Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

Examination Scheme and Syllabus

For

Post Graduate Programme

M.Sc. Chemistry

As per National Education Policy 2020 (NEP 2020)

Curriculum and Credit Framework for Post Graduate Programme
With Multiple Entry-Exit, Internship and CBCS-LOCF

With effect from the Session 2025-26
(In phased manner)

DEPARTMENT OF CHEMISTRY
FACULTY OF PHYSICAL SCIENCES
CHAUDHARY BANSI LAL UNIVERSITY, BHIWANI – 127031,
HARYANA, INDIA

Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

Summary of the Programme	
Name of Programme	M.Sc. Chemistry
Duration	2 Years (4 Semesters) Full Time
Maximum Duration	4 Years
Total Credits	100
Total Marks	2420
Passing Criteria	The pass percentage will be 40% both for theory and practicum End-Term Examination. A student has to obtain minimum 40% marks in aggregate (sum of the Internal Assessment and End-Term Examination marks) and in End-Term Examination separately to qualify a course
Medium of Instructions and Examinations	English
Minimum Attendance Requirement	75% per course
Internship	4-6 Weeks
For Other Details	See Ordinance for PG Programme

PROGRAMME LEARNING OUTCOMES

The graduate on completion of Master in Chemistry programme will be able to:

PLO 1	Demonstrate advanced knowledge about chemistry with a critical understanding of the emerging developments and issues relating to the learners domain area.
PLO 2	Demonstrate advanced knowledge and understanding of principles, methods, and techniques applicable to the chosen field of study.
PLO 3	Demonstrate the capacity to extrapolate the acquired knowledge and skills to real-life situations and apply acquired competencies in new/unfamiliar contexts.
PLO 4	Demonstrate the ability to apply the acquired conceptual, operational or technical knowledge and a range of cognitive and practical skills to identify and address problemsrelated to the chosen field of learning.
PLO 5	Demonstrate and apply the advanced knowledge relating to research methods to carryout research and investigations to formulate evidence-based solutions to complex and unpredictable problems in the field of Chemistry.
PLO 6	Demonstrate the ability to communicate, in a well-structured manner the findings/ results of the research studies undertaken in the field of Chemistry.
PLO 7	Pursue self-paced and self- directed learning to upgrade knowledge and skills, including research-related skills avoiding unethical practices.

Semester II

Couse Code	Course Type	Nomenclature of the Course	Course Level	Theory (Th)/ Practical (P)/ Internship(I)	Credits	Total Credits	Contact Hours per Week L: Lecture P: Practical T: Tutorial				Examination Scheme			Examination Hours for Internal Examinations	Examination Hours for End Term Examinations
							L	T	P	Total	Internal Assessment Marks (185)	End Term Marks (505)	Total Marks (700)		
25PN-CHE-201	CC	Inorganic Chemistry-II	500-599	Th	4	26	4	0	0	4	30	70	100	1.5	3
25PN-CHE-202	CC	Physical Chemistry-II	500-599	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-203	CC	Organic Chemistry-II	500-599	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-204	DEC	Spectroscopy	500-599	Th	3		3	0	0	3	20	50	70	1.5	3
25PN-CHE-205	PC	Practical-IV Inorganic Chemistry Practical	500-599	P	3		0	0	6	6	20	50	70	3	6
25PN-CHE-206	PC	Practical-V Physical Chemistry Practical	500-599	P	3		0	0	6	6	20	50	70	3	6
25PN-CHE-207	PC	Practical-VI Organic Chemistry Practical	500-599	P	3		0	0	6	6	20	50	70	3	6
25PN-CHE-	PC	Internship*	-	I	0		-	-	-	-	-	-	-	-	-

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V.A.C. / I.K.S.	V.A.C. / I.K.S.	To be opted from pool	500-599	Th/P**	2		-	-	-	2**	15**	35**	50	1	2

Note(s) and Abbreviations: CC = Core Course, DEC = Discipline Elective Course, PC= Skill Enhancement Course, V.A.C. = Value Added Course, I.K.S. = Indian Knowledge System. All the PC course(s) are based on the theory papers.

***Internship:** The students in summer break will do internship for 4-6 weeks duration in Academic/Industry/Company/Research Institute to increase their skills for employability/to enhance research aptitude. The internship will be evaluated by the Internship Monitoring Committee.

**Hours may increase or decrease depending upon the course chosen by the students whether it is theory or practical or combination of theory and practical. Internal and End Term Examination Marks may change as per chosen subject.

Exit Option: Students exiting the programme after second semester shall be awarded Postgraduate Diploma in Chemistry after qualifying all courses including Internship. A maximum of 10% students are allowed to exit for diploma. For other details, see ordnance for PG Programme.

	• Preparation of benzanilide from aniline. • Preparation of p-bromoacetanilide from acetanilide. • Preparation of tribromoaniline from aniline. • Preparation of p-nitroacetanilide from Acetanilide. • Preparation of benzene-azo-β-naphthol by diazotization. • Preparation of adduct of anthracene and maleic anhydride by Diels-Alder reaction. Any other reaction as per requirement **Note:** Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
	Total Contact Hours	**90**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
• Class Participation	5	• Demonstration	15+15
• Demonstration	5	• Laboratory Record	10
• Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Clarke, H.T. & revised by Haynee, B. Edward Arnold, *A Hand book of Organic Analysis -Qualitativeand Quantitative,* London (1975).
2. Furhen, B.S., *Vogel's Text Book of Practical Organic Chemistry*, Longman.
3. Middleton, H., *Systematic Qualitative Organic Analysis,* Edward Arnold (Publishers) Limited, London(1959).
4. Vogel, A. I., *Elementary Practical Organic Chemistry*, EX CBS Publishers and Distriibutors (1957).
5. Louis, F., Fieser, D.C., *Experiments in Organic Chemistry,* Heath and Company Boston (1955)
6. Vishnoi, N.K., *Advanced Practical Organic Chemistry*, Vikas Publishing 3rd ed. (2009).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Inorganic Chemistry-II		
Sub-Nomenclature of the Course (if any)	Fundamental Concepts of Inorganic Chemistry		
Course Code	25PN-CHE-201		
Course Type	CC-1		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand the fundamental concepts of magneto-chemistry and explore its applications in the structural determination of coordination compounds. CLO 2: Understand the principles of electronic spectra in transition metal complexes, including term symbols, Orgel and Tanabe-Sugano diagrams, Racah and nephelauxetic parameters, Jahn-Teller effects, and charge transfer spectra. CLO 3: Describe the synthesis, structural features, chemical properties, and reactivity of metal π-complexes. CLO 4: Classify metal boranes, carboranes, metalloboranes, and metallocarboranes, and understand their structural and chemical characteristics.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Examination Marks	70	0	70
Maximum Marks	100	0	100
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Magnetic Properties of transition metal complexes:** Elementary theory of magneto-chemistry, dia, para, ferro and antiferro magnetism, concept of magnetic susceptibility, methods for determination of magnetic susceptibility, Curie and Curie-Weiss law	**15**

	for temperature dependence of magnetic susceptibility, temperature independent paramagnetic, calculation of magnetic moments of metal ions Cr^{3+}, Co^{3+}, Mn^{2+} and Fe^{2+}, Linde factor, μ and μ , orbital contribution to the magnetic moment, quenching of magnetic moment by crystal-field, application of magneto-chemistry in structure determination, magnetic exchange coupling and spin state crossover in coordination compounds.	
II	**Electronic Spectra of Transition Metal Complexes:** Spectroscopic ground states, spin-orbit coupling in free metal ions for 3d- series of transition metals, ground state terms for transition metals/ions, Racah parameters and nephalauxetic effect, orgel diagrams (d1 to d10) and Tanabe-Sugano diagrams for transition metal complexes (d1&d2states), elementary concept of Dq, B and β parameters, effect of Jahn Teller distortion on electronic spectra of 3d-series metal complexes, charge transfer spectra, electronic spectra of molecular addition compounds of iodine.	**15**
III	**Metal л-Complexes:** 18-electron rule, counting methods and ligand contributions, haptoligands with hapticity from two to eight, Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, Low nuclearity carbonyl clusters (LNCC), High nuclearity carbonyl clusters (HNCC), clusters having interstitial atoms, electron counting schemes for high nuclearity clusters, polyhedral skeletal electron pair approach/Mingo's rules, important chemical reactions of metal carbonyls, preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand	**15**
IV	**Boranes:** Introduction, Nomenclature, synthesis and properties of some important members (B_2H_6, B_4H_{10}, B_5H_9, B_5H_{11} and $B_{10}H_{14}$), bonding in Boranes, STYX code, Borane anions; **Carboranes:** Introduction, general methods of preparations and important properties, Polyhedral skeletal electron pair theory, Metalloboranes and metallocarboranes :Introduction, general methods of preparation and properties, Isolobal analogy, Metal carbonyl and halide clusters, introduction, Structure and bonding of compounds having M-M bonds, calculation of M-M bond.	**15**
	Total Contact Hours	**60**

Suggested Evaluation Methods

Internal Assessment Marks: 30		End Term Examination Marks: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Presentation/Assignment/Quiz/Class Test/ Seminar	10		
• Mid-Term Examination	15		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Magneto Chemistry by R.L. Carlin.
2. Introduction to Magneto Chemistry by A. Earnshasw.

3. Inorganic Chemistry by Shriver and Atkins.
4. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
5. Inorganic Chemistry, J.E. Huhey, Harper & Row.
6. Organometallic Chemistry; R.C. Mehrotra and A.Singh, New Age International.
7. Basic Organometallic Chemistry: Concepts, Syntheses and Applications by B.D. Gupta and A.J. Elias.
8. Comprehensive Coordination and Organometallic Chemistry by D. Singh.
9. Concepts and Models of Inorganic Chemistry; B. Douglas, D.H.McDaniel and J.J. Alexander; John Wiley. 1
10. The Organometallic Chemistry of the Transition Metals; R.H. Crabtree, John Wiley

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Physical Chemistry-II		
Sub-Nomenclature of the Course (if any)	Statistical Mechanics for Chemist, Chemical Dynamics and Photochemistry		
Course Code	25PN-CHE-202		
Course Type	CC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Significance of statistic mechanics and its various tool to understand real world problem. CLO 2: Discussion of various theories for understanding the rate of chemical reaction such as Arrhenius, Collision theory & activated complex theory CLO 3: Realization of statistics mechanics through the result of quantum mechanics and its application to evaluate thermodynamic properties for bulk system CLO 4: Understanding laws of photochemistry and kinetics of photophysical processes.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Examination Marks	70	0	70
Maximum Marks	100	0	100
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Statistical Mechanics** Introduction, Microstates and Macrostates, Concept of distribution, Thermodynamic probability & most probable distribution for Maxwell Boltzmann statistics, Bose-Einstein & Fermi Dirac statistics, identification of the constant α and β, partition function and its significance, Application of Bose- Einstein statistics for a photon gas, Application of Femi-Dirac statistics, Partition	**15**

	function, Multiplication theorem of partition function, Thermodynamic properties in terms of partition function.	
II	**Statistical Thermodynamics:** Expression for Translational, Rotational, Vibrational, Nuclear and Electronic partition function, Thermodynamic properties of monoatomic ideal gas: Sackur Tetrode equation, Thermodynamic properties of diatomic ideal gas: (evaluation of energy, entropy, heat capacity etc.), Zero point energy for vibrational motion, Thermodynamic properties of polyatomic ideal gas: Linear molecule & Non Linear molecule (Rotational contribution and vibrational contribution towards energy and entropy)	**15**
III	**Chemical Dynamics:** Effect of temperature on reaction rates, Arrhenius equation, Collision theory of reaction rates, thermodynamic formulation of activated complex theory, correlation between various theories of reaction rates. Enzymatic reaction: Michaelis - Menton treatment, evaluation of Michaelis's constant for enzyme - substrate binding by Lineweaver - Burk plot, Concept of inhibition. Chain reactions (Formation of HBr & HCI, decomposition of acetaldehyde & ethane), apparent activation energy, chain length, Rice- Herzfeld mechanism (acetaldehyde).	**15**
IV	**Photochemistry** Laws of photochemistry: (Grothus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beer's law), quantum yield, quantum efficiency and reasons for high and low quantum yields, singlet and triplet state, Jablonskii diagram, photophysical processes: (radiative and non- radiative) fluorescence, phosphorescence and chemiluminescence, The photostationary state: Stern Volmer equation, Photochemical reactions: photoreduction, photo-oxidation, photodimerization, photochemical substitution and photosensitized reaction.	**15**
	Total Contact Hours	**60**

Suggested Evaluation Methods			
Internal Assessment Marks: 30		End Term Examination Marks: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Presentation/Assignment/Quiz/Class Test/ Seminar	10		
• Mid-Term Examination	15		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Atkins, P., Paula, J., Keeler, J., Atkins' Physical Chemistry Thermodynamics and Kinetics, Oxford University Press 11th ed. (2018).
2. Rastogi, R. P. & Misra, R. R, An Introduction to Chemical Thermodynamics, Vikas Pub. 6th Revised ed. (6/e) (2000)
3. Glasstone, S., Thermodynamics for Chemists, Narahari Press (2007)

4. Laidler, K.J., Chemical Kinetics, McGraw Hill 2nd ed. (1965).
5. Kapoor, K.L., A Textbook of Physical Chemistry Vol 5-Dynamics of chemical Reaction, Tata Mc Graw Hill (2014).
6. Rohtagi-Mukherjee, K. K., Fundamentals of photochemistry, New Age International (2018)
7. Turro, N. J., Ramamurthy, V., Scaiano, J. C., Principles of molecular photochemistry An Introduction, University Science Books 1st ed. (2009)
8. Wardle, B., Principles and Applications of Photochemistry, John & Wiley (2009)
9. Hill, T. L., An Introduction to Statistical Thermodynamics, Dover Publications (2012)
10. Upadhayay, S. K.,. Chemical Kinetics and Reaction Dynamics, Springer Science & Business Media (2006).
11. Nash, L. K., Elements of Statistical Thermodynamics, Courier Corporation (2006)
12. Puri, B. R., Sharma, L. R., Pathania, M. S., Principles of Physical Chemistry. Vishal Publishing Company (2008).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Organic Chemistry-II		
Sub-Nomenclature of the Course (if any)	Reaction Mechanism & Rearrangements		
Course Code	25PN-CHE-203		
Course Type	CC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: In-depth understanding of aromatic electrophilic and nucleophilic substitution reactions CLO 2: Fundamental and advanced knowledge of elimination reactions CLO 3: In-depth understanding of electrophilic addition reaction of alkenes, alkynes and allenes and thorough knowledge of the addition, substitution and condensation reactions of carbonyl compounds CLO 4: Thorough understanding of various rearrangement reactions and their applications in synthesis		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Examination Marks	70	0	70
Maximum Marks	100	0	100
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Aromatic Electrophilic Substitution:** The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Diazonium coupling, Gattermann-Koch reaction, Vilsmeir-Haak reaction, Reimer-Tiemann reaction, Fries rearrangement. **Aromatic Nucleophilic Substitution:** The ArSN1, ArSN2, Benzyne and SRN1 mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophile. The von Richter and Smiles	**15**

	rearrangements.	
II	**Elimination Reactions:** The E1, E2 and E1cB mechanisms. Orientation Effects in Elimination Reactions, Reactivity –effects of substrate structures, attacking base, the leaving group and the medium. Saytzeff and Hoffman rules, Stereochemistry of E2 elimination reactions and eclipsing effects in E2 eliminations. **Addition to Carbon-Carbon Multiple Bonds:** Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio– and chemoselectivity, orientation and reactivity. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.	**15**
III	**Addition to Carbon-Hetero Multiple Bonds:** Reactivity of carbonyl compounds towards addition. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and α, β-unsaturated carbonyl compounds, Wittig reaction. Mechanism of metal hydride reduction (LiAlH4 and NaBH4) of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Robinson, Reformatsky, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides.	**15**
IV	**Rearrangements:** Classification and general mechanistic treatment of nucleophilic, free radical and electrophilic rearrangement, Wagner-Meerwein, Pinacol-pinacolone, Benzil-benzilic acid, Favorskii, Steven, Wittig, Neber, Wolff, Beckmann, Hoffmann, Curtius, Lossen, Schmidt, Bayer-Villger.	**15**
	Total Contact Hours	**60**

Suggested Evaluation Methods

Internal Assessment Marks: 30		End Term Examination Marks: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Presentation/Assignment/Quiz/Class Test/ Seminar	10		
• Mid-Term Examination	15		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Sykes, P., A Guide Book to Mechanism in Organic Chemistry, Pearson 6th ed. (2003)
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Prentice –Hall 6th ed. (2001)
3. March, J., Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley 6th ed. (2007).
4. Clayden, J., Greeves, N., Warren, S. & P. Wothers Organic Chemistry, Oxford University Press (2001)
5. Wade, L. G., Siemek, J.W., Organic Chemistry, Pearson (2017)
6. Solomons, G. & Fryhle, C., Organic Chemistry, John Wiley 7th ed. (1999)
7. McMurry, J., Organic Chemistry, Mary Finch 8th ed. (2012)
8. Pine, S.H., Organic Chemistry, McGraw Hill 5th ed. (1987)
9. Mukherji, S. M. & Singh, S. P., Reaction Mechanism in Organic Chemistry, Macmillan 3rd ed. (1984)

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Spectroscopy		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-204		
Course Type	D.E.C.		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Advance knowledge of electronic and infrared spectroscopy CLO 2: Understanding of NMR and its application to organic compounds in identification CLO 3: Understanding of mass spectrometry to determine the molecular mass of the organic compounds CLO 4: Ability to understand about C-13 NMR spectroscopy		
Credits	Theory	Practical	Total
	3	0	3
Teaching Hours per Week	3	0	3
Internal Assessment Marks	20	0	20
End Term Examination Marks	50	0	50
Maximum Marks	70	0	70
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 4 questions, selecting one question from each unit and the compulsory question. All other questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Electronic Spectroscopy:** Introduction and understanding of UV-Visible phenomenon, theory of electronic spectroscopy, instrumentation and sampling, solvents effects, conjugation effects, the chromophore and auxochrome concepts, rules for prediction of wavelength, applications of electronic spectroscopy – dienes, polyenes, carbonyl compounds, benzene and its substituted derivatives, aromatic hydrocarbon other than benzene, heterocyclic systems and stereochemical factors in electronic spectroscopy. **Infrared Spectroscopy:** Principle, units of frequency, wavelength and wavenumber; molecular vibrations, factors influencing vibrational frequencies, Instrumentation – dispersive and interferometric instruments; sampling techniques, applications of IR –	**15**

	identity by fingerprinting and functional groups of different organic molecules; quantitative infrared analysis; attenuated total reflectance and multiple internal reflectance.	
II	**Nuclear Magnetic Resonance Spectroscopy:** Introduction, nuclear spin states, nuclear magnetic moments, resonance, population densities, chemical shift and shielding mechanism; instrumentation, chemical equivalence, integrals and integration, chemical environment & chemical shift, local diamagnetic shielding, magnetic anisotropy, spin-spin splitting, Pascal's triangle, comparison of spectra at low and high field strengths, spin-spin coupling – symbols, mechanism, types, role of magnetic equivalence, concept of non-equivalence within a group, measuring coupling constant from first-order and second-order spectra, coupling in aromatic and heteroaromatic system, spectra of homotopic, enantiotopic and diastereotopic systems. Applications of NMR in structure elucidation of organic compounds.	**15**
III	**Mass Spectrometry:** Introduction, ion production - EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Nitrogen rule, molecular weight determination molecular formula from isotopic ratio data, isotope profile of halogen compounds, factors affecting reaction pathways, fragmentation pattern - simple cleavage, retro-Diels Alder, Hydrogen transfer rearrangement like scrambling, ortho effect, McLafferty rearrangement, fragmentation patterns of hydrocarbons, alcohols, phenols, ethers, aldehydes, ketones, esters, carboxylic acids, amines, nitro, amides and nitriles. **Carbon-13 NMR Spectroscopy and Heteronuclear Coupling:** General considerations, carbon-13 nucleus, chemical shift and its calculation, proton-coupled and -decoupled carbon-13 spectra, nuclear overhauser enhancement, cross-polarization, problems with integration, molecular relaxation process, off- resonance decoupling; distortionless enhancement by polarization transfer, heteronuclear coupling of carbon to deuterium, fluorine and phosphorus.	**15**
	Total Contact Hours	**45**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Theory	20	➢ Theory:	50
• Class Participation:	5	Written Examination	
• Presentation/Assignment/Quiz/Class Test/ Seminar	5		
• Mid-Term Examination	10		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Pavia, D.L., Lampman, G.M. & Kriz, S., *Introduction to Spectroscopy- A Guide for Students of Organic Chemistry*, Fort Worth Harcourt Brace College Publishers, 3rd ed. (2001).
2. Silverstein, R. M., Bassler, G.C. & Morrill, T. C., *Spectrometric Identification of OrganicCompounds*, John Wiley 3rd ed. (1991).
3. Dyer, J. R., *Application of Spectroscopy of Organic Compounds,* Prentice Hall (1978).
4. Williams, D. H., Fleming, I., *Spectroscopic Methods in Organic Chemistry,* Tata McGraw-Hill 4thed. (1989).
5. Kalsi, P.S., *Spectroscopy of Organic Compounds* New Age International 6th ed. (2007).
6. Kemp, W., *Organic Spectroscopy*, Macmillan (1975).

7. Das, K. G., & James, E.P., *Organic Mass Spectrometry* Oxford & IBH Publishing (1976).
8. Mohan, J., *Organic Spectroscopy (Principles & Applications),* CRC Press (2004).
9. Roboz, J., *Introduction to Mass Spectrometry: Instrumentation and Techniques*, Interscience (1968).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Practical-IV Inorganic Chemistry Practical		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-205		
Course Type	SEC		
Level of the course	P.C.		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand the principles of gravimetric analysis and apply them to perform calculations and accurately separate and determine binary mixtures of metal ions using gravimetric and volumetric methods. CLO 2: Understand cerimetry to determine the strengths of ferrous, oxalate, and nitrite ions (by direct and indirect methods). CLO 3: Synthesize selected metal acetylacetonato complexes using green chemistry approaches and understand their relevance in environmentally friendly practices. CLO 4: Face Viva-Voce		
Credits	Theory	Practical	Total
	0	3	3
Teaching Hours per Week	0	6	6
Internal Assessment Marks	0	20	20
End Term Examination Marks	0	50	50
Maximum Marks	0	70	70
Examination Hours for End Term Examinations	0	6	6
Examination Hours for Internal Examinations	0	3	3

Part B - Contents of the Course

Instructions for Paper Setter for End Term Examination: The examiner will ask 2 experiments to demonstrate from the list of experiments. Separate experiments can be designed by examiner for each student.

Unit	Topics	Contact Hours
	1. Quantitative Inorganic Analysis a) Separation and determination of two metal ions via volumetric and gravimetric method: Cu-Ni, Cu-Zn, Cu-Al, Cu-Ag, Ca-Ba, Fe-Ni, Ni-Zn etc. b) Determination by Cerimetry: Ferrous; Oxalate; Nitrite etc. **2. Green methods of preparation of the following:** a) Bis(acetylacetonato)zinc(II) b) Bis(acetylacetonato)chromium(II)	**6 Hours per Week**

	Note: Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
	Total Contact Hours	**90**

Suggested Evaluation Methods			
Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
• Class Participation	5	• Demonstration	15+15
• Demonstration	5	• Laboratory Record	10
• Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Applied Analytical Chemistry by O.P. Vermani.
3. Vogel's Quantitative Chemical Analysis by J. Mendham.
4. Vogel's Qualitative Inorganic Analysis by G. Svehla.
5. Practical Inorganic Chemistry by Marr and Rockett.
6. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and S.R. Crouch.
7. Quantitative Chemical Analysis by D.C. Harris.

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Practical V - Physical Chemistry Practical		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-206		
Course Type	P.C.		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Able to handle the instrument potentiometer by performing various types of titration reaction and to understand the chemistry used to determine the potential set up between two electrodes. CLO 2: Realization of the concept of activation energy, temperature coefficient by determination of rate of reaction with the help of chemical kinetics CLO 3: Understand the concept of heat of solution via calorimetric experiments, Develops an idea about the determination of molar masses of Volatile & Non-Volatile substances. CLO 4: Understanding the laboratory etiquettes to perform experiment, analyse the data and compilation of experimental information in the practical notebook.		
Credits	Theory	Practical	Total
	0	3	3
Teaching Hours per Week	0	6	6
Internal Assessment Marks	0	20	20
End Term Examination Marks	0	50	50
Maximum Marks	0	50	70
Examination Hours for End Term Examinations	0	6	6
Examination Hours for Internal Examinations	0	3	3

Part B - Contents of the Course

Instructions for Paper Setter for End Term Examination: The examiner will ask 2 experiments to demonstrate from the list of experiments. Separate experiments can be designed by examiner for each student.

Unit	Topics	Contact Hours
I	**Potentiometry** 1. Determine the strength of strong acid by titration with standardized strong base. 2. Determine the strength of weak acid by titration with	**6 Hours per Week**

	standardized strong base. 3. Determine the strength of ferrous ammonium sulphate solution by titration with $K_2Cr_2O_7$ solution. 4. Study the precipitation titration between KCl and $AgNO_3$ potentiometrically. **Chemical Kinetics** 1. Determination of rate constant of hydrolysis of methyl acetate or ethyl acetate at room temperature. 2. Determination of temperature coefficient and activation energy for the ester hydrolysis in acidic medium. 3. To study the saponification reaction of ethyl acetate . sodium hydroxide solution kinetically. **Thermochemistry** 1. Determine the heat of neutralization of strong acid and strong base. 2. Determine the heat of neutralization of weak acid and strong base. **Molar Mass Determination** 1. Determination of molar masses of Volatile Substances by Victor-Meyer's method. 2. Determination of molar masses of Non-Volatile Substances by Landsberger method. **Note:** Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
		Total Contact Hours **90**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
• Class Participation	5	• Demonstration	15+15
• Demonstration	5	• Laboratory Record	10
• Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. James, A.M. & Prichard, F.E., Practical Physical Chemistry, Longman 3rd ed. (1974).
2. Lavitt, B.P., Findley's Practical Physical Chemistry, Longman 9th ed. (1973).
3. Das, R.C. & Behera, B., Experimental Physical Chemistry, Tata McGraw Hill (1983).
4. Shoemaker, D.P., Gerland, C. W., Experiments in Physical Chemistry, Tata McGraw Hill 8th ed. (2009)
5. Jahagirdhar, D.V., Experiments in Physical Chemistry, Himalaya Publishing Housing (1994).
6. Khosla, B.D., Garg, V. & Gulati, A. Senior Practical Physical Chemistry, R. Chand 4th ed. (1985).
7. Yadav, J.B., Advanced Practical Physical Chemistry, Goel Publishing House 16th ed. (2006).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Practical VI – Organic Chemistry Practical		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-207		
Course Type	P.C.		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Separation, purification and identification of compounds of binary mixtures CLO 2: Capability to ask relevant/appropriate questions for identifying, formulating and analyzing the research problems and to draw conclusion from the analysis CLO 3: Plan and execute two step organic synthesis CLO 4: Increase in his/her skills in understanding and applying the organic chemistry principle in the synthesis		
Credits	Theory	Practical	Total
	0	3	3
Teaching Hours per Week	0	6	6
Internal Assessment Marks	0	20	20
End Term Examination Marks	0	50	50
Maximum Marks	0	70	70
Examination Hours for End Term Examinations	0	6	6
Examination Hours for Internal Examinations	0	3	3

Part B - Contents of the Course

Instructions for Paper Setter for End Term Examination: The examiner will ask 2 experiments to demonstrate from the list of experiments. Separate experiments can be designed by examiner for each student.

Unit	Topics	Contact Hours
I	1. Qualitative Analysis • Separation and identification of the compounds of binary mixtures (only solids) by chemical tests, derivatization. (One set to be given in the examination) 2. Organic Synthesis: Preparation of following organic compound: • Sym-tribromophenol from phenol • Benzoylacetone from acetophenone and ethyl acetate by Claisen condensation • Benzilic acid from benzoin • p-Nitroacetanilide from aniline • Sulphanilic acid from aniline • m-Dinitrobenzene from nitrobenzene	**6 Hours per Week**

	• p-Nitroaniline from aniline **Note:** Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
	Total Contact Hours	**90**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
• Class Participation	5	• Demonstration	15+15
• Demonstration	5	• Laboratory Record	10
• Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Furniss, B.S., Vogel, A. I., Smith, P. W., *Vogel's Text Book of Practical Organic Chemistry*,Longman-Group Ltd. (1978).
2. Vogel, A. I., *Elementary Practical Organic Chemistry*, Longmans, Green, 2nd Edition (1959).
3. Fieser, F., *Experiments in Organic Chemistry by* D.C. Heath and Company Boston, (1935).
4. Mann F.G., & Saunders. B.C., *Practical Organic Chemistry* Pearson Education India (2009).
5. Campbell, B.N. and Ali M., *Organic chemistry experiments: Microscales and semimicroscales*,McCarty M, Brooks/Cole, (1994).
6. Ault A., *Techniques and experiments for organic chemistry*, University Science Books, (1998).
7. Lehman, *Multiscale operational organic chemistry: A problem solving approach to laboratorycourse,* Pearson Prentice Hall, 2nd Edition (2009).
8. Clarke, H.T., *A Hand book of Organic Analysis -Qualitative and Quantitative*, Edward ArnoldLondon (1975).
9. Vishnoi N.K., *Advanced Practical Organic Chemistry,* Vikas Publishing (2009).

Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

Examination Scheme and Syllabus
For
Postgraduate Programme

M.Sc. Chemistry

as per NEP 2020
Curriculum and Credit Framework for Postgraduate Programmes
(Multiple Entry-Exit, Internship and Choice Based Credit System LOCF)

With effect from the Session 2025-26 (in phased manner)

DEPARTMENT OF CHEMISTRY
FACULTY OF PHYSICAL SCIENCES
Chaudhary Bansi Lal University, Prem Nagar– 127031
BHIWANI
HARYANA, INDIA

Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

Summary of the Programme	
Name of Programme	M.Sc. Chemistry
Duration	2 Years (4 Semesters)
Maximum Duration	4 Years
Total Credits	100
Total Marks	2420
Passing Criteria	The pass percentage will be 40% both for theory and practicum End-Term Examination. A student has to obtain minimum 40% marks in aggregate (sum of the Internal Assessment and End-Term Examination marks) and in End-Term Examination separately to qualify a course
Medium of Instructions and Examinations	English
Minimum Attendance Requirement	75% per course
Internship	4-6 Weeks
For Other Details	See Ordinance for PG Programme

PROGRAMME LEARNING OUTCOMES

The graduate on completion of Master in Chemistry programme will be able to:

PLO 1	**Development of Understanding about BASICS**	**Demonstrate advanced knowledge about chemistry with a critical understanding of the emerging developments and issues relating to the learners domain area.**
PLO 2	**Critical thinking and analysis**	Demonstrate advanced knowledge and understanding of principles, methods, and techniques applicable to the chosen field of study.
PLO 3	**Applications of Knowledge and Skills Acquired**	Demonstrate the capacity to extrapolate the acquired knowledge and skills to real-life situations and apply acquired competencies in new/unfamiliar contexts.
PLO 4	**Ability to Identity Real World Problems**	Demonstrate the ability to apply the acquired conceptual, operational or technical knowledge and a range of cognitive and practical skills to identify and address problems related to the chosen field of learning.
PLO 5	**Developing Research Aptitude**	Demonstrate and apply the advanced knowledge relating to research methods to carryout research and investigations to formulate evidence-based solutions to complex and unpredictable problems in the field of Chemistry.
PLO 6	**Data Analysis and Its Interpretation**	Demonstrate the ability to communicate, in a well-structured manner the findings/ results of the research studies undertaken in the field of Chemistry.
PLO 7	**Values and Ethics**	Pursue self-paced and self-directed learning to upgrade knowledge and skills, including research-related skills avoiding unethical practices.

Chaudhary Bansi Lal University

Scheme of Examination for Postgraduate Programme M.Sc. Chemistry

as per NEP 2020 Curriculum and Credit Framework for Postgraduate Programmes

(CBCS LOCF) with effect from the session 2025-26

Semester I

Couse Code	Course Type	Nomenclature of the Course	Course Level	Theory (T)/ Practical (P)	Credits	Total Credits	Contact Hours per Week L: Lecture P: Practical T: Tutorial				Examination Scheme			Examination Hours for Internal Examinations	Examination Hours for End Term Examinations
							L	T	P	Total	Internal Assessment Marks (170)	End Term Marks (410)	Total Marks (580)		
25PN-CHE-101	CC	Inorganic Chemistry-I	500-599	Th	4	24	4	0	0	4	30	70	100	1.5	3
25PN-CHE-102	CC	Physical Chemistry-I	500-599	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-103	CC	Organic Chemistry-I	500-599	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-104	DEC	Industrial Chemistry *or* Analytical Chemistry *or* Chemistry in Everyday Life	500-599	Th	3		3	0	0	3	20	50	70	1.5	3
25PN-CHE-105			500-599												
25PN-CHE-106			500-599												
25PN-CHE-107	PC	Practical-I Inorganic Chemistry	500-599	P	3		0	0	6	6	20	50	70	3	6

		Practical													
25PN-CHE-108	PC	Practical-II Physical Chemistry Practical	500-599	P	3		0	0	6	6	20	50	70	3	6
25PN-CHE-109	PC	Practical-III Organic Chemistry Practical	500-599	P	3		0	0	6	6	20	50	70	3	6

Note(s) and Abbreviations: CC = Core Course, DEC = Discipline Elective Course, PC= Skill Enhancement Course; For discipline elective course, the student has to opt one course in the department/institute. All the PCcourse(s) are based on the theory papers.

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Inorganic Chemistry-I		
Sub-Nomenclature of the Course (if any)	Basic Principles of Inorganic Chemistry		
Course Code	25PN-CHE-101		
Course Type	CC-1		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand the concept of metal-ligand bonding in transition metal complexes by exploring theories such as Crystal Field Theory (CFT), Ligand Field Theory (LFT), and Molecular Orbital (MO) theory. CLO 2: Explain the mechanisms of ligand substitution in octahedral transition metal complexes, and analyze the thermodynamic aspects of coordination complexes. CLO 3: Understand the reaction mechanisms of ligand substitution in square planar transition metal complexes, and gain knowledge of the redox chemistry involved in coordination complexes. CLO 4: Describe the structures and properties of isopoly and heteropoly acids and their salts, and explain the crystal structures of selected binary and ternary compounds.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Examination Marks	70	0	70
Maximum Marks	100	0	100
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks i.e. 14 marks.

Unit	**Topics**	**Contact Hours**
I	**Metal-Ligand Bonding**: Crystal field theory, spectrochemical series, calculation of CFSE for low and high spin complexes of 3d-series elements, applications of CFSE, limitations of crystal field theory,	**15**

	Jahn-Teller effect and its applications, ligand field theory, molecular orbital theory, M.O. diagrams of octahedral, tetrahedral and square planar complexes including both σ and π bonding, factors affecting ΔE.	
II	**Reaction Mechanism of Octahedral Transition Metal Complexes-I:** Inert and labile complexes, mechanisms for ligand replacement reactions, formation of complexes from aqua ions, ligand displacement reactions in octahedral complexes – acid hydrolysis, base hydrolysis, Anation reaction, H_2O ligand exchange reactions, factors affecting ligand substitution in octahedral complexes (leaving-group effects, effects of spectator ligands, steric effects), optical rotation, cotton effect, racemization of trischelate complexes, electrophilic attack on ligands. Thermodynamic aspects: Factors affecting stability of metal complexes, Irving–Williams series.	**15**
III	**Reaction Mechanism of Square-Planar Transition Metal Complexes-II:** Mechanism of ligand displacement reactions in square planar complexes and related numerical, oxidative addition & reductive elimination reactions, trans effect and theories of trans effect, applications of trans effect. Electron Transfer Processes: Types and mechanism-outer sphere electron transfer and inner sphere electron transfer reactions, electron exchange reactions, factors affecting rate of electron transfer reactions and role of non-bridging ligand on rate of electron transfer.	**15**
IV	**Isopoly and Heteropoly Acids and Salts of Mo & W:**Isopoly acids and isopoly-ions, preparation and structure of paramolybdate and octamolybdate, heteropoly acids(only classification into six groups), Keggins's structure of 1:11 & 1:12–heteropoly acids and structure of 1:6 heteropoly acids and heteropoly blue. **Crystal Structures:** Structures of some binary and ternary crystalline solid such as fluorite, anti-fluorite, rutile, anti-rutile, crystobalite, layered lattices – CdI_2, BiI_3, ReO_3, Mn_2O_3, NiAs, corundum, pervoskite, Ilmenite, calcite, normal spinel & inverse spinel minerals, Well equation and tolerance factor.	**15**
	Total Contact Hours	**60**

Suggested Evaluation Methods

Internal Assessment Marks: 30		End Term Examination Marks: 70	
➢ Theory	30	➢ Theory:	70
● Class Participation:	5	Written Examination	
● Presentation/Assignment/Quiz/Class Test/ Seminar	10		
● Mid-Term Examination	15		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Inorganic Chemistry: Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi.
2. Inorganic Chemistry by Shriver and Atkins.
3. Inorganic Chemistry by C.E. Housecroft and A.G. Sharpe.
4. Advanced Inorganic Chemistry by Cotton and Wilkinson.

5. Inorganic Chemistry by G.L. Miessler, P.J. Fischer and D.A. Tarr.
6. Modern Aspects of Inorganic Chemistry by H.J. Emeleus and A.G. Sharpe.
7. Comprehensive Coordination and Organometallic Chemistry by D. Singh.
8. Coordination Chemistry by A. Kumar.
9. Structural Principles in Inorganic Compounds by W. E. Addison.
10. Chemical bonding & Crystal structure By Dr. R.K. Malik (Anu Books, Glasgo, U.K).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Physical Chemistry-I		
Sub-Nomenclature of the Course (if any)	(Basic, Thermodynamics, Kinetics, Electrochemistry and Quantum Mechanics)		
Course Code	25PN-CHE-102		
Course Type	CC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Basic Postulates of quantum Mechanics & Concept of Operators, Particle in a box problem CLO 2: Laws of thermodynamics & phase equilibrium, Concept of Entropy and its calculation for various processes CLO 3: Rate law of different order reactions (zero, first & second order) and consecutive, parallel, opposed & chain reactions CLO 4: Explain Debye Huckle Theory of ion-ion interactions for the determination of activity and activity coefficients of electrolytic solution.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Examination Marks	70	0	70
Maximum Marks	100	0	100
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Quantum Mechanics** Introduction to Quantum Mechanics and its postulates, Quantum Mechanical operators, Eigen function and Eigen values, Hermitian operators, Angular momentum operators and their Commutation relation (L_x, L_y, L_z & L^2) laddar operators and its effect on angular momentum operator. Schrodinger wave equation for particle in one dimensional box; evaluation of average position,	**15**

	average momentum and average energy, pictorial representation of the wave equation and energy for particle in one dimensional box, Derivation of uncertainty principle (x & p), Schrodinger wave equation for a particle in a three-dimensional box and the concept of degeneracy of energy levels.	
II	**Thermodynamics** First & Second law of thermodyanmics, Entropy changes in reversible and irreversible processes; variation of entropy with temperature, pressure and volume, criteria for the spontaneity of reaction; free energy functions and their significance, Gibb's-Duhem equation, variation of chemical potential with temperature and pressure, chemical potential for an ideal gas, thermodynamic functions of mixing (free energy, entropy, volume and enthalpy) Law of mass action and its thermodynamic derivation. Classius-Clapeyron equation and its applications. Phase diagram for two completely miscible components system. Eutectic systems, calculation of eutectic point, systems forming solid compounds AxBy with congruent and incongruent melting points, phase diagram and thermodynamic treatment of solid solutions.	**15**
III	**Chemical Dynamics:** Brief description of integrated rate laws of zero, first and second order reactions with graphical representation, Lindemann - Hinshelwood mechanism of Unimolecular reactions. Rate law for opposing reactions (Ist & IInd order), Rate law for consecutive reactions, Kinetics of parallel reactions.	**15**
IV	**Electrochemistry:** Debye -Hückel theory of ion- ion interactions (ionic cloud, Poisson's equation, excess charge density, Linearization of Boltzmann equation, Linearized Poison Boltzmann equation and its solution, excess charge density and potential as a function of distance from the central ion, Debye Hückel reciprocal length, ionic cloud and its contribution to the total potential), Debye-Hückel limiting law, activity coefficient and ion-ion interactions and its physical significance, mean ionic activity coefficient. Debye-Huckel Onsager theory for non-aqueous solutions, solvent effect on the mobility at infinite dilution, equivalent conductivity (λ_{eq}) vs. Sqaure root of concentration ($c^{1/2}$) as a function of solvent, effect of ion association upon conductivity (Debye-Huckel-Bjerrum equation).	**15**
	Total Contact Hours	**60**

Suggested Evaluation Methods			
Internal Assessment Marks: 30		End Term Examination Marks: 70	
➢ Theory	30	➢ Theory:	70
● Class Participation:	5	Written Examination	
● Presentation/Assignment/Quiz/Class Test/ Seminar	10		
● Mid-Term Examination	15		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Atkins, P., Paula, Keeler, J. J., Atkins' Physical Chemistry Thermodynamics and Kinetics. Oxford University Press, 11th ed. (2017).
2. Rastogi, R. P. & Misra, R. R, An Introduction to Chemical Thermodynamics, Vikas Pub. 6th Revised ed. (6/e) (2000)
3. Glasstone, S., Thermodynamics for Chemists, Narahari Press (2007)
4. Laidler, K.J., Chemical Kinetics, McGraw Hill 2nd ed. (1965).
5. Levine, I. N., Quantum Chemistry, Pearson 7th ed. (2016).
6. Chandra, A.K., Introductory Quantum Chemistry, Tata Mc Graw Hill, 4th ed. (1998).
7. Prasad, R.K., Quantum Chemistry through Problems and solutions, New Age International (1997).
8. Castellan, G. W., Physical Chemistry, 3/E, Narosa Publishing House Pvt. Ltd. (2004).
9. Kapoor, K.L., A Textbook of Physical Chemistry Volume 2, Macmillan 3rd ed. (2004).
10. Kapoor, K.L., A Textbook of Physical Chemistry Volume 4, Tata Mc Graw Hill (2015).
11. Kapoor, K.L., A Textbook of Physical Chemistry Vol 5-Dynamics of chemical Reaction, Tata Mc Graw Hill (2014).
12. Bockris, J.O.M. & Reddy A.K.N., Modern electrochemistry Vol-1, 2nd ed. (1970).
13. Rogers, D. W., Concise Physical Chemistry, John Wiley & sons (2011).
14. Moudgil, H. K., Textbook of Physical Chemistry, PHI Learning Pvt. Ltd. 2nd ed. (2014).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Organic Chemistry-I		
Sub-Nomenclature of the Course (if any)	Conceptual Organic Chemistry & Stereochemistry		
Course Code	25PN-CHE-103		
Course Type	CC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO1: Understand the concepts delocalisation, conjugation and aromaticity and organic reaction mechanism CLO2: Advanced knowledge of reaction intermediates, aliphatic nucleophilic and electrophilic substitution CLO3: Basic knowledge of concepts of Stereochemistry, conformational analysis of acyclic and cyclic molecule. Optical activity in absence of chiral carbon, topicity of ligands and faces and their nomenclature CO4: In-depth understanding of asymmetric synthesis		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Examination Marks	70	0	70
Maximum Marks	100	0	100
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Nature of Bonding in Organic molecules**: Delocalized chemical bonding - conjugation, cross conjugation. Concept of aromaticity; Hückel's rule, energy level of π-molecular orbitals, annulenes, antiaromaticity, homo-aromaticity. **Organic Reaction Mechanism**: Structure and Reactivity: Types of mechanisms, types of reactions, Relationship between thermodynamic stability and rates of reactions - kinetic versus thermodynamic control of product formation – Hammond postulate.	**15**

	Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, guide lines for proposing reaction mechanism. The Hammett equation and linear free energy relationship, substituent and reaction constants.	
II	**Reactive Intemediates**: Generation, structure, stability and reactivity of reactive intermediates, carbocations, carbonanions, Free Radicals, Carbenes, Nitrenes. **Aliphatic Nucleophilic and Electrophilic Substitution**: The SN1, SN2, mixed SN1 and SN2, SNi and SET mechanisms. The neighbouring group mechanisms, neighbouring group participation by p and s bonds, anchimeric assistance. Classical and non-classical carbocations, phenonium ions, common carbocation rearrangements. Reactivity- effects of substrate structure, attacking nucleophile, leaving group and reaction medium. Ambident nucleophile, regioselectivity. Phase transfer catalysis; The SE1 mechanism, Bimolecular mechanisms- SE2 and SEi., Electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.	**15**
III	**Stereochemistry-I**: Introduction to molecular symmetry and chirality. D-L, R-S, E-Z and threo-erythro nomenclature, interconversion of Fischer, Newman, Sawhorse and flying wedge formulae. Conformational analysis, enantiomerism and diastereomerism of simple acyclic, cyclic system (chair and boat configuration), fused and bridged bicyclic systems (decalins) and sugars. Conformation and reactivity some examples. Optical activity in the absence of chiral carbon (biphenyls, allenes, ansa compounds, cyclophanes, hemispiranes and spiranes); Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.	**15**
IV	**Stereochemistry-II**: Topicity of ligands and faces, their nomenclature and prostereoisomerism, stereogenecity, chirogenicity, pseudoasymmetry and prochiral centre. stereospecific and stereoselective reaction. Asymmetric synthesis: Enantiomer excess, % enantioselectivity, optical purity, % diastereomeric excess and % diastereoselectivity. Asymmetric synthesis (basic principle, auxiliary, substrate, reagent and catalyst controlled).	**15**
	Total Contact Hours	**60**

Suggested Evaluation Methods

Internal Assessment Marks: 30		End Term Examination Marks: 70	
➢ Theory	30	➢ Theory:	70
● Class Participation:	5	Written Examination	
● Presentation/Assignment/Quiz/Class Test/ Seminar	10		
● Mid-Term Examination	15		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. March, J., *Advanced Organic Chemistry Reactions, Mechanism and Structure,* John Wiley 6th ed.(2007).
2. Carey, F. A. & Sundberg, R. J., *Advanced Organic Chemistry*, Plenum 5th ed. (1977)
3. Sykes, P., *A Guide Book to Mechanism in Organic Chemistry*, Pearson 6th ed. (2003)
4. Ingold, C. K., *Structure and Mechanism in Organic Chemistry*, Cornell University Press (1957)

5. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Prentice –Hall 6th ed. (2001)
6. House, H. O., *Modern Synthetic Reactions*, Benjamin (1965)
7. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, Blackie Academic &Professional 3rd ed. (1993)
8. Prakash, O. & Singh, S. P., *Reaction Mechanism in Organic Chemistry*, Trinity (2017)
9. Eliel, E. L. & Wilen, S. H., *Stereochemistry of Organic Compounds*, John Wiley (1994)
10. Nasipuri, D., *Stereochemistry of Organic Compounds*, New Age International 3rd ed. (2018)
11. Kalsi, P.S., *Stereochemistry of Organic Compounds*, New Age International 10th ed. (2019)
12. Carruthers, W. & Coldham, I., *Modern methods of Organic Synthesis*, Cambridge University Press1st e. (2005)
13. Robinson, M.J. T., *Organic Stereochemistry*, Oxford University Press (2005)
14. Issacs, N. S., *Reactive Intermediates in Organic chemistry*, John Wiley (1974)

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Industrial Chemistry		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-104		
Course Type	DEC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Introduce students to the fundamental principles and applications of chemistry in industrial processes. CLO 2: Familiarize students with key industrial chemical processes, raw materials, and products. Develop an understanding of process design, optimization, and scale-up considerations in chemical industries. CLO 3: Highlight the importance of safety, environmental protection, and quality control in industrial settings. CLO 4: Expose students to economic aspects and sustainable practices in the chemical industry.		
Credits	Theory	Practical	Total
	3	0	3
Teaching Hours per Week	3	0	3
Internal Assessment Marks	20	0	20
End Term Examination Marks	50	0	50
Maximum Marks	70	0	70
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 4 questions, selecting one question from each unit and the compulsory question. All other questions will carry equal marks i.e. 14 marks.

Unit	**Topics**	**Contact Hours**
I	**Fundamentals & Heavy Inorganic/Organic Chemicals** **Introduction to Chemical Industry:** Scope and significance of chemical industries; types of chemical industries (heavy inorganic, organic, fine chemicals, specialty chemicals, petrochemicals, agrochemicals, pharmaceuticals). **Basic Concepts:** Raw materials, intermediates, finished products. Batch vs. continuous processes. **Unit Operations and Unit Processes:** Distinction and examples. **Material and Energy Balances:** Basic principles and their	**15**

	application in chemical processes (qualitative understanding). **Industrial Catalysis:** Types of catalysts (homogeneous, heterogeneous, biocatalysts); features of industrial catalysts; examples of catalytic processes (Haber-Bosch, Contact process, Ziegler-Natta). **Sulfuric Acid:** Production by Contact process; properties and uses. **Chlor-Alkali Industry:** Manufacture of chlorine, caustic soda (NaOH), and soda ash (Na_2CO_3); diaphragm cell and membrane cell processes; uses. **Nitrogenous Fertilizers:** Ammonia synthesis (Haber-Bosch); urea manufacture; ammonium sulfate. **Phosphatic Fertilizers:** Superphosphate; triple superphosphate.	
II	**Major Organic Products & Specialty Chemicals** **Industrial Gases:** Oxygen, nitrogen, hydrogen, argon (production and uses). **Petroleum Refining:** Crude oil composition; distillation, cracking, reforming; major fractions and their uses. Overview of primary petrochemicals derived from naphtha and natural gas; examples and their downstream products. **Dyes and Pigments:** Classification of dyes based on structure and application (e.g., azo dyes, triphenylmethane dyes, vat dyes); synthesis of selected dyes; pigments vs. dyes. **Oils, Fats, and Soaps:** Sources, refining, hydrogenation of oils; saponification; detergents (types and manufacture). **Sugar Industry:** Manufacture of sugar; by-products (molasses, bagasse). **Pulp and Paper Industry:** Raw materials; pulping processes; paper making. **Explosives:** Classification; examples (TNT, nitroglycerin); safety aspects.	**15**
III	**Industrial Practices, Environmental Aspects & Safety:** **Pharmaceutical Industry:** Overview of drug discovery and development process; APIs (Active Pharmaceutical Ingredients) and formulations; Good Manufacturing Practices (GMP); quality control. **Water Treatment:** Industrial water requirements; treatment methods (coagulation, sedimentation, filtration, disinfection, ion exchange, reverse osmosis). **Industrial Pollution and Waste Management:** Types of industrial wastes (solid, liquid, gaseous); treatment and disposal methods; Effluent Treatment Plants (ETP); Zero Liquid Discharge (ZLD) concept. **Safety in Chemical Industry:** Hazards, safety measures, Material Safety Data Sheets (MSDS).	**15**
	Total Contact Hours	**45**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Theory	20	➢ Theory:	50
● Class Participation:	5	Written Examination	
● Presentation/Assignment/Quiz/Class Test/ Seminar	5		
● Mid-Term Examination	10		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Industrial Chemistry by B.K. Sharma, Goel Publishing House.

2. Industrial Chemistry by E. Stocchi, Ellis Horwood Series in Chemical Engineering.
3. Industrial Organic Chemistry by K. Weissermel and H.-J. Arpe, Wiley-VCH.
4. Ullmann's Encyclopedia of Industrial Chemistry (Online Resource/Reference).
5. Shreve's Chemical Process Industries by G.T. Austin, McGraw-Hill.
6. Principles of Green Chemistry by M. Lancaster, Royal Society of Chemistry.
7. NPTEL courses on Chemical Engineering and Industrial Chemistry.
8. Journals: Industrial & Engineering Chemistry Research, Chemical Engineering Science.
9. Websites of major chemical companies and regulatory bodies (e.g., EPA, OSHA for safety guidelines).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Analytical Chemistry		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-105		
Course Type	DEC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Analyze and interpret experimental data using appropriate statistical tools and error analysis. CLO 2: Understand and apply fundamental concepts of classical and instrumental analytical techniques to solve real-world chemical problems. CLO 3: Understand to Operate basic analytical instruments and perform routine chemical analyses with precision and scientific rigor.		
Credits	Theory	Practical	Total
	3	0	3
Teaching Hours per Week	3	0	3
Internal Assessment Marks	20	0	20
End Term Examination Marks	50	0	50
Maximum Marks	70	0	70
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 4 questions, selecting one question from each unit and the compulsory question. All other questions will carry equal marks i.e. 14 marks.

Unit	**Topics**	**Contact Hours**
I	Introduction to Analytical Chemistry and Data Analysis: Role and Importance of Analytical Chemistry in various fields (pharmaceutical, environmental, food, clinical, etc.); Types of Analysis: Qualitative and Quantitative; Errors in Chemical Analysis; Confidence limits, standard deviation, variance; Statistical treatment of analytical data- t-test, F-test, and Q-test; Calibration methods and regression analysis; Systematic and random errors; Accuracy, precision, significant figures	**15**
II	Classical (Wet) Analytical Methods: Gravimetric Analysis Principle, types of precipitates, co-precipitation and post-precipitation, Steps in gravimetric analysis with examples; Volumetric Analysis -Acid-base titrations, redox titrations, complexometric titrations; Indicators and	**15**

	end-point detection; Calculations involving normality, molarity, and titration curves	
III	Electroanalytical and Separation Techniques: Electroanalytical Methods: Conductometry, Potentiometry, and Voltammetry (basic concepts and applications); Separation Techniques: Solvent extraction: Principles and applications, Chromatography: Principles, types (Paper, Thin-layer, Column, Gas, HPLC – basic overview); Electrophoresis – principle and types (brief introduction)	**15**
	Total Contact Hours	**45**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Theory	20	➢ Theory:	50
● Class Participation:	5	Written Examination	
● Presentation/Assignment/Quiz/Class Test/ Seminar	5		
● Mid-Term Examination	10		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Fundamentals of Analytical Chemistry by D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch
2. Quantitative Chemical Analysis by Daniel C. Harris
3. Analytical Chemistry by Gary D. Christian
4. Basic Concepts of Analytical Chemistry by S.M. Khopkar
5. Vogel's Textbook of Quantitative Chemical Analysis by J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas
6. Analytical Chemistry Handbook by J.A. Dean

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Chemistry in Everyday Life		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-106		
Course Type	DEC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Explain the fundamental chemical principles governing the properties and applications of common everyday products and materials. CLO 2: Analyze the chemical composition and impact of food, pharmaceuticals, and personal care items on human health. CLO 3: Evaluate the role of chemistry in understanding and addressing environmental challenges and promoting sustainable practices. CLO 4: Discuss the societal implications of chemical advancements and critically assess chemically-related information in various contexts.		
Credits	Theory	Practical	Total
	3	0	3
Teaching Hours per Week	3	0	3
Internal Assessment Marks	20	0	20
End Term Examination Marks	50	0	50
Maximum Marks	70	0	70
Examination Hours for End Term Examinations	3	0	3
Examination Hours for Internal Examinations	1.5	0	1.5

Part B - Contents of the Course

Instructions for Paper Setter: The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus and consists of 2 marks each. The examinee will be required to attempt 4 questions, selecting one question from each unit and the compulsory question. All other questions will carry equal marks i.e. 14 marks.

Unit	Topics	Contact Hours
I	**Household & Personal Care Chemistry:** Soaps, detergents, cleaning agents (bleaches, disinfectants); Cosmetics (moisturizers, sunscreens, hair products); Toothpaste; Mechanisms of action and safety. **Polymeric Materials:** Types of polymers (thermoplastics, thermosets, elastomers); Common plastics (PVC, PET, nylon, Teflon), their properties, applications, and recycling; Bioplastics. **Surface & Structural Materials:** Paints, coatings, and adhesives	**15**

	(components, film formation, bonding); Textiles (natural vs. synthetic fibers) and the chemistry of dyes; Ceramics and glass (composition, properties, applications). **Energy & Storage:** Basic electrochemistry; Common battery types (alkaline, lithium-ion); Fuel cells and their chemical principles.	
II	**Food Chemistry:** Macronutrients (carbohydrates, proteins, lipids – structure, digestion, chemical changes); Micronutrients (vitamins, minerals – chemical roles); Food additives (preservatives, colorants, flavors, sweeteners); Chemical aspects of food processing (Maillard reaction, fermentation) and preservation; Chemistry of taste and aroma. **Pharmaceuticals & Toxicology:** Principles of drug action (receptor binding, enzyme inhibition); Common drug classes (analgesics, antibiotics, antacids) and their chemical structures; Drug discovery overview; Classes of poisons, toxins, and their mechanisms of toxicity; Principles of antidotal therapy.	**15**
III	**Environmental Chemistry:** Air pollution (sources, smog, acid rain, ozone depletion); Soil pollution (pesticides, herbicides); Principles of green chemistry and sustainable practices. **Chemistry of Art & Conservation:** Chemical composition of historical pigments and binders; Application of analytical techniques for art authentication and degradation studies; Chemical principles in art conservation and restoration.	**15**
	Total Contact Hours	**45**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Theory	20	➢ Theory:	50
● Class Participation:	5	Written Examination	
● Presentation/Assignment/Quiz/Class Test/ Seminar	5		
● Mid-Term Examination	10		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. McMurry, John, Castellion, Mary, and Ballantine, David. Chemistry in Your Life. Pearson. (Provides a broad overview and good starting point.)
2. Atkins, Peter, Jones, Loretta, and Laverman, Leroy. Chemical Principles: The Quest for Insight. W. H. Freeman. (For foundational chemical principles.)
3. Snyder, Carl H. The Extraordinary Chemistry of Ordinary Things. Wiley. (Excellent for everyday applications.)
4. Flick, Ernest W. Industrial Solvents Handbook. Noyes Publications. (For cleaning agents, paints, adhesives).
5. Brydson, J.A. Plastics Materials. Butterworth-Heinemann. (For polymeric materials).
6. Winter, Ruth. A Consumer's Dictionary of Cosmetic Ingredients. Three Rivers Press. (For personal care products).
7. Belitz, Hans-Dieter, Grosch, Werner, and Schieberle, Peter. Food Chemistry. Springer. (A comprehensive text on food chemistry).
8. Patrick, Graham L. An Introduction to Medicinal Chemistry. Oxford University Press. (For pharmaceuticals and drug action).
9. Timbrell, John A. Principles of Biochemical Toxicology. CRC Press. (For toxicology).
10. Sawyer, Clair N., McCarty, Perry L., and Parkin, Gene F. Chemistry for Environmental Engineering and Science. McGraw-Hill Education. (For water chemistry and treatment).

11. Manahan, Stanley E. Environmental Chemistry. CRC Press. (A standard textbook for environmental chemistry).
12. Bell, Suzanne. Forensic Chemistry. Pearson. (For forensic chemistry applications).
13. Eastaugh, Nicholas, Walsh, Valentine, Chaplin, Tracey, and Siddall, Ruth. The Pigment Compendium: A Dictionary of Historical Pigments. Butterworth-Heinemann. (For chemistry of art).
14. Erhardt, David, and Mecklenburg, Marion F. (Eds.). Materials Issues in Art and Archaeology. Materials Research Society. (For art conservation).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Practical-I Inorganic Chemistry Practical		
Sub-Nomenclature of the Course (if any)	-		
Course Code	24PN-CHE-107		
Course Type	P.C.		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Perform iodometric, iodimetric, and potassium iodate titrations to estimate substances such as Cu(II), $K_2Cr_2O_7$, iodide, and hydrazine. CLO 2: Apply potassium bromate titrations and the oxine method to determine metals like aluminium, magnesium, cobalt, and zinc CLO 3: Conduct EDTA titrations—including direct, back titrations, and those involving masking/demasking agents—for the analysis of metal ions and water hardness. CLO 4: Synthesize selected metal acetylacetonato complexes using environmentally friendly (green chemistry) methods.		
Credits	Theory	Practical	Total
	0	3	3
Teaching Hours per Week	0	6	6
Internal Assessment Marks	0	20	20
End Term Examination Marks	0	50	50
Maximum Marks	0	70	70
Examination Hours for End Term Examinations	0	6	6
Examination Hours for Internal Examinations	0	3	3

Part B - Contents of the Course

Instructions for Paper Setter for End Term Examination: The examiner will ask 2 experiments to demonstrate from the list of experiments. Separate experiments can be designed by examiner for each student.

Unit	**Topics**	**Contact Hours**
	1. Volumetric Analysis: a) Iodo/Iodimetric Titrations : Estimation of Cu (II) , $K_2Cr_2O_7$ using sodium thiosulphate solution iodometrically. b) Potassium Iodate Titrations: Determination of iodide, hydrazine. c) Potassium Bromate Titrations: Determination of aluminium, magnesium, cobalt and zinc (by Oxine method). d) EDTA Titrations: Determination of magnesium, calcium, barium, nickel, copper; Back titration; Titration of mixtures using masking and demasking agents; Determination of	**6 Hours per Week**

	hardness of water. **2. Green methods of preparation of the following**: a) Bis(acetylacetonato)copper(II) b) Tris(acetylacetonato)iron(III) c) Tris(acetylacetonato)manganese(III) **d)** Silver nanoparticles by plant extract and characterization using UV-Visible spectrophotometer **Note:** Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
	Total Contact Hours	**90**

Suggested Evaluation Methods			
Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
● Class Participation	5	• Demonstration	15+15
● Demonstration	5	• Laboratory Record	10
● Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. A Text Book of Quantitative Inorganic Analysis by A.I.Vogel.
2. Applied Analytical Chemistry by O.P.Vermani.
3. Vogel's Quantitative Chemical Analysis by J. Mendham.
4. Vogel's Qualitative Inorganic Analysis by G. Svehla.
5. Practical Inorganic Chemistry by Marr and Rockett.
6. Synthesis and characterization of inorganic compounds by W. L. Jolly.
7. Instrumental Methods of Analysis by B. K. Sharma.

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Practical-II Physical Chemistry Practical		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PNCHE-108		
Course Type	P.C.		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Handling of instruments like pH meter and conductivity meter along with electrodes with basic experiments. CLO 2: Realization of the concept of Viscosity using Ostwald's Viscometer. CLO 3: To understand the basic concept of photometry with the help of instrument colorimeter. CLO 4: Understanding the laboratory etiquettes to perform experiment, analyse the data and compilation of experimental information in the practical notebook.		
Credits	Theory	Practical	Total
	0	3	3
Teaching Hours per Week	0	6	6
Internal Assessment Marks	0	20	20
End Term Examination Marks	0	50	50
Maximum Marks	0	70	70
Examination Hours for End Term Examinations	0	6	6
Examination Hours for Internal Examinations	0	3	3

Part B - Contents of the Course

Instructions for Paper Setter for End Term Examination: The examiner will ask 2 experiments to demonstrate from the list of experiments. Separate experiments can be designed by examiner for each student.

Unit	Topics	Contact Hours
I	**pH metry** 1. Caliberate the pH meter and hence prepare basic buffer solution and acidic buffer solution with different pH values. 2. Determine the strength of strong acid by titration with standardized strong base. 3. Determine the strength of weak acid by titration with standardized strong base. 4. Determine the strength of dibasic acid by titration with standardized strong base. 5. Determine the strength of mixture of acids (strong & weak)	**6 Hours per Week**

	by titration with standardized strong base. Note: Comment on the shape and nature of the curve extensively. **Conductometry** 1. Determine the cell constant of the conductivity cell and hence calibrate the instrument. 2. Study the variation of conductivity with concentration for strong electrolyte & weak electrolyte. 3. Determine the strength of strong acid by titration with standardized strong base. 4. Determine the strength of weak acid by titration with standardized strong base. 5. Determine the strength of given mixture of acids (strong & weak) by titration with standardized strong base. Note: Comment on the shape of the graph extensively. **Viscometry** 1. Determination of absolute & relative viscosity of organic solvents using Ostwald's viscometer. 2. Determination of the percentage composition of a liquid mixture by viscosity measurement. **Colorimeter** 1. Verification of Lambert Beer's Law. 2. Determination of concentration of $KMnO_4$ & $K_2Cr_2O_7$ colorimetrically. **Note:** Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
	Total Contact Hours	**90**

Suggested Evaluation Methods			
Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
• Class Participation	5	• Demonstration	15+15
• Demonstration	5	• Laboratory Record	10
• Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. James, A.M. & Prichard, F.E., Practical Physical Chemistry, Longman 3rd ed. (1974).
2. Lavitt, B.P., Findley's Practical Physical Chemistry, Longman 9th ed. (1973).
3. Das, R.C. & Behera, B., Experimental Physical Chemistry, Tata McGraw Hill (1983).
4. Shoemaker, D.P., Gerland, C. W., Experiments in Physical Chemistry, Tata McGraw Hill 8th ed. (2009)
5. Jahagirdhar, D.V., Experiments in Physical Chemistry, Himalaya Publishing Housing

(1994).
6. Khosla, B.D., Garg, V. & Gulati, A. Senior Practical Physical Chemistry, R. Chand 4th ed. (1985).
7. Yadav, J.B., Advanced Practical Physical Chemistry, Goel Publishing House 16th ed. (2006).

<table>
<tr><th colspan="4">Part A - Introduction</th></tr>
<tr><td>Name of Programme</td><td colspan="3">M.Sc. Chemistry</td></tr>
<tr><td>Semester</td><td colspan="3">I</td></tr>
<tr><td>Nomenclature of the Course</td><td colspan="3">Practical III – Organic Chemistry Practical</td></tr>
<tr><td>Sub-Nomenclature of the Course (if any)</td><td colspan="3">-</td></tr>
<tr><td>Course Code</td><td colspan="3">24PN-CHE-109</td></tr>
<tr><td>Course Type</td><td colspan="3">P.C.</td></tr>
<tr><td>Level of the course</td><td colspan="3">500-599</td></tr>
<tr><td>Pre-requisite for the course (if any)</td><td colspan="3">Chemistry as a subject at UG level</td></tr>
<tr><td>Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:</td><td colspan="3">CLO 1: Safe laboratory conduct and good practices
CLO 2: Purification techniques for solids such as crystallization, sublimation and chromatography
CLO 3: Purification techniques for liquids such as distillation and chromatography Determination of melting and boiling point of organic compounds
CLO 4: Preparation of organic compounds</td></tr>
<tr><td rowspan="2">Credits</td><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>0</td><td>3</td><td>3</td></tr>
<tr><td>Teaching Hours per Week</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td>Internal Assessment Marks</td><td>0</td><td>20</td><td>20</td></tr>
<tr><td>End Term Examination Marks</td><td>0</td><td>50</td><td>50</td></tr>
<tr><td>Maximum Marks</td><td>0</td><td>70</td><td>70</td></tr>
<tr><td>Examination Hours for End Term Examinations</td><td>0</td><td>6</td><td>6</td></tr>
<tr><td>Examination Hours for Internal Examinations</td><td>0</td><td>3</td><td>3</td></tr>
<tr><th colspan="4">Part B - Contents of the Course</th></tr>
<tr><td colspan="4">Instructions for Paper Setter for End Term Examination: The examiner will ask 2 experiments to demonstrate from the list of experiments. Separate experiments can be designed by examiner for each student.</td></tr>
<tr><th>Unit</th><th colspan="2">Topics</th><th>Contact Hours</th></tr>
<tr><td>I</td><td colspan="2">1. General experimental techniques:
• Common laboratory glasswares
• Purification of organic solids
➢ Purification of organic compounds by sublimation
➢ Recrystallization of benzoic acid from water
• Purification of organic liquids by simple distillation.
• Determination of melting point of solid organic compounds.
• Determination of boiling point of liquid organic compounds.
• Separation of organic compounds by paper, TLC, column chromatography.
2. Organic Synthesis: Preparation of following organic compounds:
• Preparation of benzanilide from aniline.
• Preparation of p-bromoacetanilide from acetanilide.
• Preparation of tribromoaniline from aniline.</td><td>6 Hours per Week</td></tr>
</table>

	• Preparation of p-nitroacetanilide from Acetanilide. • Preparation of benzene-azo-β-naphthol by diazotization. • Preparation of adduct of anthracene and maleic anhydride by Diels-Alder reaction. Any other reaction as per requirement **Note:** Any experiments can be introduced/ omitted in the practical class on the basis of availability of instruments/ chemicals/ glasswares and other facilities in the laboratory.	
	Total Contact Hours	**90**

Suggested Evaluation Methods

Internal Assessment Marks: 20		End Term Examination Marks: 50	
➢ Practical	20	➢ Practical	50
● Class Participation	5	• Demonstration	15+15
● Demonstration	5	• Laboratory Record	10
● Laboratory Record	10	• Viva-Voce	10

Part C - Learning Resources

Recommended Books/e-resources/LMS:

1. Clarke, H.T. & revised by Haynee, B. Edward Arnold, *A Hand book of Organic Analysis -Qualitativeand Quantitative,* London (1975).
2. Furhen, B.S., *Vogel's Text Book of Practical Organic Chemistry*, Longman.
3. Middleton, H., *Systematic Qualitative Organic Analysis,* Edward Arnold (Publishers) Limited, London(1959).
4. Vogel, A. I., *Elementary Practical Organic Chemistry*, EX CBS Publishers and Distriibutors (1957).
5. Louis, F., Fieser, D.C., *Experiments in Organic Chemistry,* Heath and Company Boston (1955)
6. Vishnoi, N.K., *Advanced Practical Organic Chemistry*, Vikas Publishing 3rd ed. (2009).