumetric methods of analysis of gasses, determination to H_2O_2 , determination of available chlorine in bleaching powder.

UNIT-III (Analysis of oils and fats) 09

Acid value, Saponification number, Iodine number; Commercial analysis of milk, sugar and vitamins; Chemical analysis of paints and cement.

UNIT-IV (Biochemical Microanalysis) 09

Estimation of carbohydrates, amino acids, ascorbic acid, creatinine and bilirubins in biological systems, Estimation of protein in egg albumin, Estimation of blood cholesterol, blood urea nitrogen and barbiturates in biological fluids.

UNIT-V (Clinical methods) 09

Immunoassays (ELISA, Western blots, RIA and immunodiffusion), DNA-fingerprinting, Examination and grouping of blood strains and seminal strains.

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. Peter Fordham, Non-destructive Testing Techniques, 1st edition (1968), London Business Publications Ltd., London
3. W. Horwitz, Official Methods of Analysis, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.
4. K. Simpson and B. Knight, Forensic Medicine, 9th Edition (1985), Edward Arnold Publishers Ltd., London.
5. L. J. Kricka, Immunoassays: A practical approach, Oxford university press, 2000.
6. P. L. Kirk, Quantitative ultramicroanalysis, John Wiley, 1950.

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	ANALYTICAL CHEMISTRY LAB COURSE CODE CHE 542	Number of Credits: 10
On completion of the course, students will be able to get:		
CO 1	Hands-on training on the use of Atomic Absorption spectrophotometry for the determination of calcium and other alkali metals.	
CO 2	Hands-on training on the use of gas chromatography for the determination of ternary gas mixtures.	
CO 3	Experimental knowledge on enzymatic determination of glucose using colorimetric technique.	

CO 4	Training on polarography for the determination of Cd^{2+} and Zn^{2+} ions.
CO 5	Hands-on training on the use of TG analysis for various composite materials such as fiberglass, polymers etc.
CO 6	Training on the determination of acid value, saponification number and ester value of oils and fats.
CO7	Training on the spectrophotometric estimation of dyes and metal complexes using UV-Vis spectrophotometer.
CO 8	Analytical understanding of experimental data for a particular experiment mentioned for CO1 to CO7 to compare least square fitting and perform student's t-test and F-test.
CO 9	Mentorship from branch specific faculty members for a research project in the relevant fields.

SEMESTER IV

ANALYTICAL CHEMISTRY LAB COURSE

COURSE CODE-ANALYTICAL CHE-542

(In addition to CHE CODE - 530, 531 & 532)

Course Credit = 10 (160 hrs)

1. Determination of calcium by Atomic Absorption spectrophotometry
2. Gas chromatographic analysis of a ternary mixture
3. Enzymatic Determination of glucose
4. Determination of Cd^{2+} ion using polarography
5. Determination of Zn^{2+} ion using polarography
6. TGA
7. Determination of acid value, saponification number and ester value of oils and fats
8. Spectroscopic analysis of unknown synthetic dyes
9. Spectroscopic analysis of copper ammonium complex
10. Least Square fitting
11. Composition of two sets of results of significance by
 - (i) student's t-test
 - (ii) F-test
12. Project Experiment

Course Outcomes (COs)		
M.Sc. Semester IV		
Course Code and Title of the Course	CHE 558-ELECTIVE-D PAPER PPAER IV Environmental Chemistry	Number of Credits: 03
Through this course, students will:		
CO 1	Understand the basic segments of environment and terminology and nomenclatures meant for the environment.	
CO 2	Have a qualitative and quantitative idea of natural elemental cycles (H ₂ O, O, N, C, P and S) that the biosphere requires for the sustenance of life.	
CO 3	Knowledge of analysis of waste water for example monitoring of soaps, detergents and pesticides, sampling and measurement of air pollutants, monitoring automobile emissions, monitoring emissions from stationary sources.	
CO 4	Have an understanding of chemical toxicology including toxic chemicals in the environments, impact of toxic chemicals on enzymes, biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, nitrogen oxides, sulphur oxides.	
CO 5	Gain basic knowledge of monitoring of trace level pollutants (toxic metals) in water samples by ICP-OES/MS and anodic stripping voltammetry.	

SEMESTER IV– ELECTIVE-D PAPER

COURSE CODE: CHE 558

Paper-IV

(Environmental Chemistry)

Course Credit= 03 (45 Lectures)

No of Lectures

UNIT-I (Introduction to Environmental Chemistry) 09

Concept and scope of environmental chemistry, Environmental segments. Green chemistry- Significance and basic components of green chemistry. Solid waste management - A case study from rural to urban perspective.

UNIT-II (Elemental Cycles) 09

The natural cycles of environment: (Hydrological, Oxygen, Nitrogen, Carbon, Sulphur and Phosphorus).

UNIT-III (Chemical Toxicology) 09

Causes of toxic chemicals and their impacts on enzymes, Biochemical effects of toxic metals (As, Cd, Pb & Hg), Chemical toxicity of cyanide, nitrogen oxides, sulphur oxides; Biological effects of pesticides and herbicides.

UNIT-IV (Air Pollution) 09

Composition of air, Particulates, Aerosols, SO_x, NO_x, CO_x and hydrocarbon, Photochemical smog, Air-quality standards, Sampling of Air Pollutants.

UNIT-V (Water Pollution) 09

Introduction to Water Quality Standards and online water monitoring sensors, Monitoring of trace level pollutants (toxic metals) in water samples by ICP-OES/MS and anodic stripping voltammetry,

extraction and preconcentration of trace level pollutants, Total organic carbon, total nitrogen, total sulfur, total phosphorus and chlorine, chemical speciation of (Pb, As, Hg).

Recommended Books

1. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
3. G.W. Vanloon, S.J. Duffer, *Environmental Chemistry - A Global Perspective*, Oxford University Press (2000).
4. F.W. Fifield and W.P.J. Hairens, *Environmental Analytical Chemistry*, 2nd Edition (2000), Black Well Science Ltd.
5. S.M. Khopkar, Basic concepts of Analytical Chemistry, 2nd Ed. New Age Int. Ltd., 2004