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).