

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
(NHEQF Level 6.5)

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

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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 Bansilal 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
						24	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		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										
25PN-CHE-105			500-599				3	0	0	3	20	50	70	1.5	3
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

1st and 2nd Semester approved by AC on 29 July 2025 and 16 February 2026, respectively. 3rd Semester Approved by PGBOs on 08 July 2026 and by FPS on 20 July 2026.

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Semester II

Course Code	Course Type	Nomenclature of the Course	Course Level	Theory (Th)/ Practical (P)/ Internship(I)	Credits	Total Credits	Contact Hours per Week				Examination Scheme			Examination Hours for Internal Examinations	Examination Hours for End Term Examinations
							L	T	P	Total	Internal Assessment Marks (185)	End Term Marks (445)	Total Marks (630)		
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	CC	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	2	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-208	PC	Internship*	-	I	0		-	-	-	-	-	-	-	-	-
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

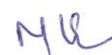
M.Sc. Chemistry Syllabus w.e.f. 2025-26 in Phased Manner, Chaudhary Bansi Lal University, Bhiwani

Knowledge System. All the PCourse(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. This is a 4-credit (100 marks), non-creditable component; marks will not be added to the final SGPA/CGPA. Instead, a separate letter grade will be awarded and reflected independently on the transcript/grade card.

****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.



Semester III

Course 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 (165)	End Term Marks (395)	Total Marks (560)		
25PN-CHE-301 or 25PN-CHE-302 or 25PN-CHE-303	DEC	Inorganic Chemistry Special-I	600-699	Th	4	23	4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
		Physical Chemistry Special-I or Organic Chemistry Special-I	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-304 or 25PN-CHE-305 or 25PN-CHE-306	DEC	Inorganic Chemistry Special-II	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
		Physical Chemistry Special-II or Organic Chemistry Special-II	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-307 or	DEC	Inorganic Chemistry Special-III	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3

M.Sc. Chemistry Syllabus w.e.f. 2025-26 in Phased Manner, Chaudhary Bansi Lal University, Bhiwani

25PN-CHE-308 or 25PN-CHE-309		Physical Chemistry Special-III or Organic Chemistry Special-III	600-699	Th	4	4	0	0	4	30	70	100	1.5	3
25PN-CHE-310		Inorganic Chemistry Special Practical-I	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-311	PC	Physical Chemistry Special Practical-I	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-312		Organic Chemistry Special Practical-I	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-313		Inorganic Chemistry Special Practical-II	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-314	PC	Physical Chemistry Special Practical-II	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-315		Organic Chemistry Special Practical-II	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-316	PC	Inorganic Chemistry Special Practical-III	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-317		Physical Chemistry Special	600-699	P	3	0	0	6	6	20	50	70	3	6

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		Practical-III													
25PN-CHE-318		Organic Chemistry Special Practical-III	600-699	P	3		0	0	6	6	20	50	70	3	6
25PN-CHE-319	EEC	Business Skills for Chemist	600-699	Th	2		2	0	0	2	15	35	50	1	2

Note(s) and Abbreviations: DEC = Discipline Elective Course, PC= Skill Enhancement Course, EEC = Employability and Entrepreneurship Skills Course. The DEC/ Special Course will be allotted on the basis of choice-cum-merit of students in the Semester I Examination. The student has to opt one course from each group of DEC depending upon the specialization and accordingly opt special practical course from the PC group. The special course will be run in the colleges as per recommendation of the committee constituted for the same by the University. The EEC paper may be chosen from MOOCs/SWAYAM or other Online Platforms depending upon the availability with the permission of the Chairperson, Department of Chemistry, CBLU Bhiwani/ Principal of the College.

Semester IV (Option I)

Course Code	Course Type	Nomenclature of the Course	Course Level	Theory (Th)/ 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-401 or 25PN-CHE-402 or 25PN-CHE-403	DEC	Inorganic Chemistry Special-IV or Physical Chemistry Special-IV or Organic Chemistry Special-IV	600-699	Th	4	24	4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-404 or 25PN-CHE-405 or 25PN-CHE-406	DEC	Inorganic Chemistry Special-V or Physical Chemistry Special-V or Organic Chemistry Special-V	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-407 or 25PN-	DEC	Inorganic Chemistry Special-VI or Physical	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-	Th	4		4	0	0	4	30	70	100	1.5	3

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CHE-408 or 25PN-CHE-409		Chemistry Special-VI or Organic Chemistry Special-VI	699											
25PN-CHE-410 or 25PN-CHE-411 or 25PN-CHE-412	DEC	Advanced Inorganic Spectroscopy or Advanced Physical Spectroscopy or Advanced Organic Spectroscopy	600-699 600-699 600-699	Th Th Th	3 3 3	3 3 3	0 0 0	0 0 0	3 3 3	20 20 20	50 50 50	70 70 70	1.5 1.5 1.5	3 3 3
25PN-CHE-413	PC	Inorganic Chemistry Special Practical-IV	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-414	PC	Physical Chemistry Special Practical-IV	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-415	PC	Organic Chemistry Special Practical-IV	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-416	PC	Inorganic Chemistry Special Practical-V	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-417	PC	Physical Chemistry Special Practical-V	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-		Organic	600-	P	3	0	0	6	6	20	50	70	3	6

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CHE-418		Chemistry Special Practical-V	699											
25PN-CHE-419	PC	Inorganic Chemistry Special Practical-VI	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-420		Physical Chemistry Special Practical-VI	600-699	P	3	0	0	6	6	20	50	70	3	6
25PN-CHE-421		Organic Chemistry Special Practical-VI	600-699	P	3	0	0	6	6	20	50	70	3	6

Note(s) and Abbreviations: DEC = Discipline Elective Course, PC= Skill Enhancement Course, VAC. = Value Added Course, IKS. = Indian Knowledge System, EEC. = Employability and Entrepreneurship Skills Course. All the Practical courses are based on the theory papers. The student has to opt one course from each group of DEC depending upon the specialization in the Semester III.

Semester IV (Option II: For those students who opt Dissertation)

Course Code	Course Type	Nomenclature of the Course	Course Level	Theory (Th)/ 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-401 or 25PN-CHE-402 or 25PN-CHE-403	DEC	Inorganic Chemistry Special-IV or Physical Chemistry Special-IV or Organic Chemistry Special-IV	600-699	Th	4	24	4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-404 or 25PN-CHE-405 or 25PN-CHE-406	DEC	Inorganic Chemistry Special-V or Physical Chemistry Special-V or Organic Chemistry Special-V	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
25PN-CHE-407 or 25PN-	DEC	Inorganic Chemistry Special-VI or Physical	600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-699	Th	4		4	0	0	4	30	70	100	1.5	3
			600-	Th	4		4	0	0	4	30	70	100	1.5	3

M.Sc. Chemistry Syllabus w.e.f. 2025-26 in Phased Manner, Chaudhary Bansi Lal University, Bhiwani

CHE-408 or 25PN-CHE-409		Chemistry Special-VI or Organic Chemistry Special-VI	699												
25PN-CHE-422	PC	Dissertation	600-699	P	12		0	0	24	24			280	-	-

Note(s) and Abbreviations: DEC = Discipline Elective Course, PC= Skill Enhancement Course, V.A.C. = Value Added Course, I.K.S. = Indian Knowledge System, E.E.C. = Employability and Entrepreneurship Skills Course. The student has to opt one course from each group of DEC depending upon the specialization in the Semester III.

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 ₂ O 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), Keggin'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, cristobalite, layered lattices – CdI ₂ , BiI ₃ , ReO ₃ , Mn ₂ O ₃ , NiAs, corundum, perovskite, 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) ladder 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 thermodynamics, 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 A_xB_y 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 Poisson 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. Square 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
② Theory	30	② 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 Intermediates: 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, stereogenicity, 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
② Theory	30	② 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., <i>Advanced Organic Chemistry Reactions, Mechanism and Structure</i> , John Wiley 6 th ed.(2007).		
2. Carey, F. A. & Sundberg, R. J., <i>Advanced Organic Chemistry</i> , Plenum 5 th ed. (1977)		
3. Sykes, P., <i>A Guide Book to Mechanism in Organic Chemistry</i> , Pearson 6 th ed. (2003)		
4. Ingold, C. K., <i>Structure and Mechanism in Organic Chemistry</i> , 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 Press 1st 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 (Na₂CO₃); 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. Weissmermel 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
② Theory	20	② 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

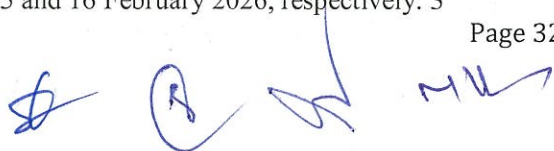
Internal Assessment Marks: 20		End Term Examination Marks: 50	
☐ Theory	20	☐ Theory:	50
• Class Participation:	5	Written Examination	
• Presentation/Assignment/Quiz/Class Test/ Seminar	5		
• Mid-Term Examination	10		

Part C - Learning Resources

Recommended Books/e-resources/LMS:

- McMurry, John, Castellion, Mary, and Ballantine, David. Chemistry in Your Life. Pearson. (Provides a broad overview and good starting point.)
- Atkins, Peter, Jones, Loretta, and Laverman, Leroy. Chemical Principles: The Quest for Insight. W. H. Freeman. (For foundational chemical principles.)
- Snyder, Carl H. The Extraordinary Chemistry of Ordinary Things. Wiley. (Excellent for everyday applications.)
- Flick, Ernest W. Industrial Solvents Handbook. Noyes Publications. (For cleaning agents, paints, adhesives).
- Brydson, J.A. Plastics Materials. Butterworth-Heinemann. (For polymeric materials).
- Winter, Ruth. A Consumer's Dictionary of Cosmetic Ingredients. Three Rivers Press. (For personal care products).
- Belitz, Hans-Dieter, Grosch, Werner, and Schieberle, Peter. Food Chemistry. Springer. (A comprehensive text on food chemistry).
- Patrick, Graham L. An Introduction to Medicinal Chemistry. Oxford University Press. (For pharmaceuticals and drug action).
- Timbrell, John A. Principles of Biochemical Toxicology. CRC Press. (For toxicology).
- 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	PC		
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	PC		
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. Calibrate 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 & $\text{K}_2\text{Cr}_2\text{O}_7$ 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).



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	I		
Nomenclature of the Course	Practical III – Organic Chemistry Practical		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25 PN-CHE-109		
Course Type	PC		
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: 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		
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. 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.		6 Hours per Week

• 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, <i>A Hand book of Organic Analysis -Qualitativeand Quantitative</i>, London (1975). 2. Furhen, B.S., <i>Vogel's Text Book of Practical Organic Chemistry</i>, Longman. 3. Middleton, H., <i>Systematic Qualitative Organic Analysis</i>, Edward Arnold (Publishers) Limited, London(1959). 4. Vogel, A. I., <i>Elementary Practical Organic Chemistry</i>, EX CBS Publishers and Distriibutors (1957). 5. Louis, F., Fieser, D.C., <i>Experiments in Organic Chemistry</i>, Heath and Company Boston (1955) 6. Vishnoi, N.K., <i>Advanced Practical Organic Chemistry</i>, 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 π-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 $\text{B}_{10}\text{H}_{14}$), 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. Earnshaw.		

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 & HCl, 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, Vilsmeier-Haack reaction, Reimer-Tiemann reaction, Fries rearrangement. Aromatic Nucleophilic Substitution: The $ArSN_1$, $ArSN_2$, Benzyne and SRN_1 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 (LiAlH_4 and NaBH_4) 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-Villiger.	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	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: 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., <i>Introduction to Spectroscopy- A Guide for Students of Organic Chemistry</i> , Fort Worth Harcourt Brace College Publishers, 3 rd ed. (2001).		
2. Silverstein, R. M., Bassler, G.C. & Morrill, T. C., <i>Spectrometric Identification of Organic Compounds</i> , John Wiley 3 rd ed. (1991).		
3. Dyer, J. R., <i>Application of Spectroscopy of Organic Compounds</i> , Prentice Hall (1978).		
4. Williams, D. H., Fleming, I., <i>Spectroscopic Methods in Organic Chemistry</i> , Tata McGraw-Hill 4 th ed. (1989).		
5. Kalsi, P.S., <i>Spectroscopy of Organic Compounds</i> New Age International 6 th ed. (2007).		
6. Kemp, W., <i>Organic Spectroscopy</i> , 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	24PN-CHE-205		
Course Type	SEC		
Level of the course	PG		
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) Note: Any experiments can be introduced/ omitted in the practical		6 Hours per Week

	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	25PNCHE-206		
Course Type	PC		
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 standardized strong base. 3. Determine the strength of ferrous ammonium sulphate	6 Hours per Week	

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

Part A - Introduction	
Name of Programme	M.Sc. Chemistry
Semester	II
Nomenclature of the Course	Internship
Sub-Nomenclature of the Course (if any)	-
Course Code	25PN-CHE-208
Course Type	PC
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: Apply advanced theoretical chemistry concepts to operate sophisticated laboratory instrumentation and execute industrial chemical processes. CLO 2: Identify chemical or environmental problems, analyze scientific literature, and develop practical, data-driven solutions. CLO 3: Adhere to industry safety hazards, Good Laboratory Practices (GLP), chemical regulations, and sustainable green chemistry principles. CLO 4: Demonstrate professional ethics, teamwork, and technical communication through a structured internship report and viva-voce presentation.
Internship (Guidelines Extracted from Ordinance)	
Introduction to the M.Sc. Chemistry Internship Program The M.Sc. Chemistry internship is a compulsory curricular component designed to transition students from academic learning to practical, professional application. This program requires students to actively engage in work-based learning, research, or co-operative education activities with organizations external to Chaudhary Bansi Lal University (CBLU) and its affiliated colleges. Typically undertaken during the summer term, the internship bridges the gap between theoretical chemistry concepts and real-world execution under the direct supervision of industry professionals, senior scientists, or established researchers. A core objective of this internship is the induction of students into actual, formal, and organized professional environments. Students will have the opportunity to pursue experiential learning across a diverse spectrum of sectors, including: Chemical & Allied Industries: Pharmaceutical firms, bulk drug manufacturing units, agrochemicals, polymers, dyes, paints, and specialty chemical industries. Analytical & Quality Control Labs: Testing laboratories, environmental monitoring agencies, and food and drug safety standard establishments. Research & Academic Institutions: Advanced research laboratories and instrumentation centers within CBLU, other universities, or national research organizations (such as CSIR, DRDO, or ICAR labs). Beyond industrial and laboratory expertise, the internship incorporates a vital component of community engagement and socioeconomic development. This exposes students to real-world environmental, industrial safety, and socioeconomic challenges. By applying green	

chemistry principles, waste management strategies, and sustainable chemical solutions, students will supplement their classroom knowledge to help solve practical, real-life problems.

Furthermore, this exposure provides students with a firsthand understanding of industrial protocols, safety regulations, quality management systems (like ISO/GLP), and organizational structures that govern the chemical sector. Ultimately, this internship aims to cultivate a highly skillful research aptitude, sharpen technical problem-solving capabilities, and significantly enhance the employability and professional readiness of M.Sc. Chemistry graduates.

Rules Related to the Internship

- **Duration:** A student for the PG Programme shall be required to undergo internship after the semester II examination in summer for 2-4 weeks.
- **Supervision and Evaluation Committee:** A supervisor should be appointed by the Department/College. The Internship Monitoring Committee (IMC)—composed of the Chairperson/Principal, Nodal Officer, Supervisor, Mentor at the place of internship, and an external member—duly assigned by the Chairperson/Principal, will evaluate the process of internship and the assignment.
- **Credits and Hours:** As per Scheme.
- **Institutional Collaboration:** Each Department/College should provide the list of areas/organizations etc. to the Nodal Officer in their College/Department to collaborate with these organizations in the form of MOUs etc. for the training of students.
- **Prior Approval:** A student will inform and get approval from the Chairperson/Principal/Director of the Department/College/Institute before going for an internship. The internship will involve working with local industry (Government or Private organizations/Institutions), business establishments, artists, craft persons, or a professional (individual/organization).
- **Supervisor Qualifications:** The training will be decided by the supervisor and student. A supervisor should have a minimum of three years of research/teaching experience. In case an eligible supervisor is not available in the department/college, the supervisor could be assigned by the principal (with recommendations from the head of the department of a related discipline from the same or other institutions, with due consultation from the supervisor and head of the department of the institute concerned).
- **Report Submission:** At the end of the training, the student will submit the report in the same format as given by the University. A student will submit a copy of the report (a hard copy and a soft copy in PDF) to the Department/College/Institute within 15 days after the completion of the internship. The student has to submit a certificate of attendance and a work done report from the organization/professional where the internship was done.
- **Plagiarism:** Plagiarism up to 20% is acceptable in the report.
- **Timeline for Internal Evaluation:** The internal evaluation should be completed within a week after the training.
- **Evaluation Process:** The evaluation of the internship shall be done by the IMT and other participants from the Department/College mainly on the basis of the report and Seminar/Presentation/viva-voce. The outcomes of their project work may be published in peer-reviewed journals, presented in conferences/seminars, or patented.

- **Governance:** The internship will be governed by the prevailing rules of the University from time to time.

Structure of the Internship Report

The student will write the report strictly incorporating the following sections:

1. Title
2. Certification of originality of the work duly signed by the student, supervisor, mentor, and chairperson/principal
3. Abstract
4. Introduction
5. Main body text (comprising Methodology, Results, Observations, and Discussion)
6. Conclusion
7. Future Scopes
8. Plagiarism Report

Note: Headings, sub-headings, and graphics must be used wherever necessary. A list of books/references cited in the main text must be provided at the end of the report.

Scheme of Evaluation & Marks Distribution

This is a 4-credit (100 marks), non-creditable component; marks will not be added to the final GPA/Grade Card. Instead, a separate letter grade will be awarded and reflected independently on the transcript. The total evaluation consists of 100 Marks divided into Attendance (20 Marks) and Evaluation Components (80 Marks).

1. Attendance (20 Marks Max)

A minimum attendance of 75% is required. Marks are awarded based on the following criteria:

Total Attendance (%)	Marks Awarded (Max Marks: 20)
>75 – 80	04
>80 – 85	16
>85 – 90	18
>90	20

2. Main Evaluation Components (80 Marks)

- **Presentation / Seminar:** 20 Marks
- **Viva-voce:** 20 Marks
- **Internship / Project Report:** 40 Marks

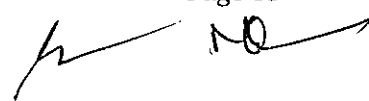
Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Environmental Science		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-EVS		
Course Type	VAC		
Level of the course	500-599		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Describe the fundamental chemical processes governing major environmental compartments (air, water, soil) and analyze the sources, transformations, and impacts of key environmental pollutants (e.g., SO_x, NO_x, heavy metals, pesticides) with relevance to regional issues in Haryana. CLO 2: Outline the chemical and biological principles behind various techniques used for controlling air pollution and treating wastewater and drinking water, recognizing their application in addressing environmental challenges. CLO 3: Explain the major types of solid and hazardous waste, their management strategies, and identify the chemical aspects of soil contamination, particularly from agricultural and industrial activities. CLO 4: Demonstrate an understanding of the principles of green chemistry and propose how chemical knowledge can be leveraged for environmental monitoring, impact assessment, and the development of sustainable solutions to local and global environmental problems.		
Credits	Theory	Practical	Total
	2	0	2
Teaching Hours per Week	2	0	2
Internal Assessment Marks	15	0	15
End Term Examination Marks	35	0	35
Maximum Marks	50	0	50
Examination Hours for End Term Examinations	2	0	2
Examination Hours for Internal Examinations	1	0	1
Part B - Contents of the Course			
Instructions for Paper Setter: The examiner will set 5 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 1 mark each. The examinee will be required to			

attempt 3 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 Environmental Science and Basic Chemical Principles: Definition and Scope: Environmental science as an interdisciplinary field. Importance for chemists. Components of the Environment: Overview of atmosphere, hydrosphere, lithosphere, and biosphere. Water Chemistry and Water Pollution: Water Resources and Hydrological Cycle: Global and local water availability. Chemistry of Natural Waters: pH, dissolved oxygen (DO), alkalinity, hardness, major ions. Water Pollutants: Classification (organic, inorganic, biological, thermal). Sources of Water Pollution: Industrial effluents (e.g., from textile, sugar, paper industries – relevant to Haryana), agricultural runoff (pesticides, fertilizers), domestic sewage, thermal pollution. Water Quality Parameters: Significance and measurement of BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), TDS (Total Dissolved Solids), heavy metals, pesticides, and microbial contamination.	15
II	Wastewater Treatment and Drinking Water Purification: Wastewater Characteristics: Physical, chemical, and biological characteristics of domestic and industrial wastewater. Conventional Wastewater Treatment: Primary Treatment: Screening, grit removal, sedimentation. Secondary Treatment: Biological processes (aerobic – activated sludge process, trickling filters; anaerobic – briefly). Emphasis on the chemical and biological transformations. Tertiary Treatment (Brief Overview): Adsorption (activated carbon), advanced oxidation processes (AOPs), membrane filtration (reverse osmosis, ultrafiltration) for removal of specific pollutants. Drinking Water Purification: Conventional Steps: Coagulation-flocculation, sedimentation, filtration (sand filtration). Disinfection: Chlorination (chemistry of chlorine residuals), UV disinfection, ozonation.	15
Total Contact Hours		30
Suggested Evaluation Methods		
Internal Assessment Marks: 15		End Term Examination Marks: 35
② Theory	15	② Theory: 35
● Class Participation:	4	Written Examination
● Presentation/Assignment/Quiz/Class Test/ Seminar	4	
● Mid-Term Examination	7	
Part C - Learning Resources		
Recommended Books/e-resources/LMS:		
1. "Environmental Chemistry" by Stanley E. Manahan, 10th Edition (CRC Press)		
2. "Environmental Chemistry" by Anil K. De, 8th Edition (New Age International Publishers)		
3. "Introduction to Environmental Sciences" by R.S. Khoiyangbam and Navindu Gupta, Latest Edition (TERI Press)		
4. "Environmental Science: Towards a Sustainable Future" by Richard T. Wright and Dorothy F. Boorse, 13th Edition (Pearson)		
5. "Green Chemistry: An Introductory Text" by Mike Lancaster, 3rd Edition (Royal Society of Chemistry)		
6. "Fundamentals of Air Pollution" by Arthur C. Stern, 5th Edition (Academic Press)		
7. "Water Chemistry" by Patrick L. Brezonik and William A. Arnold, 2nd Edition		

(Oxford University Press)

8. Central Pollution Control Board (CPCB), India: www.cpcb.nic.in
9. Ministry of Environment, Forest and Climate Change (MoEF&CC), India: moef.gov.in
10. Haryana State Pollution Control Board (HSPCB): www.hspcb.gov.in



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Laboratory Skills and Safety		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-LSS		
Course Type	VAC		
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: Comply with Indian statutory regulations (BMW 2016) and NABL safety standards. CLO 2: Prepare accurate chemical reagents and calibrate instruments to industry QC levels. CLO 3: Manage lab emergencies, including chemical spills and fire hazards, effectively. CLO 4: Document experimental data according to global data integrity (ALCOA+) standards.		
Credits	Theory	Practical	Total
	2	0	2
Teaching Hours per Week	2	0	2
Internal Assessment Marks	15	0	15
End Term Examination Marks	35	0	35
Maximum Marks	50	0	50
Examination Hours for End Term Examinations	2	0	2
Examination Hours for Internal Examinations	1	0	1
Part B - Contents of the Course			
Instructions for Paper Setter: The examiner will set 5 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 1 mark each. The examinee will be required to attempt 3 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	Safety Protocols and Regulatory Compliance The Regulatory Landscape: Overview of NABL (ISO 15189/17025) and its importance in Indian diagnostic and research labs. Introduction to GLP (Good Laboratory Practices) and OECD guidelines followed by Indian Pharma. Chemical & Biological Hazards: Classification of hazardous chemicals; interpreting MSDS (Material Safety Data Sheets). Bio-safety levels (BSL-1 to BSL-4) with reference to Indian institutes like NIV Pune. Waste Management: Deep dive into the Biomedical Waste		15

	Management Rules, 2016 (and subsequent amendments). Segregation protocols: Yellow, Red, White, and Blue categories. Treatment of chemical effluents before drainage. Emergency Preparedness: Fire safety (Types of extinguishers: A, B, C, and D), use of spill kits (acid vs. base), and first aid for lab-specific injuries (hydrofluoric acid burns, bromine exposure).	
II	Technical Skills and Lab Operations Precision Measurement: Volumetric Analysis: Calibration and handling of micropipettes, burettes, and volumetric flasks. Gravimetric Analysis: Correct usage of analytical balances; effects of buoyancy and static electricity. Solution Chemistry: Practical calculations for Molarity, Normality, and Molality. Understanding v/v, w/v, and ppm—essential for industry quality control (QC). Common Instrumentation (SOPs): Principles and "Do's & Don'ts" for pH meters, Centrifuges, Incubators, and Autoclaves. Prevention of cross-contamination in PCR and Microbiology hoods. Digital & Physical Documentation: Maintaining the Laboratory Notebook (LNB) as per Indian patent law requirements. Data integrity: Introduction to ALCOA+ principles (Attributable, Legible, Contemporaneous, Original, Accurate). Glassware & Consumables: Selection of Borosilicate 3.3 glassware; cleaning protocols (chromic acid vs. detergent cleaning).	15
Total Contact Hours		30
Suggested Evaluation Methods		
Internal Assessment Marks: 15		End Term Examination Marks: 35
☐ Theory	15	☐ Theory: 35
● Class Participation:	4	Written Examination
● Presentation/Assignment/Quiz/Class Test/ Seminar	4	
● Mid-Term Examination	7	
Part C - Learning Resources		
"Hand Book of Laboratory Safety" by A. Keith Furr (CRC Press) – The global gold standard for safety protocols. "Biomedical Waste Management Rules, 2016" – Published by the Ministry of Environment, Forest and Climate Change, Government of India (Essential for compliance). "Vogel's Textbook of Quantitative Chemical Analysis" – For foundational measurement and solution preparation skills. "NABL 160" – Guide for Internal Audit and Management Review for Laboratories (Available on the NABL India website). - CSIR-National Chemical Laboratory (NCL) Safety Manuals: Excellent localized resources for chemical handling. - CDSO Guidelines: For students aiming for the Pharmaceutical industry (Central Drugs Standard Control Organization). - WHO Laboratory Biosafety Manual: For standardized biological risk assessment.		

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	II		
Nomenclature of the Course	Rassshastra		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-RAS		
Course Type	IKS		
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: Compare Vedic atomic theory (<i>Paramanu</i>) with modern molecular science. CLO 2: Explain the chemical necessity of <i>Shodhana</i> (purification) in metallurgy. CLO 3: Identify the functions of ancient lab tools like the <i>Dola</i> and <i>Damaru Yantras</i> . CLO 4: Evaluate the role of <i>Bhasmas</i> as early forms of nanotechnology.		
Credits	Theory	Practical	Total
	2	0	2
Teaching Hours per Week	2	0	2
Internal Assessment Marks	15	0	15
End Term Examination Marks	35	0	35
Maximum Marks	50	0	50
Examination Hours for End Term Examinations	2	0	2
Examination Hours for Internal Examinations	1	0	1
Part B - Contents of the Course			
Instructions for Paper Setter: The examiner will set 5 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 1 mark each. The examinee will be required to attempt 3 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	Theoretical Foundations & The Atomic Vision Philosophical Framework: The Vaisheshika School: Deep dive into the Vaisheshika Sutras of Acharya Kanad. Paramanu (The Atom): The definition of the atom as indivisible, eternal, and the cause of the perceptible world. Chemical Combination: The concept of Dvyanuka (diatomic molecules) and Tryanuka (triatomic molecules). States of Matter (Pancha Mahabhuta): Understanding the five-element theory not as "elements" in the modern periodic sense, but as phases of matter: Solid (Prithvi), Liquid (Ap), Plasma/Energy (Tejas), Gas (Vayu), and Space/Ether (Akasha). Properties & Changes: Paka-Vada: The theory of chemical change through heat. Pilupaka vs. Pitharapaka: Debates between different schools on whether chemical change happens at the atomic level or the molecular		15

	level.	
II	Applied Rasashastra & Experimental Metallurgy The Ancient Laboratory (Rasashala): Setup and Safety: Traditional protocols for handling toxic substances. Yantras (Equipment): Mechanics of the Vidyadhara Yantra (for extraction) and Patala Yantra (sublimation/distillation). Mineralogy & Purification (Shodhana): The Rasa-Varga: Classification of minerals into Maharasa (primary), Uparasa (secondary), and Sadharana Rasa. Purification Science: The chemical logic behind using organic acids (citrus juices) and bases (cow urine) to neutralize heavy metal toxicity. Advanced Metallurgy (The Bhasma Process): Marana (Calcination): Turning metals into "ash" or nanoparticles. Case Study - Zinc & Steel: The history of Zinc distillation in Zawar and the creation of Wootz Steel (the high-carbon Damascus steel). Iatrochemistry: The transition of chemistry from "gold-making" (Alchemy) to "body-saving" (Medicine/Ayurveda).	15
Total Contact Hours		30
Suggested Evaluation Methods		
Internal Assessment Marks: 15		End Term Examination Marks: 35
☐ Theory	15	☐ Theory: 35
● Class Participation:	4	Written Examination
● Presentation/Assignment/Quiz/Class Test/ Seminar	4	
● Mid-Term Examination	7	
Part C - Learning Resources		
1. The Positive Sciences of the Ancient Hindus, Brijendra Nath Seal (2016). 2. Fine Arts & Technical Sciences in Ancient India (with reference to Mānasollāsa), Dr. Shiv Shekhar Mishra (1982). 3. Mints and Minting in India, Upendra Thakur (1972). 4. A Concise History of Science in India, ed. DM Bose, S N Sen, and B V Subbarayappa (2009). 5. Science and Technology in Medieval India, A Rahman et al. (1982) . 6. History of Technology in India, Vol. I (ed. A K Bag), Vol. II (Harbans Mukhia), and Vol. III (ed. K V Mital).		

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Inorganic Chemistry Special-I		
Sub-Nomenclature of the Course (if any)	Organo-transition Metal Chemistry		
Course Code	25PNCHE-301		
Course Type	DEC		
Level of the course	600-699		
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: To Learn about alkyl, aryls of transition metals and fluxional behavior of organometallic compounds CLO 2: To Learn about Organometallic reactions and Compounds of Transition Metal-Carbon Multiple Bonds CLO 3: To learn about Transition Metal π -Complexes CLO 4: To learn about Organometallic Catalysis		
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	Introduction and classification of organometallic compounds by bond types viz. covalent, ionic, electron deficient and cluster compounds Alkyls and Aryls of Transition Metals: Types, routes of synthesis, stability and decomposition pathways; Organometallic Reagents: organocopper in organic synthesis; Fluxional Organometallic compounds: Fluxionality and dynamic equilibria in compounds such as η^2 -olefin, η^3 -allyl and dienyl complexes, Carbonyl scrambling.	15	
II	Organometallic reactions: Oxidative addition, reductive elimination, reaction involving modification of ligand /alkyl and hydrogen migration and ligand substitution reactions, factors affecting substitution reactions; Compounds of Transition Metal-	15	

	Carbon Multiple Bonds: Alkylidenes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligand.	
III	Transition Metal π-Complexes: Transition metal π -complexes with unsaturated organic molecules (alkenes, alkynes & allyl): nature of bonding and structural features, preparations and properties; Structure, bonding and properties MCp ₂ complexes, ferrocene, reactions of metal sandwich and bent sandwich compounds; Important reactions relating to nucleophilic and electrophilic attack on ligands related to organic synthesis.	15
IV	Organometallic Catalysis: Homogeneous catalysis: Alkene hydrogenation- Wilkinson's catalyst, Hydroformylation or oxo process, Olefin Oxidation- Wacker's process, Monsanto acetic acid Cativa process, olefin metathesis; Heterogenous catalysis: Zeigler-Natta polymerization of olefins, syn gas and Fischer-Tropsch process, zeolites as catalysts.	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. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegehus, J.R. Norton and R.G. Finke, University Science Books.		
2. The Organometallic Chemistry of the Transition Metals; R.H. Crabtree, John Wiley.		
3. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.		
4. Concepts and Models of Inorganic Chemistry; B. Douglas, D.H. McDaniel and J.J. Alexander; John Wiley and Sons Inc.		
5. Basic Organometallic Chemistry: Concepts, Syntheses and Applications by B.D. Gupta and A.J. Elias		
6. Organometallic Chemistry by R.C. Mehrotra and A. Singh		

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Physical Chemistry Special- I		
Sub-Nomenclature of the Course (if any)	Advanced Quantum Chemistry		
Course Code	25PN-CHE-302		
Course Type	DEC		
Level of the course	600-699		
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: Set up and solving the Schrödinger wave equation for systems like rigid rotator, harmonic oscillator & hydrogen atom CLO 2: Application of Valence Bond Method & Linear Combination of Atomic Orbital (LCAO-MO) approximation to hydrogen and hydrogen molecule ion. CLO 3: Understand the concept of Approximate Methods and application of Variation Method and Perturbation to the Helium Atom. CLO 4: Huckel Molecular Orbital (HMO) Theory for linear and cyclic conjugated systems and its application in calculating the resonance energy		
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 - I: Schrodinger wave equation for three dimensional Rigid rotator and its solution using method of variable separation, Spherical harmonics (physical		15

	interpretation, angular momentum), Schrodinger wave equation for linear harmonic oscillator and its solution by polynomial method, Interpretation of its wave functions, zero point energy, Schrodinger wave equation for hydrogen atom, separation of variable in polar spherical coordinates and its solution, principle, azimuthal and magnetic quantum numbers and the magnitude of their values, probability distribution function, radial distribution function and shape of atomic orbitals (s, p & d).	
II	Quantum Mechanics - II: Born Oppenheimer Approximation, approaches for approximate solution of Schrodinger equation, LCAO-MO treatment of H_2^+ ion (without actual evaluation of various integrals), and Hydrogen molecule, Valence bond treatment of Hydrogen molecule, Comparison between MO and VB treatment of Hydrogen molecule MO treatment of homonuclear diatomic molecules (including sp interactions and without sp interactions), Pauli Exclusion principle, Term symbols.	15
III	Quantum Mechanics - III: Quantum mechanical treatment of Helium atom and the failure of rigorous quantum mechanical method, need of approximate methods, Approximate Methods: The variation theorem, Linear variation Principle, perturbation theory (first order, second order) Applications of variation method and perturbation theory to the Helium atom.	15
IV	Molecular Orbital Theory: Hückel molecular orbital (HMO) theory of linear and cyclic conjugated systems, Applications of HMO theory (i) Set up and solve Hückel determinant equation (ii) Calculate resonance energy (iii) Wave functions for molecular orbitals (iv) Molecular diagrams of (a) Ethylene molecule (b) Allyl system (Allyl radical and related ions) (c) Butadiene (d) Cyclobutadiene (e) Cyclopropenyl system (cyclopropenyl radical and the related ions) (f) Benzene ring.	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. Kapoor, K.L., *A Textbook of Physical Chemistry Volume 4*, Tata Mc Graw Hill (2015).
2. Mcquarrie, D. A., *Quantum Chemistry*, University Science Books 2nd ed. (2008)
3. Chandra, A.K., *Introductory Quantum Chemistry*, Tata Mc Graw Hill, 4th ed. (1998)
4. Levine, I. N., *Quantum Chemistry*, Pearson 7th ed. (2016).
5. Sen, B. K., *Quantum Chemistry Including Spectroscopy*, Tata Mc Graw Hill (1992)
6. Prasad, R.K., *Quantum Chemistry through Problems and solutions*, New Age International (1997).
7. Pauling, L., Wilson B. E., *Introduction to Quantum Mechanics with Applications to Chemistry*, Dover Publications (2012)



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Organic Chemistry Special-I		
Sub-Nomenclature of the Course (if any)	Pericyclic Chemistry		
Course Code	25PN-CHE-303		
Course Type	DEC		
Level of the course	600-699		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level, Basic Organic Chemistry, Molecular Orbital Theory, and Stereochemistry		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Map molecular orbital interactions and determine reaction feasibility using FMO, Woodward-Hoffmann, and Hückel-Möbius symmetry rules. CLO 2: Predict the exact stereochemical and regiochemical outcomes of electrocyclic, cycloaddition, cheletropic, and sigmatropic reactions. CLO 3: Use advanced named pericyclic transformations (e.g., Nazarov, Claisen variants, Click Chemistry) to design retrosynthetic routes for complex targets. CLO 4: Apply pericyclic mechanisms to solve industrial, polymer, or pharmaceutical problems.		
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	Theoretical Foundations and Symmetry Rules: Introduction to Pericyclic Reactions - Definition, characteristics, and distinction from		15

	ionic and radical pathways. The concept of concerted pathways, cyclic transition states, and solvent independence. Molecular Orbital Theory (MOT): Construction of Molecular Orbitals (MOs) for conjugated systems - Ethylene, 1,3-butadiene, 1,3,5-hexatriene, and conjugated ions - allyl, pentadienyl systems). Nodes, nodal planes, wave function signs, and orbital symmetry (C_2 axis and σ_v mirror plane symmetry. Identification of Frontier Molecular Orbitals (FMO): HOMO and LUMO. Theoretical Approaches: Frontier Molecular Orbital (FMO) Approach - Fukui's formulation. Conservation of Orbital Symmetry - Woodward-Hoffmann rules and correlation diagrams (applied to cyclization and cycloadditions). Hückel-Möbius (HMA) / Perturbational Molecular Orbital (PMO) Approach - Dewar-Zimmerman aromatic/anti-aromatic transition state concept.	
II	Electrocyclic Reactions: General Principles - Definition, classification, and microscopic reversibility. Stereochemical outcomes: Conrotatory vs. Disrotatory ring-closing and ring-opening. System Analysis - $4n\pi$-electron systems: Thermal and photochemical analysis of cyclobutene-butadiene interconversions. $(4n+2)\pi$-electron systems: Thermal and photochemical analysis of 1,3,5-hexatriene to 1,3-cyclohexadiene conversions. Stereochemical analysis using FMO, Correlation Diagrams, and Möbius-Hückel parameters. Advanced Topics & Named Transformations - Electrocyclic reactions of charged systems (cyclopropyl cations/anions, pentadienyl cations). Nazarov Cyclization: Mechanism, stereochemical control, and modern catalytic variants. Torquoselectivity in electrocyclic ring-opening.	15
III	Cycloadditions and Cheletropic Reactions: Cycloadditions - $[2+2]$ and $[4+2]$ Systems Classification ($[i+j]$ systems and stereochemical notation (suprafacial and antarafacial). $[2+2]$ Cycloadditions - Thermal (antarafacial) and photochemical (suprafacial) modes. Ketene cycloadditions. Diels-Alder Reaction ($[4+2]$ Cycloaddition): Stereochemistry (endo/exo selectivity, cis-principle). Regioselectivity (ortho/para orientation using FMO coefficients). Asymmetric Diels-Alder reactions and chiral auxiliaries. Retro-Diels-Alder reactions. 1,3-Dipolar Cycloadditions - Structure and behavior of 1,3-dipoles (azides, nitrones, ozone, diazoalkanes). Mechanism, FMO analysis, and applications in synthesizing 5-membered heterocycles. Higher Cycloadditions Reactions - $[4+4]$ and $[6+4]$ cycloadditions. Cheletropic Reactions - Definition and formal analysis of SO_2 and carbene extrusion/addition ($4n$ vs $4n+2$ systems).	15
IV	Sigmatropic Rearrangements and Group Transfer Reactions: Sigmatropic Rearrangements - Classification based on $[i,j]$ shifts. Stereochemical pathways - Suprafacial/antarafacial shifts with respect to π-frameworks; retention/inversion with respect to migrating centers. Woodward-Hoffmann rules for $[1,3]$ and $[1,5]$ hydrogen and carbon shifts. $[3,3]$-Sigmatropic Rearrangements: Cope Rearrangement: Mechanism, chair/boat transition states, stereochemistry. Degenerate Cope systems (Bullvalene, Fluxional tautomerism). Oxy-Cope and	15

Anionic Oxy-Cope Rearrangements: Rate acceleration and synthetic utility. Claisen Rearrangement: Mechanism and variations (Eschenmoser, Johnson, Ireland-Claisen variants). Aromatic Claisen and ortho-ester Claisen modifications. [2,3]-Sigmatropic Shifts & Group Transfer Reactions - Wittig, Sommelet-Hauser, and Mislow-Evans rearrangements. Group Transfer Reactions: Ene reaction and Retro-Ene reaction (FMO analysis, stereochemistry, and synthetic utility). Industrial and Biological Applications: Diels-Alder and retro-Diels-Alder reactions in self-healing polymers and smart materials; Industrial synthesis of Pyrethroid insecticides (via Ene reactions).			
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. Fleming, I., Pericyclic Reactions, Oxford University Press, 2nd Edition (2015). 2. Sankararaman, S., Pericyclic Reactions: A Textbook: Reactions, Applications and Theory, Wiley-VCH, 1st Edition (2005). 3. Carey, F. A. & Sundberg, R. J., Advanced Organic Chemistry, Part A: Structure and Mechanisms, Springer, 5th Edition (2007). 4. Zweifel, G. S., Nantz, M. H. & Somfai, P., Modern Organic Synthesis: An Introduction, Wiley, 2nd Edition (2017). 5. Woodward, R. B. & Hoffmann, R., The Conservation of Orbital Symmetry, Verlag Chemie, 1st Edition (1st Reprint) (2004). 6. Smith, M. B., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Wiley, 8th Edition (2020). 7. National Programme on Technology Enhanced Learning (NPTEL), Pericyclic Reactions and Organic Photochemistry, Ministry of Education, Government of India, https://nptel.ac.in . 8. Evans, D. A., Evans Lecture Notes: Pericyclic Reactions, Harvard University Chem 206, https://evans.harvard.edu . 9. Reich, H. J., Advanced Organic Chemistry: Pericyclic Reactions, University of Wisconsin-Madison, Online Repository (2018). 10. SWAYAM Portal, Advanced Organic Chemistry Structure and Reactivity Interactive Modules, UGC-CEC Resource Hub, Government of India.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Inorganic Chemistry Special-II		
Sub-Nomenclature of the Course (if any)	Instrumental Techniques-I		
Course Code	25PNCHE-304		
Course Type	DEC		
Level of the course	600-699		
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: To understand the principles of electrochemical techniques and analyse the characteristics of polarographic waves. CLO 2: To learn about DC polarography for determining stability constants of metal complexes and the applications of amperometric titrations in chemical analysis. CLO 3: To understand the principles, instrumentation, and applications of flame photometry, spectrophotometry, and colorimetry in inorganic analysis. CLO 4: To learn about the principles and analytical applications of TGA, DTA, DSC, nephelometry, and turbidimetry.		
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	Electroanalytical methods of Analysis-I : Working Principles: Saturated calomel electrode(SCE) and dropping mercury electrode(DME) and Nernst equation, basic principle of polarography, types of current in polarography : residual current, migration current, diffusion current and limiting current, charging current, Ilkovic equation, Koutecky equation for diffusion current and its importance.		15

	Polarographic Waves: Type of polarographic waves (cathodic and anodic) and their mathematical expressions, half wave potential and its applications, determination of electron change in redox reaction, factors affecting $E_{1/2}$, oxygen interference, maxima and its types, function of supporting electrolyte.	
II	Electroanalytical methods of Analysis-II : DC Polarography: Determination of stability constants of complexes (reversible systems only) by polarography, catalytic hydrogen wave, principles of amperometric titrations, types of titration curves with suitable examples, beauty of amperometry, apparatus and precautions of these techniques, advantages and applicationsof amperometry.	15
III	Flame photometry : Theory of flame photometry, flame temperature, Emission Flame photometry - intensity of spectral lines, selection of optimum working conditions, application of flame photometry in trace metal analysis. Spectrophotometry and Colorimetry : Fundamental concepts, instrumentation for absorption measurements, interferences, application of absorption spectroscopy and Colorimetry to analysis of inorganic substance.	15
IV	Thermal Techniques : Thermogravimetry Analysis (TGA), differential thermal analysis (DTA) and differential scanning calorimetry (DSC) principles and applications. Nephelometry and Turbidimetry : Theory-light scattering, choice and comparison between nephelometry and turbidimetry, factors affecting measurement, instrumentation, applications.	15
Total Contact Hours		60
Suggested Evaluation Methods		
Internal Assessment Marks: 30		End Term Examination Marks: 70
② Theory	30	② 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. Fundamentals of Analytical Chemistry; D.A. Skoog, O.M. West and F.J. Holler; W.B. Saunders.		
2. Instrumental methods of Analysis; L.L. Merritt, R.H. Willard and J.A. Dean; Van Nostrand- Reinhold.		
3. Introduction to Polarography & Allied Techniques by K. Zutshi.		
4. Basic Concepts of Analytical Chemistry by S.M. Khopkar.		
5. Principles of Polarography by R.C. Kapoor and B.S. Aggarwal.		

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Physical Chemistry Special-II		
Sub-Nomenclature of the Course (if any)	Advanced Electrochemistry & Surface Kinetics		
Course Code	25PN-CHE-305		
Course Type	DEC		
Level of the course	600-699		
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: Describe the electrified interfaces and surface excess in electrochemical system, Buttlar Volmer Equation CLO 2: Thermodynamics of Electrified interface & electroanalytical techniques such as cyclic voltammetry, impedance. CLO 3: Understand the Potentiometric methods and ion-selective electrodes. CLO 4: Designing and understand the working mechanism of Fuel Cells, Solar Cells & various Batteries.		
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	Electrodics: Rate of charge-transfer reactions under zero field, under the influence of an electric field, the equilibrium exchange current density, the non-equilibrium drift-current density (Butler-Volmer) equation. Some general and special cases of Butler-Volmer equation, the high-field and low-field approximations, physical meaning of the symmetry factor (β), a preliminary to a second theory of β , a simple		15

	picture of the symmetry factor and its dependence on overpotential.	
II	Electrified Interface: Thermodynamics of potential difference across electrified interfaces: concept of polarizable and non-polarizable interface, electrocapillary curve, Lippmann equation, determination of charge density on the electrode, capacitance of interface and surface excess. Tafel equation Brief introduction of various electrochemical methods such as cyclic voltammetry, chronoamperometry, chronopotentiometry, coulometry, AC impedance spectroscopy (EIS)	15
III	Electroanalytical & Potentiometric Methods: Effect of concentration on Liquid –junction potential, reference electrode (Calomel, Ag/AgCl), Metallic redox indicator electrode: Membrane and ion-selective electrodes, electrical properties of the membrane, glass electrode with special reference to H⁺, Na⁺, K⁺ ions. Application of ion selective electrode in determination of some toxic metals and anions (F⁻, Cl⁻, Br⁻, I⁻ and NO₃⁻).	15
IV	Applied Electrochemistry: Batteries: Characteristics, Lead storage battery, Dry cell, Silver-Zinc cell, Sodium-Sulphur cell and Ni-Cd Battery, Li-ion batteries. Supercapacitors: Introduction, types, history, charge storage mechanism, applications Fuel cells: H₂-O₂, hydrocarbon– air, and natural gas & CO -air fuel cells, Solar cells: Introduction, Dye-sensitized solar cells.	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. Glasstone, S., <i>Electrochemistry</i> , Read Books Ltd. (2013)		
2. Castellan, G.W., <i>Physical Chemistry</i> , Addison Wesley 3 rd ed. (1983)		
3. Bard, A. J. & Faulkner, L. R., <i>Electrochemical Methods: Fundamentals and Applications</i> , John Wiley 2 nd ed. (2002)		
4. Bockris, J. O' M. & Reddy, A. K. N., <i>Modern Electrochemistry 1: Ionics</i> Springer 2 nd ed. (1998)		
5. Bockris, J. O' M., & Reddy, A. K. N., <i>Modern Electrochemistry 2B:</i>		

Electrodics in Chemistry, Engineering, Biology and Environmental Science
Springer 2nd ed. (2001)

6. Moudgil, H. K., *Textbook of Physical Chemistry*, PHI Learning Pvt. Ltd. 2nd ed. (2014).



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Organic Chemistry Special-II		
Sub-Nomenclature of the Course (if any)	Organic Photochemistry		
Course Code	25PN-CHE-306		
Course Type	DEC		
Level of the course	600-699		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level, Basic Organic Chemistry, Molecular Orbital Theory, and Stereochemistry		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Explain photophysical processes and analyze electronic transitions using Jablonski diagrams. CLO 2: Propose mechanisms and apply organic photochemical reactions to synthetic problems. CLO 3: Use FMO theory and Woodward-Hoffmann rules to evaluate pericyclic pathways. CLO 4: Predict the stereochemical and regiochemical outcomes of electrocyclizations, cycloadditions, and sigmatropic shifts.		
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	Light Absorption and Excited States: Interaction of electromagnetic radiation with organic molecules, Franck-Condon principle, and electronic transitions. Characteristics of singlet and triplet states. Photophysical Processes (The Jablonski Diagram): Radiative pathways (fluorescence, phosphorescence) and non-radiative pathways (internal conversion, intersystem crossing). Delayed	15	

	fluorescence and its types. Kinetics and Quantum Yield: Quantum yield, quantum efficiency Primary and secondary photochemical processes. Quenching: Quenching process with suitable examples.	
II	Photochemistry of Carbonyl Compounds: Norrish Type I and Type II cleavages acyclic and cyclic systems, photo-elimination and photo-cyclization. Photo-reduction of ketones (benzophenone vs acetone), solvent and structural influences. Paterno-Büchi reaction - Oxetane formation, regioselectivity, stereochemistry and the role of exciplexes. Photochemistry of Aromatic Compounds: Ring isomerization of benzene - Dewar benzene, prismane, benzvalene paths. Photo-substitution reactions and photo-cycloaddition types (ortho, meta, para additions).	15
III	Photochemistry of Alkenes and Diene Systems: <i>Z-E</i> photoisomerization, <i>Cis-trans</i> equilibration, photosensitized isomerization. Photochemistry of conjugated dienes – dimerization and cyclization. Schenck Ene Reaction. Rearrangements & Name Reactions: Di-pi-methane Rearrangement - Mechanism, regioselectivity, and scope in both acyclic and cyclic non-conjugated dienes. Rearrangements of α , β -unsaturated ketones - cyclohexenone lumiketone rearrangement. Photo-Favorskii rearrangements, Photo-Fries Rearrangement, Hoffmann-Loeffler-Freytag Reaction	15
IV	Modern Development and Applications: Visible-Light Photoredox Catalysis: Transition metal complexes ($[\text{Ru}(\text{bpy})_3]^{2+}$, $[\text{Ir}(\text{ppy})_3]$) and organic dyes (Eosin Y, Rose Bengal). Oxidative and reductive quenching cycles. Singlet oxygen ($^1\text{O}_2$) generation and reactions (Ene and cycloaddition reactions). Industrial Applications: Synthesis of ϵ -caprolactam (precursor to Nylon-6) <i>via</i> photonitrosation of cyclohexane - Toray process.. Biological and Medical Applications: Chemistry of Vision: Photochemical 11- <i>cis</i> to all- <i>trans</i> retinal isomerization in rhodopsin. Photodamage.	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. Turro, N. J., Ramamurthy, V. & Scaiano, J. C., Modern Molecular Photochemistry of Organic Molecules, University Science Books, 1st Edition (2010).		
2. Turro, N. J., Ramamurthy, V. & Scaiano, J. C., Principles of Molecular Photochemistry: An Introduction, University Science Books, 1st Edition (2009).		
3. Singh, J. & Singh, J., Photochemistry and Pericyclic Reactions, New Age		

- International Publishers, 4th Edition (2019).
4. Rohatgi-Mukherjee, K. K., Fundamentals of Photochemistry, New Age International Wiley Eastern, 3rd Edition (2013).
 5. Kopecky, J., Organic Photochemistry: A Visual Approach, VCH Publishers, 1st Edition (1992).
 6. Carey, F. A. & Sundberg, R. J., Advanced Organic Chemistry, Part B: Reactions and Synthesis, Springer, 5th Edition (2007).
 7. Smith, M. B., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Wiley, 8th Edition (2020).
 8. NPTEL / SWAYAM Central (IIT/IISc): Advanced Organic Chemistry and Photochemistry digital video modules (Available online at nptel.ac.in).
 9. MIT OpenCourseWare (OCW): Principles of Inorganic/Organic Photochemistry and Excited-State Kinetics (Available online at ocw.mit.edu).
 10. IUPAC Gold Book: Compendium of Chemical Terminology, Photochemical Nomenclature Reference Standard (Available online at goldbook.iupac.org).
 11. Organic Syntheses Digital Library: Checked and verified experimental procedures for photochemical name reactions (Available online at orgsyn.org).



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Inorganic Chemistry Special-III		
Sub-Nomenclature of the Course (if any)	Contemporary Topics in Inorganic Chemistry		
Course Code	25PNCHE-307		
Course Type	DEC		
Level of the course	600-699		
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: To understand the classification and applications of inorganic polymers and the reactivity of non-aqueous solvents. CLO 2: To understand the environmental chemistry of sewage treatment, fertilizers, surfactants, and toxic substances. CLO 3: To understand the principles and applications of photochemistry and photochemical kinetics. CLO 4: To understand the methods of nuclear radiation detection and the applications of radiochemical techniques.		
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	Inorganic Polymers: Classification, types of inorganic polymerization, comparison with organic polymers, boron-nitrogen polymers, silicones, coordination polymers, phosphorus-nitrogen compounds. Non-aqueous Solvents: Reaction in non-aqueous media with respect to H_2SO_4 , BrF_3 , N_2O_4 and phosphoryl chloride; Kinetics and mechanism of coordination reactions in non-aqueous media.	15	
II	Sewage and fertilizers : Sewage treatment (Primary, Secondary and Tertiary), Biochemistry of sewage, Water quality parameters,	15	



	Nitrogen cycle; ammonification, nitrification, denitrification, fixation of nitrogen, biochemistry and ecology of nitrogen fixation, Nitrogenase (Mo-, V- and Fe- nitrogenase), factors limiting biological nitrogen fixation, fertilizers -nitrogen and phosphorus fertilizers in agriculture, surfactants - cationic, anionic and non-ionic, specific properties, degradation of surfactants. Toxicology: Definition of toxicology, Dose-response relationship. Absorption, distribution and excretion of toxic materials. Toxicity of metal ions, (Pb, Hg, Al, Ni, As) organic toxicants such as Halogenated hydrocarbons, pesticides and solvents, Chemical Carcinogens.	
III	Photochemistry: Absorption, absorption spectra, excitation, photochemical laws, quantum yield, electronically excited states-Jablonski Diagrams: Vibrational Relaxation, Internal Conversion, Intersystem Crossing, Fluorescence, and Phosphorescence; Fluorescence Spectra, Rules of fluorescence, Fluorescence Quantum Yield, Franck-Condon principle, Radiative Lifetime. Bimolecular quenching: Stern-Volmer relation, photochemical kinetics, photochemical stages-primary and secondary.	15
IV	Nuclear & Radiochemistry: Detection of Nuclear Radiation: Various methods of detecting nuclear radiations, gas-filled counters-ionization chamber, proportional counter and G.M. counters, scintillation detectors, solid-state detectors. Radiochemical Techniques: NAA: Principle, applications and limitations, IDA: Principle, applications and limitations. Radiometric titrations, radioisotopes, radio pharmacology, nuclear medicines, radioiodine-131, technetium-99m, gallium and indium scan.	15
Total Contact Hours		60
Suggested Evaluation Methods		
Internal Assessment Marks: 30		End Term Examination Marks: 70
☐ Theory	30	☐ Theory: 70
● Class Participation:	05	Written Examination
● Presentation/Assignment/Quiz/Class Test/ Seminar	10	
● Mid-Term Examination	15	
Part C - Learning Resources		
Recommended Books/e-resources/LMS:		
1. Environmental Pollution Analysis; S. M. Khopkar, Wiley Eastern.		
2. Environmental Chemistry; A. K. De, Wiley Eastern.		
3. Basic concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.		
4. Photochemistry of coordination compounds, K.Balzani and V.Carassti, Academic press.		
5. Elements of Inorganic Photochemistry; G.J. Ferraudi, Wiley.		
6. Essentials of Nuclear Chemistry by H. J. Arnikar.		
7. Nuclear Chemistry by M. Sharon.		

8. Modern Nuclear Chemistry by W.D. Loveland, D.J. Morrissey and G.T. Seaborg.



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Physical Chemistry Special- III		
Sub-Nomenclature of the Course (if any)	Physical Spectroscopy		
Course Code	25PN-CHE-308		
Course Type	DEC		
Level of the course	600-699		
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: Illuminate the various structural parameters of molecules by using various spectroscopic technique CLO 2: To learn about ESR spectroscopy and its application CLO 3: Get insight about the technique X-Ray Diffraction and its application CLO 4: To solve the numerical problems based upon theoretical spectroscopic techniques.		
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	Rotational Spectra: Introduction, rotational spectra of rigid diatomic molecules, intensities of rotational spectral lines, isotopic		15

	effect, non-rigid rotator, spectra of polyatomic linear molecules and symmetric top molecules. Vibrational and Vibrational-Rotational Spectra: The vibrating diatomic molecule, force constant, zero point energy, simple harmonic vibrator, anharmonicity, Morse potential, overtones, hot bands, P, Q, R branches, normal mode of vibrations, breakdown of Born Oppenheimer approximation, interaction of rotation and vibration, vibration of polyatomic molecules, analysis by infra red technique.	
II	Raman Spectra: Classical and quantum theories, polarization of light and the Raman effect, depolarization of Raman lines, pure rotational Raman spectra of linear molecules, vibrational Raman spectra, mutual exclusion principle, structure determination from Raman and infrared spectroscopy. Electronic Spectra: Electronic spectra of diatomic molecules, vibrational coarse structure and rotational fine structure of electronic band, The Franck Condon Principle, intensity of vibrational electronic band, dissociation energy.	15
III	Electron Spin Resonance Spectroscopy: Basic principles and elementary idea of ESR, experimental technique, the g-value hyperfine structure, Instrumentation of ESR and its applications to the study of free radicals and fast reactions. Nuclear Magnetic Resonance Spectroscopy: Hydrogen Nuclei, chemical shift, coupling constant, coupling between several nuclei,	15
IV	X-Ray Diffraction: Introduction:- unit cell its classifications, lattice, lattice planes, Weiss indices, miller indices, d spacing formulae, interfacial angle, crystal densities, packing fraction, Bragg's law, Laue's Method, Bragg's method, Debye- Scherrer method, Crystal structure of some ionic solid structures:- rock salt, zinc blende or sphalerite, fluorite, antiferite, wurtzite, caesium chloride, rutile structure, perovskite, carbide(CaC ₂). Spinel (normal and inverse), silicate structures.	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. Skoog, D.A., West, D. M., Holler, F. J. & Crouch, S.R., *Fundamentals of Analytical Chemistry*, Thomson 8th ed. (2004).
2. Vogel, A.I., Revised by Jeffery, G. H., Bassett, J., Mendham, J. & Denney, R. C., *A text book of Quantitative Analysis*, ELBS 5th ed. (1989).
3. Jose, A. C., *Analytical Atomic Spectrometry with flames and Plasmas*, Wiley-VCH (2002)
4. Parish, R.V., *NMR, NQR, EPR and MB Spectroscopy in inorganic Chemistry*, Ellis Horwood(1991).
5. Kaur, H., *Instrumental Methods of Chemical Analysis*, Pragati Parkashan (2016).
6. Chatwal, G.R., Anand, S.K., *Instrumental Methods of Chemical Analysis*, Himalaya PublishingHouse (2015).
7. Banwell, C. N., McCash, E.M., Choudhary, H.K., *Fundamental of Molecular Spectroscopy*, Tata Mc Graw Hill Education Pvt. Ltd. Publishing Company (2013)

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Organic Chemistry Special-III		
Sub-Nomenclature of the Course (if any)	Organic Transformations and Reagents		
Course Code	25PN-CHE-309		
Course Type	DEC		
Level of the course	600-699		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level; Basic understanding of Organic substitution, addition, elimination mechanisms, reactive intermediates, functional groups and standard laboratory reagents.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Select and apply appropriate oxidizing and reducing agents with proper mechanistic justification for complex functional group interconversions. CLO 2: Evaluate and utilize organometallic, organic, and enzymatic catalysts for strategic carbon-carbon bond formation and selective transformations. CLO 3: Formulate advanced synthetic routes using radical pathways, C-H functionalization, modern olefinations, photoredox, and electrochemical methods. CLO 4: Apply green chemistry metrics, sustainable solvents, and scale-up principles to design safe and economically viable industrial chemical 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	Oxidation Reagents: Principle, reactions and mechanism of		15

	following oxidising agents: Manganese oxidants -KMnO ₄ , MnO ₂ : Chromium oxidants - Chromic acid, PCC, PDC. Collins & Jones reagent; Peracids and Peroxides; Miscellaneous oxidants - Oxygen, Ozone, Lead tetra-acetate. Selenium dioxide. OsO ₄ . Periodic acid. Silver Carbonate (Fetizon's reagent). Thallium nitrate. Woodward and Prevost reagents. Modern Hypervalent Iodine Reagents – IBD, HTIB, IBX. Oxidative cleavage -KMnO ₄ , NaIO ₄ .	
II	Reduction Reagents: Principle, reactions and mechanism of following reducing agents: PtO ₂ (Adam's catalyst). Pd/CaCO ₃ (Lindlar's catalyst), Pd/BaSO ₄ . Raney Ni, NaBH ₄ /CeCl ₃ (Luche reagent), NaBH ₃ CN, NaBH(OAc) ₃ , LiAlH(OR) ₃ , LiBH. DIBAL-H. Sodium-liquid ammonia, Sodium alcohol, Zinc hydrochloric acid, hydrazine, diimide, silanes, stannous chloride, selectrides (K and L). Dissolving Metal Reduction – Birch reduction (alkenes, arenes, alkynes).	15
III	Organometallic Reagents: Preparation, properties and applications of following reagents in organic synthesis with mechanistic details. Lithium cuprates (Gillman's reagent), organocadmium, organosulphur reagent (1,3-dithiane), organosilicon reagent (trimethylsilyliodide TMSI), organoiodines, organotin (tributyl tin hydride TBTH), organozirconium (Swartz reagent), Organotitanium (Tebbe olefination), Organomagnesium (Grignard), Organozinc (Reformatsky).	15
IV	Other Reagents: Principle, preparations properties and applications of the following in organic synthesis with mechanistic detail DDQ, DCC, IBX, NBS, LDA. DABCO, TEMPO. Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Negishi and Sonagashira. Industrial case study – Ziegler-Natta catalyzed stereoregular polyolefins, BHC synthesis, Olefination Reagents & Ylides: Wittig, & Peterson.	15
Total Contact Hours		60
Suggested Evaluation Methods		
Internal Assessment Marks: 30		End Term Examination Marks: 70
② Theory	30	② 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. Carey, F. A. & Sundberg, R. J., Advanced Organic Chemistry, Part B: Reactions and Synthesis, Springer, 5th Edition (2007).		
2. Carruthers, W. & Coldham, I., Modern Methods of Organic Synthesis, Cambridge University Press, 4th Edition (2004).		
3. Smith, M. B. & March, J., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Wiley, 8th Edition (2020).		
4. Wyatt, P. & Warren, S., Organic Synthesis: Strategy and Control, Wiley, 1st Edition (2007).		
5. Kurti, L. & Czako, B., Strategic Applications of Named Reactions in Organic		

- Synthesis, Elsevier Academic Press, 1st Edition (2005).
6. Anderson, N. G., Practical Process Research & Development: A Guide for Organic Chemists, Academic Press, 2nd Edition (2012).
 7. Clayden, J., Greeves, N. & Warren, S., Organic Chemistry, Oxford University Press, 2nd Edition (2012).
 8. Zweifel, G. S., Nantz, M. H. & Somfai, P., Modern Organic Synthesis: An Introduction, Wiley, 2nd Edition (2017).
 9. Li, J. J., Name Reactions: A Collection of Detailed Mechanisms and Synthetic Applications, Springer, 6th Edition (2021).
 10. Berkessel, A. & Gröger, H., Asymmetric Organocatalysis: From Biomimetic Concepts to Applications in Asymmetric Synthesis, Wiley-VCH, 1st Edition (2005).
 11. Roughley, S. D., The Peptides: Analysis, Synthesis, Biology, Academic Press, 1st Edition (2020).
 12. Afonso, C. A. M., Candeias, N. R., Simão, D. P., Afonso, S. B. & Trindade, A. F., Comprehensive Organic Chemistry Experiments for the Laboratory Classroom, Royal Society of Chemistry, 1st Edition (2016).
 13. National Programme on Technology Enhanced Learning (NPTEL), Advanced Organic Synthesis - Reagents and Reactions, MHRD, Government of India LMS Portal (<https://nptel.ac.in>).

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Inorganic Chemistry Special Practical –I		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PNCHE-310		
Course Type	PC		
Level of the course	600-699		
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 coordination chemistry and complex formation. CLO 2: Synthesize and characterize a variety of coordination complexes using appropriate laboratory techniques. CLO 3: Analyse the properties and reaction mechanisms of coordination complexes. CLO 4: Analyse synthesized complexes by observing their physical properties, estimating yield, and evaluating the experimental results.		
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	Preparation of selected Inorganic Compounds complexes: (i) $\text{Hg}[\text{Co}(\text{SCN})_4]$ (ii) Chromous Acetate (iii) $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$ (iv) $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$ (v) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$ (vi) $\text{VO}(\text{acac})_2$ (vii) Prussian Blue (viii) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$, $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$, $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$, (ix) $\text{K}_3[\text{Al}(\text{C}_2\text{O}_4)_3]$ (x) $[\text{Ni}(\text{en})_3]\text{S}_2\text{O}_3$ 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.	6 Hours per Week	

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. Descriptive Inorganic Chemistry by G.R. Canham and T. Overton.			
2. Inorganic Chemistry by G.L. Miessler, P.J. Fischer and D.A. Tarr.			
3. A Vogel's Text Book of Quantitative Inorganic Analysis, J. Bassett, R. C. Denney, G. B. Jaffery and J. Menaham, Longman, London.			
4. Purification of Laboratory Chemicals by W.L.F. Armarego and C.L. Chai.			
5. Experimental Inorganic Chemistry: A Laboratory Workbook by J.D. Woollins.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Physical Chemistry Special Practical-I		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-311		
Course Type	PC		
Level of the course	600-699		
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: Ability to understand surface tension CLO 2: Understand the concept of adsorption CLO 3: Develop an understanding for Distribution Concept. CLO 4: Able to handle spectrophotometer instrument		
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	Surface Tension 1. Determine the surface tension of given organic solvents. 2. Study the effect of soap concentration on the lowering of surface tension of water. 3. Compare the cleansing powers of two cloth detergents provided to you. Adsorption 4. Verify the Freundlich and Langmuir adsorption isotherms for adsorption of acetic acid/oxalic acid on activated charcoal. Distribution Law 5. Determine the distribution coefficient of iodine between carbon tetrachloride and water. 6. Determine distribution coefficient of ammonia between chloroform and water. Spectrophotometer 7. Verification of the Lambert-Beer's law using aqueous solutions of KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$ or CuSO_4 .		6 Hours per Week

8. Determination of the composition of Potassium dichromate and potassium permanganate mixture spectrophotometrically: 9. Determine the dissociation constant of an indicator spectrophotometrically.			
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., <i>Practical Physical Chemistry</i>, Longman 3rd ed. (1974). 2. Findlay, A. & Lavitt, B.P., <i>Findlay's Practical Physical Chemistry</i>, John Wiley 9th ed. (1981). 3. Athawale, V. D., <i>Experimental Physical Chemistry</i>, New Age International (2007). 4. Viswanathan, B., <i>Practical Physical Chemistry</i>, Viva Books (2012). 5. Shoemaker, D.P., <i>Experiments in Physical Chemistry</i>, Tata McGraw Hill 6th ed. (1988). 6. Jahagirdhar, D.V., <i>Experiments in Physical Chemistry</i>, Himalaya Publisher (2013). 7. Khosla, B.D., Garg, V. C. & Gulati, A., <i>Senior Practical Physical Chemistry</i>, R. Chand (2014). 8. Yadav, J.B., <i>Advanced Practical Physical Chemistry</i>, Goel Publishing (2014). 9. Khosla, B.D., Garg V.C. and Khosla A. 10. <i>Senior Practical Physical Chemistry</i> R. Chand & Co New Delhi. 11. Thawale A. and Mathur P. <i>Experimental Physical Chemistry</i> by New Age International Publisher 12. Vishwanatha B. and Raghav P. S., <i>Practical Physical Chemistry</i> by MV Learning 13. Sindhu P.S., <i>Practical in Physical Chemistry</i> by MacMillan India Ltd.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Organic Chemistry Special Practical-I		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-312		
Course Type	PC		
Level of the course	600-699		
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: Separate components of binary organic mixtures using appropriate physical and chemical methods. CLO 2: Identify functional groups through systematic chemical tests and prepare suitable crystalline derivatives. CLO 3: Interpret provided spectral data (^1H-NMR, ^{13}C-NMR, IR, and Mass spectrometry) for structural elucidation. CLO 4: Correlate wet chemical analysis with spectroscopic data to completely characterize unknown organic compounds.		
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 of Binary Mixtures: Separation of solid-solid, solid-liquid, and liquid-liquid mixtures using appropriate chemical and physical methods. - Systematic identification through functional group chemical tests and the preparation of suitable crystalline derivatives. - Structural characterization and elucidation using provided spectroscopic data (^1H-NMR, ^{13}C-NMR, IR, and Mass spectrometry). (One binary mixture shall be assigned for complete characterization (via chemical and spectral methods) during the practical examination)		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. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R., Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Longman Group UK Ltd. (1989). 2. Silverstein, R.M., Webster, F.X., Kiemle, D.J., Spectrometric Identification of Organic Compounds, 7th Ed., John Wiley & Sons (2005). 3. Pavia, D.L., Lampman, G.M., Kriz, G.S., Vyvyan, J.A., Introduction to Spectroscopy, 5th Ed., Cengage Learning (2015). 4. Shriner, R.L., Hermann, C.K.F., Morrill, T.C., Curtin, D.Y., Fuson, R.C., The Systematic Identification of Organic Compounds, 8th Ed., John Wiley & Sons (2004). 5. Kalsi, P.S., Spectroscopy of Organic Compounds, 6th Ed., New Age International Publishers (2004). 6. Fieser, F., Experiments in Organic Chemistry by D.C. Heath and Company Boston, (1935). 7. Mann F.G., & Saunders. B.C., Practical Organic Chemistry Pearson Education India (2009). 8. Campbell, B.N. and Ali M., Organic chemistry experiments: Microscales and semimicroscales, McCarty M, Brooks/Cole, (1994). 9. Ault A., Techniques and experiments for organic chemistry, University Science Books, (1998). 10. Lehman, Multiscale operational organic chemistry: A problem solving approach to laboratory course, Pearson Prentice Hall, 2nd Edition (2009). 11. Clarke, H.T., A Hand book of Organic Analysis -Qualitative and Quantitative, Edward Arnold London (1975). 12. Vishnoi N.K., Advanced Practical Organic Chemistry, Vikas Publishing (2009). 13. National Institute of Advanced Industrial Science and Technology (AIST), Spectral Database for Organic Compounds (SDBS), https://sdb.sdb.aist.go.jp. 14. Ministry of Education (Govt. of India), National Programme on Technology Enhanced Learning (NPTEL) / SWAYAM Portal: Organic Chemistry / Molecular Spectroscopy Courses, https://swayam.gov.in.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Inorganic Chemistry Special Practical-II		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PNCHE-313		
Course Type	PC		
Level of the course	600-699		
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 conductometric, pH-metric, and potentiometric titrations for quantitative analysis. CLO 2: Determine the composition of mixtures and pKa values using electroanalytical techniques. CLO 3: Perform electroanalytical experiments, analyse the results, and interpret the experimental data. CLO 4: Develop proficiency in laboratory techniques, data interpretation, and scientific record keeping.		
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	Electro-analytical Technique (i) Conductometrically- Composition of a mixture of weak and strong acid, precipitation and displacement titrations. (ii) pH-metry-Composition of mixture of strong and weak acid, pKa value of acids. (iii) Potentiometry- Redox titrations, precipitations, simultaneous determination of halide ions. (iv) Ion-selective electrodes – F, Ca, Na, K, etc. Note: Any experiments can be introduced/ omitted in the practical	6 Hours per Week	

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. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and S.R. Crouch.			
2. Electroanalytical Chemistry: A Series of Advances by J. Wang.			
3. Electrochemical Methods: Fundamentals and Applications by A.J. Bard and L.R. Faulkner.			
4. Modern Electrochemistry by J.O'M. Bockris, A.K.N. Reddy, and M.E.G. Aldeco.			
5. Senior Practical Physical Chemistry by B.D. Khosla, V.C. Garg and A. Gulati.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Physical Chemistry Special Practical-II		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-314		
Course Type	PC		
Level of the course	600-699		
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: Become efficient in evaluating refractive index of compound. CLO 2: ability to understand various heat changes during chemical reaction CLO 3: In depth understanding of distribution coefficient. CLO 4: Capable of advanced application of Potentiometer.		
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
	Refractometry - Determine refractive index of methyl alcohol, ethyl alcohol and n-hexane. - Determine the percentage composition of liquids in the given binary mixture - Determine the molecular refractivity of p-dichlorobenzene. Thermochemistry <i>Heat of Solutions and Hydrations</i> - Determine heat of solution of potassium nitrate in water. - Determine heat of hydration of sodium sulphate and copper sulphate. Distribution Law		6 Hours per Week

6. Study the complex formation of cuprammonium ion or study the complex formation between copper sulphate and ammonia solution. 7. Determination of Equilibrium constant for $I_2 + I^- \rightleftharpoons I_3^-$ Potentiometry: 8. Titrate mixture of halides (KCl + KI) with AgNO ₃ and determine the concentration of each component in the mixture potentiometrically. 9. Titrate mixture of halides (KCl + KI + KBr) with AgNO ₃ and determine the concentration of each component in the mixture potentiometrically. 10. Titrate Fe ²⁺ with Ce ⁴⁺ potentiometrically. 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., <i>Practical Physical Chemistry</i> , Longman 3 rd ed. (1974). 2. Findlay, A. & Lavitt, B.P., <i>Findlay's Practical Physical Chemistry</i> , John Wiley 9 th ed. (1981). 3. Athawale, V. D., <i>Experimental Physical Chemistry</i> , New Age International (2007). 4. Viswanathan, B., <i>Practical Physical Chemistry</i> , Viva Books (2012). 5. Shoemaker, D.P., <i>Experiments in Physical Chemistry</i> , Tata McGraw Hill 6 th ed. (1988). 6. Jahagirdhar, D.V., <i>Experiments in Physical Chemistry</i> , Himalaya Publisher (2013). 7. Khosla, B.D., Garg, V. C. & Gulati, A., <i>Senior Practical Physical Chemistry</i> , R. Chand (2014). 8. Yadav, J.B., <i>Advanced Practical Physical Chemistry</i> , Goel Publishing (2014). 9. Khosla, B.D., Garg V.C. and Khosla A. 10. Senior Practical Physical Chemistry R. Chand & Co New Delhi. 11. Thawale A. and Mathur P. <i>Experimental Physical Chemistry</i> by New Age International Publisher 12. Vishwanatha B. and Raghav P. S., <i>Practical Physical Chemistry</i> by MV Learning 13. Sindhu P.S., <i>Practical in Physical Chemistry</i> by MacMillan India Ltd.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Organic Chemistry Special Practical-II		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-315		
Course Type	PC		
Level of the course	600-699		
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: Execute core synthetic techniques (oxidation, reduction) safely and efficiently within a standard 2 to 3-hour laboratory period. CLO 2: Implement cost-effective and green chemistry alternatives, utilizing microscale methods and benign reagents to minimize expense and waste. CLO 3: Demonstrate practical skills in handling catalytic and organometallic transformations using robust, moisture-tolerant, or aqueous reaction media. CLO 4: Monitor reaction progress, document synthetic observations, and evaluate the final product yield and economic efficiency of the experiment.		
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. Experiments based on Oxidation Reactions - Oxidation of Benzyl Alcohol to Benzoic Acid using Sodium Hypochlorite (Bleach) - Oxidation of Benzyl Alcohol to Benzoic Acid using Potassium Permanganate (KMnO₄) - Green Oxidation of Cyclohexanol to Cyclohexanone using Hydrogen Peroxide and a Copper Catalyst - Green Oxidation of Cyclohexanol to Cyclohexanone using Chromic Acid (Jones Oxidation) - Oxidation of Benzoin to Benzil using Ammonium		6 Hours per Week

	Nitrate and Copper(II) Acetate (Catalytic Oxidation) f. Oxidation of Isoborneol to Camphor using NaOCl (Household Bleach) and Acetic Acid g. Green Oxidation of Acetophenones to Benzoic Acids using Household Bleach (Sodium Hypochlorite) 2. Experiments based on Reduction Reactions a. Reduction of Benzil to Hydrobenzoin using Sodium Borohydride b. Reduction of Camphor to Isoborneol using Sodium Borohydride c. Reduction of m-Dinitrobenzene to m-Nitroaniline using Sodium Sulfide (Selective Reagents Reduction) d. Reduction of Vanillin to Vanillyl Alcohol using Sodium Borohydride e. Reduction of Benzil to Benzoin using Thiamine Hydrochloride (Vitamin B1) as a Catalyst f. Reduction of Ethyl Acetoacetate to Ethyl 3-Hydroxybutanoate using Baker's Yeast g. Microscale Reduction of Benzophenone to Benzhydrol using Sodium Borohydride (NaBH₄) 3. Experiments based on Organometallic Reagents & Carbon-Carbon Bond Formation a. Preparation of Phenylmagnesium Bromide and its Immediate Quenching with Water (Microscale Grignard Demonstration) b. The Reformatsky Reaction: Zinc-Mediated Synthesis of β-Hydroxy Esters under Mild Conditions c. The Barbier Reaction: Zinc-Mediated Alkylation of Benzaldehyde in Aqueous Medium d. The Copper-Catalyzed Azide-Alkyne Cycloaddition (CuAAC "Click Chemistry") Synthesis of 1,4-Disubstituted Triazoles 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., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R., Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Longman Group UK Ltd. (1989).			
2. Mann, F.G., Saunders, B.C., Practical Organic Chemistry, 4th Ed., Longman Green & Co. Ltd. (1960).Mann, F.G., Saunders, B.C., Practical Organic Chemistry, 4th Ed., Longman Green & Co. Ltd. (1960).			
3. Williamson, K.L., Minard, R.D., Masters, K.M., Macroscale and Microscale Organic Experiments, 5th Ed., Houghton Mifflin Co. (2007).Williamson, K.L., Minard, R.D., Masters, K.M., Macroscale and Microscale Organic Experiments, 5th Ed., Houghton			

Mifflin Co. (2007).

4. Leonard, J., Lygo, B., Procter, G., Advanced Practical Organic Chemistry, 3rd Ed., CRC Press (2013). Leonard, J., Lygo, B., Procter, G., Advanced Practical Organic Chemistry, 3rd Ed., CRC Press (2013).
5. Royal Society of Chemistry (RSC), Interactive Lab Primer (e-Resource), Royal Society of Chemistry (2020). Royal Society of Chemistry (RSC), Interactive Lab Primer (e-Resource), Royal Society of Chemistry (2020).
6. National Programme on Technology Enhanced Learning (NPTEL), Organic Chemistry Lab Course Modules (LMS/e-Resource), MHRD Government of India (2022). National Programme on Technology Enhanced Learning (NPTEL), Organic Chemistry Lab Course Modules (LMS/e-Resource), MHRD Government of India (2022).



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Inorganic Chemistry Special Practical -III		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PNCHE-316		
Course Type	PC		
Level of the course	600-699		
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 and instrumentation of spectrophotometric analysis. CLO 2: Apply spectrophotometric methods for quantitative analysis of chemical and real-world samples. CLO 3: Develop proficiency in quantitative analytical techniques and interpret experimental results. CLO 4: Apply analytical methods for the quality assessment of commercial chemical products.		
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. Spectrophotometric Analysis: i) Spectrophotometric determination (chemical method) of Fe, Ni, Mn, Cr, V, nitrate and phosphate etc. ii) Spectrophotometric determination of the following: a) Nitrate in plant sample b) Ca and Mg in milk c) Phosphate in given water sample d) Fe in vitamin tablets 2. Analysis of commercially available compounds:		

i) Determination of available chlorine in bleaching powder. ii) Determination of oxygen in hydrogen peroxide. iii) Determination of phosphoric acid in commercial phosphoric acid. iv) Determination of boric acid in borax.		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. Analytical Chemistry: Principles and Techniques by C. Gary and D. Christian. 2. Analytical Chemistry: An Introduction by D.A. Skoog and D.M. West. 3. Instrumental Methods of Analysis by B. K. Sharma. 4. Quantitative Chemical Analysis by D.C. Harris.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Physical Chemistry Practical Special-III		
Sub-Nomenclature of the Course (if any)			
Course Code	25PN-CHE-317		
Course Type	PC		
Level of the course	600-699		
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: Develops an understanding of various application of Ostwald's Viscometer CLO 2: Capable of handling advanced experiments of pHmeter. CLO 3: Understand the concept of polarimeter and its application. CLO 4: Describe the concept of order of chemical reaction experimentally via chemical kinetics		
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
	Viscosity 1. Study the variation of viscosity with concentration for a glycerol/amyl alcohol solution using Ostwald viscometer and thereafter determine the concentration of unknown solution of glycerol and amyl alcohol. 2. Determination of molar mass of a polymer by using viscometer. pHmetrically 3. Determine the strength of borax by titrating it against hydrochloric acid. 4. Determine the strength of sodium carbonate by titrating it against hydrochloric acid. 5. Determine the dissociation constant of acetic acids in acetone by		6 Hours per Week

titrating it with potassium hydroxide.			
6. Determine the degree of hydrolysis of aniline hydro chloride pH-metrically.			
Polarimetry			
7. Determination of the specific rotation for various optically active substances.			
8. Determination of the concentration of glucose, fructose, sucrose and tartaric acid in solution.			
Chemical Kinetics			
9. Study the oxidation of iodide ions by H ₂ O ₂ as an iodine clock reaction.			
10. Investigation of mutarotation of glucose catalysed by (a) an acid and (b) base			
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	
② Practical	20	② 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., <i>Practical Physical Chemistry</i> , Longman 3 rd ed. (1974).			
2. Findlay, A. & Lavitt, B.P., <i>Findlay's Practical Physical Chemistry</i> , John Wiley 9 th ed. (1981).			
3. Athawale, V. D., <i>Experimental Physical Chemistry</i> , New Age International (2007).			
4. Viswanathan, B., <i>Practical Physical Chemistry</i> , Viva Books (2012).			
5. Shoemaker, D.P., <i>Experiments in Physical Chemistry</i> , Tata McGraw Hill 6 th ed. (1988).			
6. Jahagirdhar, D.V., <i>Experiments in Physical Chemistry</i> , Himalaya Publisher (2013).			
7. Khosla, B.D., Garg, V. C. & Gulati, A., <i>Senior Practical Physical Chemistry</i> , R. Chand (2014).			
8. Yadav, J.B., <i>Advanced Practical Physical Chemistry</i> , Goel Publishing (2014).			
9. Khosla, B.D., Garg V.C. and Khosla A.			
10. Senior Practical Physical Chemistry R. Chand & Co New Delhi.			
11. Thawale A. and Mathur P. <i>Experimental Physical Chemistry</i> by New Age International Publisher			
12. Vishwanatha B. and Raghav P. S., <i>Practical Physical Chemistry</i> by MV Learning			
13. Sindhu P.S., <i>Practical in Physical Chemistry</i> by MacMillan India Ltd.			

Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Organic Chemistry Special Practical-III		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-318		
Course Type	PC		
Level of the course	600-699		
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: Execute microscale pericyclic and photochemical reactions efficiently within a 2–3 hour timeframe using safe, low-cost laboratory setups. CLO 2: Apply molecular orbital symmetry rules and excited-state principles to interpret the pathways and stereochemistry of the synthesized products. CLO 3: Monitor reaction progress and verify product purity using economical analytical techniques like Thin-Layer Chromatography (TLC) and melting point analysis. CLO 4: Evaluate chemical processes for atom economy, minimal waste generation, and the sustainable use of alternative energy sources like sunlight.		
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. Experiments based on Pericyclic Chemistry a. Solvent-Free Diels-Alder Reaction between Cyclopentadiene and Maleic Anhydride b. Aqueous-Phase Diels-Alder Reaction between Furan and Maleic Anhydride in Water c. Diels-Alder Cycloaddition of Anthracene and Maleic Anhydride in Xylene d. Thermal Isomerization of Dimethyl Maleate to		6 Hours per Week

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8. Mayo, D.W., Pike, R.M., Forbes, D.C., Microscale Organic Laboratory with Multistep and Multiscale Syntheses, 6th Ed., John Wiley & Sons, Inc. (2014).
9. SWAYAM / NPTEL (MHRD, Government of India): Online advanced organic chemistry and photochemistry laboratory video modules.
10. Virtual Labs (vlab.co.in): Ministry of Education simulated platforms for organic chemistry techniques and molecular modeling.
11. e-PG Pathshala (UGC): High-quality e-text curriculum, interactive modules, and open-access laboratory manuals for postgraduate students.



Part A - Introduction			
Name of Programme	M.Sc. Chemistry		
Semester	III		
Nomenclature of the Course	Business Skills for Chemist		
Sub-Nomenclature of the Course (if any)	-		
Course Code	25PN-CHE-319		
Course Type	EES		
Level of the course	600-699		
Pre-requisite for the course (if any)	Chemistry as a subject at UG level, Fundamental knowledge of functional group transformations or analytical techniques, along with standard laboratory safety and chemical handling protocols and proficiency in MS Word and Excel for drafting business plans and calculating simple financial costing.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Formulate a commercially viable business plan centered around chemical products or testing services. CLO 2: Navigate the legal layout and secure required clearances (Pollution, Safety, MSME) for setting up a factory or lab in Haryana. CLO 3: Analyze the financial viability, asset procurement strategies, and funding avenues available for tech-startups. CLO 4: Effectively pitch a sustainable chemical business model that focuses on employment generation.		
Credits	Theory	Practical	Total
	2	0	2
Teaching Hours per Week	2	0	2
Internal Assessment Marks	15	0	15
End Term Examination Marks	35	0	35
Maximum Marks	50	0	50
Examination Hours for End Term Examinations	2	0	2
Examination Hours for Internal Examinations	1	0	1
Part B - Contents of the Course			
Instructions for Paper Setter: The examiner will set 5 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 1 mark each. The examinee will be required to attempt 3 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	Ideation, Scale-Up, and Regulatory Framework:		15

	Chemical Entrepreneurship & Ideation: • Key Business concepts and Plan • Moving from lab-scale synthesis to commercial production (Gram to Kilogram scale-up factors). • Identifying market gaps - Agrochemicals, pharmaceuticals, specialty chemicals, dyes, cosmetics, and testing laboratories. • Case studies of successful Indian chemical startups and MSMEs. Legal and Regulatory Compliances in India: • Registration pathways: Sole Proprietorship, Partnership, and Private Limited Company; registering under MSME/Udyam Akanksha. • Environmental & Safety Clearances: Role of State Pollution Control Boards (Haryana State Pollution Control Board - HSPCB), obtaining Consent to Establish (CTE) and Consent to Operate (CTO). • Industrial Licensing: Introduction to PESO (Petroleum and Explosives Safety Organization) guidelines, Narcotics Control Bureau (NCB) permits for precursor chemicals and FSSAI/BIS standards where applicable. Factory Setup & Infrastructure: Basic plant layout design, hazard zoning, and safety infrastructure (MOC, ventilation, effluent treatment plants - ETP).	
II	Financial Management, IP, and Business Planning: Financial Literacy & Government Ecosystem • Understanding Capital Expenditure (CapEx) for equipment (FTIR, HPLC, Reactors) vs. Operational Expenditure (OpEx) for raw materials. • Introduction to costing, pricing strategies for chemical products, and break-even analysis. • Government Schemes: Startup India initiative, Mudra Loans, PMEGP (Prime Minister's Employment Generation Programme), and SIDBI funding opportunities for science graduates. Intellectual Property Rights (IPR) & Technology Transfer • Patents, Trademarks, and Trade Secrets in chemical sciences. • How to read a patent and protect a novel chemical process or formulation. • Technology licensing from universities or national labs (CSIR, DRDO) to industry. Business Architecture Conceptualizing a business model using the Lean Canvas framework.	15
Total Contact Hours		30
Suggested Evaluation Methods		
Internal Assessment Marks: 15		End Term Examination Marks: 35
⑦ Theory	15	⑦ Theory: 35
• Class Participation:	4	Written Examination
• Project/Assignment - Drafting a mock Detailed Project Report (DPR) for a chemical start-up (e.g., a hand sanitizer unit, custom synthesis lab, eco-friendly pesticide formulation, or analytical testing consultancy or any other chemistry related set up).	4	
• Mid-Term Examination	7	
Part C - Learning Resources		

Recommended Books/e-resources/LMS

1. García-Martínez, J., Chemistry Entrepreneurship, Wiley-VCH, 1st Edition (2022).
2. Khanka, S. S., Entrepreneurship Development, S. Chand Publishing, 5th Edition (2012).
3. Jordan, J. F., Innovation, Commercialization, and Start-Ups in Life Sciences, CRC Press, 1st Edition (2021).
4. Lancaster, M., Green Chemistry: An Introductory Text, Royal Society of Chemistry, 3rd Edition (2016).
5. Wadehra, B. L., Law Relating to Intellectual Property, Universal Law Publishing, 5th Edition (2012).
6. Swaminathan, M., Industrial Pollution Control and Management, New Age International Publishers, 2nd Edition (2018).
7. Ministry of Micro, Small and Medium Enterprises, Udyam Registration Portal and MSME Schemes Guidelines, Government of India (Available at: <https://udyamregistration.gov.in>) (2020).
8. Haryana State Pollution Control Board, Guidelines for Obtaining Consent to Establish (CTE) and Consent to Operate (CTO) for Green and Orange Category Industries, Government of Haryana (Available at: <https://hspcb.gov.in>) (2024).
9. Petroleum and Explosives Safety Organization, Explosives Rules and Petroleum Rules Configuration Manuals, DPIIT, Ministry of Commerce and Industry, Government of India (Available at: <https://peso.gov.in>) (2021).
10. Startup India Hub, Startup India Action Plan and Seed Fund Scheme Guidelines, Department for Promotion of Industry and Internal Trade, Government of India (Available at: <https://www.startupindia.gov.in>) (2016).
11. Controller General of Patents, Designs and Trade Marks, Manual of Patent Office Practice and Procedure, DPIIT, Government of India (Available at: <https://ipindia.gov.in>) (2019).
12. UGC-CEC / SWAYAM Central, Course on Entrepreneurship Development and Industrial Coordination, Ministry of Education, Government of India (Available at: <https://swayam.gov.in>).
13. NPTEL, Course on Intellectual Property Rights and Tech-Transfer in Publicly Funded Research, IIT Kharagpur (Available at: <https://nptel.ac.in>).