To,

The Additional Chief Secretary

Bihar Lok Bhawan, Patna.

Date: 15th June 2026

Subject: Submission of Proposed Course Structure and Uniform Syllabus for M.Sc. in Chemistry (Semester I and II) under the Two-Year Postgraduate Programme in accordance with NEP 2020 and UGC Regulations

Ref.- Letter No. BSU(UGC)-02/2023-1153/GS(1), Dated 10/06/2026

Sir,

With reference to the letter cited above, and in compliance with the directions contained therein, we are pleased to submit the proposed Course Structure and Uniform Syllabus for M.Sc. in (Chemistry) for Semester I and Semester II of the Two-Year Postgraduate Programme.

The proposed curriculum has been prepared in conformity with the University Grants Commission (UGC) Regulations, the UGC Curriculum and Credit Framework for Postgraduate Programmes, and the provisions of the National Education Policy (NEP), 2020, with due emphasis on multidisciplinary learning, outcome-based education, academic flexibility, and research orientation.

The same is submitted for kind consideration and further necessary action.

Enclosed – as above.

Yours' faithfully

Professor Kalpana Shahi
Department of Chemistry
Pataliputra University, Patna

K Shahi
15.6.26

Dr. Dimple Kumari
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15-6-26

Post Graduate Curriculum Framework

With effect from the Academic Session 2026–27, the M.Sc. in Chemistry programme in the Universities of Bihar shall be offered in accordance with the UGC Curriculum and Credit Framework for Postgraduate Programmes (PGCF) and the provisions of the National Education Policy (NEP), 2020.

The programme provides flexibility to students to pursue either a Two-Year Master's Degree Programme or a One-Year Master's Degree Programme for candidates who have completed a four-year undergraduate degree with the requisite credits and qualifications as prescribed by UGC.

The curriculum is designed under the Choice Based Credit System (CBCS) and comprises a combination of Core Courses (CCs), Discipline Specific Electives (DSEs), Generic Electives (GEs), Skill Enhancement Courses (SECs), Ability Enhancement Courses (AECs), and Value Added Courses (VACs). The programme seeks to impart advanced theoretical knowledge, computational proficiency, research aptitude, and practical skills in Chemistry and its applications.

Each academic year shall consist of two semesters. Students shall be required to successfully complete the prescribed combination of Core, Elective (Discipline/Generic/Open), Skill Enhancement, Ability Enhancement, and Value Added Courses in each semester to fulfill the credit requirements of the programme.

The curriculum incorporates contemporary developments in Chemistry, including Inorganic Chemistry, Physical Chemistry, Organic Chemistry, practical aspects of Chemistry, Fundamentals of Analytical chemistry and their applications, spectroscopy, Advances in Chemistry, Macromolecules, Research Methodology, and Indian knowledge System. The syllabus and reading materials shall be reviewed periodically to ensure alignment with emerging developments in academia, research, industry, and public policy.

Teaching-learning methodologies may include lectures, tutorials, seminars, laboratory sessions, statistical computing exercises, case studies, project work, field-based applications, and research assignments. Practical training shall provide hands-on experience in the use of statistical software packages, data analysis techniques, computational tools, and real-world problem-solving.

Assessment shall be conducted through a combination of continuous evaluation and end-semester examinations, including assignments, presentations, practical examinations, projects, viva-voce examinations, and written tests, as prescribed by the authorities concerned from time to time.

Students shall have the opportunity to choose elective and generic courses in accordance with their academic interests, subject to the availability of courses and institutional regulations, thereby promoting interdisciplinary learning and specialization within the broad domain of Chemistry.

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COURSE OF STUDIES

CHEMISTRY/ M.Sc.

Programme Level	Master of Science (M.Sc.)
Subject / Discipline	Chemistry
Faculty	Faculty of Science
University	Universities of Bihar Established under the BSU AC 1976/PU Act 1976.
Duration	Two Years / Four Semesters
NHEQF Level	Level 6.5
Effective from	2026-27 onwards

PART A — PROGRAMME OVERVIEW & OBJECTIVES

A.1 Graduate Attributes (GAs)

The programme nurtures the following Graduate Attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

- Strong understanding of core concepts in chemistry, including inorganic, organic, physical, and analytical chemistry.
- Ability to apply chemical principles to analyze and solve theoretical and practical problems.
- Competence in performing experiments, handling instruments, and following safe laboratory practices.
- Capabilities to interpret data, evaluate results, and draw logical scientific conclusions.
- Basic understanding of experimental design, data analysis, and scientific investigation.
- Ability to present chemical information clearly in written, oral, and graphical forms.

A.2 Programme Outcomes (POs)

The Programme Educational Objectives describe the career and professional accomplishments that graduates are expected to attain within three to five years of graduation.

PO1: Graduates will build successful careers in chemistry-related fields such as industry, academia, research, and government sectors.

PO2: Graduates will apply their chemical knowledge and laboratory skills to solve real-world scientific and industrial problems.

PO3: Graduates will pursue higher education and research in chemistry or allied interdisciplinary areas.

PO4: Graduates will demonstrate professional ethics, teamwork, and effective communication in their workplace.

PO5: Graduates will contribute to sustainable development by applying green and environmentally responsible chemical practices.

A.3 Programme Specific Outcomes (PSOs)

Upon successful completion of this programme, a student shall demonstrate the following learning outcomes:

PSO1: Perform qualitative and quantitative chemical analysis using classical and modern laboratory techniques.

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PSO2: Synthesize, purify, and characterize organic and inorganic compounds using appropriate methods and instrumentation.

PSO3: Analyze and interpret experimental data using scientific reasoning and chemical principles.

PSO4: Apply green chemistry principles and sustainable practices in chemical synthesis and laboratory work.

PSO5: Demonstrate competence in handling chemical instruments and adopting safe laboratory practices.

PSO6: Develop problem-solving skills for industrial, environmental, and research-oriented chemical Knowledge.

PART B — COURSE STRUCTURE (CBCS/NHEQF FRAMEWORK)

B.1 Semester-wise Course Structure

The following table presents the full four-semester course structure. Column headings: L = **Lectures per week**; T = Tutorials per week; P = Practicals per week; CC = Core Course; DSE = Discipline Specific Elective; GE/OE = Generic/Open Elective; SEC = Skill Enhancement Course; PROJ = Project/Dissertation.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
		SEMESTER I						
1	MSCHE-CC101	Core Course I: Inorganic Chemistry	3	1	0	4	100	CC
2	MSCHE-CC102	Core Course II: Physical Chemistry	3	1	0	4	100	CC
3	MSCHE-CC103	Core Course III: Organic Chemistry	3	1	0	4	100	CC
4	MSCHE-CC104	Core Course IV: Inorganic Chemistry Practical	0	0	4	4	100	CC
5	MSCHE-GE105/GE106	Generic Elective I: Fundamental of Analytical chemistry/ Research Methodology	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester I	14	4	**4**	**22**	**600**	
		SEMESTER II						
1	MSCHE-CC201	Core Course I: Molecular Spectroscopy	3	1	0	4	100	CC
2	MSCHE-CC202	Core Course II: Frontiers in Chemistry	3	1	0	4	100	CC
3	MSCHE-CC203	Core Course III: Macromolecules	3	1	0	4	100	CC
4	MSCHE-CC204	Core Course IV: Organic Chemistry Practical	0	0	4	4	100	CC

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S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
5	MSCHE-GE205/GE206	Generic Elective I: Applied Analytical Chemistry/ Indian knowledge System and Chemistry	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester II	**14**	**4**	**4**	**22**	**600**	

Particulars	Semester	Course Code	Course Title
Basket I	I	MSCHE-GE105	Fundamental of Analytical chemistry
		MSCHE-GE106	Research Methodology
Basket II	II	MSCHE-GE205	Applied Analytical Chemistry
		MSCHE-GE206	Indian knowledge System and Chemistry

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PART C — COURSES OF STUDIES

Semester 1

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-CC101
Title of the Paper	Core Course I: Inorganic Chemistry
Programme / Subject	M.Sc. — Chemistry
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand molecular structure and bonding using VSEPR, hybridization, and MO theory.
COB 2	Explain magnetic properties and electronic states of transition and inner-transition metal ions.
COB 3	Study metal–ligand equilibria and factors affecting complex stability.
COB 4	Understand reaction mechanisms of coordination compounds and electron transfer processes.
COB 5	Learn the structure and chemistry of isopoly and heteropoly compounds of Mo and W.

C.4 Course Outcomes (COs)

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CLO No.	Course Learning Outcome
CLO 1	Predict and explain the geometry, bonding, and electronic structure of inorganic molecules and coordination compounds using appropriate theoretical models.
CLO 2	Determine and interpret the magnetic behavior of transition and inner transition metal ions from their electronic configurations and term symbols.
CLO 3	Explain the chelate effect and methods for determining stability constants.
CLO 4	Calculate and analyze metal–ligand stability constants and assess factors governing the formation and stability of coordination complexes.
CLO5	Differentiate and evaluate various reaction mechanisms of transition metal complexes, including substitution and electron-transfer processes.
CLO5	Upon completion, students will be able to recall and describe the foundational concepts of inorganic chemistry.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Inorganic Chemistry (MSCHE-CC101)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction** (a) VSEPR theory, *d*π-*p*π bonding, and energetic of hybridisation. (b) M.O. diagram for hetero-nuclear diatomic-molecules.	12
II	**Magnetochemistry** Term symbols, ground state and all possible term, symbols for p^2 and d^2 configuration, quenching of orbital contribution in metal complexes, magnetic properties of inner transition metals, anomalous magnetic behavior of Eu^{3+} and Sm^{3+} ions.	12
III	**Metal-Ligand Equilibrium in Solution** Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin. Determination of formation constants by *p*H metry and spectrophotometer.	15
IV	**Reaction Mechanism of Transition metal complexes.** Inert and labile complexes, kinetic application of VBT and CFT, kinetics of octahedral substitution, acid hydrolysis, base hydrolysis, CB mechanism, Evidences of CB mechanism. Anation reaction, reaction without M-L bond cleavage, substitution reactions in square planar complexes. The *trans*-effect, Theories of *trans*-effect. Electron transfer reactions-inner and outer sphere mechanism. Marcus-Hush theory.	15
V	**Isopoly and Heteropoly Acids and salts** Isopoly d Heteropoly acids and salts of Mo and W. structure of isopoly and heteropoly anions.	6
	Total Suggested Lectures	**60 (For 4 Credit Course)**

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1. Lee, J. D. (2010). *Concise Inorganic Chemistry* (5th ed.). Wiley India.
2. Moeller, T. (2010). *Inorganic Chemistry: A Modern Introduction*. Wiley Eastern.
3. Emeleus, H. J., & Sharpe, A. G. (1983). *Modern Aspects of Inorganic Chemistry* (4th ed.). Routledge.
4. Figgis, B. N. (1976). *Introduction to Ligand Fields*. Wiley Eastern.
5. Basolo, F., & Pearson, R. G. (1967). *Mechanisms of Inorganic Reactions* (2nd ed.). Wiley.

C.7 Reference Books & Readings

1. Addison, W. E. (1961). *Structural Principles in Inorganic Chemistry*. Longmans.
2. Earnshaw, A. (1968). *Introduction to Magnetochemistry*. Academic Press.
3. Cotton, F. A., Wilkinson, G., Murillo, C. A., & Bochmann, M. (1999). *Advanced Inorganic Chemistry* (6th ed.). Wiley.
4. Huheey, J. E., Keiter, E. A., & Keiter, R. L. (1993). *Inorganic Chemistry: Principles of Structure and Reactivity* (4th ed.). HarperCollins.
5. Miessler, G. L., Fischer, P. J., & Tarr, D. A. (2014). *Inorganic Chemistry* (5th ed.). Pearson.

C.7 Suggested E-Resources / Digital Repositories

1. **SWAYAM/NPTEL:** Courses on Inorganic Chemistry, Coordination Chemistry, Organometallic Chemistry, and Chemical Bonding.
2. **e-PG Pathshala:** Modules on Chemical Bonding, Magnetochemistry, Coordination Chemistry, and Reaction Mechanisms.
3. **NDLI (National Digital Library of India):** Access to e-books, journals, theses, lecture notes, and chemistry learning resources.
4. **INFLIBNET:** Access to scholarly databases, e-journals, e-books, and academic resources.
5. **ChemLibreTexts:** Open-access educational resources on bonding theories, ligand field theory, and inorganic reaction mechanisms.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-CC102
Title of the Paper	Core Course II: Physical Chemistry
Programme / Subject	M.Sc. — Chemistry
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE : 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and Viva Voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the principles of electrochemistry and ionic solutions.
COB 2	Study reaction kinetics, mechanisms, and catalysis.
COB 3	Learn the fundamentals of chemical thermodynamics and solution behaviour.
COB 4	Understand the concepts of statistical thermodynamics and partition functions.
COB 5	Develop knowledge of quantum mechanics and its applications in chemistry.

C.4 Course Outcomes (COs)

Students will be able to

CLO No.	Course Learning Outcome
CLO 1	Explain electrochemical processes, electrode potentials, ionic activities, and electrolyte behavior.
CLO 2	Analyze reaction kinetics, reaction mechanisms, catalysis, and photochemical processes.
CLO 3	Use statistical thermodynamic concepts and partition functions to relate molecular

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and thermodynamic properties.

CLO 4 Apply the fundamental concepts of quantum mechanics, operators, and the Schrödinger equation to the study of atomic and molecular systems.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Physical Chemistry (MSCHE-CC102)		
Unit	**Content**	**Suggested Lectures hours**
I	**Electro Chemistry** Electrode potential in terms of chemical potential and activity; Debye–Hückel theory of electrolyte solutions—applications and limitations; quantitative treatment of the Debye–Hückel limiting law and its modification for finite ion size; effect of ion–solvent interactions on activity coefficients; Butler–Volmer equation under equilibrium and non-equilibrium conditions, exchange current density, and Tafel plots.	12
II	**Chemical Dynamics** Mechanism and dynamics of consecutive and opposing reactions. Activated complex theory of reaction rates; evaluation of free energy, enthalpy, and entropy of activation. Mechanism and dynamics of the photolysis of acetaldehyde, photodimerization of anthracene, polymerization, and auto-oxidation reactions. Homogeneous catalysis and enzyme kinetics. Study of fast reactions by flow and relaxation methods.	12
III	**Chemical Thermodynamics** Partial molar properties of ideal mixtures; chemical potential: determination and dependence on temperature and pressure; Gibbs–Duhem equation. Fugacity and activity: determination and variation with temperature and pressure; fugacity of gases in mixtures; Duhem–Margules equation and its applications.	12
IV	**Statistical Thermodynamics** Ensembles, Thermodynamic probability, Boltzman Distribution Law, Boltzman Planck Equation, Partition function and its significance, Relationship with thermodynamic functions, Translational, Rotational, Vibrational and Electronic partition function. Its application in the case of monatomic and diatomic molecules, Sackur-Tetrode Equation.	12
V	**Quantum Chemistry** Functions and operators: types, properties, and applications; Dirac bra–ket notation; normalization and orthogonalization of wave functions; Kronecker delta. Quantum mechanical operators and physical observables; time-dependent and time-independent Schrödinger equations; expectation values and mathematical concepts underlying quantum mechanics.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Atkins, P. W., & de Paula, J. (2018). *Atkins' Physical Chemistry* (11th ed.). Oxford University Press.

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2. Prasad, R. K. (2018). *Quantum Chemistry*. New Age International Publishers.
3. Bakris, J. O'M., & Reddy, A. K. N. (2001). *Modern Electrochemistry* (2nd ed.). Springer.
4. Raj, G. (2014). *Advanced Physical Chemistry*. Goel Publishing House.
5. Barrow, G. M. (1996). *Physical Chemistry* (6th ed.). McGraw-Hill.

C.7 Reference Books & Readings

1. Levine, I. N. (2014). *Quantum Chemistry* (7th ed.). Pearson.
2. McQuarrie, D. A. (2000). *Statistical Mechanics*. University Science Books.
3. Laidler, K. J. (1987). *Chemical Kinetics* (3rd ed.). Harper & Row.
4. Hill, T. L. (1986). *An Introduction to Statistical Thermodynamics*. Dover Publications.
5. Glasstone, S. (2007). *Thermodynamics for Chemists*. East-West Press.

C.7 Suggested E-Resources / Digital Repositories

1. **SWAYAM/NPTEL:** Courses on Physical Chemistry, Electrochemistry, Chemical Kinetics, Statistical Thermodynamics, and Quantum Chemistry.
2. **e-PG Pathshala:** Modules on Electrochemistry, Chemical Dynamics, Thermodynamics, Statistical Thermodynamics, and Quantum Chemistry.
3. **NDLI (National Digital Library of India):** Access to e-books, journals, theses, lecture notes, and chemistry learning resources.
4. **INFLIBNET:** Access to scholarly databases, e-journals, e-books, and academic resources.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks

Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-CC103
Title of the Paper	Core Course III: Organic Chemistry
Programme / Subject	M.Sc. – Chemistry
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the nature of bonding, electron delocalization, and aromaticity in organic molecules.
COB 2	Study the mechanisms and factors affecting nucleophilic, electrophilic, and free radical substitution reactions.
COB 3	Analyze elimination reactions, their stereochemistry, and orientation of products.
COB 4	Understand addition reactions to carbon–carbon and carbon–heteroatom multiple bonds.
COB 5	Learn the mechanisms of free radical reactions and important molecular rearrangements.

C.4 Course Outcomes (COs)

students will be able to

CLO No.	Course Learning Outcome

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CLO 1 Explain bonding concepts such as resonance, conjugation, hyperconjugation, aromaticity, and molecular orbital approaches in organic molecules.

CLO 2 Analyze the mechanisms, stereochemistry, and reactivity of nucleophilic, electrophilic, and free radical substitution reactions.

CLO 3 Differentiate E1, E2, and E1CB elimination mechanisms and predict the stereochemical and regiochemical outcomes of reactions.

CLO 4 Interpret the mechanisms and selectivity of addition reactions involving carbon–carbon and carbon–heteroatom multiple bonds.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Organic Chemistry (MSCHE-CC103)		
Unit	**Content**	**Suggested Lectures hours**
I	**Nature of Bonding in Organic Molecules** Delocalized chemical bonding conjugation, cross conjugation, resonance, hyperconjugation, Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule, energy level of π-molecular orbitals, annulenes, antiaromaticity, homo-aromaticity, PMO approach.	12
II	**Aliphatic Nucleophilic Substitution:** The S_N2, S_N1, mixed S_N2 and S_N1, S_Ni mechanisms. The neighbouring group participation by л and σ bonds. Classical and nonclassical carbocations, phenonium ions, Reactivity- effects of substrate structure, attacking nucleophile, leaving group and reaction medium. Ambident nucleophiles and regioselectivity. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Aromatic Nucleophilic Substitution: The ArSN1, ArSN2, Benzyne and SRN1 mechanisms. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. Von- Richter, Sommelet-Hauser, and Smiles rearrangements. Free radical Substitution: Allylic halogenation, arylation of aromatic componds, Sandmeyer reaction, Hunsdiecker reaction. Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.	12
III	**Elimination Reactions:** The E2, E1 and E1CB mechanisms. Orientation of the double bond. Stereochemistry of E2 reaction, Hofmann's rule and Saytzeff's rule. Reactivity effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.	12
IV	**Addition to Carbon-Carbon Multiple Bonds:** Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio -selectivity, orientation and reactivity. Hydrogenation, Hydroxylation Hydroboration, Michael reaction. Addition to Carbon- Hetero Atom Multiple Bonds: Nucleophilic addition of carbonyl compounds, Mechanism of metal hydride reduction of saturated carbonyl compounds,	12

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	Wittig reaction. Mechanism of condensation reactions involving enolates - Aldol, Benzoin, Perkin and Stobbe reactions.	
V	**Free Radical Reactions and Molecular rearrangements** a. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes, Free radical rearransement. Hunsdiecker reaction. b. A detail study of the following rearrangements: Wegner-Meerwein rearrangements Neber, Curtius, Arndt Eistert reaction, Benzilic acid, Beckmann rearrangements.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. March, J. (2013). *Advanced Organic Chemistry: Reactions, Mechanisms and Structure*. Wiley.
2. Sykes, P. (1986). *A Guidebook to Mechanism in Organic Chemistry* (6th ed.). Longman.
3. Morrison, R. T., & Boyd, R. N. (2011). *Organic Chemistry*. Pearson Education.
4. Mukherji, S. M., & Singh, S. P. (2019). *Reaction Mechanism in Organic Chemistry*. Trinity Press.
5. Nasipuri, D. (2018). *Stereochemistry of Organic Compounds: Principles and Applications*. New Age International.

C.7 Reference Books & Readings

1. Carey, F. A., & Sundberg, R. J. (2007). *Advanced Organic Chemistry, Part A: Structure and Mechanisms*. Springer.
2. Carey, F. A., & Sundberg, R. J. (2007). *Advanced Organic Chemistry, Part B: Reactions and Synthesis*. Springer.
3. Singh, J., & Yadav, L. D. S. (2010). *Advanced Organic Chemistry*. Pragati Prakashan.
4. Finar, I. L. (2008). *Organic Chemistry, Volume I*. Pearson Education.
5. Finar, I. L. (2008). *Organic Chemistry, Volume II*. Pearson Education.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL: Courses on Organic Reaction Mechanisms, Stereochemistry, Advanced Organic Chemistry, and Organic Synthesis.
2. e-PG Pathshala: Modules on Organic Chemistry, Reaction Mechanisms, Aromaticity, Stereochemistry, and Reactive Intermediates.
3. National Digital Library of India (NDLI): Digital repository of e-books, journals, theses, lecture notes, and multimedia resources in Organic Chemistry.
4. PubChem: Database of chemical structures, properties, reactions, and spectral information.
5. Organic Chemistry Portal: Open educational resource for named reactions, reaction mechanisms, and synthetic methodologie

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

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Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-PC-104
Title of the Paper	Core Course IV : Inorganic Chemistry Practical
Programme / Subject	M.Sc. — Chemistry
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Develop skills in qualitative and quantitative analysis of inorganic compounds and mixtures.
COB 2	Understand complexometric and volumetric methods for estimation of metal ions.
COB 3	Learn green synthesis techniques for the preparation of coordination compounds.
COB 4	Study the characterization of inorganic compounds using spectroscopic and thermal methods.
COB 5	Develop laboratory skills in identification, separation, and analysis of inorganic radicals.

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C.4 Course Outcomes (COs)

Upon completion, students will be able to

CLO No.	Course Learning Outcome
CLO 1	Analyze and identify cations and anions in complex inorganic mixtures, including interfering radicals.
CLO 2	Synthesize coordination compounds using environmentally friendly (green) methods.
CLO 3	Interpret IR, UV-Visible, and TGA data for characterization of inorganic compounds.
CLO 4	Apply analytical and laboratory techniques for accurate identification and determination of inorganic species.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Inorganic Practical (MSCHE-PC-104)		
Unit	**Content**	**Suggested Lectures hours**
I	1. **Quantitative analysis of two constituent ions of the following.** (a) Cu, Zn (b) Fe, Ni (c) Ca, Mg (d) Al, Mg the cations Mg Ca and Al can be estimated using EDTA.	
II	2. **Green methods of preparation of the following and their study by IR, UV spectra and T.G.A.** (a) Pot. trioxalato ferrate (III) (b) Pot. trioxalato chromate (III) (c) Chromus Acetate (d) Hg[Co (SCN)4] (e) Hexa-ammine Ni (II) chloride	
III	**Qualitative analysis of inorganic mixture containing six radicals including interfering radicals**	
IV	Viva- voce	
V	Note Book	
	Total Suggested Contact Hours For Practical Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Vogel, A. I. (2000). *Vogel's Textbook of Quantitative Chemical Analysis* (6th ed.). Prentice Hall.
2. Vermani, O. P. (2006). *Applied Analytical Chemistry: Theory and Practice*. CBS Publishers & Distributors.
3. Svehla, G. (1996). *Vogel's Qualitative Inorganic Analysis* (7th ed.). Prentice Hall.
4. Marr, G., & Rockett, B. W. (1972). *Practical Inorganic Chemistry*. Van Nostrand Reinhold.

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5. Pass, G., & Sutcliffe, H. (1974). *Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods*. Chapman and Hall.

C.7 Reference Books & Readings

1. Jeffery, G. H., Bassett, J., Mendham, J., & Denney, R. C. (1989). *Vogel's Textbook of Quantitative Chemical Analysis* (5th ed.). Longman.
2. Day, R. A., & Underwood, A. L. (2001). *Quantitative Analysis* (6th ed.). Prentice Hall.
3. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2014). *Fundamentals of Analytical Chemistry* (9th ed.). Cengage Learning.
4. Cotton, F. A., Wilkinson, G., Murillo, C. A., & Bochmann, M. (1999). *Advanced Inorganic Chemistry* (6th ed.). Wiley.
5. Housecroft, C. E., & Sharpe, A. G. (2018). *Inorganic Chemistry* (5th ed.). Pearson Education.

C.7 Suggested E-Resources / Digital Repositories

1. **SWAYAM / NPTEL:** Courses on Analytical Chemistry, Coordination Chemistry, Inorganic Chemistry, and Instrumental Methods of Analysis.
2. **e-PG Pathshala:** Modules on Qualitative Analysis, Quantitative Analysis, Coordination Chemistry, and Spectroscopic Techniques.
3. **National Digital Library of India (NDLI):** E-books, laboratory manuals, journals, and learning resources in Inorganic and Analytical Chemistry.
4. **INFLIBNET:** Access to scholarly databases, e-journals, and digital academic resources.
5. **PubChem:** Database of chemical compounds, structures, properties, and safety information.
6. **Royal Society of Chemistry (RSC) Education Resources:** Laboratory experiments, analytical techniques, and inorganic chemistry learning materials.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Practical Exam: 50 Marks (Attempt any two experiments)
- Viva Voce: 10 Marks
- Note Book : 10 Marks

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-GE105
Title of the Paper	General Elective I: **Fundamentals of Analytical Chemistry**
Programme / Subject	M.Sc. — Chemistry
Semester	Semester I
Nature of Course	General Elective (GC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the fundamentals and scope of analytical chemistry.
COB 2	Apply statistical and chromatographic methods in chemical analysis.
COB 3	Analyze food, water, soil, fuel, drugs, and biological samples.
COB 4	Develop skills in environmental and clinical analytical techniques.
COB 5	Study thermal analysis methods and their applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain principles and methods of analytical chemistry and data analysis.
CLO 2	Perform separation and chromatographic techniques for qualitative and quantitative analysis. Apply thermal analysis techniques such as TGA, DTA, and DSC in material characterization.

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CLO 3	Analyze environmental, food, clinical, and pharmaceutical samples accurately. .
CLO 4	Interpret analytical data related to pollution control and quality assurance.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Fundamentals of Analytical Chemistry (MSCHE-GE105)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction** Role and scope of analytical chemistry; classification of analytical methods, types of instrumental analysis; criteria for selection of analytical methods including sensitivity, selectivity, accuracy and precision. Sampling techniques including random and systematic sampling; sample collection, preservation and preparation; dissolution and decomposition methods (wet digestion, dry ashing, microwave digestion).	12
II	**Statistical methods in chemical analysis** Errors in analysis including systematic and random errors; accuracy and precision; significant figures; propagation of errors; statistical treatment of analytical data; normal error curve and Gaussian distribution; confidence limits and intervals. Statistical tests including Student's t-test, F-test, Q-test and Chi-square test; rejection of data; regression analysis(leastsquaremethod) and least square method; correlation coefficient and calibration curves.	12
III	**Separation Techniques & Chromatographic Methods** Principles and classification of separation techniques; solvent extraction including distribution law, partition coefficient and extraction efficiency; mechanisms of extraction including solvation and chelation; techniques including batch, continuous and counter-current extraction; applications in metal ion and organic compound separation. **Theory of Chromatographic Separation** Principles and classification of chromatography; chromatographic equilibria; stationary and mobile phases; adsorption, partition, ion-exchange, size-exclusion, and affinity mechanisms; retention parameters and selectivity; band broadening processes; plate theory and rate theory, column efficiency and resolution; factors affecting chromatographic separations and optimization of separation conditions; qualitative and	12

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	quantitative interpretation of chromatograms.	
IV	**Surface analysis** Introduction to surfaces and interfaces, Adsorption phenomena: physical adsorption and chemisorption, Factors affecting, adsorption, Adsorption kinetics and mechanisms, Concept of adsorption isotherms, Langmuir adsorption isotherm: applications, Freundlich adsorption isotherm: equation, significance, limitations, BET adsorption isotherm and surface area determination, Desorption processes and desorption isotherms, Experimental methods for adsorption–desorption studies and hysteresis loops.	12
V	**Thermal analysis:** Principles, instrumentation, methodology and applications of TGA, DTA and DSC. Interpretation of thermal curves, Determination of composition, purity and thermal stability, kinetic analysis of thermal decomposition, determination of activation energy, glass transition temperature, crystallization and melting phenomena.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Christian, G. D. (2004). *Analytical Chemistry* (6th ed.). John Wiley & Sons.
2. Day, R. A., & Underwood, A. L. (2001). *Quantitative Analysis* (6th ed.). Prentice Hall of India.
3. Ditts, R. V. (1974). *Analytical Chemistry: Methods of Separation*. Van Nostrand Reinhold.
4. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2014). *Fundamentals of Analytical Chemistry* (9th ed.). Cengage Learning.
5. Kapoor, K. L. (2013). *A Textbook of Physical Chemistry* (Vol. 5). Macmillan India.

C.7 Reference Books & Readings

1. Harris, D. C. (2020). *Quantitative Chemical Analysis* (10th ed.). W. H. Freeman.
2. Miller, J. N., & Miller, J. C. (2018). *Statistics and Chemometrics for Analytical Chemistry* (7th ed.). Pearson.
3. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). *Principles of Instrumental Analysis* (7th ed.). Cengage Learning.
4. Khopkar, S. M. (2018). *Basic Concepts of Analytical Chemistry* (4th ed.). New Age International.
5. Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (1988). *Instrumental Methods of Analysis* (7th ed.). CBS Publishers.

C.7 Suggested E-Resources / Digital Repositories

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1. SWAYAM / NPTEL: Courses on Analytical Chemistry, Instrumental Methods of Analysis, Separation Techniques, Chromatography, and Statistical Methods in Chemical Analysis.
2. e-PG Pathshala: Modules on Analytical Chemistry, Chromatography, Surface Chemistry, Thermal Analysis, and Environmental Analysis.
3. National Digital Library of India (NDLI): E-books, journals, theses, laboratory manuals, and learning resources in Analytical Chemistry.
4. INFLIBNET: Access to scholarly databases, e-journals, dissertations, and academic resources.
5. PubChem: Chemical structures, physicochemical properties, spectral data, and analytical information.
6. Royal Society of Chemistry (RSC) Education Resources: Learning materials on analytical techniques, chromatography, spectroscopy, and data analysis.
7. IUPAC Gold Book: Authoritative definitions and terminology in analytical chemistry and chemical measurements.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-GE106
Title of the Paper	General Elective I: Research Methodology
Programme / Subject	M.Sc. — Chemistry
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To introduce the fundamental concepts, types, and significance of research and develop an understanding of the research process.
COB 2	To familiarize students with various research designs, sampling techniques, and the formulation of research questions and hypotheses.
COB 3	To provide knowledge of primary and secondary data collection methods and the principles of validity and reliability.
COB 4	To develop skills in organizing, analyzing, interpreting, and presenting research data using basic statistical techniques and software tools.
COB 5	To promote ethical and responsible conduct of research, including awareness of plagiarism, intellectual property rights, and professional standards.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Formulate research problems, objectives, questions, and hypotheses, and identify appropriate research approaches for different investigations.

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CLO 2	Select and apply suitable research designs and sampling methods for conducting scientific studies.
CLO 3	Design and implement data collection tools such as questionnaires, interviews, observations, and case studies while ensuring data quality.
CLO 4	Organize, analyze, and interpret research data using descriptive statistical methods and appropriate software tools. Demonstrate ethical research practices by avoiding plagiarism, respecting intellectual property rights, and adhering to accepted ethical guidelines in research.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Research Methodology (MSCHE-GE106)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction** Definition and objectives of research, Types of research: Theoretical-experimental, basic-applied, qualitative-quantitative, Steps in the research process, Research questions and hypothesis formulation, Criteria and component of good research	12
II	**Research Design and Sampling** Research design: exploratory, descriptive, experimental, Variables and control groups, Sampling methods: probability and non-probability, Sample size determination, Limitations and delimitations	12
III	**Data Collection Methods** Primary and secondary data, Techniques: questionnaires, interviews, observation, case studies Survey tools and fieldwork, online and offline data collection, Validity and reliability of data	12
IV	**Data Analysis and Interpretation** Basics of data organisation, Introduction to descriptive statistics: mean, median, mode, standard deviation Graphical representation: tables, charts, graphs, Introduction to inferential statistics Use of software tools (e.g.MS Office, Chem Draw, Origin, SPSS/R/PAST–demo-based)	12
V	**Report Writing and Research Ethics** Structure of a research report/thesis, Referencing and citation styles, Referencing using software like Zotero, Mendeley (APA/MLA) Plagiarism, Intellectual property rights, patents and copyright, ethical issues in research	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th ed.). New Age International.

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2. Panneerselvam, R. (2014). *Research Methodology*. PHI Learning.
3. Kumar, R. (2019). *Research Methodology: A Step-by-Step Guide for Beginners* (5th ed.). Sage Publications.
4. Montgomery, D. C. (2019). *Design and Analysis of Experiments* (10th ed.). Wiley.
5. Gurumani, N. (2006). *Research Methodology for Biological Sciences*. MJP Publishers.

C.7 Reference Books & Readings

1. Day, R. A., & Gastel, B. (2016). *How to Write and Publish a Scientific Paper* (8th ed.). Cambridge University Press.
2. Wallwork, A. (2016). *English for Writing Research Papers* (2nd ed.). Springer.
3. Dawson, C. (2019). *Introduction to Research Methods* (5th ed.). Little, Brown Book Group.
4. Montgomery, D. C., & Runger, G. C. (2018). *Applied Statistics and Probability for Engineers* (7th ed.). Wiley.
5. Salkind, N. J. (2017). *Exploring Research* (9th ed.). Pearson.

C.7 Suggested E-Resources / Digital Repositories

1. **SWAYAM / NPTEL:** Courses on Research Methodology, Research Ethics, Scientific Writing, Statistics, and Experimental Design.
2. **e-PG Pathshala:** Modules on Research Methodology, Research Design, Data Analysis, Scientific Communication, and Research Ethics.
3. **Shodhganga / Shodhgangotri:** Research theses, dissertations, and research proposals across science disciplines.
4. **National Digital Library of India (NDLI):** E-books, theses, journals, research guides, and academic resources.
5. **INFLIBNET:** Access to scholarly databases, dissertations, and e-resources.
6. **Google Scholar:** Scholarly literature, citations, and research articles across disciplines.
7. **DOAJ (Directory of Open Access Journals):** Open-access peer-reviewed journals in chemistry and allied sciences.
8. **ORCID & Crossref:** Researcher identification, citation tracking, and scholarly publishing resources.
9. **COPE (Committee on Publication Ethics):** Resources on publication ethics, plagiarism, authorship, and responsible research practices.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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Semester II

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-CC201
Title of the Paper	Core Course I: Molecular Spectroscopy
Programme / Subject	MSc — Chemistry
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	**00**	**30**	**100**
Passing Marks	**32**	**00**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and Viva Voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the principles of major spectroscopic techniques.
COB 2	Explain molecular properties through spectroscopy.
COB 3	Apply spectroscopy for compound characterization.
COB 4	Interpret spectral data for structure determination.
COB 5	Correlate molecular structure with spectral behavior.

C.4 Course Outcomes (COs)

After completing the course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the interaction of electromagnetic radiation with matter.
CLO 2	Describe the principles of rotational, vibrational, and electronic spectroscopy.

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CLO 3	Understand the fundamentals of NMR and Mass Spectrometry.
CLO 4	Apply spectral rules and fragmentation patterns in analysis.
CLO 4	Integrate spectroscopic data for molecular structure elucidation.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Molecular Spectroscopy (MSCHE-CC201)		
Unit	**Content**	**Suggested Lectures hours**
I	**Rotational Spectroscopy** Interaction of electromagnetic radiation with molecules and various types of molecular spectra; Born–Oppenheimer approximation. Classification of molecules; rigid rotor model; effect of isotopic substitution on transition frequencies and intensities; non-rigid rotor model. Stark effect and Zeeman effect; nuclear and electron spin interactions and the effects of external fields. Applications of molecular spectroscopy. Quantization of rotational energy and interactions of radiation with rotators. Classification of rotators; rigid rotator and Non-rigid rotator linears, Symmetric top, symmetric and asymmetric rotators, isotopic effect, starck effect, effect of nuclear spin, and electron spin on rotational spectra. Determination of internuclear distance of diatomic molecule, dipolemoment, atomic mass of isotope, effect of bond distortion on rotational energies.	8
II	**Vibrational Spectroscopy:** **A. Infrared Spectroscopy-Theory:** Linear harmonic oscillator, vibrational energies of diatomic molecules, zero-point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P, Q, R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities. Infrared spectroscopy-application IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions). Effect of H-bonding, conjugation, resonance and ring size on IR absorptions, Fingerprint region and its significance, application in functional group analysis. *B. Raman Spectroscopy* Classical & quantum theories of the Raman effect .Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Rule of the mutual exclusion principle. Resonance Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy (CARS).	16
III	**UV Spectroscopy** Types of electronic transitions; absorption maxima (λ_{max}); chromophores and auxochromes; bathochromic and hypsochromic shifts; intensity of absorption. Application of Woodward–Fieser rules for the calculation of $\lambda_{max}$of α,β-unsaturated aldehydes, ketones, carboxylic acids, and esters; conjugated dienes	12

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	including alicyclic, homoannular, heteroannular, and extended conjugated systems. Distinction between cis and trans isomers using electronic spectroscopy.	
IV	**Magnetic Resonance Spectroscopy:** Proton Nuclear Magnetic Resonance (^{1}H NMR) spectroscopy: basic principles, chemical shifts and factors affecting them, spin–spin coupling, and coupling constants. spin-spin interaction and factors affecting its value. Spin Lattice relaxation and quantative treatment of relaxation, selection rule and relative intensities of line. Anisotropic effects in alkenes, alkynes, aldehydes, and aromatic systems. Interpretation and structural applications of ^{1}H NMR spectra of simple organic compounds. Principle of ESR spectroscopy, presentation of spectrum, theory of hyperfine, interaction, Isotopic g and ▲ values. PMR and CMR Spectroscopy Chemical shifts value and correlation for proton-bonded with carbon. Effect of chemical exchange on line width, coupling constants, Interpretation of PMR and CMR spectra of organic compounds. Double resonance application of 19F and 31P spectra of inorganic compounds.	14
V	**Mass Spectroscopy:** Basic fragmentation patterns in organic compounds; molecular ion peak, base peak, and metastable ions; McLafferty rearrangement. Examples of mass spectra of organic compounds. Nitrogen rule and index of hydrogen deficiency (IHD). Applications of fragmentation patterns in the characterization of organic compounds. Structure elucidation of organic compounds using spectral data. Combined applications of IR, UV–Visible, NMR, and mass spectrometry for the identification and structural characterization of simple organic molecules.	10
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Kemp, W. (2022). *Organic Spectroscopy* (3rd ed.). ELBS.
2. Banwell, C. N., & McCash, E. M. (2006). *Fundamentals of Molecular Spectroscopy* (4th ed.). Tata McGraw-Hill.
3. McQuarrie, D. A., & Simon, J. D. (1998). *Physical Chemistry: A Molecular Approach*. University Science Books.
4. Elementary Organic Spectroscopy by Y.R. Sharma
5. Spectroscopy of Organic Compounds by P S Kalsi.

C.7 Reference Books & Readings

1. **Silverstein, R. M., Bassler, G. C., & Morrill, T. C.** ***Spectrometric Identification of Organic Compounds.*** John Wiley & Sons.
2. Dyer, J. R. (2012). *Applications of Absorption Spectroscopy of Organic Compounds*. Prentice Hall India.
3. Rohatgi-Mukherjee, K. K. *Fundamentals of Photochemistry* (Revised 2nd ed.). New Age International.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM/NPTEL: Molecular Spectroscopy; Analytical Chemistry (NPTEL Courses)

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2. e-PG Pathshala: Chemistry Modules on Molecular Spectroscopy, UV-Visible Spectroscopy, IR Spectroscopy, NMR Spectroscopy, and Mass Spectrometry
3. NDL India: https://ndl.iitkgp.ac.in for e-books, journals, theses, and learning resources in spectroscopy and chemistry.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-CC202
Title of the Paper	Core Course II: Frontiers in Chemistry
Programme / Subject	MSc — Chemistry
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand key concepts in modern chemistry.
COB 2	Explain principles of nuclear, materials, and environmental chemistry.
COB 3	Apply chemistry to industrial and environmental problems.
COB 4	Analyze sustainable chemical processes.
COB 5	Evaluate chemistry-based solutions for global challenges.

C.4 Course Outcomes (COs)

After completing the course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain applications of nuclear chemistry.
CLO 2	Describe advanced materials and their uses.
CLO 3	Apply waste management and recycling concepts.

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CLO 4	Use green chemistry principles in problem-solving.
CLO 4	Analyze environmental issues and control measures.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Frontiers in Chemistry (MSCHE-CC202)		
Unit	**Content**	**Suggested Lectures hours**
I	**Nuclear Chemistry:** **Nuclear Structure and Reactions:** Shell Model and Liquid Drop Model of the nucleus; nuclear reactions and their classification; nuclear reaction cross-section. **Applications of Radioactivity:** Radioisotopes and their applications; tracer techniques; neutron activation analysis; isotope dilution method; nuclear reactors and their applications.	12
II	**Advanced materials** Nanomaterials: Definition, sources, examples, Bottom-up Method of synthesis, Solid State Chemistry Conducting Materials: Conductor, Semiconductor, and superconductor; Theory and Applications Industrial Application of Chemistry Industrial Materials: Chemistry of Cement, Paper and Pulp, and Petroleum	12
III	**Green Chemistry** **Fundamentals of Green Chemistry:** Definition, objectives, significance, and the twelve principles of Green Chemistry; atom economy in chemical synthesis; solvent-free reactions; microwave-assisted and ultrasound-assisted synthesis; renewable feedstocks and biosynthetic routes. **Green Processes and Applications:** Green reagents, solvents, and catalysts; organic waste management; industrial applications of Green Chemistry, including the use of CO_2 as a blowing agent in polystyrene production and supercritical CO_2/surfactant-assisted systems as alternatives to ozone-depleting solvents. Environmental and economic benefits of green technologies.	12
IV	**Environment Chemistry:** Atmosphere and Environment: Composition of the atmosphere; vertical temperature variation, heat budget, and atmospheric stability; biogeochemical cycles of carbon, nitrogen, phosphorus, sulfur, and oxygen; biodistribution of elements. Hydrological cycle and chemical composition of natural waters. Pollution Monitoring and Control: sources and types of water pollution including inorganic, organic, agricultural, industrial, sewage, detergent, and oil pollutants. Water quality parameters and standards; analytical methods for water quality assessment; water purification and treatment. Atmospheric particles, ions, and radicals; chemical and photochemical reactions, smog formation, greenhouse effect, and acid rain; pollutants arising from oxides of nitrogen, carbon, sulfur, petroleum products, minerals, and CFCs. Air pollution control measures and monitoring techniques.	12
V	**Waste Management:**	12

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Principles and practices of nuclear waste and electronic waste (e-waste) management. Recycling of plastics: collection, sorting, washing, shredding, identification and classification of plastic materials, and extrusion techniques for recycling and reuse.	
Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. West, A. R. (2014). Solid State Chemistry and Its Applications (2nd ed.). Wiley.
2. Callister, W. D., & Rethwisch, D. G. (2018). Materials Science and Engineering: An Introduction (10th ed.). Wiley.
3. Housecroft, C. E., & Sharpe, A. G. (2018). Inorganic Chemistry (5th ed.). Pearson Education.
4. Arnikar, H. J. (1987). Essentials of Nuclear Chemistry (2nd ed.). Wiley Eastern.
5. Das, A. K. (2014). Environmental Chemistry and Green Chemistry. Books and Allied (P) Ltd., Kolkata.
6. Kaur, H. (2010). Environmental Chemistry. Pragati Prakashan.

C.7 Reference Books & Readings

4. **Rao, C. N. R., Müller, A., & Cheetham, A. K. (Eds.). (2004).** ***The Chemistry of Nanomaterials: Synthesis, Properties and Applications.*** **Wiley-VCH.**
5. **Poole, C. P., & Owens, F. J. (2003).** ***Introduction to Nanotechnology.*** **Wiley-Interscience.**
6. **Austin, G. T. (2005).** ***Shreve's Chemical Process Industries*** **(5th ed.). McGraw-Hill.**
7. **Friendlander, G., Kennedy, J. W., & Miller, J. M. (1981).** ***Nuclear and Radiochemistry*** **(3rd ed.). Wiley.**
8. **Spinks, J. W. T., & Woods, R. J. (1990).** ***An Introduction to Radiation Chemistry*** **(3rd ed.). Wiley.**
9. **Manahan, S. E. (2017).** ***Environmental Chemistry*** **(10th ed.). CRC Press..**

C.7 Suggested E-Resources / Digital Repositories

1. **SWAYAM/NPTEL: Courses on Nuclear Chemistry, Materials Science, Nanotechnology, Environmental Chemistry, and Green Chemistry.**
2. **e-PG Pathshala: Chemistry modules on Nuclear, Materials, Environmental, and Green Chemistry.**
3. **NDLI: Digital repository of books, journals, theses, and learning resources.**
4. **INFLIBNET: Access to scholarly databases and academic resources.**
5. **DOAJ & PubChem: Open-access journals and chemical information databases.**
6. IAEA Resources: Digital resources on nuclear chemistry and radiochemistry.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

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- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-CC203
Title of the Paper	Core Course III: **Macromolecules**
Programme / Subject	MSc — Chemistry
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and Viva Voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the classification and properties of macromolecules.
COB 2	Explain polymerization mechanisms and molecular weight determination.
COB 3	Describe the structure and functions of biomacromolecules.
COB 4	Analyze the chemistry of vitamins and nucleic acids.
COB 5	Evaluate the synthesis and applications of silicon-based macromolecules.

C.4 Course Outcomes (COs)

After completing the course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Classify polymers and explain their polymerization processes.
CLO 2	Describe the structures of carbohydrates, proteins, and nucleic acids.
CLO 3	Apply molecular weight determination techniques to polymers.

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CLO 4	Analyze the structural features of biologically important macromolecules.
CLO 4	Evaluate the properties and applications of silicones, silicates, and zeolites.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Macromolecules (MSCHE-CC203)		
Unit	**Content**	**Suggested Lectures hours**
I	**Physico- chemical aspect of Macromolecules**: Classification of polymers; kinetics and mechanisms of polymerization reactions. Polymer molecular masses: number-average and weight-average molecular masses. Determination of polymer molecular masses using osmometric, viscometric, and light-scattering techniques.	12
II	**Carbohydrates** Conformation of mono saccharides and important derivatives of mono saccharides, deoxycosides, deoxysugar, aminosugar, disaccharides,structure determination and chemical synthesis of sucrose, maltose and lactose.	12
III	**Amino acids, peptides and proteins** Amino acids, essential and non-essential amino acids, isoelectric point, amino acids sequencing primary, secondary structure, a-helix, ß-sheet structure of protein and tertiary and quaternary structures of protein	12
IV	**Nucleic Acids:** Structure and properties of purine and pyrimidine bases, nucleosides, and nucleotides. Polynucleotide Structure: 3'-5' phosphor diester linkages and primary structure of DNA/RNA	12
V	**Silicon and Phosphorus Based Macromolecules:** **Silicones:** Synthetic routes, mechanisms of formation, curing processes, and thermal/mechanical properties. **Silicates and Alumino-silicates:** Structure and classification of silicates (ortho, pyro, cyclic, chain, sheet, and 3D frameworks). **Zeolites:** Structure, shape-selectivity, molecular sieving, and applications in catalysis and ion exchange	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Cowie, J. M. G., & Arrighi, V. (2007). *Polymers: Chemistry and Physics of Modern Materials* (3rd ed.). CRC Press.
2. Seymour, R. B., & Carraher, C. E. (2003). *Polymer Chemistry: An Introduction* (6th ed.). Marcel Dekker.
3. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2021). *Lehninger Principles of Biochemistry* (8th ed.). W. H. Freeman.
4. Berg, J. M., Tymoczko, J. L., Gatto, G. J., &Stryer, L. (2019). *Biochemistry* (9th ed.). W. H. Freeman.
5. Mark, J. E. (2007). *Physical Properties of Polymers Handbook* (2nd ed.). Springer.

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C.7 Reference Books & Readings

1. Billmeyer, F. W. (1984). *Textbook of Polymer Science* (3rd ed.). Wiley.
2. Odian, G. (2004). *Principles of Polymerization* (4th ed.). Wiley.
3. Voet, D., Voet, J. G., & Pratt, C. W. (2019). *Fundamentals of Biochemistry: Life at the Molecular Level* (6th ed.). Wiley.
4. Morrison, R. T., & Boyd, R. N. (2010). *Organic Chemistry* (7th ed.). Pearson Education.
5. Rochow, E. G. (1987). *Silicon and Silicones: About Stone-Age Tools, Antique Pottery, Modern Ceramics, Computers, Space Materials and How They All Got That Way*. Springer.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM/NPTEL: Courses on Polymer Chemistry, Biomolecules, Biochemistry, and Macromolecular Science.
2. e-PG Pathshala: Modules on Polymers, Carbohydrates, Proteins, Nucleic Acids, and Biomolecular Chemistry.
3. NDLI (National Digital Library of India): Access to books, lecture notes, journals, theses, and multimedia learning resources in chemistry.
4. INFLIBNET: Access to e-books, e-journals, research databases, and academic resources.
5. PubChem &ChemSpider: Open-access databases for chemical structures, properties, and molecular information.
6. DOAJ (Directory of Open Access Journals): Open-access journals in polymer, materials, and biochemical sciences.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-PC204
Title of the Paper	Core Course IV : Organic Chemistry Practical
Programme / Subject	M.Sc. — Chemistry
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	0 – 0 – 4
Credits	4

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CLO 3	Perform multistep organic syntheses following standard laboratory procedures.
CLO 4	Explain the reaction mechanisms involved in the synthesis of substituted aromatic compounds, azo compounds, and chalcones.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Organic Chemistry Practical (MSCHE-PC204)		
Unit	**Content**	**Suggested Lectures hours**
I	**Quantitative Analysis** Separation and identification of organic compounds in binary mixtures by chemical tests and preparation of their derivatives.	
II	**Organic Synthesis via two steps preparation** a. p-Nitroaniline from acetanilide. b. p-Nitroacetanilide from aniline. c. p-Bromoacetanilide from aniline. d. Anthranilic acid from phthalic anhydride. e. Synthesis of Azobenzene (Diazotization, Reduction/Coupling f. Synthesis of Chalcone (Aldol Condensation, Dehydration)	
III	Viva Voce	
IV	Note Book	
	Total Suggested Contact Hours For Practical Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

Vogel, A. I. (1989). *Vogel's Textbook of Practical Organic Chemistry* (5th ed.). Longman Scientific & Technical.

Mann, F. G., & Saunders, B. C. (2009). *Practical Organic Chemistry* (4th ed.). Pearson Education.

Mohrig, J. R., Hammond, C. N., Schatz, P. F., & Morrill, T. C. (2014). *Laboratory Techniques in Organic Chemistry* (4th ed.). W. H. Freeman and Company.

C.7 Reference Books & Readings

Ahluwalia, V. K., & Dhingra, S. (2004). *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*. Universities Press.

Leonard, J., Lygo, B., & Procter, G. (2013). *Advanced Practical Organic Chemistry* (3rd ed.). CRC Press.

Pavia, D. L., Lampman, G. M., Kriz, G. S., & Engel, R. G. (2014). *Introduction to Organic Laboratory Techniques: A Microscale Approach* (5th ed.). Cengage Learning.

C.7 Suggested E-Resources / Digital Repositories

National Programme on Technology Enhanced Learning (NPTEL). (n.d.). *Chemistry and Organic Chemistry Laboratory Courses*. Indian Institute of Technology (IITs) and Indian Institute of Science (IISc). Available at: https://nptel.ac.in

INFLIBNET Centre. (n.d.). *e-PG Pathshala: Chemistry*. Ministry of Education, Government of India. Available at: https://epgp.inflibnet.ac.in

National Digital Library of India (NDLI). (n.d.). *Digital Repository of Books, Laboratory Manuals, Research Articles, and Learning Resources in Chemistry*. Ministry of Education, Government of India. Available at: https://ndl.iitkgp.ac.in

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C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Practical Exam : 50 Marks (Attempt any two experiments)
- Viva Voce: 10 Marks
- Note Book : 10 Marks

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-GE205
Title of the Paper	Core Course: Applied Analytical Chemistry
Programme / Subject	M.Sc. — Chemistry
Semester	Semester II
Nature of Course	General Elective (GE)-2
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE : 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the principles and applications of modern analytical techniques.
COB 2	Explore chromatographic methods for chemical separation and analysis.
COB 3	Apply analytical methods in environmental, food, pharmaceutical, and forensic investigations.
COB 4	Examine thermal analysis techniques for material characterization.
COB 5	Develop knowledge of quality assurance and quality control in analytical laboratories

C.4 Course Outcomes (COs)

After completing the course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the principles and applications of chromatographic techniques.
CLO 2	Analyze environmental samples using standard analytical methods.
CLO 3	Detect adulterants, impurities, and contaminants in food and pharmaceutical products.

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CLO 4	Interpret thermal analysis data for diverse materials and applications.
CLO 4	Apply quality assurance and quality control practices in analytical laboratories.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Applied Analytical Chemistry (MSCHE-GE205)		
Unit	**Content**	**Suggested Lectures hours**
I	Chromatography techniques: Paper chromatography, thin-layer chromatography (TLC), column chromatography; gas chromatography (GC), gas-liquid chromatography (GLC), high-performance liquid chromatography (HPLC), ion chromatography (IC) and gel permeation chromatography (GPC). Mechanism of separation; development techniques including frontal, elution and displacement methods; qualitative and quantitative analysis; concept of chiral HPLC, detector systems and applications in chemical and biological analysis.	12
II	Environmental Analysis Environmental sampling and sample preservation; analysis of air, water, and soil; determination of physicochemical parameters (pH, conductivity, hardness, DO, BOD, COD); analysis of nutrients, heavy metals, and other pollutants; air quality monitoring; instrumental methods in environmental analysis; environmental quality standards; wastewater characterization and pollution assessment.	12
III	Food, Pharmaceutical and Forensic Analysis: Analysis of drugs, narcotic substances, poisons, and toxic materials; food adulteration and detection of common adulterants in milk, edible oils, spices, cereals, beverages, and other food products; chemical and instrumental methods for adulteration analysis; pharmaceutical adulteration and detection of adulterants and impurities in pharmaceutical products; applications of analytical techniques in food, pharmaceutical, and forensic investigations	12
IV	Application of Thermal analysis: Application in polymers(thermal stability, degradation, glass transition, crystallization, and melting behavior) catalysts (precursor decomposition, calcination, and activation studies) ceramics and metallurgical materials (phase transitions, oxidation, and sintering behavior) pharmaceutical materials: polymorphism, purity, and stability studies nanomaterials and composites	12
V	Quality Control and Quality Assurance: Concepts of QA and QC; Good Laboratory Practices; sampling and sample handling; calibration and standardization; analytical method validation; accuracy, precision, sensitivity, selectivity, detection and quantification limits; statistical quality control and control charts; analytical errors and their minimization; quality control in food, pharmaceutical, environmental, and industrial analysis.	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

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1. **Skoog, D. A., Holler, F. J., & Crouch, S. R. (2018). *Principles of Instrumental Analysis* (7th ed.). Cengage Learning.**
2. **Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2014). *Analytical Chemistry* (7th ed.). Wiley.**
3. **Harris, D. C. (2020). *Quantitative Chemical Analysis* (10th ed.). W. H. Freeman.**
4. **Dean, J. R. (2009). *Analytical Chemistry Handbook* (2nd ed.). McGraw-Hill.**
5. **Fifield, F. W., & Kealey, D. (2000). *Principles and Practice of Analytical Chemistry* (5th ed.). Blackwell Science.**

C.7 Reference Books & Readings

1. **Miller, J. N., & Miller, J. C. (2018). *Statistics and Chemometrics for Analytical Chemistry* (7th ed.). Pearson.**
2. **Snyder, L. R., Kirkland, J. J., & Dolan, J. W. (2010). *Introduction to Modern Liquid Chromatography* (3rd ed.). Wiley.**
3. **Haines, P. J. (Ed.). (2002). *Principles of Thermal Analysis and Calorimetry*. Royal Society of Chemistry.**
4. **Nollet, L. M. L., & Toldrá, F. (Eds.). (2018). *Handbook of Food Analysis* (3rd ed.). CRC Press.**
5. **Settle, F. A. (Ed.). (1997). *Handbook of Instrumental Techniques for Analytical Chemistry*. Prentice Hall.**

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM/NPTEL: Courses on Analytical Chemistry, Chromatography, Environmental Analysis, Quality Control, and Instrumental Methods.
2. e-PG Pathshala: Modules on Analytical Chemistry, Environmental Monitoring, Food Analysis, and Pharmaceutical Analysis.
3. NDLI (National Digital Library of India): Access to books, journals, theses, laboratory manuals, and learning resources in analytical chemistry.
4. Shodhganga/Shodhgangotri: Theses and research proposals in Analytical, Environmental, Pharmaceutical, and Forensic Chemistry.
5. INFLIBNET: Access to scholarly journals, e-books, dissertations, and scientific databases.
6. PubChem & ChemSpider: Open-access chemical databases for compound identification and analytical information.
7. EPA Environmental Monitoring Resources & WHO Water Quality Resources: Digital resources on environmental analysis, pollution monitoring, and quality standards.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCHE-GE206
Title of the Paper	Core Course: **Indian Knowledge System and Chemistry**
Programme / Subject	MSc — Chemistry
Semester	Semester II
Nature of Course	General Elective (GE)-2
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	NA	NA	70
Practical / Lab Work	NA	NA	NA	
Internal Assessment	NA	NA	30	30
Maximum Marks	**70**	00	**30**	**100**
Passing Marks	**32**	00	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand Indian concepts of matter and chemical phenomena.
COB 2	Explore Rasashastra and traditional chemical practices.
COB 3	Examine indigenous metallurgical and material technologies.
COB 4	Study traditional applications of chemistry in society and environment.
COB 5	Appreciate the scientific relevance of Indian knowledge systems.

C.4 Course Outcomes (COs)

After completing the course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain Indian theories of matter and substance classification.
CLO 2	Describe key processes and principles of Rasashastra.
CLO 3	Analyze traditional methods of metallurgy and materials preparation.

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CLO 4	Interpret indigenous chemical practices related to health, food, and environment.
CLO 4	Evaluate traditional knowledge using modern chemical principles.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Indian Knowledge System and Chemistry (MSCHE-GE206)		
Unit	**Content**	**Suggested Lectures hours**
I	**Foundations of Indian Chemical Thought:** Concept of Panchamahabhuta and its interpretative scientific perspectives, atomism in Vaisheshika philosophy (Paramanu theory), classification of substances and properties in classical Indian thought, knowledge of matter in Vedic and medieval literature	12
II	**Rasashastra and Chemical Traditions** Origin and development of Rasashastra, processes such as *Shodhana* and *Marana,* preparation and significance of Bhasma and Rasayana, apparatus and laboratory practices described in classical texts.	12
III	**Metallurgy and Materials Science:** Extraction and processing of metals:Iron, zinc, copper, and alloys, Corrosion resistance and preservation techniques, Traditional materials:Glass, ceramics, pigments, dyes	12
IV	**Chemical Practices in Society and Environment** Traditional chemical processes: Fermentation, food chemistry, natural products, textile and dyeing technologies, indigenous methods of water purification and environmental management, ethnochemical knowledge of natural substances.	12
V	**Case Studies in Traditional Knowledge and Applied Chemistry:** Study of selected case studies illustrating the chemical principles underlying traditional knowledge systems and indigenous technologies: Natural Dyes and Pigments in Mithila Paintings, Traditional Ink (Masi) Preparation, Makhana Processing Technology, Traditional Fermentation Technologies, Ethnochemistry of Medicinal Plants, Indigenous Water Purification Systems, Ayurvedic Bhasma Preparation, Traditional Soil Fertility Management, Natural Resin and Lac Technology, and Traditional Food Preservation Technologies. The case studies will highlight the relationship between traditional practices and modern concepts in chemistry, materials science, environmental science, food technology, and sustainable development. (Any three case studies from the above list shall be taught in detail.)	12
	Total Suggested Lectures	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. **Ray, P. C. (1956).** ***A History of Hindu Chemistry*** **(Vol. I). The Asiatic Society.**
2. **Ray, P. C. (1956).** ***A History of Hindu Chemistry*** **(Vol. II). The Asiatic Society.**
3. **Subbarayappa, B. V. (2001).** ***The Roots of Ancient Indian Science.*** **University Press.**

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4. **Chattopadhyaya, D. (1991). *History of Science and Technology in Ancient India*. Firma KLM.**
5. Balasubramaniam, R. (2002). *The Saga of the Delhi Iron Pillar*. Aryan Books International.

C.7 Reference Books & Readings

1. **Vagbhata. (2003). *RasaratnaSamuccaya* (Translated Edition). Chaukhambha Sanskrit Series.**
2. ***Rasarnava* (Translated Edition). Chaukhambha Sanskrit Series.**
3. **Sharma, P. V. (2014). *Charaka Samhita* (Revised Edition). Chaukhambha Orientalia.**
4. **Sharma, P. V. (2014). *Sushruta Samhita* (Revised Edition). Chaukhambha Visvabharati.**
5. **Kak, S. (2014). *Matter and Mind*. MunshiramManoharlal Publishers.**

C.7 Suggested E-Resources / Digital Repositories

8. SWAYAM/NPTEL: Courses on Indian Knowledge Systems, History of Science, Metallurgy, Materials Science, and Environmental Studies.
9. e-PG Pathshala: Modules on Indian Knowledge Systems, History of Science, Traditional Technologies, and Chemistry.
10. NDLI (National Digital Library of India): Access to books, manuscripts, research articles, and learning resources on Indian science and technology.
11. INFLIBNET: Access to e-books, e-journals, dissertations, and scholarly databases.
12. Digital Library of India & Internet Archive: Classical texts on Rasashastra, Ayurveda, Indian metallurgy, and history of science.
13. CSIR-NIScPR& Indian Journal of History of Science: Research articles on the history of Indian science, technology, and chemical traditions.
14. Ayush Research Portal: Digital resources on Ayurveda, Rasashastra, medicinal plants, and traditional knowledge systems.

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

Note:*Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*
For fulfilment of the programme requirements, a student shall be required to successfully complete any one of

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the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

PART D — GENERAL REGULATIONS & PROVISIONS

D.1 Attendance & Eligibility

- A student must have a minimum of 75% attendance in each paper to be eligible to appear in the Semester / Annual Examination.
- Condonation of attendance deficiency shall be governed by the Regulation..
- A student detained due to shortage of attendance may appear to the examinations of same semester in the next academic session subject to payment of prescribed fees.

D.2 Examination & Promotion Rules

- A student is required to clear **at least**60%(4 out of 6) papers of a particular Semester before being promoted to the succeeding Semester.
- Back / Ex-Student candidates shall be governed by the rules in force at the time of their original admission unless otherwise specifically notified.
- A candidate who fails in one or more papers shall be required to appear only in the failed paper(s) (Carry Forward System) in subsequent examinations of the same Semester.
- A candidate is required to clear all his papers within a maximum of **Five Years of duration** to qualify for the degree.

D.3 Grading System (CBCS)

Letter Grade	% Range	Grade Point	Performance Description	Remarks
O	≥90-100	10	Outstanding	Pass
A+	≥80<90	9	Excellent	Pass
A	≥70<80	8	Very Good	Pass
B+	≥60<70	7	Good	Pass
B	≥55<60	6	Above Average	Pass
C	≥50<55	5	Average	Pass
P	≥45<50	4	Pass	Pass
F	<45	0	Fail	Fail
Ab/M	0	0	Absent/Malpractice	Fail / Reappear

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PART E — ABBREVIATIONS & AUTHENTICATION

E.1 List of Abbreviations

Abbr.	Expansion	Abbr.	Expansion
CC	Core Course	**DSE**	Discipline Specific Elective
GE	Generic Elective	**OE**	Open Elective
AEC	Ability Enhancement Course	**VAC**	Value Added Course
SEC	Skill Enhancement Course	**IKS**	Indian Knowledge System
L	Lecture (hours per week)	**T**	Tutorial (hours per week)
P	Practical (hours per week)	**IA**	Internal Assessment
CCA	Continuous & Comprehensive Assess.	**CLO**	Course Learning Outcome
PLO	Programme Learning Outcome	**GA**	Graduate Attribute
NHEQF	National HE Qualifications Framework	**PROJ**	Project / Dissertation

E.2 Authentication

Subject Expert-1
Prof. Kalpana Shahi
Professor, Department of Chemistry
Patliputra University, Patna
Date: 15.6.26

Subject Expert-2
Dr. Dimple Kumari
Department of Chemistry
College of Commerce, Arts and Science, Patna, Patliputra University, Patna
Date: 15.6.2026

Subject Expert-3
Dr. Sonu Ram Shankar
University Department of Chemistry
Tilka Manjhi Bhagalpur University, Bhagalpur
Date: 15-6-26

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