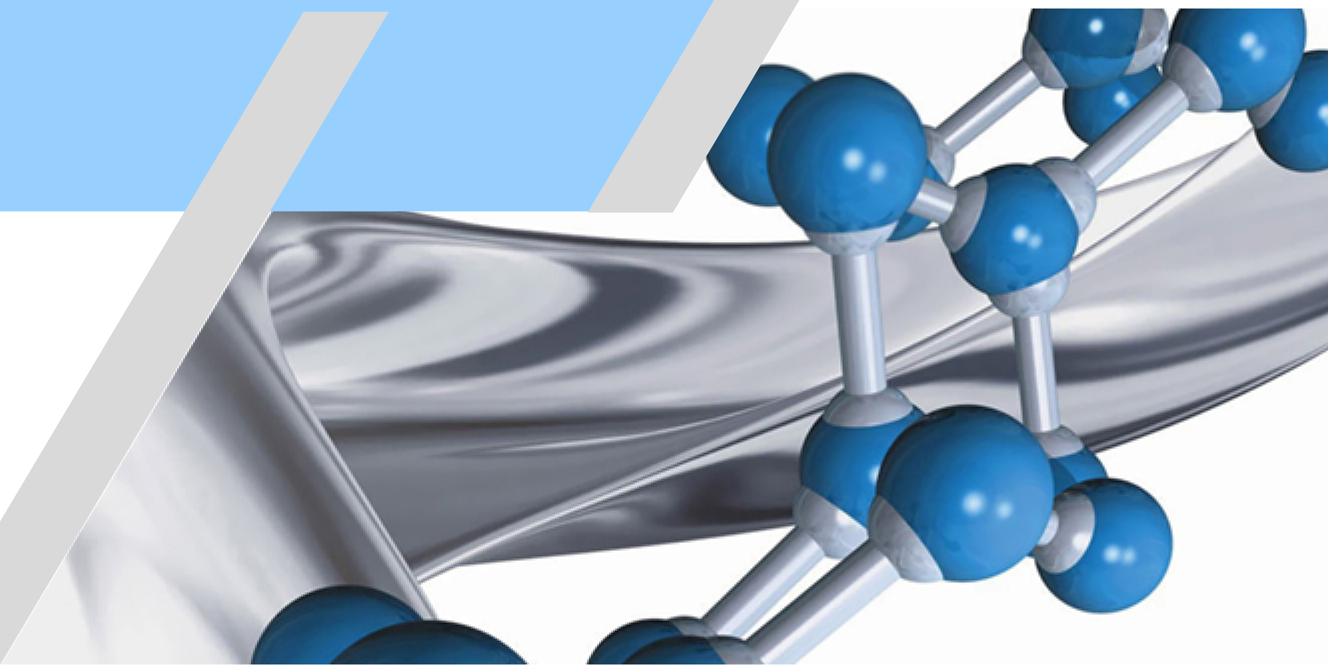
Rajiv Gandhi University

(NAAC Accredited with 'A' Grade)

Curriculum and Syllabus of

Post Graduate Programmes in Chemistry



Effective from Academic Session 2024-25

Department of Chemistry
Faculty of Basic Sciences
Rajiv Gandhi University, Arunachal Pradesh

CURRICULUM AND SYLLABUS OF POST-GRADUATE PROGRAMMES
in
CHEMISTRY

(*as per NEP 2020*)

Department of Chemistry

Faculty of Basic Sciences
Rajiv Gandhi University
Rono Hills, Doimukh, Arunachal Pradesh

Contents

PART 1: OVERVIEW

1.1 Introduction

The National Education Policy 2020 (hereafter referred to as NEP 2020) addresses the nation's developmental goals envisioned in its Constitution - a democratic, just, socially conscious, cultured, and humane nation upholding liberty, equality, fraternity, and justice. This Policy proposes to revise and revamp all aspects of the education structure, including its regulation and governance, to create a new system aligned with the aspirational goals of 21st-century higher education, including the United Nations Sustainable Development Goal 4 (SDG 4), while building upon India’s traditions and value systems. The NEP 2020 emphasises the development of good, thoughtful, well-rounded, and creative individuals. This policy envisions a complete overhaul and re-energising of the higher education system to overcome the current challenges and deliver high-quality higher education with equity and inclusion.

The NEP 2020 states, *“Assessments of educational approaches that integrate the humanities and arts with Science, Technology, Engineering and Mathematics (STEM) have consistently shown positive learning outcomes, including increased creativity and innovation, critical thinking and higher-order thinking capacities, problem-solving abilities, teamwork, communication skills, more in-depth learning and mastery of curricula across fields, increases in social and moral awareness, etc., besides general engagement and enjoyment of learning.”*

A robust research and innovation ecosystem is a prime requisite for becoming a leading knowledge society worldwide. For that to happen, the nation needs a significant expansion of its research capabilities and output across disciplines. The National Education Policy 2020 proposes several vital changes impacting postgraduate programmes. It envisages the development of a flexible postgraduate curriculum structure that allows students to experience the full range of holistic and multidisciplinary education, emphasising research and innovation. The knowledge and specialised skills they gain in the PG programmes are crucial for building an ‘*Atmanirbhar Bharat*’ in science and technology.

In conformity with the restructured undergraduate programmes, a new student-centric ***Curriculum and Credit Framework for PG Programmes in Chemistry*** has been formulated based on the UGC ‘Curriculum and Credit Framework for PG Programmes (2024)’. This framework incorporates a flexible choice-based credit system, a multidisciplinary approach, and multiple entry and exit options. It will facilitate students' pursuit of their career path by allowing them to choose the subject/field of their interest.

The curriculum has been prepared to support a uniform, advanced and effective teaching-learning at the postgraduate level in Chemistry. The concerns, needs and interests of students and teachers, as well as societal expectations, have been considered while developing the syllabus. Each course aims to present learning targets and objectives and thus provide learning and teaching strategies, assessments and resources. The programme also states the attributes that should be taught at the postgraduate level. These attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability.

1.2 Recommendations of NEP 2020 Relevant to Postgraduate Education

The NEP 2020 envisions an education system rooted in Indian ethos that contributes directly to transforming the country sustainably into an equitable and vibrant knowledge society by providing high-quality education to all, thereby making India a global knowledge superpower. The Policy envisages that the curriculum and pedagogy of our institutions must develop among the students a deep sense of respect towards the Fundamental Duties and Constitutional values, bonding with one's country, and a conscious awareness of one's roles and responsibilities in a changing world. The vision of the Policy is to inculcate among the learners a deep-rooted pride in being Indian, not only in thought but also in spirit, intellect, and deeds, as well as to develop knowledge, skills, values, and dispositions that support responsible commitment to human rights, sustainable development and living, and global well-being, thereby reflecting a truly global citizen. Following are the recommendations relevant to PG programmes.

- There may be a 2-year programme with the second year devoted entirely to research for those who have completed the 3-year Bachelor's programme.
- For students completing a 4-year Bachelor's programme with Honours/Honours with Research, there could be a 1-year Master's programme; and
- There may be an integrated 5-year Bachelor's/Master's programme.
- Universities will aim to offer Master's programmes in core areas such as Machine Learning, multidisciplinary fields such as AI, and professional areas like health care, agriculture, and law.
- The National Higher Education Qualifications Framework (NHEQF) shall describe higher education qualifications leading to a degree/diploma/certificate in terms of such learning outcomes. Accordingly, the levels prescribed for the master's programme are 6, 6.5, and 7.
- PG framework should be in sync with the National Credit Framework (NCrF) for all learning and assignment, accumulation, storage, transfer & redemption of credits, subject to assessment.

PART 2: CURRICULUM & CREDIT FRAMEWORK

2.1 Eligibility

- A bachelor's degree with Honours/ Honours with Research with a minimum of 160 credits for a 1-year/2-semester master's programme at level 6.5 on the NHEQF.
- A 3-year/6-semester bachelor's degree with a minimum of 120 credits for a 2-year/4-semester Master's programme at level 6.5 on the NHEQF.
- A student is eligible for a master's programme in a discipline corresponding to either major or minor(s) discipline in the UG programme based on performance in the UG programme or through an entrance examination. However, irrespective of the significant or minor disciplines chosen by a student in a UG programme, a student is eligible for admission in any discipline of Master's programmes if the student qualifies for the National level or University level entrance examination in the discipline of the Master's programme.

2.2 Duration

- **1-year PG:** Students entering 1-year PG after a 4-year UG programme can choose to do (i) coursework or (ii) coursework and research.

- **For 2-year PG:** Students entering 2-year PG after a 3-year UG programme can choose to do (i) coursework in the third and fourth semesters or (ii) coursework in the third semester and research in the fourth semester.

2.3 PG Diploma and Degrees

2.3.1 PG Diploma

If a student wants to leave after completing the first year PG (2 semesters), the student will receive a PG Diploma in Chemistry. Students who exit with a PG Diploma can re-enter within three years and complete the PG programme.

2.3.1 1-Year PG Degree (Coursework)

Students entering a one-year PG programme **after a four-year UG programme** and choosing to do only coursework will be awarded a Master's Degree (Coursework) in Chemistry.

2.3.2 1-Year PG Degree (Coursework & Research)

Students entering a one-year PG programme **after a four-year UG programme** and choosing to do coursework and research will be awarded a Master's Degree (Coursework & Research) in Chemistry.

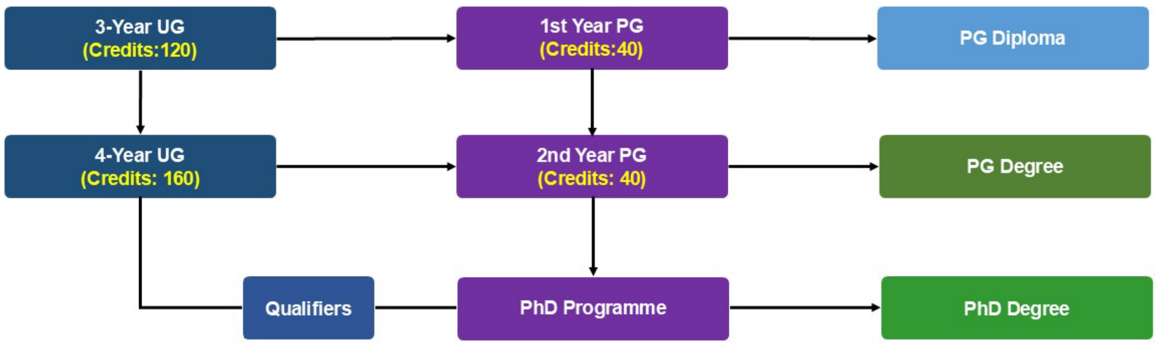
2.3.3 2-Year PG Degree (Coursework)

Students entering a 2-year PG programme **after a 3-year UG programme** and choosing to do only coursework will be awarded a Master's Degree (Coursework) in Chemistry.

2.3.4 2-Year PG Degree (Coursework & Research)

Students entering a 2-year PG **after a 3-year UG programme** and choosing to do coursework and research will be awarded a Master's Degree (Coursework & Research) in Chemistry.

2.4 Progression of PG Programmes in Chemistry



2.5 Nature and Extent of the PG Programmes in Chemistry

The new curriculum of the PG Programmes in Chemistry offers inorganic, organic, physical, materials and analytical chemistry courses. All the courses have defined course objectives and outcomes, which will help prospective students choose the elective courses to broaden their skills in chemistry and interdisciplinary areas. New interdisciplinary subjects and their applications from a chemistry point of view will provide a new dimension to their understanding of chemistry. Thus, the programme bridges the overlapping areas of chemistry with physics, biology, and environmental sciences. Further, a broad range of frontier areas of chemistry has also been introduced, which can be helpful for students to broaden their theoretical and experimental knowledge that suits the needs of academia and industry.

The curriculum will enable the students to extend the horizons of their knowledge of chemistry and prepare them for higher research studies. The advanced knowledge and specialised skills they gain in the PG programmes will enable them to create knowledge. The curriculum will also equip students for national-level competitive examinations they may appear. In addition, the employability of graduates is given due importance so that their core competency in the subject matter, both theoretical and practical, is ensured.

2.6 Programme Educational Objectives (PEOs)

The PG Programme in chemistry has the following Programme Educational Objectives (PEOs):

PEO 1: Broad and balanced knowledge of chemistry and understanding of advanced chemical concepts, principles and theories.

PEO 2: To develop the ability and skill of the students to acquire expertise in solving theoretical and applied chemistry problems.

PEO 3: To provide knowledge and skills to the students, thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/ entrepreneurship.

PEO 4: To provide an environment that ensures the cognitive development of students in a holistic manner. A complete dialogue about chemistry, chemical equations and their significance is fostered in this framework rather than mere theoretical aspects.

PEO 5: To provide the latest subject matter, both theoretical and practical, in such a way as to foster their core competency and discovery learning. As envisioned in this framework, a chemistry graduate would be sufficiently competent to undertake further discipline-specific studies and begin domain-related employment.

PEO 6: To make a responsible citizen aware of basic domain-independent knowledge, including critical thinking and communication.

2.7 Programme Outcomes (POs)

	Type of Programme Outcome (PO)	*Programme Outcome (PO) Descriptor*
PO 1	**Problem Solving**	A graduate student should be able to demonstrate the capability to: • make judgements and take decisions regarding adopting approaches to solving problems, including real-life issues, based on the analysis and evaluation of information and empirical evidence collected. • make judgments across a range of functions requiring the exercise of full responsibility and accountability for personal and group actions to generate solutions to specific problems associated with the chosen fields/subfields of study, work, or professional practice.
PO 2	**Analytical Reasoning & Critical Thinking**	The graduates should be able to demonstrate the ability to: • evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyse and synthesise data from various sources; draw valid conclusions and support them with evidence and examples; and address opposing viewpoints.
PO 3	**Creativity & Innovation**	The graduates should be able to demonstrate the ability to: • create, perform, or think in different and diverse ways about the same objects or scenarios, • deal with problems and situations that do not have simple solutions, • innovate and perform tasks in a better manner, • view a problem or a situation from multiple perspectives, • think 'out of the box' and generate solutions to complex problems in unfamiliar contexts, • adopt innovative, imaginative, lateral thinking, interpersonal skills and emotional intelligence.
PO 4	**Communication Skills**	The graduates should be able to demonstrate the skills that enable them to: • listen carefully, read texts and research papers analytically, and present complex information clearly and concisely to peers and the public at large, • communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the chosen field of study, • present concisely a view of the relevance and applications of the findings of recent research and evaluation studies in the context of emerging developments and issues.

PO 5	**Research Aptitude**	The graduates should be able to demonstrate the ability to: • problematise, synthesise and articulate issues and design research proposals, • define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships, • develop appropriate methodology and tools for data collection, • use appropriate statistical and other analytical tools and techniques for the analysis of data collected for research and evaluation studies, • plan, execute and report the results of an experiment or investigation, • follow basic research ethics and skills in practising/doing ethics in the field/ in one's research work.
PO 6	**Leadership Readiness and Teamwork Qualities**	The graduates should be able to demonstrate the ability to: • map out the tasks of a team or an organisation and set direction. • formulating an inspiring vision and building a team that can help achieve the vision, motivating and inspiring team members to engage with that vision. • using management skills to guide people to the right destination. • work effectively and respectfully with diverse teams, • facilitate cooperative or coordinated effort on the part of a group, • act together as a group or a team in the interests of a common cause and work efficiently as a team member.
PO 7	**Constitutional, Humanistic, Ethical, and Moral Values**	The graduates should be able to demonstrate the willingness and ability to: • embrace and practice constitutional, humanistic, ethical, and moral values in life, including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values, • adopt objective, unbiased, and truthful actions in all aspects of work related to the chosen fields/subfields of study and professional practice, • participate in actions to address environmental protection and sustainable development issues, • support relevant ethical and moral issues by formulating and presenting coherent arguments, • follow ethical principles and practices in all aspects of research and development, including inducements for enrolling participants, avoiding unethical practices such as fabrication, falsification or misrepresentation of data or committing plagiarism and adhering to intellectual property rights.

PO 8	**Employability and Skill Development**	The graduates should be able to demonstrate the acquisition of knowledge and skill sets required for: • adapting to the future of work and responding to the demands of the fast pace of technological developments and innovations that drive the shift in employers' demands for skills, particularly concerning the transition towards more technology-assisted work involving the creation of new forms of work and rapidly changing work and production processes, • adapting to changing trades and demands of the workplace, including adapting to the changes in work processes through knowledge/ skill development/reskilling.
PO 9	**Entrepreneurship Skills and Capabilities/Qualities and Mindset**	The graduates should be able to demonstrate the ability to: • envision a future, anticipate trends, identify gaps and conceptualise innovative solutions that address the problem, • think outside the box, challenge conventional wisdom, and push the boundaries of possibility, • pivot strategies, seize new opportunities, and navigate uncertainty, • adjust course as circumstances dictate while staying true to their long-term vision.
PO 10	**Lifelong Learning**	The graduates should be able to demonstrate the ability to: • acquire new knowledge and skills necessary for pursuing learning activities throughout life through self-paced and self-directed learning aimed at personal development, meeting the nation's economic, social, and cultural objectives, • acquire organisational skills and time management to set self-defined goals and targets with timelines, • inculcate a healthy attitude to be a lifelong learner.

2.8 Programme Specific Outcomes (PSOs)

	Type of Programme Specific Outcome (PSO)	*Programme Specific Outcome (PSO) Descriptor*
PSO 1	**Knowledge & Understanding**	Graduates should be able to demonstrate the acquisition of: • comprehensive knowledge and understanding of theoretical and experimental chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. • application of knowledge and understanding in a broad multidisciplinary context, their different learning areas, their linkages with related fields of study, and current and emerging developments.
PSO 2	**Skills Related to One's Specialisation**	• skills involving the constructive use of knowledge in the subfields of chemistry (analytical, inorganic, organic and physical) and other related fields of study in a range of settings, including pursuing higher studies related to the chosen area of specialisation within chemical sciences.

PSO 3	**Application of Knowledge and Skills**	Graduates should be able to apply: • standard chemistry-related methodologies to conduct chemical syntheses, analyses or other chemical investigations to seek solutions to problems that emerge from the subfields of chemistry and broader interdisciplinary subfields relating to chemistry.
PSO 4	**Quantitative, Analytical and Instrument-based Skills**	Graduates should be able to acquire: • hands-on training on various analytical instruments and classical quantitative techniques. It will enable them to cross branches and join analytical, pharmaceutical, material testing and biochemical labs besides standard chemical laboratories.

2.9 Credit Distribution of the PG Programmes

2.9.1 For 1-Year PG

Curricular Components	**PG Programmes for 4-yr UG (Hons. / Hons. with Research)** Minimum Credits			
	Course Level	**Major / Minor / Coursework**	**Research thesis/ project/ Patent**	**Total Credits**
Coursework	500	40	-	**40**
Coursework + Research	500	20	20	**40**

2.9.2 For 2-Year PG

Curricular Components		**PG Programmes** Minimum Credits			
		Course Level	**Major / Minor / Coursework**	**Research thesis / project / Patent**	**Total Credits**
1st Year (1st & 2nd Semester)		400	40	-	**40**
Students who exit at the end of 1st year shall be awarded a **PG Diploma**.					
2nd Year (3rd & 4th Semester)	Coursework	500	40	-	**40**
	Coursework + Research	500	20	20	**40**

2.10 Structure of the PG Programmes

The curriculum is drafted according to the '*UGC Curriculum and Credit Framework for Postgraduate Programmes (2024)*' to equip students with the knowledge to extend their chosen subject and prepare them for higher research studies. The advanced knowledge and specialised skills they gain in the PG programmes are crucial to transforming a student from an acquirer of knowledge to a creator of knowledge.

The curriculum consists of advanced courses, including lecture courses with practicum, seminar-based courses, term papers, research methodology, advanced laboratory experiments/software training, research projects and hands-on training. Overall, the courses in the PG programmes consist of core courses, departmental electives, minor courses, and coursework.

2.10.1 Core Courses

The core courses allow students to gain in-depth knowledge of diverse frontier areas of chemistry. These courses are designed to provide advanced knowledge and specialised skills. Through advanced laboratory experiments, the use and application of software, research projects, and hands-on training on analytical instruments, the students will enhance their academic prowess, develop a passion for advancing their understanding of chemistry, and prepare themselves for higher research studies. The departmental elective courses are also part of these courses.

Departmental Elective Courses: A departmental elective course can be chosen from a pool of courses. These specialised courses support the discipline of study, provide an extended scope, enable exposure to other domains, and nurture the candidate's proficiency/skill. Departmental Electives allow students to tailor their academic journey to their interests and career aspirations. These courses complement the core courses and provide insights into specialised knowledge and analytical skills for solving complex scientific challenges by exploring diverse topics.

2.10.2 Minor Courses

The minor courses in postgraduate programmes consist of courses on research methodology and research and publication ethics. Instead of the minor courses, the students can also opt for online courses (MOOCs) on research methodology and ethics from the SWAYAM platform.

2.10.3 Coursework

These courses are designed to encourage students to engage critically with current research, theories, and practices in the frontier areas of chemistry. The courses on advanced laboratory experiments, which include the use and application of software and hands-on training on analytical instruments, will help the students develop research skills. Furthermore, courses on literature surveys, data analysis and presentation of findings as scientific reports will prepare them for higher research studies.

2.10.4 Research Project/Dissertation

Students choosing a 1-year PG (Coursework & Research) or 2-year PG (Coursework & Research) must undertake research projects under the guidance of a faculty member. The research outcomes of their project work may be published in peer-reviewed journals, presented at conferences /seminars, or patented.

2.11 Credit Distribution of the PG Programmes

2.11.1 1-Year PG (Coursework)

NCrF Credit Level	Semester	Course	Course Level	Credit	Total Credit
6.5	1st	Coursework 1	500	4	20
		Coursework 2	500	4	
		Coursework 3	500	4	
		Coursework 4	500	4	
		Coursework 5	500	4	
	2nd	Coursework 6	500	4	20
		Coursework 7	500	4	
		Coursework 8	500	4	
		Coursework 9	500	4	
		Coursework 10	500	4	
			Total	**40**	**40**

2.11.2 1-Year PG (Coursework & Research)

NCrF Credit Level	Semester	Course	Course Level	Credit	Total Credit
6.5	1st	Coursework 1	500	4	20
		Coursework 2	500	4	
		Coursework 3	500	4	
		Coursework 4	500	4	
		Coursework 5	500	4	
	2nd	Research Project	500	20	20
			Total	**40**	**40**

2.11.3 2-Year PG (Coursework)

NCrF Credit Level	Semester	Course	Course Level	Credit	Total Credit
6.0	1st	Core 1	400	4	20
		Core 2	400	4	
		Core 3	400	4	
		Core 4	400	4	
		Minor 1 (Research Methodology)	400	4	
	2nd	Core 5	400	4	20
		Core 6 (Departmental Elective 1)	400	4	
		Core 7 (Departmental Elective 2)	400	4	
		Core 8 (Departmental Elective 3)	400	4	
		Minor 2 (Research and Publication Ethics)	400	4	
Students exiting the programme after securing 40 credits will be awarded a **PG Diploma** in the relevant Discipline /Subject					

6.5	3rd	Coursework 1	500	4	20
		Coursework 2	500	4	
		Coursework 3	500	4	
		Coursework 4	500	4	
		Coursework 5	500	4	
	4th	Coursework 6	500	4	20
		Coursework 7	500	4	
		Coursework 8	500	4	
		Coursework 9	500	4	
		Coursework 10	500	4	
			Total	80	80

2.11.4 2-Year PG (Coursework & Research)

NCrF Credit Level	Semester	Course	Course Level	Credit	Total Credit
6.0	1st	Core 1	400	4	20
		Core 2	400	4	
		Core 3	400	4	
		Core 4	400	4	
		Minor 1 (Research Methodology)	400	4	
	2nd	Core 5	400	4	20
		Core 6 (Departmental Elective 1)	400	4	
		Core 7 (Departmental Elective 2)	400	4	
		Core 8 (Departmental Elective 3)	400	4	
		Minor 2 (Research and Publication Ethics)	400	4	
Students exiting the programme after securing 40 credits will be awarded a **PG Diploma** in the relevant Discipline /Subject					
6.5	3rd	Coursework 1	500	4	20
		Coursework 2	500	4	
		Coursework 3	500	4	
		Coursework 4	500	4	
		Coursework 5	500	4	
	4th	Research Project	500	20	20
			Total	80	80

2.12 Semester-Wise Credit Distribution

2.12.1 1-Year PG (Coursework)

Course Code	Course Title	Course Component	Contact Hour	Maximum Marks			Credit (L:T:P)	Credit	Total Credit
				End Semester Examination	Internal Assessment	Total			
SEMESTER I									
CHE-101-CW-6110	Advanced Topics in Chemistry I	Theory	60	80	20	100	3:1:0	4	**20**
CHE-101-CW-6120	Advanced Topics in Chemistry II	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6130	Applications of Molecular Spectroscopy & X-Ray Crystallography / MOOCs	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6140	Advanced Laboratory Course I	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6150	Advanced Laboratory Course II	Practical	120	80	20	100	0:0:4	4	
SEMESTER II									
CHE-101-CW-6210	Chemistry of Nanomaterials / MOOCs	Theory	60	80	20	100	3:1:0	4	**20**
CHE-101-CW-6220	Biochemistry	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6230	Literature Survey	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6240	Advanced Laboratory Course III	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6250	Research Methods in Chemistry	Practical	120	80	20	100	0:0:4	4	

2.12.2 1-Year PG (Coursework & Research)

Course Code	Course Title	Course Component	Contact Hour	Maximum Marks			Credit (L:T:P)	Credit	Total Credit
				End Semester Examination	Internal Assessment	Total			
SEMESTER III									
CHE-101-CW-6110	Advanced Topics in Chemistry I	Theory	60	80	20	100	3:1:0	4	**20**
CHE-101-CW-6120	Advanced Topics in Chemistry II	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6130	Applications of Molecular Spectroscopy & X-Ray Crystallography / MOOCs	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6140	Advanced Laboratory Course I	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6150	Advanced Laboratory Course II	Practical	120	80	20	100	0:0:4	4	
SEMESTER IV									
CHE-101-RP-6210	Research Project	Research	600	400	100	500	0:0:20	20	**20**

2.12.3 2-Year PG (Coursework)

Course Code	Course Title	Course Component	Contact Hour	Maximum Marks: End Semester Examination	Maximum Marks: Internal Assessment	Maximum Marks: Total	Credit (L:T:P)	Credit	Total Credit
SEMESTER I									
CHE-101-CC-5110	Inorganic Chemistry	Theory	45	80	20	100	3:0:1	4	**20**
		Practical	30	80	20	100			
CHE-101-CC-5120	Organic Chemistry	Theory	45	80	20	100	3:0:1	4	
		Practical	30	80	20	100			
CHE-101-CC-5130	Physical Chemistry	Theory	45	80	20	100	3:0:1	4	
		Practical	30	80	20	100			
CHE-101-CC-5140	Advanced Molecular Spectroscopy	Theory	60	80	20	100	3:1:0	4	
CHE-101-RC-5110	Research Methodology / MOOCs	Theory	60	80	20	100	3:1:0	4	
SEMESTER II									
CHE-101-CC-5210	Advanced Organometallic Chemistry	Theory	45	80	20	100	2:1:1	4	**20**
		Practical	30	80	20	100			
CHE-101-DE-52XX0	Departmental Elective I	Theory	45	80	20	100	2:1:1	4	
		Practical	30	80	20	100			
CHE-101-DE-52XX0	Departmental Elective II	Theory	45	80	20	100	2:1:1	4	
		Practical	30	80	20	100			
CHE-101-DE-52XX0	Departmental Elective III	Theory	45	80	20	100	2:1:1	4	
		Practical	30	80	20	100			
CHE-101-RC-5210	Research and Publication Ethics / MOOCs	Theory	60	80	20	100	3:1:0	4	
SEMESTER III									
CHE-101-CW-6110	Advanced Topics in Chemistry I	Theory	60	80	20	100	3:1:0	4	**20**
CHE-101-CW-6120	Advanced Topics in Chemistry II	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6130	Applications of Molecular Spectroscopy & X-Ray Crystallography / MOOCs	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6140	Advanced Laboratory Course I	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6150	Advanced Laboratory Course II	Practical	120	80	20	100	0:0:4	4	
SEMESTER IV									
CHE-101-CW-6210	Chemistry of Nanomaterials / MOOCs	Theory	60	80	20	100	3:1:0	4	**20**
CHE-101-CW-6220	Biochemistry	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6230	Literature Survey	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6240	Advanced Laboratory Course III	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6250	Research Methods in Chemistry	Practical	120	80	20	100	0:0:4	4	

2.12.4 2-Year PG (Coursework & Research)

Course Code	Course Title	Course Component	Contact Hour	Maximum Marks			Credit (L:T:P)	Credit	Total Credit
				End Semester Examination	Internal Assessment	Total			
SEMESTER I									
CHE-101-CC-5110	Inorganic Chemistry	Theory	45	80	20	100	3:0:1	4	**20**
		Practical	30	80	20	100			
CHE-101-CC-5120	Organic Chemistry	Theory	45	80	20	100	3:0:1	4	
		Practical	30	80	20	100			
CHE-101-CC-5130	Physical Chemistry	Theory	45	80	20	100	3:0:1	4	
		Practical	30	80	20	100			
CHE-101-CC-5140	Advanced Molecular Spectroscopy	Theory	60	80	20	100	3:0:1	4	
CHE-101-RC-5110	Research Methodology / MOOCs	Theory	60	80	20	100	3:1:0	4	
SEMESTER II									
CHE-101-CC-5210	Advanced Organometallic Chemistry	Theory	45	80	20	100	2:1:1	4	**20**
		Practical	30	80	20	100			
CHE-101-DE-52XX0	Departmental Elective I	Theory	45	80	20	100	2:1:1	4	
		Practical	30	80	20	100			
CHE-101-DE-52XX0	Departmental Elective II	Theory	45	80	20	100	2:1:1	4	
		Practical	30	80	20	100			
CHE-101-DE-52XX0	Departmental Elective III	Theory	45	80	20	100	2:1:1	4	
		Practical	30	80	20	100			
CHE-101-RC-5210	Research and Publication Ethics / MOOCs	Theory	60	80	20	100	3:1:0	4	
SEMESTER III									
CHE-101-CW-6110	Advanced Topics in Chemistry I	Theory	60	80	20	100	3:1:0	4	**20**
CHE-101-CW-6120	Advanced Topics in Chemistry II	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6130	Applications of Molecular Spectroscopy & X-Ray Crystallography / MOOCs	Theory	60	80	20	100	3:1:0	4	
CHE-101-CW-6140	Advanced Laboratory Course I	Practical	120	80	20	100	0:0:4	4	
CHE-101-CW-6150	Advanced Laboratory Course II	Practical	120	80	20	100	0:0:4	4	
SEMESTER IV									
CHE-101-RP-6210	Research Project	Research	600	400	100	500	0:0:20	20	**20**

2.12.5 Departmental Electives

SEMESTER II								
Course Code	Course Title	Course Component	Contact Hour	Maximum Marks			Credit (L:T:P)	Credit
				End Semester Examination	Internal Assessment	Total		
CHE-001-DE-52010	Bioinorganic Chemistry	Theory	45	80	20	100	2:1:1	4
		Practical	30	80	20	100		
CHE-001-DE-52020	Inorganic Reaction Mechanisms	Theory	45	80	20	100	2:1:1	4
		Practical	30	80	20	100		
CHE-001-DE-52030	Organic Synthesis	Theory	45	80	20	100	2:1:1	4
		Practical	30	80	20	100		
CHE-001-DE-52040	Chemistry of Natural Products	Theory	45	80	20	100	2:1:1	4
		Practical	30	80	20	100		
CHE-001-DE-52050	Polymer Chemistry	Theory	45	80	20	100	2:1:1	4
		Practical	30	80	20	100		
CHE-001-DE-52060	Advanced Chemical Kinetics	Theory	45	80	20	100	2:1:1	4
		Practical	30	80	20	100		

*Students must choose any 3 (three) Departmental Electives from the above.

2.13 Conversion of Percentage into Credit(s) and Grade(s)

- Under the absolute grading system adopted by the University, the marks shall be converted to grades based on pre-determined class intervals. The grading system with the following letter grades shall be adopted to award the grades and CGPA under the credit-based semester system.

% of Marks	Grade Point	Letter Grade
90-100 %	10	O (Outstanding)
80-less than 90 %	9	A+ (Excellent)
70-less than 80 %	8	A (Very Good)
60-less than 70 %	7	B+ (Good)
50-less than 60 %	6	B (Above Average)
40-less than 50 %	5	C (Average)
35-less than 40 %	4	P (Pass)
Less than 35	0	F (Fail)
Absent	0	AB (Absent)

- Conversion to grade point to percentage = Grade Point × 10.0.
- A student obtaining a Grade F shall be considered failed and required to reappear in the examination.
- **Semester Grade Point Average (SGPA)** is the sum of the products of the course credit and grade points scored by a student divided by the sum of all course credits offered by the student. It can be calculated in the following manner:

$$SGPA\ (S_i) = \frac{\sum(C_i \times G_i)}{\sum C_i}$$

  Where, C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

- Illustration of computation of SGPA

Semester	Course	**Marks Obtained** (Internal Assessment + End semester exam)	Letter Grade	Grade Point (G)	Credit (C)	Credit Point (G × C)
1st	Course 1	92	O	10	4	10 × 4 = 40
1st	Course 2	85	A+	9	4	9 × 4 = 36
1st	Course 3	73	A	8	4	8 × 4 = 32
1st	Course 4	52	B	6	4	6 × 4 = 24
1st	Course 5	62	B+	7	4	7 × 4 = 28
					20	160
					SGPA	160/20 = **8.0**

- **Cumulative Grade Point Average (CGPA)** is the sum of the products of the total number of credits of all courses taken by a student in a semester, with the SGPA in that semester divided by the total number of credits of all courses taken. It can be calculated in the following manner:

$$CGPA = \frac{\sum(C_i \times S_i)}{\sum C_i}$$

Where, S_i is the SGPA of the i^{th} semester and C_i is the number of credits in that semester.

- Illustration of computation of CGPA

Semester I	Semester II	Semester III	Semester IV
Credit 20 SGPA 8.0	Credit 20 SGPA 7.5	Credit 20 SGPA 8.2	Credit 20 SGPA 6.9
CGPA = [(20 × 8.0) + (20 × 7.5) + (20 × 8.2) + (20 × 6.9)] / 80 = 7.65			

2.14 Teaching-Learning Processes

PG programmes are designed to provide students with a sound theoretical background and practical training in all aspects of chemistry and help them appreciate its importance in different contexts. The programme includes advanced courses that span the traditional sub-disciplines of chemistry. Along with the above core courses, there are discipline-specific elective courses that will address the needs of the hour.

These courses shall be delivered through classroom, laboratory work, and projects in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and tools (PowerPoint presentations, audiovisual resources, e-resources, seminars, workshops, models, and software).

The laboratory training complements the theoretical principles learned in the classroom. It includes molecule synthesis, measurement of chemical properties and phenomena, hands-on experience with modern instruments, computational data analysis, modelling, and laboratory safety procedures.

2.15 Assessment Methods

The NEP 2020 emphasises formative and continuous assessment rather than summative assessment. Therefore, the assessment scheme should have components of these two types of assessments. Assessments must correlate with the learning outcomes a student will achieve after completing the course. Therefore, the mode and assessment system must be guided by the learning outcomes.

The primary objective of the assessment of the academic performance of a student in various courses is to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge and practical laboratory skills. The assessment methodologies that should be adopted for this curriculum include (but are not limited to) the following.

- The oral and written examinations (scheduled and surprise tests),
- Problem-solving exercises,
- Practical assignments and laboratory reports,
- Individual and group assignments,
- seminar presentations,
- *Viva voce* interviews.

2.16 Conduct of Examinations

(a) All students shall be assessed through continuous evaluation. Accordingly, a student must attend and duly pass at least two Internal Assessment tests out of three and the End Semester Examination.

(b) The structure of these Internal Assessment Tests and End Semester Examinations shall be 20:80.

(c) To calculate the SGPA, the two best internal assessment tests taken shall be considered. Attending two Internal Assessment tests out of three shall be compulsory.

(d) The following shall be applicable:
   (i) At least two Internal Assessment tests will be written.
   (ii) At least one Internal Assessment test shall be an assignment such as a term course, book review, group discussion, PowerPoint presentation, or even another written test. The format to apply shall be at the discretion of the course teacher.
   (iii) Internal Assessment tests for all practical courses shall always be a practical test.

(e) In terms of marks, a theoretical component of each course is 100 marks: 20 marks for internal assessment and 80 marks for end-semester examination. The practical component will be 100 marks: 20 for the internal assessment and 80 for the end-semester practical examination.

(f) The minimum pass mark for each course at the end-semester examination shall be 35 %. The minimum pass mark for the internal assessment tests shall be 35 % for each course. The minimum pass mark for a practical course shall be the same as that of the theory course. The questions for the end-term theory examination will be distributed as follows:

For courses (L:T:P): 2:1:1 / 3:0:1

Section	Total Questions	Marks for Each Question	To Attempt	TOTAL
A	4	5	4	20
B	4	10	3	30
C	3	15	2	30
				80

For courses (L:T:P): 3:1:0

Section	Total Questions	Marks for Each Question	To Attempt	TOTAL
A	5	5	4	20
B	4	10	3	30
C	4	15	2	30
				80

(g) Upon completion of the research project, students must submit the work as a dissertation followed by an oral presentation in the presence of faculty members and external expert(s).

PART 3: COURSE CONTENTS

SEMESTER I

SEMESTER I

NCrF Level	6.0	
Course Code	CHE-101-CC-5110	
Title of the Course	Inorganic Chemistry	
Nature of the Course	Core	
Total Credits	4 (L 3 – T 0 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives
This course introduces students to the importance of symmetry and group theory. It deals with the application of group theory in the determination of spectroscopic properties and the construction of hybrid orbitals for molecular bonding. It also deals with the magnetic and electronic properties of *d*- and *f*-block elements. The course will enable the students to learn how to prepare and characterise coordination complexes using various analytical techniques.

Course Outcomes
On completion of this course, the students will be able to:

CO1: Understand the basics and importance of symmetry and learn about the matrix representation of symmetry elements and the construction of character tables.

CO2: Understand the application of group theory in IR, Raman and electronic spectroscopy.

CO3: Acquire basic knowledge in constructing hybrid orbitals for σ- & π-bonding.

CO4: Apply concepts in interpreting the electronic spectral properties of *d*- and *f*-block metal complexes.

CO5: Learn the preparation of coordination complexes and their characterisation employing different analytical techniques (including quantitative estimation).

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Molecular Symmetry and Group Theory Symmetry elements and operations. Group and its characteristics, subgroup, classes, similarity transformations. Product of symmetry operations, equivalent atoms and equivalent symmetry elements. Relation between symmetry elements and operations, classes of symmetry operations. Matrix representation of groups, reducible and irreducible representations. Orthogonality theorem, properties of irreducible representations, character tables and their construction. Mulliken notations.	15	CO1
Applications of Group Theory Direct product representation, projection operator and symmetry-adapted linear combination (SALC), symmetry selection rules for IR, Raman and electronic spectra. Hybrid orbital and hybridisation in polyatomic molecules, construction of hybrid orbitals for sigma & π-bonding (e.g. D_{3h}, D_{4h}, T_d, O_h).	15	CO2, CO3

Molecular Orbital Theory: LCAO-MO approach; Construction of MO diagrams of polyatomic molecules (e.g. BeH_2, H_2O, BH_3, NH_3, CH_4) including coordination complexes (O_h and T_d).		
Electronic Spectra of *d*- and *f*-Block Metal Complexes Microstates and term symbols, term symbols of d_n system, Racah parameters, splitting of terms into weak and strong octahedral and tetrahedral fields. Selection rules for electronic transition-effect of spin-orbit coupling and vibronic coupling, *d-d* transition. Orgel diagrams, Tanabe-Sugano diagrams, D_q, B and β (Nephelauxetic ratio) values calculation, charge transfer spectra. Spectral properties of lanthanide and actinide metal complexes.	15	CO4
Practical: Inorganic Chemistry 1. Preparation and characterisation of coordination complexes by various analytical techniques, wherever appropriate and possible: (a) Metal acetylacetonate complexes (e.g., $Mn(acac)_2$, $Fe(acac)_3$, $Cu(acac)_2$). (b) Optical isomers of tris(ethylenediamine)cobalt(III)chloride. (c) Preparation of Werner complex, $[Co(NH_3)_5Cl]Cl_2$ and subsequent preparation of linkage isomers – $[Co(NH_3)_5NO_2]Cl_2$ and $[Co(NH_3)_5ONO]Cl_2$. (d) Polyoxometallates: tetrabutylammoniumhexamolybdate (VI)) ion. (e) Magnetochemistry: Mercury cobalt(II)tetrathiocyanate, $Hg[Co(SCN)_4]$, Prussian blue *Other new novel syntheses reported in the literature from time to time may be included during the semester.*	30	CO5

Recommended Books

Theory

1. Reddy, K. V., *Symmetry and Spectroscopy of Molecules*, 2nd Ed., New Age International Publishers, New Delhi (2020). (ISBN: 978-8122424515).
2. Cotton, F. A., *Chemical Applications of Group Theory*, 3rd Ed., Wiley India, New Delhi (2020). (ISBN: 978-8194726364).
3. Carter, R. L., *Symmetry and Group Theory*, 1st Ed., Wiley India, New Delhi (2009). (ISBN: 978-0471149552).
4. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018). (ISBN: 978-1292134147).
5. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015). (ISBN: 978-0198757177).
6. Miessler, G.; Tarr, D. A., Inorganic Chemistry, 3rd Ed., Pearson Education India, New Delhi (2008). (ISBN: 978-8131718858).
7. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 5th Ed., Pearson Education India (2022). (ISBN: 978-9356064485).

Practical

1. Woolins, J. D. (Ed.), *Inorganic Experiments*, 3rd Ed., Wiley-VCH (2010). (ISBN: 978-3527324729).
2. Girolami, G. S.; Rauchfuss, T. B.; Angelici, R. J., *Synthesis and Techniques in Inorganic Chemistry: A Laboratory Manual*, 3rd Ed., University Science Books (1999). (ISBN: 978-0935702484).
3. Jahagirdar, D. V., *Experiments in Chemistry*, Himalaya Publishing (2011). (ISBN: 978-9351421276).
4. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut (2013). (ISBN: 978-8185842837).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO2	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO3	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO4	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO5	H	M	-	-	-	H	-	-	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER I

NCrF Level	6.0	
Course Code	CHE-101-CC-5120	
Title of the Course	Organic Chemistry	
Nature of the Course	Core	
Total Credits	4 (L 3 – T 0 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

The course covers important organic chemistry topics, such as carbohydrate chemistry, pericyclic reactions, and organic photochemistry. It discusses the classification, configurations, interconversion, structure elucidation, synthesis, and degradation of carbohydrates. The course also covers the basic and advanced concepts of organic photochemistry, pericyclic reactions, and the mechanisms involved. The students will learn about the qualitative analysis of binary mixtures and the application of purification techniques.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Know the occurrence, classification and biological importance of carbohydrates.

CO2: Know the IUPAC naming of disaccharides and their structure elucidation.

CO3: Know and understand photochemistry, mechanisms, and different rearrangement reactions.

CO4: Have good insights into different types of pericyclic reactions and selection rules that decide the stereochemistry thereof.

CO5: Perform qualitative analysis of binary organic mixtures.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Carbohydrates Occurrence, classification and their biological importance. *Monosaccharides*: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, reducing and non-reducing sugars, Haworth projections and conformational structures; interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation. *Disaccharides*: IUPAC nomenclature, structure elucidation and reactions of maltose, lactose and sucrose. Polysaccharides: Elementary treatment of starch, cellulose and glycogen.	15	CO1, CO2

Organic Photochemistry Introduction to organic photochemistry, electronic transitions, Laws of photochemistry, quantum yield; cis-trans isomerisation, Norrish Type I & II reactions, photoreduction of ketones, Paterno-Buchi reaction, Lumiketone rearrangement, Di-π-methane and Di-π-methane type rearrangement, Aza-Di-π-methane type rearrangement, rearrangement of dienones and β, γ-Unsaturated ketones.	15	CO3
Pericyclic Reactions Introduction, types of pericyclic reactions: electrocyclic reaction, cycloaddition, 1,3-dipolar addition, cheletropic reactions, sigmatropic and group transfer reaction: Ene reaction, selection rules, general orbital symmetry rules.	15	CO4
Practical: Organic Chemistry 1. Qualitative Organic Analysis (Maximum three samples) of supplied organic binary mixtures: (a) Qualitative separation by physicochemical method, (b) Identification of the compounds by chemical analysis, (c) Preparation of suitable derivatives, purification and determination of melting points.	30	CO5

Recommended Books

Theory

1. Morrison, R. T.; Boyd, R. N.; Bhattacharjee, S. K., *Organic Chemistry*, 7th Ed., Pearson Education India, New Delhi (2010). (ISBN: 978-8131704813).
2. Finar, I. L., *Organic Chemistry*, Volume 1, 6th Ed., Pearson Education (2002). (ISBN: 978-8177585421).
3. Finar, I. L., *Organic Chemistry*, Volume 2, 5th Ed., Pearson Education (2002). (ISBN: 978-8177585414).
4. Graham Solomons, T.W.; Fryhle, C. B.; Snyder, S. A., *Solomon's Organic Chemistry*, Global Edition., Wiley (2024). (ISBN: 978-8126568116).
5. Greeves, N.; Clayden, J.; Warren, S., *Organic Chemistry*, 2nd Ed., Oxford University Press, New Delhi (2014). (ISBN: 978-0198728719).
6. Singh, J.; Singh, J., *Photochemistry and Pericyclic Reactions*, 6th Ed., New Age International Publishers (2024). (ISBN: 978-9360742720).
7. Klán, P.; Wirz, J., *Photochemistry of Organic Compounds: From Concepts to Practice: 7 (Postgraduate Chemistry Series)*, Wiley (2009). (ISBN: 978-1405161732).
8. Fleming, I., *Molecular Orbitals and Organic Chemical Reactions* - Student Edition, Wiley (1991). (ISBN: 978-0470746592).

Practical

1. Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India, New Delhi (2003). (ISBN: 978-8177589573).
2. Mann, F. G.; Saunders, B. C., *Practical Organic Chemistry*, 4th Ed., Pearson Education India, New Delhi (2009). (ISBN: 978-8131727102).
3. Clarke, H. T., *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers, New Delhi (2007). (ISBN: 978-8123915012).
4. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014). (ISBN: 978-8182835054).

5. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2004). (ISBN: 978-8173714757).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	-	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO2	H	-	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO3	H	-	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO4	H	-	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO5	H	H	-	-	-	H	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER I

NCrF Level	6.0	
Course Code	CHE-101-CC-5130	
Title of the Course	Physical Chemistry	
Nature of the Course	Core	
Total Credits	4 (L 3 – T 0 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course introduces the concept of statistical thermodynamics and different distribution laws. It aims to expand knowledge of partition function, its properties, and different laws of non-equilibrium thermodynamics. This course will also introduce the learners to surface chemistry and surface-catalysed reactions. The students will also learn how to examine the validity of isotherms experimentally and other experiments related to surface tension.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Develop the concept of statistical thermodynamics and different distribution laws.

CO2: Understand partition function and its relation with the different thermodynamic parameters.

CO3: Learn different aspects of non-equilibrium thermodynamics and postulates of non-equilibrium thermodynamics.

CO4: Acquire knowledge of different adsorption isotherms and understand the mechanism of surface-catalysed reactions.

CO5: Perform experiments to compare/investigate the cleansing and adsorption properties of different materials.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Statistical Thermodynamics Concepts of statistical thermodynamics, entropy and thermodynamic probability. Different types of ensembles, ensemble averaging, Stirling approximation. Distribution laws: Maxwell–Boltzmann, Fermi–Dirac and Bose-Einstein; limitation of applicability of various distribution laws. Partition function and its properties, thermodynamic properties in terms of partition functions, evaluation of translational, rotational, vibrational, electronic and nuclear partition functions, law of equipartition of energies, and heat capacity. Molecular partition function and its importance; determination of thermodynamic properties of a monoatomic gas.	15	CO1, CO2

Non-Equilibrium Thermodynamics Difference between equilibrium and non-equilibrium thermodynamics, Postulates of non-equilibrium thermodynamics, Curie-Prigogine principle and microscopic reversibility. Onsagar's relations: thermodynamic and kinetics point of view; phenomenological laws. The entropy of irreversible processes: Clausius inequality; entropy production due to heat flow, mass flow, chemical reactions and electrochemical reactions; rate of entropy productions-generalized fluxes and forces; thermodynamic forces and fluxes; the relation between forces and fluxes; Thermoelectric phenomenon: Peltier, Seebeck and Thomson effect. Relation between chemical potential and thermodynamic potentials.	15	CO3
Surface Chemistry and Catalysis *Adsorption*: Physical adsorption, chemisorption, nature of the adsorbed state, thermodynamics of adsorption, factors affecting adsorption. *Adsorption from solution*: surface tension and surface free energy, application of surface tension, capillary action: Young-Laplace equation; formation of bubbles: Kelvin equation. Capillary condensation; adsorption in micropores and hysteresis loop; Gibbs adsorption equation; surface active and surface inactive materials. *Adsorption isotherms*: Freundlich isotherm, Langmuir isotherm and BET isotherm; determination of the surface area of an adsorbent (Langmuir and BET equation); isosteric enthalpy of adsorption. *Catalytic activity at surfaces*: mechanism of surface reaction, Langmuir-Hinshelwood and Eley-Rideal model, kinetic effects of surface heterogeneity and interactions. Kinetics of heterogeneous catalysis: unimolecular and bimolecular surface reactions.	15	CO4
Practical: Physical Chemistry 1. Determination of the critical micelle concentration of a surfactant by surface tension method. 2. Comparison of the cleansing powers of two samples of detergents by surface tension method. 3. Investigation of the adsorption of oxalic acid from aqueous solutions by activated charcoal and examination of the validity of Freundlich isotherm. 4. Investigation of the adsorption of iodine from aqueous potassium iodide solutions by activated charcoal and examination of the validity of Langmuir isotherm. 5. Any other related experiment may be introduced as and when needed.	30	CO5

Recommended Books

Theory

1. Atkins, P. W.; de Paula, J.; Keeler, J., *Physical Chemistry,* 11th Ed., Oxford University Press India (2018). (ISBN: 978-0198814740).
2. Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing (2020). (ISBN: 978-9382956013).
3. Rakshit, P. C., *Physical Chemistry*, 7th Ed., Sarat Book House (2020). (ISBN: 978-9388069359).
4. Gupta, M. C., *Statistical Thermodynamics,* New Age International Publishers, New Delhi (2007). (ISBN: 978-8122410662).
5. McQuarrie, D. A., *Statistical Mechanics*, Viva Student Edition, Viva Books, New Delhi (2018). (ISBN: 978-8181282361).
6. Kalidas, C.; Sangaranarayanan, M. V., *Non-Equilibrium Thermodynamics-Principles and Applications*, Macmillan Publishers India, New Delhi (2002). (ISBN: 9780333936863).
7. Adamson, A. W.; Gast, A. P., *Physical Chemistry of Surfaces,* 6th Ed, Wiley India, New Delhi (2011). (ISBN: 978-8126534173).
8. Kapoor, K. L., *A Textbook of Physical Chemistry: Dynamics of Chemical Reactions, Statistical Thermodynamics, Macromolecules and Irreversible Processes*, Vol. V, 4th Ed., McGraw Hill Education India (2020). (ISBN: 978-9389811322).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014). (ISBN: 978-8130920696).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015). (ISBN: 978-8182839168).
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2008). (ISBN: 978-8180450792).
4. Sreedher, N. *A Comprehensive Guide to Physical Chemistry Experiments and Viva Questions*, Notion Press (2023). (ISBN: 979-8891861916).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO3	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO4	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO5	H	H	-	-	L	H	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER I

NCrF Level	6.0	
Course Code	CHE-101-CC-5140	
Title of the Course	Advanced Molecular Spectroscopy	
Nature of the Course	Core	
Total Credits	4 (L 3 – T 1 – P 0)	
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course introduces the learners to the basics of NMR, EPR, IR, UV-Vis spectroscopy, and mass spectrometry. It aims to provide students with an understanding of these spectroscopic/spectrometric techniques, which will be needed in the structural elucidation of organic and inorganic compounds in subsequent semesters.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Understand the fundamentals of NMR spectroscopy and interpretation of 1D and 2D NMR spectra.

CO2: Understand the basics of EPR spectroscopy and interpret EPR spectra of organic radicals and inorganic compounds.

CO3: Know the basic principle of mass spectrometry and fragmentation patterns of different classes of organic compounds.

CO4: Know the expected region of IR bands for different vibration and their reasons thereof.

CO5: Know about various factors affecting λ_{max} and ϵ_{max} in UV-vis spectroscopy and to calculate λ_{max} using Woodward-Fieser rules.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
NMR Spectroscopy Basic principles: Zeeman effect, Magnetic properties of nuclei- resonance condition, nuclear spin, population of nuclear spin levels and NMR isotopes, relaxation methods. FT-NMR. Chemical shift, Factors influencing chemical shifts: electronegativity and electrostatic effects; Mechanism of shielding and de-shielding. Spin systems: First-order and second-order coupling of AB systems, Simplifying complex spectra. Spin-spin interactions: Homonuclear coupling interactions - AX, AX_2, AX_3, AMX, AB types. Vicinal, germinal and long-range coupling-spin decoupling. Nuclear Overhauser effect (NOE), factors influencing coupling constants and relative intensities. ^{13}C NMR, DEPT and structural correlations, Satellites. A brief introduction to 2D NMR – COSY, NOESY.	15	CO1

EPR Spectroscopy Characteristic features of EPR spectra, line shapes and line widths; EPR spectrometer. The *g* value and the hyperfine interaction. Interpretation of EPR spectra and structure elucidation of organic radicals using EPR spectroscopy. Spin-orbit coupling and significance of *g*-tensors, zero/non-zero field splitting, Kramer's degeneracy, application to transition metal complexes (having one to five unpaired electrons), including biological molecules and inorganic free radicals. EPR spectra of magnetically dilute samples.	15	CO2
Mass Spectrometry Basic principle. Ionisation techniques – Electron ionisation (EI), chemical ionisation (CI), desorption ionisation (FAB/MALDI), electrospray ionisation (ESI), isotope abundance, molecular ion, base peak, fragmentation processes of organic molecules (hydrocarbons, alcohols, phenols, carbonyl compounds, carboxylic acids, esters). McLafferty rearrangement, deduction of structure through mass spectral fragmentation.	15	CO3
IR & UV-Vis Spectroscopy *IR Spectroscopy*: Fundamental and non-fundamental molecular vibrations; IR absorption positions of hydrocarbons and other important organic functional groups, including alcohols and phenols, ethers, aldehydes, ketones, esters, amides, anhydrides, carboxylic acids, amines, nitro, nitriles, azo and thiols. Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis. *UV-Vis Spectroscopy*: Types of electronic transitions, λ_{max}, chromophores and auxochromes, bathochromic and hypsochromic shifts, the intensity of absorption; application of Woodward-Fieser rules for the calculation of λ_{max} for the following systems: α,β-unsaturated aldehydes, ketones, carboxylic acids and esters; conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans-isomers.	15	CO4, CO5

Recommended Books

1. Pavia, D. L.; Lampman, G. M.; Kriz, G. S.; Vyvyan, J. A., *Introduction to Spectroscopy*, 5th Ed., Cengage Learning India (2015). (ISBN: 978-9381466476).
2. Sathyanarayana, D. N. *Handbook of Molecular Spectroscopy: From Radio Waves to Gamma Rays*, 2nd Ed., IK International Publishing, New Delhi (2019). (ISBN: 978-9386768230).
3. Silverstein, R. M.; Webster, F. X.; Kiemle, D. J.; Bryce, D. L., *Spectrometric Identification of Organic Compounds*, 8th Ed., Wiley India, New Delhi (2022). (ISBN: 978-9354642296).
4. Kemp, W., *Organic Spectroscopy*, 3rd Ed., Macmillan Publishers India, New Delhi (2019). (ISBN: 978-1403906847).
5. Nakamoto, K., *Infrared and Raman Spectra of Inorganic and Coordination compounds*, Part A and Part B, 6th Ed., Wiley Blackwell, New York (2009). (ISBN: 978-0471744924).

6. Gunther, H., *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, 3rd Ed., Wiley India, New Delhi (2013). (ISBN: 978-3527330003).
7. Drago, R. S., *Physical Methods for Chemists*, 2nd Ed., Affiliated East West Press (2016). (ISBN: 978-8176710992).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO2	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO3	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO4	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO5	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER I

NCrF Level	6.0
Course Code	CHE-101-RC-5110
Title of the Course	Research Methodology
Nature of the Course	Minor
Total Credits	4 (L 3 – T 1 – P 0)
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)
Distribution of Marks	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

The course is designed to help students formulate appropriate research aims and objectives and frame a reasonable research hypothesis. It also aims to impart knowledge about sampling techniques, data collection, and analysis using software. Further, students will acquire knowledge about effective scientific report writing.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Understand the aims and objectives of research and formulate a research hypothesis and work plan scientifically.
CO2: Design appropriate sampling techniques and collect data for their experiments.
CO3: Obtain and evaluate information from a variety of databases.
CO4: Process and analyse the data using computer software.
CO5: Communicate effectively in various forms like research publications, patents, etc.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Introduction to Research Methodology An introduction to the basics of scientific research: research objectives, types of research, research process and steps involved. Identification, selection and formulation of a research problem. Intellectual property rights.	15	CO1
Sampling and Data Collection Sampling: design and types; steps involved in sampling; sample size; advantages and limitations. Data types and collection: qualitative and quantitative, data processing, data analysis. Use of databases (SciFinder, Cambridge Structural Database, etc.).	15	CO2, CO3
Computational Methods for Data Analysis and Presentation The application of mean, mode, median, variance, bivariate data: scatterplots, correlation coefficient, standard deviation, least squares fitting methods (linear and non-linear regression analyses). Measures of relative standings: sample z-score, concept of percentile. Software packages for data analysis: MS Excel, Origin, etc. (introductions only). Use of computational chemistry software (Gaussian 09, GAMESS); construction of z-matrix and concept of force field. Classical Molecular Dynamics (MD) simulation.	15	CO4

Scientific Report Writing and Publication Process Forms and types of scientific reports. Steps involved in scientific article writing. Publication process, selection of journals. Writing research proposals and steps involved. Dissertation/Thesis writing: format and content. Bibliography and references, referencing styles. Appendices.	15	CO5

Assignment: Literature survey/ review writing on selected topics

Recommended Books

1. Kothari, C. K.; Garg, G. *Research Methodology-Methods and Techniques*, 5th Ed., New Age International, New Delhi (2023). (ISBN: 978-9389802559).
2. Kumar, R. *Research Methodology–A Step-By-Step Guide for Beginners*; 2nd Ed., SAGE Publications (2024). (ISBN: 978-9351501336).
3. Montgomery, D. C. *Design & Analysis of Experiments*; 8th Ed., Wiley India (2013). (ISBN: 978-8126540501).
4. Mendenhall, W.; Beaver, R. J.; Beaver, B. M. *Introduction to Probability and Statistics*; 14th Ed., Cenage Learning: New Delhi (2013). (ISBN: 978-8131533048).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	H	-	H	-	-	-	-	-	-	-	H	-	H	-
CO2	H	H	H	-	H	-	-	M	-	-	-	-	H	-	H	M
CO3	H	H	-	-	H	M	-	H	-	-	-	-	H	M	H	-
CO4	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	H
CO5	H	M	H	H	H	H	-	H	-	-	-	-	H	M	H	-

H = High; M = Medium; L = Low

SEMESTER II

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-CC-5210	
Title of the Course	Advanced Organometallic Chemistry	
Nature of the Course	Core	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course is intended for students to gain knowledge of organometallic compounds and reagents and their application in organic synthesis and catalysis. It is designed to cover a broad range of topics, such as different types of mechanisms involved in organometallic chemistry, mechanisms of various homogeneous and heterogeneous organometallic catalysis, N-heterocyclic carbene, olefin metathesis, etc. The course also introduces the students to the preparation and characterisation of organometallic compounds by various analytical techniques.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Know the various reactions of organometallic compounds and their characteristics.

CO2: Learn about the synthesis, structure, & reactivity of organometallic compounds and reagents.

CO3: Acquire knowledge of various organometallic compounds containing M-C bonds, metal carbene complexes, N-heterocyclic carbene metal complexes, etc.

CO4: Understand the mechanisms of various homogeneous and heterogeneous organometallic catalysis and their industrial importance.

CO5: Prepare and characterise organometallic compounds using various analytical techniques.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Reactions of Organometallic Compounds Substitution reactions-nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands. Addition and elimination reactions-1,2 additions to double bonds, carbonylation and decarbonylation, oxidative addition and reductive elimination, insertion (migration) and elimination reactions. Rearrangement reactions, redistribution reactions, fluxional isomerism.	15	CO1, CO2
Organometallic Compounds containing M-C, M=C and M≡C Bonds Types of M-C bonds, synthesis and reactivity of metal alkyls, carbenes, alkenes, alkynes, and arene complexes; metallocenes and bent metallocenes. Metal carbene complexes: Fischer, Schrock and Grubbs type carbene complexes, comparison of their stability and	15	CO3

reactivity, reactions of Fischer carbene complexes and their synthetic utility; Alkene metathesis reactions using Schrock and Grubbs carbene metal complexes. Introduction to N-heterocyclic carbene metal complexes. Metal carbyne complexes: synthesis, structure and reactivity.		
Catalysis by Organometallic Compounds Homogeneous organometallic catalysis: alkene hydrogenation using Wilkinson catalyst; hydroformylation of olefins using cobalt or rhodium catalyst; Monsanto acetic acid process; oxidation of olefins by Wacker method; olefin oligomerisation and isomerisation. Palladium catalysed C-C coupling reactions: Negishi, Suzuki, Stille, Heck and Sonogashira coupling Heterogeneous organometallic catalysis: Fischer-Tropsch reaction, Ziegler Natta olefin polymerisation.	15	CO4
Practical: Advanced Organometallic Chemistry 1. Preparation and characterisation by various analytical techniques, wherever appropriate and possible: (a) Ferrocene and its derivatives. (b) Metal hydride complexes: $CoH[(P(OPh_3)_3]_4$ and $NiH[(P(OPh_3)_3]_4$. (c) Triphenylphosphine complexes of transition metals: $NiCl_2(PPh_3)_2$, $RuHCl(CO)(PPh_3)_3$, $RuH_2(CO)(PPh_3)_3$. (d) Metal-Metal bonded complexes: $[Mo_2(O_2CMe)_4]$ and $K_4[Mo_2(Cl)_8]$. *Other new novel syntheses and experiments reported in the literature from time to time may be included during the semester.*	30	CO5

Recommended Books

Theory

1. Spessard, G. O.; Miessler, G. L., *Organometallic Chemistry*, 3rd Ed., Oxford University Press, Oxford (2015). (ISBN: 978-0199342679).
2. Elschenbroich, C., *Organometallics*, 3rd Ed., Wiley-VCH, Weinheim (2016). (ISBN: 978-3527293902).
3. Elias, A.; Gupta, B. D., *Basic Organometallic Chemistry: Concepts, Syntheses and Applications*, 2nd Ed., Universities Press, Hyderabad (2013). (ISBN: 978-8173718748)
4. Crabtree, R. H., *The Organometallic Chemistry of the Transition Metals*, 6th Ed., Wiley-Blackwell, New York (2014). (ISBN: 978-1119465881).
5. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018). (ISBN: 978-1292134147).
6. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., Shriver *Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press, New Delhi (2015). (ISBN: 978-0198757177).
7. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India, New Delhi (2008). (ISBN: 978-8131718858).

Practical

1. Woolins, J. D. (Ed.), *Inorganic Experiments*, 3rd Ed., Wiley-VCH (2010). (ISBN: 978-352732472-9).

2. Parshall, G. W. (Ed.), *Inorganic Syntheses*, Vol XIV, McGraw-Hill (1974). (ISBN: 978-0470131763).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO3	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO4	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO5	H	H	-	-	-	H	-	-	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

DEPARTMENTAL ELECTIVES

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-DE-52010	
Title of the Course	Bioinorganic Chemistry	
Nature of the Course	Departmental Elective	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives
This course introduces students to advanced knowledge of the role of metal ions in biological systems and their structure-function relationship. It also aims to provide a basic understanding of metal-containing proteins and enzymes and their significance. The course also introduces the students to the preparation and characterisation of model compounds of biomolecules.

Course Outcomes
On completion of this course, the students will be able to:

CO1: Understand the role of ion transport across membranes in biological systems and the role of metal ions in photosynthesis.

CO2: Acquire knowledge of the iron-containing proteins and enzymes and their roles in biological systems.

CO3: Understand the structure, function and role of Mo, Cu, Zn and Co-containing enzymes in biological systems.

CO4: Acquire practical experience in synthesising and characterising model compounds of biomolecules.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Ion Transport Across Membrane and Photosynthesis Scope, inorganic elements in the biological system. Mechanism of ion transport across the membrane. Energetics of transport, kinetics and mechanism of transport, ionophores, valinomycin; ATP mediated active transport, Na^+ /K^+ pump. Ca^{2+} transport. Role of calcium in muscle contraction, blood-clotting mechanism. Photosynthesis: Chlorophyll-structural features, role of Mg^{2+}, Z-scheme of photosynthesis - PSI and PSII. Water Oxidation Centre (WOC) and model studies.	15	CO1
Iron-Containing Proteins and Enzymes Oxygen transport and oxygen uptake proteins: transport and storage of dioxygen; Haem proteins and oxygen uptake, structure and functions of haemoglobin and myoglobin, dioxygen binding, cooperativity effect, Bohr effect, Hill equation; model complexes for dioxygen binding; Non-haem systems: hemerythrin and hemocyanin.	15	CO2

Cytochromes: cytochrome c, cytochrome P-450. Iron-sulphur proteins: rubredoxin and ferredoxin. Iron-containing enzymes: peroxidase, catalase. Iron storage and transport: siderophores, ferritin and transferrins.		
Mo, Cu, Zn and Co-Containing Enzymes Molybdenum-containing enzymes: xanthine oxidase, nitrate reductase, nitrogenase, biological fixation of N_2. Copper-containing enzymes: superoxide dismutase, cytochrome c oxidase, plastocyanin and ceruloplasmin. Zinc-containing enzymes: zinc fingers, carbonic anhydrase, carboxypeptidase, alcohol dehydrogenase, phosphodiesterase and nuclease, interchangeability of zinc and cobalt in enzymes. Cobalt-containing enzymes: Vitamin B_{12} and B_{12} coenzymes and cyanocobalamin.	15	CO3
Practical: Bioinorganic Chemistry 1. The synthesis, characterisation and electrochemical studies of Cobalt-based models of water oxidation catalysts. 2. The synthesis and coordination chemistry of macrocyclic complexes. 3. Metalloporphyrin Chemistry: The synthesis and characterisation of porphyrins and their complexes. 4. Stability constants and pH titration of amino acid complexes copper and nickel. 5. Models of Vitamin B_{12}: Cobaloximes. *Other new novel syntheses and experiments reported in the literature from time to time may be included during the semester.*	30	CO4

Recommended Books

Theory

1. Kaim, W.; Schwederski, B.; Klein, A., *Bioinorganic Chemistry-Inorganic Elements in the Chemistry of Life: An Introduction and Guide*, 2nd Ed., John Wiley & Sons, West Sussex (2013). (ISBN: 978-0470975237).
2. Bertini, I.; Gray, H. B.; Lippard, S. J.; Valentine, J. S., *Bioinorganic Chemistry*, Viva Books, New Delhi (2007). (ISBN: 978-8176490009)
3. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018). (ISBN: 978-1292134147)
4. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press, New Delhi (2015). (ISBN: 978-0198757177).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India, New Delhi (2006). (ISBN: 978-9356064485).
6. Rehder, D., *Bioinorganic Chemistry*, Oxford University Press, London (2014). (ISBN: 978-0199655199)

7. Roat-Malone, R. M., *Bioinorganic Chemistry: A Short Course*, 2nd Ed., Wiley-Blackwell, New York (2007). (ISBN: 978-1119535218).
8. Reddy, K. H., *Bioinorganic Chemistry*, New Age International Publishing, New Delhi (2009). (ISBN: 978-9387788879).

Practical
1. Woolins, J. D. (Ed.), *Inorganic Experiments*, 3rd Ed., Wiley-VCH (2010). (ISBN: 978-3527324729).
2. Girolami, G. S.; Rauchfuss, T. B.; Angelici, R. J., *Synthesis and Techniques in Inorganic Chemistry: A Laboratory Manual*, 3rd Ed., University Science Books (1999). (ISBN: 978-0935702484).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO3	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO4	H	H	-	-	H	H	-	-	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-DE-52020	
Title of the Course	Inorganic Reaction Mechanisms	
Nature of the Course	Departmental Elective	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course introduces students to advanced concepts of inorganic reaction mechanisms and inorganic photochemistry. Students will also learn how to study the reaction kinetics of coordination complexes and their redox properties.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Learn about ligand substitution reaction and its mechanism in square planar and octahedral complexes.

CO2: Acquire knowledge of redox reactions and applications of electron transfer reactions in synthesising complexes.

CO3: Understand the kinetics and mechanism of inorganic photochemical reactions.

CO4: Learn about photo splitting of water and inorganic photochemistry in biological processes and their model studies.

CO5: Gain hands-on experience to study the reaction kinetics of coordination complexes and their redox properties using cyclic voltammetric techniques.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Ligand Substitution Reactions Inert and labile complexes; mechanisms of substitution reaction and their kinetic consequences. Ligand substitution reactions in octahedral complexes: ligand and steric effect on reaction rate; water exchange, Eigen-Wilkins mechanism; base-catalysed hydrolysis; isomerisation and racemisation reactions. Ligand substitution in square planar complexes: trans effect and its influence.	15	CO1
Redox Reactions Inner sphere electron transfer, Taube mechanism, bridging ligand effect; outer sphere electron transfer, Marcus theory, Excited state outer sphere electron transfer reactions, use of electron transfer reactions for synthesising complexes. Half-cell reaction, redox potential, electrochemical series, Nernst equation, Latimer and Frost diagram, disproportionation reactions, basics of cyclic voltammetry.	15	CO2
Photochemical Reactions Introduction to Inorganic Photochemistry, photophysical and photochemical processes, characteristics of the electronically excited	15	CO3, CO4

states of inorganic compounds–ligand field states, charge transfer states, Frank-Condon, and thexi states, kinetics of photochemical process. Photochemical reactions: substitution and redox reactions of chromium, cobalt and ruthenium complexes. Relevance of ruthenium polypyridine complexes in solar energy conversion and storage, photo splitting of water, Inorganic photochemistry in biological processes and their model studies.		
Practical: Inorganic Reaction Mechanisms 1. Synthesis of cobalt complexes and their ligand substitution kinetics: Aquation of $[Co(NH_3)_5Cl_2]^{2+}$ and *trans*-$[Co(en)_2Cl_2]^+$. 2. Kinetics of acid hydrolysis of *trans*-$[Co(en)_2Cl_2]^+$. 3. Determination of the diffusion coefficient of the ion $[Fe(CN)_6]^{3-}$ by cyclic voltammetry. 4. Verify the Randles-Sevcik equation for cyclic voltammetry using a reversible system (10 mM mixture of $K_3[Fe(CN)_6]$ and $K_4[Fe(CN)_6]$ in 2 M KCl). Identify the peak current and peak potential at different scan rates. Verify the reversibility of the Fe^{2+}/Fe^{3+} system by using the ratio of cathodic and anodic peak currents. 5. Investigation of the complex ion formation between Ni^{2+} and o-phenanthroline by Job's method. 6. Study of complex formation by the method of isobestic point. 7. Determination of the number of chloride ions in the $[Co(NH_3)_5]Cl_3$ and $[Co(NH_3)_5Cl]Cl_2$. *Other new novel syntheses and experiments reported in the literature from time to time may be included during the semester.*	30	CO5

Recommended Books

Theory

1. Miessler, G.; Tarr, D. A., *Inorganic Chemistry*, 3rd Ed., Pearson Education India, New Delhi (2008). (ISBN: 978-8131718858).
2. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018). (ISBN: 978-1292134147)
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press, New Delhi (2015). (ISBN: 978-0198757177).
4. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 4th Ed., Pearson Education India, New Delhi (2006). (ISBN: 978-9356064485)
5. Jordan, R. B.; *Reaction Mechanisms of Inorganic and Organometallic Systems*, 3rd Ed., Oxford University Press, New York (2007). (ISBN: 978-0195301007).
6. Roundhill, D. M., *Photochemistry and Photophysics of Metal Complexes*, Plenum: New York (1994). (ISBN: 978-1489914972).
7. Basolo, F.; Pearson, R. G., *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution*, 2nd Ed., John Wiley and Sons, New Jersey (1975). (ISBN: 978-0471055457).

Practical

1. Woolins, J. D. (Ed.), *Inorganic Experiments*, 3rd Ed., Wiley-VCH (2010). (ISBN: 978-3527324729).

2. Girolami, G. S.; Rauchfuss, T. B.; Angelici, R. J., *Synthesis and Techniques in Inorganic Chemistry: A Laboratory Manual*, 3rd Ed., University Science Books (1999). (ISBN: 978-0935702484).
3. Jahagirdar, D. V., *Experiments in Chemistry*, Himalaya Publishing (2011). (ISBN: 978-9351421276).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO3	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO4	H	M	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO5	H	H	-	-	-	H	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-DE-52030	
Title of the Course	Organic Synthesis	
Nature of the Course	Departmental Elective	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objective

This course will teach the students about planning the synthesis of complex organic molecules and reagents and methods to achieve targeted synthetic molecules. The course also aims to help learners acquire hands-on experience in synthesising organic molecules.

Course Outcome

On completion of this course, the students will be able to:

CO1: Plan the synthesis of organic molecules via retrosynthesis.
CO2: Have knowledge of different types of disconnections and the importance of the order of events in retrosynthesis.
CO3: Familiarise themselves with different reagents used in organic synthesis.
CO4: Acquire knowledge of the synthesis of organic compounds via C-N coupling and various named reactions.
CO5: Acquire practical expertise in organic synthesis.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Planning a Synthesis Retrosynthesis, synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, importance of the order of events in organic synthesis. One and two group C-X disconnection: synthesis of alcohols, ethers, sulfides, amines; chemoselectivity guidelines; One group C-C disconnections: in alcohols and carbonyl compounds, regioselectivity, Two group C-C disconnections: Diels-Alder reaction, α,β -unsaturated carbonyl compounds, control in carbonyl condensations, difunctionalised compounds, Michael addition and Robinson annulation.	15	CO1, CO2
Reagents in Organic Synthesis Boranes and Alkyl borane; 9-BBN, reduction with trialkylsilanes; tributyltin hydride (Barton-McCombie reaction, radical decarboxylation etc); IBX, Dess-Martin periodinane, Fetizon reagent, dioxiranes, Gilman's reagent, lithium disopropylamide, dicyclohexylcarbodimide, 1,3-dithiane reactivity: Umpolung effect, Phase transfer catalyst, Baker's yeast, NBS, Mosher's reagent, DDQ.	15	CO3

Modern Synthetic Methods Metal-mediated C-N coupling reactions: Buchwald-Hartwig, Ullmann and Chan-Lam cross-coupling reactions; Olefination reactions: Tebbe, Petasis, McMurry, Peterson and Julia olefination reactions; Mannich reaction, Biginelli reaction, Hantzsch reaction, Passerini reaction, Ugi reaction, Mitsonobu reaction, Henry reaction, Nef reaction.	15	CO4
Practical: Organic Synthesis 1. $NaBH_4$ reduction of carbonyl compounds. 2. Oxidation of alcohol using Cr reagent. 3. Nitration of acetanilide/nitrobenzene by conventional method. 4. Benzolyation of amines (aniline/ *o*-, *m*-, *p*-toluidine/ *o*-, *m*-, *p*-anisidine). 5. Dehydration of phthalic acid to phthalic anhydride. 6. Nitration of nitrobenzene.	30	CO5

Recommended Books

Theory

1. Warren, S., *Organic Synthesis: The Disconnection Approach*, Wiley India, New Delhi (2007). (ISBN: 978-8126511464).
2. Carruthers, W., *Modern Methods of Organic Synthesis*, 4th Ed., Cambridge University Press, New Delhi (2005). (ISBN: 978-1107567450).
3. Smith, M. B., *Organic Synthesis*, 4th Ed., Academic Press, Cambridge, Massachusetts (2016). (ISBN: 978-0128007204).
4. Kurti, L., Czako, B., *Strategic Application of Named Reactions in Organic Synthesis,* Elsevier, Amsterdam (2005). (ISBN: 978-0124297852).

Practical

1. Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education, New Delhi (2005). (ISBN: 978-8177589573).
2. Sharma, R. K.; Sidhwani, I. T.; Chaudhari, M. K. *Green Chemistry Experiment: A Monograph*, I. K. International Publishing, New Delhi (2012). (ISBN: 978-9381141557).
3. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2013). (ISBN: 978-8173714757)

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	H	-	-	-	-	-	-	-	-	-	H	H	M	-
CO2	H	-	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO3	H	-	-	-	H	-	-	-	-	-	-	-	H	H	M	-
CO4	H	-	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO5	H	H	-	-	H	H	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-DE-52040	
Title of the Course	Chemistry of Natural Products	
Nature of the Course	Departmental Elective	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course introduces the learners to the classical and advanced concepts and theories of isolation and structure elucidation of biologically important pure molecules from natural products. It also aims to give the learners practical knowledge on synthesising natural products and their characterisation.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Acquire knowledge of extraction, isolation, and purification of natural products from different sources.

CO2: Gain knowledge about the classification and structure determination of terpenoids and alkaloids.

CO3: Learn the basic strategies of using natural products in drug discovery and design.

CO4: Acquire practical knowledge on extracting and isolating natural products and their characterisation.

CO5: Use computational software to learn molecular docking and simulation experiments

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Isolation and Purification of Natural Products *Introduction*: Introduction, sources (plant, animal, microbial, marine), classification on chemical basis. *Extraction of natural products*: Conventional and modern extraction methods, including maceration, percolation, Soxhlet extraction, batch extraction, continuous extraction, counter-current extraction, accelerated solvent extraction and supercritical fluid extraction. Concepts of extraction for activity-guided fractionation. *Introduction to chromatographic techniques*: High-performance thin layer chromatography (HPTLC), flash chromatography, high-performance liquid chromatography (HPLC), gas chromatography (GC), chiral chromatography and reverse phase chromatography and their use in the identification of markers/biomarkers.	15	CO1

Terpenoids and Alkaloids *Terpenoids*: Definition, classification and structure determination (general methods), chemistry of some important terpenoids: geraniol, limonene, carvone. *Alkaloids*: Introduction, isolation technique, general methods of structure determination, classification, chemistry of some well-known alkaloids: morphine, heroin, quinine, nicotine reserpine, etc.	15	CO2
Natural Products in Drug Discovery Drug Discovery, design and development. ADMET of drugs: Factors affecting Absorption, Distribution, Metabolism, Elimination and Toxicity. Structure-activity relationships: Strategies in drug design. QSAR and combinatorial synthesis. Optimization of drug target interactions and access to drug targets. Pro drugs and drug delivery systems. Source, structure and applications of Artemisinin, Ephedrines, Ergot alkaloids, Vasicine, Taxol and their derivatives.	15	CO3
Practical: Chemistry of Natural Products 1. TLC studies of natural extracts and isolation of natural products: (a) Caffeine from tea leaves (b) Nicotine from tobacco (c) β-Carotene from carrot (d) Lycopene from tomato (e) Euginol from cloves (f) Casein from milk (g) Piperine from black pepper (h) Any other extraction possible in the laboratory. 2. Molecular docking and simulation experiments using docking freeware such as AutoDock.	30	CO4, CO5

Recommended Books

Theory

1. Finar, I. L. *Organic Chemistry,* 5th Ed., Vol. 2, Pearson Education, New Delhi (2011). (ISBN: 978-8177585414).
2. Silverman, R. B., *The Organic Chemistry of Drug Design and Drug Action*, 2nd Ed.; Elsevier Academic Press, Cambridge, Massachusetts (2012). (ISBN: 978-9351072720).
3. Mann, J.; Davidson, R. S.; Hobbs, J. B.; Banthrope, D. V., Harborne, J. B., *Natural Products, Their Chemistry and Biological Significance*, Longman, Essex (1994). (ISBN: 978-0582060098).
4. Silverstein, R. M.; Webster, F. X.; Kiemle, D. J.; Bryce, D. L., *Spectrometric Identification of Organic Compounds*, 8th Ed., Wiley India, New Delhi (2022). (ISBN: 978-9354642296).
5. Patrick, G. L., *An Introduction to Medicinal Chemistry*. 6th Ed.; Oxford University Press, New Delhi (2017). (ISBN: 978-0198749691).
6. Nicolaou, K. C.; Sorensen, E. J. *Classics in Total Synthesis: Targets, Strategies, Methods*; Wiley-VCH: New York (1996). (ISBN: 978-3527292318).

7. Lemke, T. L.; Zito, S. W.; Roche, V. F.; Williams, D. A. *Essentials of Foye's Principles of Medicinal Chemistry*; Wolters Kluwer India: New Delhi (2016). (ISBN: 978-9351296683).

Practical

1. Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India, New Delhi (2003). (ISBN: 978-8177589573).
2. Mann, F. G.; Saunders, B. C., *Practical Organic Chemistry*, 4th Ed., Pearson Education India, New Delhi (2009). (ISBN: 978-8131727102).
3. Clarke, H. T., *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers, New Delhi (2007). (ISBN: 978-8123915012).
4. Agarwal, O. P., *Advanced Practical Organic Chemistry*, Krishna Prakashan, Meerut (2014). (ISBN: 978-8182835054).
5. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2004). (ISBN: 978-8173714757).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	H	-	H	-	-	-	-	-	H	H	H	H	H	-
CO2	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO3	H	H	H	-	H	-	-	-	-	-	-	-	H	H	H	-
CO4	H	-	-	-	-	-	-	-	-	-	H	H	H	H	H	-
CO5	H	H	H	-	H	H	-	-	-	-	H	H	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-DE-52050	
Title of the Course	Polymer Chemistry	
Nature of the Course	Departmental Elective	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course is designed to introduce the theory and applications of polymer chemistry to the students. They will also learn the kinetics of polymerisation and study a few industrially important polymers, including conducting polymers and promising polymeric material classes for next-generation devices. The course also aims to help learners acquire hands-on experience synthesising simple and common polymeric materials.

Course Outcomes

After completion of this course, the students will be able to:

CO1: Learn the basic concepts, definitions and classifications of polymers.

CO2: Understand the concept of different types of molecular weight of polymers and the theories involved in their determination.

CO3: Understand various properties of polymers and their solutions.

CO4: Get introduced to the preparation, structure and properties of some industrially important and technologically promising polymers.

CO5: Carry out laboratory syntheses of simple and common polymeric materials and determine the molecular weights.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Introduction to Polymers Brief overview of polymers: Different schemes of classification of polymers, polymer nomenclature, molecular forces and chemical bonding in polymers, texture of polymers. Concept and types of molecular weight; significance of molecular weight; Methods of determining molecular weights of polymers: End group analysis; osmometry, viscometry and light scattering methods. Molecular weight distribution and its significance. Polydispersity index (PDI). Different models for describing the size and shape of dissolved macromolecules, configuration and conformation of macromolecules. Diffusion and Stokes-Einstein equation. Distribution of chain lengths: average end-to-end, root mean square end-to-end and most probable end-to-end chain length.	15	CO1, CO2

Types of polymerisations; kinetics of addition and step growth (condensation) polymerisation; degree of polymerisation and chain length.		
Properties of Polymer and Polymer Solution Determination of crystalline melting point and degree of crystallinity, morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers, structure-property relationships. Glass transition temperature (T_g) and determination of T_g, free volume theory, Williams-Landel-Ferry (WLF) equation, factors affecting glass transition temperature (T_g). Polymer Solution: Criteria for polymer solubility, solubility parameter, thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory-Huggins theory, lower and upper critical solution temperatures. Properties of polymers (physical, thermal, flow & mechanical properties).	15	CO3
Synthesis of Polymers Criteria for synthetic polymer formation. A brief introduction to the preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro-polymers, polyamides and related polymers. Phenol formaldehyde resins (bakelite, novalac), polyurethanes, silicone polymers, polydienes, polycarbonates. Conducting polymers [polyacetylene, polyaniline, poly(*p*-phenylene sulphide polypyrrole, polythiophene)].	15	CO4
Practical: Polymer Chemistry 1. Determination of molecular weight: (a) Determination of molecular weight of a polymer (polystyrene, poly (vinylproplylidine), etc.) by viscometry method. (b) Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer. (c) Determination of molecular weight of polyethylene glycol (PEG) (OH group) by end-group analysis. 2. Polymer Synthesis: (a) Oxidative polymerisation of aniline using ammonium peroxydisulphate. (b) Free radical solution polymerisation of (i) styrene and (ii) Acrylic acid (AA). (c) Preparation of nylon 66/6 (d) Precipitation polymerisation of acrylonitrile (e) Preparation of urea-formaldehyde resin (f) Preparations of novalac resin 3. Polymer Analysis: Estimation of the amount of HCHO in the given solution by sodium sulphite method 4. Instrumental Techniques: IR studies of polymers	30	CO5

Recommended Books

Theory

1. Odian, G., *Principles of Polymerization*, 4th Ed., Wiley India (2004). (ISBN: 978-8126513918).
2. Billmeyer, F.W., *Textbook of Polymer Science*, 3rd Ed., Wiley Interscience (2007). (ISBN: 978-8126511105).
3. Ghosh, P., Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rd Ed., Tata McGraw-Hill Education (2017). (ISBN: 978-0070707047).
4. Flory, P. J., *Principles of Polymer Chemistry*, Asian Books, New Delhi (2006). (ISBN: 978-0801401343).
5. Gowariker, V. R.; Viswanathan, N. V.; Sreedhar, J., *Polymer Science*, 5th Ed., New Age International (2023). (ISBN: 978-9389802580).

Practical

1. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2004). (ISBN: 978-8173714757).
2. Hundiwala, D. G.; Athawale, V. D.; Kapadi, U. R.; Gite, V. V., *Experiments in Polymer Science*, 1st Ed., New Age International (2008). (ISBN: 978-8122423884).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	-	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO2	H	H	-	-	M	-	-	-	-	-	-	-	H	H	M	-
CO3	H	H	-	-	M	-	-	-	-	-	-	-	H	H	M	-
CO4	H	M	-	-	-	-	-	-	-	-	-	-	H	H	M	-
CO5	H	H	-	-	H	H	-	-	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER II

NCrF Level	6.0	
Course Code	CHE-101-DE-52060	
Title of the Course	Advanced Chemical Kinetics	
Nature of the Course	Departmental Elective	
Total Credits	4 (L 2 – T 1 – P 1)	
Total Contact Hours (CH)	75 (Theory – 45; Practical – 30)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)
	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course on physical chemistry covers advanced chemical kinetics, focusing on reactions in solutions and reaction dynamics. The students will also learn how to study the kinetics of various chemical reactions.

Course Outcomes

On successful completion of this course, students will be able to:

CO1: Learn about the methods of studying chemical reactions.

CO2: Develop an understanding of the reaction kinetics in solutions and molecular reaction dynamics.

CO3: Know different theories of dynamics of unimolecular reactions.

CO4: Acquire experience performing least square fitting while conducting experiments on chemical kinetics.

CO5: Determine the order of reaction and activation energy by performing conductometric titration.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Study of Chemical Reactions Methods of studying chemical reactions: molecular beam study; stopped flow technique, temperature and pressure jump methods, NMR studies in fast reactions, shock tube kinetics. Relaxation kinetics: linearized rate equation, relaxation time in single step fast reactions, determination of relaxation time and rate constant.	15	CO1
Reactions in Solutions Kinetics of ion – ion and ion – dipole reactions, effect of dielectric constant on reaction rate; effect of pressure on reaction rate; cage reactions, cluster reactions, electron transfer reactions, kinetics of diffusion-controlled reactions; transport phenomena; Linear free energy relationship, Hammet equation, Taft equation and their applications.	15	CO2
Molecular Reaction Dynamics Potential energy surfaces; features of potential energy surfaces; estimation of activation energy and calculation of potential energy surfaces; collisions of real molecules; trajectory calculations. Dynamics of unimolecular reactions: limitations of Lindemann and	15	CO3

Hinshelwood theory, RRK theory, RRKM theory (quantitative treatment). Femtochemistry: dynamics and chemical reactivity.		
Practical: Advanced Chemical Kinetics 1. To study the kinetics of the reaction between $K_2S_2O_8$ and KI and hence determine the rate constant and order of the reaction. Also, study the influence of ionic strength on the reaction rate. 2. To determine the relative strengths of two acids by studying the acid-catalysed hydrolysis of methyl acetate (use least square fitting). 3. To study the saponification of ethyl acetate by sodium hydroxide conductometrically and determine the order of reaction and activation energy. 4. Determine the dissociation constant of methyl red by spectrophotometric method. 5. To study the autocatalytic reaction between potassium permanganate and oxalic acid.	30	CO4, CO5

Recommended Books

Theory

1. Laidler, K. J., Chemical Kinetics, 3rd Ed., Pearson Education, New Delhi (2011). (ISBN: 978-8131709726).
2. Rajaram, V.; Kuriakose, J. C., Kinetics and Mechanism of Chemical Transformation, McMillan India, New Delhi (2009). (ISBN: 978-0333926581).
3. Pilling, M. J.; Pilling, S.; Seakins, P. W., Reaction Kinetics, Oxford University Press, London (1996). (ISBN: 978-0198554813).

Practical

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books, India (2014). (ISBN: 978-8130920696).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015). (ISBN: 978-8182839168).
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2008). (ISBN: 978-8180450792).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO2	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO3	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO4	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CO5	H	H	-	-	M	H	-	-	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER II

NCrF Level	6.0
Course Code	CHE-101-RC-5210
Title of the Course	Research and Publication Ethics
Nature of the Course	Minor
Total Credits	4 (L 3 – T 1 – P 0)
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)
Distribution of Marks	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course aims to help students understand the philosophy of science and ethics, research integrity, and publication ethics. It also imparts hands-on sessions to identify research misconduct and predatory publications. The course introduces the learners to Indexing and citation databases, open-access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Understand the philosophy of ethics in science and scientific research, as well as intellectual honesty and research integrity.
CO2: Learn to avoid scientific misconduct such as falsification, fabrication, and plagiarism.
CO3: Follow ethical practices in scientific publications, misrepresentation of data, etc.
CO4: Use Indexing and citation databases and understand the importance of research metrics.
CO5: Handle the plagiarism software for their research work.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Philosophy, Ethics and Scientific Conduct Introduction to philosophy: definition, nature and scope, concept, branches. Ethics: definition, moral philosophy, nature of moral judgements and reactions. Ethics concerning science and research. Intellectual honesty and research integrity. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP). Redundant publications: duplicate and overlapping publications, salami slicing. Selective reporting and misrepresentation of data.	15	CO1
Publication Ethics Publication ethics: definition, introduction and importance. Best practices/ standards-setting initiative and guidelines: COPE, WAME, etc. Conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types. Violation of publication ethics, authorship and contributorship. Identification of publication misconduct, complaints and appeals. Predatory publishers and journals.	15	CO2

Open Access Publication and Publication Misconduct Open access publications and initiatives. SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies. Software tools to identify predatory publications developed by SPPU. Journal finder/ journal suggestion tools. Subject-specific ethical issues, FFP, authorship. Conflicts of interest. Complaints and appeals: examples and fraud from India and abroad.	15	CO3
Research Metrics Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score. Metrics: *h*-index, g index, i10 index, altmetrics. **Practice** Use of Journal Suggestion Tools Use of Plagiarism Software Group Discussions on Publication Misconduct	15	CO4, CO5

Recommended Books

1. Bird, A. *Philosophy of Science*; Routledge: London, U.K. (1998). (ISBN: 978-1857285048).
2. MacIntyre, A., *A Short History of Ethics: A History of Moral Philosophy from the Homeric Age to the 20th Century*; 2nd Ed., Routledge: London, U.K. (1998). (ISBN: 978-0415287494).
3. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. *On Being a Scientist: A Guide to Responsible Conduct in Research*; 3rd Ed., The National Academic Press: Washington DC, USA (2009). (ISBN: 978-0309119702).
4. Muralidhar, K.; Ghosh. A.; Singhvi, A. K., Eds. *Ethics in Science Education, Research and Governance*; Indian National Science Academy: New Delhi, India (2019). (ISBN: 978-8193948217).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	M	M	-	-	H	-	-	-	-	-	-	-	H	-	H	-
CO2	M	H	-	-	H	-	-	H	-	-	-	-	H	-	H	M
CO3	M	H	-	H	H	-	-	H	-	-	-	-	H	-	H	M
CO4	H	H	-	-	H	-	-	H	-	-	-	-	H	-	H	H
CO5	H	M	-	-	H	-	-	H	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER III

SEMESTER III

NCrF Level	6.5	
Course Code	CHE-101-CW-6110	
Title of the Course	Advanced Topics in Chemistry I	
Nature of the Course	Coursework	
Total Credits	4 (L 3 – T 1 – P 0)	
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

The course aims to give students a comprehensive understanding of metal clusters, including their structures, bonding, and role in catalysis. The course will enable students to acquire knowledge of protection-deprotection strategies for selective functional group modifications, explore asymmetric synthesis techniques and their applications in catalytic transformations and also study the conformations and reactivity of fused polycyclic systems. The course also aims to provide students with an in-depth understanding of ionic activity, activity coefficients, and their relationship with ionic strength, along with key models such as the Born model, Debye-Hückel equation, and Butler-Volmer equation, focusing on ion-solvent interactions, ion association, and the effects on conductance and diffusion.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Have an in-depth understanding of metal clusters, including their structures, bonding types, and roles in catalysis.

CO2: Acquire an understanding of the Polyhedral Skeletal Electron Pair Theory (PSEPT), capping rules, and isolobal relationships between main-group and transition metal fragments.

CO3: Have a comprehensive understanding of protection-deprotection chemistry and asymmetric synthesis, covering selective protection strategies, chiral catalysis, asymmetric induction, and key stereoselective name reactions.

CO4: Understand the conformational analysis of fused polycyclic systems, the stereochemistry of C-C bond formation reactions, the influence of ring size on cyclisation, and the reactivity of cyclohexane derivatives in various organic transformations.

CO5: Acquire key concepts of ionic solutions, including activity, activity coefficients, and ion-solvent interactions.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Metal-Metal Bond and Clusters Definition of metal clusters, metal-metal multiple bonding in $[M_2X_8]^{2-}$, metal halide clusters. Metal-carbonyl clusters – Low Nuclearity Carbonyl Clusters (LNCC) and High Nuclearity Carbonyl Clusters (HNCC), Clusters having interstitial main group elements. Polyhedral Skeletal Electron Pair Theory (PSEPT), capping rules,	15	CO1, CO2

isolobal relationships between main-group and transition metal fragments. Molecular clusters in catalysis.		
Protection-Deprotection Chemistry and Asymmetric Synthesis Protection-deprotection chemistry: Chemo- and regio-selective protection and deprotection. Commonly used reagents for protection and deprotection of hydroxyl, amino, carboxyl, carbonyl, and carboxy amino groups. Asymmetric synthesis: Introduction, asymmetric induction: substrate, reagent and catalyst-controlled reactions, use of chiral auxiliaries, Prelog's rule, diastereoselective synthesis: Crame's rule, Felkin-Anh model. Stereochemistry of aldol condensation reaction, Zimmerman-Traxler model. Enantioselective synthesis, Sharpless asymmetric dihydroxylation, Noyori asymmetric hydrogenation, Jacobsen epoxidation, Shi epoxidation, Sharpless asymmetric aminohydroxylation.	15	CO3
Advanced Topics in Stereochemistry Conformations of fused polycyclic systems: decalin, 1-decalone and 2-decalone; Stereochemistry of C-C bond formations reactions involving enolate anions; ring size and ease of cyclisation reactions: Baldwin's rule. Effect of conformation of reactivity of cyclohexane: Hydrolysis of esters of cyclohexane carboxylic acid, esterification of cyclohexane carboxylic acids, substitution and elimination in cyclohexane system, reduction of cyclohexanol, rearrangement involving cyclohexanes, epoxidation of cyclohexane halohydrin.	15	CO4
Advanced Topics in Electrochemistry Activity and activity coefficient, mean ionic activity, mean ionic activity coefficient, and ionic strength. Free energy changes due to ion-solvent interaction: Born model; electrical double layer: Helmholtz–Perrin model; The basic electrodic equation: Butler-Volmer equation; over potential. Ion–ion interaction: Debye-Hückel equation (derivation, validity and limitations), extended Debye-Hückel equation. Ion association and effect of conductance: Debye-Hückel-Onsager equation; the random walk model of ionic diffusion: Einstein-Smoluchowski relation.	15	CO5

Recommended Books

1. Steed, J. W.; Turner, D., R.; Wallace, K. J., *Core Concepts in Supramolecular Chemistry and Nanochemistry*, John Wiley & Sons, West Sussex (2007). (ISBN: 978-0470858677).
2. Steed, J. W.; Atwood, J. L., *Supramolecular Chemistry*, 2nd Ed., John Wiley & Sons, West Sussex (2009). (ISBN: 978-8126566730).
3. Kocienski, P. J. *Protecting Groups: Foundations of Organic Chemistry*, 3rd Ed., Thieme Publishing Group, NOIDA (2005). (ISBN: 978-3131370037).
4. Zweifel, G. S.; Nantz, M. H.; Somfai, P., *Modern Organic Synthesis: An Introduction*, 2nd Ed., Wiley-Blackwell, New York (2017). (ISBN: 978-1119086536).

5. Smith, M. B., *Organic Synthesis*, 4th Ed., Academic Press, Cambridge, Massachusetts (2016). (ISBN: 978-0128007204).
6. Warren, S., *Organic Synthesis: The Disconnection Approach*, Wiley India, New Delhi (2007). (ISBN: 978-8126511464).
7. Nasipuri, D. *Stereochemistry of Organic Compounds: Principles and Applications*, 4th Ed., New Age International Publishers, New Delhi (2020). (ISBN: 978-9389802474).
8. Bockris, J. O. M.; Reddy, A. K. N., *Modern Electrochemistry 1: Ionics*, 2nd Ed., Springer India, New Delhi (2018). (ISBN: 978-1493977291).
9. Bockris, J. O. M.; Reddy, A. K. N.; Gamboa-Aldeco, M., *Modern Electrochemistry 2A: Fundamentals of Electrodics*, 2nd Ed., Vol. 2, Springer India, New Delhi (2006). (ISBN: 978-8131727478).
10. Glasstone, S., *An Introduction to Electrochemistry*, East-West Press (2006). (ISBN: 978-8176710138).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO2	H	H	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO3	H	H	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO4	H	H	-	-	-	-	-	-	-	-	-	-	H	H	H	-
CO5	H	M	-	-	-	-	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER III

NCrF Level	6.5	
Course Code	CHE-101-CW-6120	
Title of the Course	Advanced Topics in Chemistry II	
Nature of the Course	Coursework	
Total Credits	4 (L 3 – T 1 – P 0)	
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)

Course Objective

The course aims to introduce students to the fundamentals of supramolecular chemistry. It will enable students to understand magnetic susceptibility, measurement techniques, and the magnetic properties of lanthanides and actinides. The course will also enable students to name small-ring heterocycles and understand various synthetic methods, structural properties, reactions, and substitution mechanisms of small-ring heterocycles. The course will also provide a comprehensive understanding of photochemical and photophysical processes, including absorbance, quantum efficiency, energy transfer mechanisms, fluorescence quenching, and the kinetics of photochemical reactions.

Course Outcome

On completion of this course, the students will be able to:

CO1: Gain a thorough understanding of supramolecular chemistry, including key interactions, host-guest chemistry, binding dynamics, and self-assembly processes.

CO2: Understand magnetic susceptibility, spin and orbital contribution to the magnetic moment, magnetic properties of spin crossover complexes and temperature dependence of magnetic behaviour.

CO3: Learn IUPAC nomenclature of mono- and bicyclic heterocycles, synthesis and chemical properties, reactions, and substitution mechanisms of small heterocycles.

CO4: Understand the laws of photochemistry, photophysical processes, and photochemical reactions, including techniques like flash photolysis and fluorescence quenching.

CO5: Acquire knowledge about quantum efficiency, energy transfer mechanisms, and the kinetics of photophysical and photochemical processes.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Supramolecular Chemistry Origin of supramolecular chemistry. Concepts and terminology of supramolecular chemistry. Types of supramolecular interactions (Hydrogen bonding, van der Waals interaction, π-stacking, CH-π, anion-π interaction). *Host-Guest Chemistry*: macrocyclic effect and their thermodynamic origin, Step-wise and overall binding constant in host-guest chemistry, kinetic and thermodynamic selectivity. Binding of organic and inorganic cationic, anionic, ion pair and neutral guest molecules with host molecules.	15	CO1

Self-Assembly: Definitions and basic concepts of self-assembly, self-assembly using metal templates. Applications of self-assembled molecules.		
Magnetic Properties of *d*- and *f*-block Metal Complexes Magnetic susceptibility, measurement of magnetic susceptibility using Gouy and Faraday methods. Spin-orbit coupling, spin and orbital contributions to the magnetic moment, quenching of orbital angular momentum. Spin crossover complexes; magnetic properties of lanthanides and actinides. Effect of Temperature on magnetic moment: Curie, Curie-Weiss laws. A brief review of different types of cooperative magnetic behaviour.	15	CO2
Heterocyclic Chemistry IUPAC nomenclature of mono- and bicyclic heterocycles. *Small Ring Heterocycles*: Syntheses of aziranes, oxiranes and thiiranes; ring openings and heteroatom extrusion; synthesis and reactions of azetidines, oxetanes and thietanes. *Diazines*: Structural & chemical properties; Synthesis of pyridazines, pyrimidines, pyrazines, nucleophilic and electrophilic substitutions.	15	CO3
Photochemistry Photophysical processes: types and radiationless transitions; photophysical kinetics: unimolecular and bimolecular processes; delayed fluorescence; fluorescence quenching and Stern–Volmer equation, concentration dependence of quenching and excimer formation, quenching by added substances. Electronic energy transfer mechanism of quenching, photosensitisation. Photochemical processes: types of photochemical processes; kinetics of photochemical reactions; quenching of fluorescence; photosensitised reactions; flash photolysis technique and fluorescence quenching technique.	15	CO4, CO5

Recommended Books

1. Steed, J. W.; Turner, D., R.; Wallace, K. J., *Core Concepts in Supramolecular Chemistry and Nanochemistry*, John Wiley & Sons, West Sussex (2007). (ISBN: 978-0470858677).
2. Steed, J. W.; Atwood, J. L., *Supramolecular Chemistry*, 2nd Ed., John Wiley & Sons, West Sussex (2009). (ISBN: 978-8126566730).
3. Housecroft, C. E; Sharpe, A. G., *Inorganic Chemistry*, 5th Ed., Pearson Education (2018). (ISBN: 978-1292134147).
4. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., *Shriver Atkins's Inorganic Chemistry*, 6th Ed., Oxford University Press India (2015). (ISBN: 978-0198757177).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., *Inorganic Chemistry: Principles of Structures and Reactivity*, 5th Ed., Pearson Education India (2022). (ISBN: 978-9356064485).
6. Speicher, A., Hauptmann, S., Eicher, T., *The Chemistry of Heterocycles:Structure, Reactions, Syntheses and Applications*, 3rd Ed., Wiley-VCH Verlag GmbH (2012). (ISBN: 978-3527327478).

7. Acheson, R. M., *An Introduction to the Chemistry of Heterocyclic Compounds*, 3rd Ed., Wiley India, New Delhi (2008). (ISBN: 978-8126516605).
8. Singh, J.; Singh, J., *Photochemistry and Pericyclic Reactions*, 6th Ed., New Age International Publishers (2024). (ISBN: 978-9360742720).
9. Klán, P.; Wirz, J., *Photochemistry of Organic Compounds: From Concepts to Practice: 7 (Postgraduate Chemistry Series)*, Wiley (2009). (ISBN: 978-1405161732).
10. Rohatgi, K. K.; Mukherjee, K. K., *Fundamentals of Photochemistry*, New Age International Pvt. Ltd. (2021). (ISBN: 978-8122472264).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	M	-	-	-	-	-	-	-	-	-	-	-	H	H	L	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	H	H	M	L
CO3	H	-	-	-	-	-	-	-	-	-	-	-	H	H	L	-
CO4	M	M	-	-	-	-	-	-	-	-	-	-	H	H	M	L
CO5	M	M	-	-	-	-	-	-	-	-	-	-	H	H	M	L

H = High; M = Medium; L = Low

SEMESTER III

NCrF Level	6.5	
Course Code	CHE-101-CW-6130	
Title of the Course	Applications of Molecular Spectroscopy & X-Ray Crystallography	
Nature of the Course	Coursework	
Total Credits	4 (L 3 – T 1 – P 0)	
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)

Course Objective

This course on advanced spectroscopy aims to introduce students to the fundamental principles of magnetic resonance spectroscopy – NMR, Infrared (IR) spectroscopy, Raman spectroscopy, Mössbauer, and NQR Spectroscopy. The course also aims to introduce the students to X-ray crystallography. Students will also learn to solve composite problems using UV, IR, NMR, and mass spectrometry in organic, inorganic, and organometallic compounds.

Course Outcome

On completion of this course, the students will be able to:

CO1: Understand the mutual exclusion principle and the IR and Raman spectra interpretation for inorganic and coordination compounds.

CO2: Acquire knowledge in interpreting proton NMR spectra of metal hydride complexes and the NMR spectra of other nuclei (^{19}F, ^{31}P, ^{11}B) for simple inorganic and organometallic compounds.

CO3: Understand the principles of Mössbauer spectroscopy and its applications in studying the bonding and structure of Fe^{2+}, Fe^{3+}, Sn^{2+}, Sn^{4+} compounds, and metal carbonyls.

CO4: Learn about the principles of NQR spectroscopy and its applications in transition metal complexes.

CO5: Understand X-ray crystallography along with data collection, reduction, refinement, and structure solution.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Application of Spectroscopic Techniques in Inorganic and Organometallic Chemistry IR and Raman spectroscopy: Mutual exclusion principle; interpretation of IR and Raman spectra of simple inorganic and coordination compounds. Vibrational spectra of metal carbonyls, metal carbonyl hydrides. NMR Spectroscopy: Proton NMR spectra of metal hydride complexes, NMR spectra of nuclei other than hydrogen: ^{19}F, ^{31}P, ^{11}B NMR spectra of simple inorganic and organometallic compounds. Composite problems: Application of UV, IR, NMR and mass spectrometry in the structural elucidation of organic compounds.	15	CO1

Application of Spectroscopic Techniques in Organic Chemistry Composite problems: Application of UV, IR, NMR and mass spectrometry in the structural elucidation of organic compounds**.**	15	CO2
Mössbauer and NQR Spectroscopy *Mössbauer spectroscopy:* Basic principle, Doppler shift, recoil energy, isomer shift and interpretation. Quadrupole coupling. Application to the studies of (a) bonding and structure of Fe^{2+} and Fe^{3+} compounds, (b) metal carbonyls, (c) Sn^{2+} and Sn^{4+} compounds and (d) iodine. *NQR Spectroscopy*: Basic principle, electric field gradient (EFG), asymmetry parameter, effect of magnetic field. Application of NQR in transition metal complexes.	15	CO3, CO4
X-Ray Crystallography X-ray diffraction and Bragg's law; Crystal systems and symmetry, point groups, stereographic projection of point groups and space groups-Hermann–Mauguin notations, space group in triclinic and monoclinic system; Primitive and non-primitive unit cells; Symmetry elements: isogonal symmetry groups and reciprocal lattice. Crystal growth; X-ray-instrumentation: Data collection, data reduction, refinement and structure solution.	15	CO5

Recommended Books

1. Pavia, D. L.; Lampman, G. M.; Kriz, G. S.; Vyvyan, J. A., Introduction to Spectroscopy, 5th Ed., Cengage Learning India (2015). (ISBN: 978-9381466476).
2. Silverstein, R. M.; Webster, F. X.; Kiemle, D. J.; Bryce, D. L., *Spectrometric Identification of Organic Compounds*, 8th Ed., Wiley India, New Delhi (2022). (ISBN: 978-9354642296).
3. Kemp, W., *Organic Spectroscopy*, 3rd Ed., Macmillan Publishers India, New Delhi (2019). (ISBN: 978-1403906847).
4. Nakamoto, K., *Infrared and Raman Spectra of Inorganic and Coordination compounds*, Part A and Part B, 6th Ed., Wiley Blackwell, New York (2009). (ISBN: 978-0471744924).
5. Gunther, H., *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, 3rd Ed., Wiley India, New Delhi (2013). (ISBN: 978-3527330003).
6. Gütlich, P.; Bill, E.; Trautwein, A. X., *Mössbauer Spectroscopy and Transition Metal Chemistry: Fundamentals and Applications*, Springer Berlin, Heidelberg (2016). (ISBN: 978-3540884279).
7. Greenwood, N. N.; Gibb, T. C., *Mössbauer Spectroscopy*, Chapman and Hall, London (1971). (ISBN: 978-9400956995).
8. Cullity, B. D.; *Elements of X-Ray Diffraction*, 3rd Ed., Pearson Education India (2014). (ISBN: 978-9332535169)
9. Hammond, C., *The Basics of Crystallography and Diffraction*, 4th Ed., OUP Oxford (2015). (ISBN: 978-0198738688)
10. Massa, W., *Crystal Structure Determination*, 2nd Ed., Springer-Verlag: Berlin (2004). (ISBN: 978-3642058417).
11. Blake, A. J.; Clegg. W.; Cole, J. M.; Evans, J. S. O.; Main, P.; Parsons, S.; Watkins, D. J., *Crystal Structure Analysis: Principle and Practice*, 2nd Ed., Clegg, W. (Ed.), Oxford University Press: New York (2009). (ISBN: 978-0199219476).

12. Muller, P.; Herbst-Irmer, R.; Spek, A. L.; Schneider, T. R.; Sawaya, M. R. *Crystal Structure Refinement: A Crystallographer's Guide to SHELXL*, Muller, P. (Ed.), Oxford University Press: New York (2006). (ISBN: 978-0198570769).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	-
CO2	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	-
CO3	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	-
CO4	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	-
CO5	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER III

NCrF Level	6.5	
Course Code	CHE-101-CW-6140	
Title of the Course	Advanced Laboratory Course I	
Nature of the Course	Coursework	
Total Credits	4 (L 0 – T 0 – P 4)	
Total Contact Hours (CH)	120 (Theory – 0; Practical – 120)	
Distribution of Marks	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objective

The advanced laboratory course would expose students to experimental quantitative analysis skills using titrimetric and gravimetric analysis. The course also aims to teach the students about the green synthesis of selected organic compounds and experimentally understand chromatography techniques for checking purity, determining the number of components, and separating different components. This advanced laboratory course introduces students to experimental physical chemistry involving surface tension, critical solution temperatures, solubility products, and complex formation.

Course Outcome

On completion of this course, the students will be able to:

CO1: Acquire experimental skills encompassing titrimetric and gravimetric analysis to determine the composition of ores and alloys.

CO2: Check the purity of organic samples, determine the number of components in a mixture, and separate specific components using paper/thin layer chromatography.

CO3: Synthesise organic compounds using environmentally friendly techniques, including acetylation, bromination, nitration, rearrangement reactions, etc.

CO4: Gain experimental skills to study surface tension, critical solution temperatures, and solubility products.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
1. Quantitative estimation of ores and alloys using titrimetric and gravimetric methods: (a) Ores: Hematite, Limestone, Dolomite, Pyrolusite etc. (b) Alloys: Brass, Gunmetal, Cupro-nickel, Solder, Bronze, Phosphor-bronze etc.	30	CO1
2. Chromatography (a) Check the purity of the supplied organic sample using a paper/thin layer chromatographic technique. (b) Determination of the number of components present in a supplied organic mixture using paper/thin layer chromatographic technique. 3. Separation of a mixture of o-and p-nitrophenol or *o*- and *p*-aminophenol by thin layer chromatography (TLC) and determination of R_f of each of the components.	30	CO2

4. Greener practice in organic synthesis: (a) Acetylation of primary amine (b) Bromination of acetanilide (c) Nitration of phenol (d) Pinacol Pinacolone rearrangement (e) Any other possible reaction	30	CO3
5. Physical Chemistry Experiments: (a) To study the variation of surface tension of aqueous solution of n-propyl alcohol at different concentrations and determine the limiting cross-sectional area of the alcohol molecule. (b) To compare the cleansing powers of two detergent samples using the surface tension method. (c) To determine the critical solution temperature of phenol and water in the presence of (a) 1% NaCl, (b) 0.5% naphthalene, and (c) 1% succinic acid. (d) To study the variation of $Ca(OH)_2$ solubility in NaOH solution and determine its solubility product. (e) To determine the formula of the complex formed between the cupric ion and ammonia by distribution method. (f) To study the influence of ionic strength on the solubility of $CaSO_4$ and determine its thermodynamic solubility product.	30	CO4

Other new novel syntheses and experiments reported in the literature from time to time may be included during the semester.

Recommended Books

1. Mendham, J.; Denney, R. C.; Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, New Delhi (2009). (ISBN: 978-8131723258).
2. Sharma, R. K.; Sidhwani, I. T.; Chaudhari, M. K. *Green Chemistry Experiment: A Monograph*, I. K. International Publishing, New Delhi (2012). (ISBN: 978-9381141557).
3. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014). (ISBN: 978-8130920696).
4. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015). (ISBN: 978-8182839168).
5. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi (2018). (ISBN: 978-8180450792).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO2	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO3	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO4	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER III

NCrF Level	6.5	
Course Code	CHE-101-CW-6150	
Title of the Course	Advanced Laboratory Course II	
Nature of the Course	Coursework	
Total Credits	4 (L 0 – T 0 – P 4)	
Total Contact Hours (CH)	120 (Theory – 0; Practical – 120)	
Distribution of Marks	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objective

This core advanced laboratory course would expose students to experimental skills in synthesising coordination compounds. Spectroscopic techniques like UV-visible, infrared, fluorescence, and other characterisation techniques such as magnetic susceptibility and electrical conductivity measurements will be introduced. The course also aims to experimentally introduce students to various important name reactions, such as oxidation and selective reduction reactions. The course will enable students to perform physical chemistry experiments employing conductometric methods and potentiometric titration, determine ionisation constants, and analyse binary mixtures spectrophotometrically.

Course Outcome

On completion of this course, the students will be able to:

CO1: Have experimental skills encompassing synthesis and characterisation of different inorganic compounds.

CO2: Use UV-visible, FT-IR and fluorescence spectrophotometers through hands-on training.

CO3: Learn experimental techniques for various name reactions, oxidation reactions and selective reduction reactions.

CO4: Develop the ability to compare acid strengths using conductometric methods and determine standard electrode potentials and ionisation constants through potentiometric titrations.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
1. Preparation and characterisation of coordination complexes by various analytical techniques, wherever appropriate and possible and their applications: (a) $VO(acac)_2$ and oxidation of anthracene by H_2O_2 in the presence of $VO(acac)_2$. (b) $Co(acac)_3$ and its nitration. (c) Solid phase synthesis of coordination compounds (e.g. Reinecke salt, *cis*-, *trans*-Copper(II) glycine complexes) and their properties. (d) Metal complexes of Schiff base ligands: (e.g., bis-(N, N'-disalicylalethylenediamine) and its Cobalt(II) complex). (e) Dithiocarbamato complexes: (e.g., diethyldithiocarbamate/ diphenyldithiocarbamate and their nitrosyl complexes.	45	CO1, CO2

2. Organic Name Reactions (a) Beckmann rearrangement (b) Benzoin condensation. (c) Benzil-Benzilic acid rearrangement. (d) Cannizaro reaction. (e) Clemmensen reduction. (f) Anthracene to anthraquinone using CrO_3. (g) Selective reduction of *m*-nitrobenzene to *m*-nitroaniline.	45	CO3
3. Physical Chemistry Experiments (a) To compare the relative strengths of acetic and mono-chloroacetic acid by conductometric method. (b) To determine the standard electrode potential of the ferrous/ferric system by potentiometric titration of ferrous ammonium sulphate against potassium dichromate. (c) To determine the apparent ionisation constant of acetic acid by potentiometric titration against NaOH solution. (d) To determine the composition of a binary mixture containing $KMnO_4$ and $K_2Cr_2O_7$ spectrophotometrically. 4. To determine the partial molar volume of the ethanol-water mixture at a given composition.	30	CO2, CO4

Other new novel syntheses and experiments reported in the literature from time to time may be included during the semester.

Recommended Books

1. Woolins, J. D. (Ed.), *Inorganic Experiments*, 3rd Ed., Wiley-VCH (2010). (ISBN: 978-3527324729).
2. Girolami, G. S.; Rauchfuss, T. B.; Angelici, R. J., *Synthesis and Techniques in Inorganic Chemistry: A Laboratory Manual*, 3rd Ed., University Science Books (1999). (ISBN: 978-0935702484).
3. Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education, New Delhi (2005). (ISBN: 978-8177589573).
4. Sharma, R. K.; Sidhwani, I. T.; Chaudhari, M. K. *Green Chemistry Experiment: A Monograph*, I. K. International Publishing, New Delhi (2012). (ISBN: 978-9381141557).
5. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2013). (ISBN: 978-8173714757)
6. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014). (ISBN: 978-8130920696).
7. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015). (ISBN: 978-8182839168).
8. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi (2018). (ISBN: 978-8180450792).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO2	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO3	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO4	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER IV

SEMESTER IV

NCrF Level	6.5	
Course Code	CHE-101-CW-6210	
Title of the Course	Chemistry of Nanomaterials	
Nature of the Course	Coursework	
Total Credits	4 (L 3 – T 1 – P 0)	
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course introduces students to the interdisciplinary field of nanoscience, the properties of nanomaterials, different chemical synthetic strategies, and the characterisation of materials and their applications. It also aims to help learners acquire hands-on experience in the synthesis and characterisation of different nanomaterials.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Describe the different types of nanomaterials, their properties, synthesis, characterisation and applications.

CO2: Understand how surface functionalities can help nanomaterials find appropriate technological applications.

CO3: Synthesize independently different nanomaterials by coprecipitation, sol-gel and hydrothermal methods.

CO4: Characterize the synthesised nanomaterials by X-ray diffractometry and electron microscopy techniques.

CO5: Learn the various applications of nanomaterials.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Nanomaterials History of Nanoscience, Classification of Nanomaterials, Major challenges in nanoscience and technology. Properties of Nanomaterials: Physiochemical properties; optical properties of nanomaterials, electrical and electronic properties; magnetic properties of nanomaterials. Structure and properties of C_{60}; Structure and applications of single-walled (SWNTs) and multi-walled (MWNTs) carbon nanotubes.	15	CO1, CO2
Synthetic Approaches to Nanomaterials A brief overview of different synthesis approaches (top-down and bottom-up), thermodynamics of formation of nanomaterials. Synthesis of nanomaterials by the following techniques: (a) Vapour deposition (b) Precipitation and co-precipitation methods (c) Sol-gel methods	15	CO3

(d) Hydrothermal and solvothermal methods (e) Micellar/ Template based synthesis (f) Green chemical methods		
Characterisation of Nanomaterials *X-ray methods*: Introduction, basic principles, instrumentation and applications of Powder X-ray diffractometry. *Microscopy*: Introduction, basic principles, instrumentation and applications of scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM). *Surface characterisation techniques*: Introduction, basic principles, instrumentation and applications of X-ray photoelectron spectroscopy (XPS), and Brunauer-Emmett-Teller (BET) surface area analysis. *Optical spectroscopy*: Introduction, basic principles, instrumentation and applications of Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS), Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES), and Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES).	15	CO4
Application of Nanomaterials Assembly of nanostructures and their importance for various applications. Stabilisation of nanomaterials and their importance. Surface modification of nanomaterials with specific examples of metal oxide nanoparticles and their significance. Applications of nanomaterials in sensors, batteries, solar cells, catalysis, water treatment, etc.	15	CO5

Recommended Books

1. West, A. R., *Solid State Chemistry and its Application*, Wiley India, New Delhi (2007). (ISBN: 978-8126511075).
2. Poole Jr., C. P.; Owens, F. J. *Introduction to Nanoscience and Nanotechnology*; Wiley India: Noida, (2020). (ISBN: 978-9354240201)
3. Hornyak, G. L.; Tibbals, H. F.; Dutta, J.; Moore, J. J., *Introduction to Nanoscience and Nanotechnology*; CRC Press, 2008. (ISBN: 978-1420047790).
4. Rao, C. N. R.; Gopalakrishnan, J., *New Direction in Solid State Chemistry*, 2nd Ed., Cambridge University Press, Cambridge (1997). (ISBN: 978-0521499071).
5. Pradeep, T. *Nano: The Essentials: Understanding Nanoscience and Nanotechnology*; McGraw Hill Education: New Delhi, 2017. (ISBN: 978-0070617889).
6. Viswanathan, B., *Nanomaterials*, Narosa Publishing House, New Delhi (2014). (ISBN: 978-8173199363).
7. Skoog, D. A.; Holler, F. J.; Nieman, T. A. *Principles of Instrumental Analysis*; 7th Ed., Cengage Learning: New Delhi, (2020). (ISBN: 978-9353506193).
8. Christian, G. D. *Analytical Chemistry*; 6th Ed., John Wiley and Sons: New Delhi, (2007). (ISBN: 978-8126511136).
9. Braun, R. D.; *Introduction to Instrumental Analysis*, 2nd Ed., BSP Books, Hyderabad (2012). (ISBN: 978-9381075920).
10. Pradeep, T., *Textbook of Nanoscience and Nanotechnology*, McGraw Hill Education, India (2012). (ISBN: 978-1259007323).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	M	-	-	-	L	-	-	H	-	-	-	-	H	M	-	-
CO2	M	-	-	-	L	-	-	H	-	-	-	-	H	M	-	-
CO3	H	M	-	-	H	-	-	H	-	-	-	-	H	H	H	L
CO4	H	H	-	-	H	-	-	H	-	-	-	-	H	H	H	H
CO5	H	M	-	-	H	-	-	H	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER IV

NCrF Level	6.5	
Course Code	CHE-101-CW-6220	
Title of the Course	Biochemistry	
Nature of the Course	Coursework	
Total Credits	4 (L 3 – T 1 – P 0)	
Total Contact Hours (CH)	60 (Theory – 60; Practical – 0)	
Distribution of Marks	Theory	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course aims to help students understand the significant features of the chemistry of biomolecules, viz. carbohydrates, enzymes and proteins, lipids, and nucleic acids. Classification, characteristic reactions, and the biological importance of these biomolecules will be thoroughly discussed.

Course Outcomes

On completion of this course, students will be able to:

CO1: Understand the cell structure and metabolic processes involved in biological systems.

CO2: Gain knowledge about the enzymes, mechanism of enzyme action and its role in biological reactions.

CO3: Understand the structure and synthesis of proteins.

CO4: Acquire knowledge about the biological importance of fatty acids and lipids and their biosynthesis.

CO5: Nucleic acids and their role in protein biosynthesis, genetic codes and the basis of hereditary.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Metabolic Processes and their Regulation Glycolysis, fate of pyruvate under anaerobic conditions, TCA cycle and gluconeogenesis. Electron transport and oxidative phosphorylation. Photosynthesis-light and dark reactions.	15	CO1
Enzymes and Proteins Introduction, classification and characteristics of enzymes. Salient features of the active site of enzymes. Mechanism of enzyme action (taking chymotrypsin as an example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition). Protein conformations–globular and fibrous. Ramachandran plot. Protein folding and denaturation. Protein synthesis.	15	CO2, CO3

Lipids Definition, nature, biological importance of fatty acids and lipids, saturated and unsaturated fats, ketone bodies, fatty acid metabolism, calorific value of foods. Triglycerides, phospholipids, glycolipids, steroids. A brief introduction to biological membranes, properties and function of lipid bilayers and liposomes. Biosynthesis of lipids.	15	CO4
Nucleic Acids Nucleotides and nucleosides, structure of nucleic acids, biosynthesis of nucleotides, Chemical and enzymatic hydrolysis of nucleic acids, purine metabolism, DNA Replication, Types of RNA. Role of DNA and RNA (*m*-RNA, *t*-RNA, *r*-RNA) in protein biosynthesis. Genetic code and basis of hereditary. Gene mutation and carcinogenesis.	15	CO5

Recommended Books

1. Berg, J. M.; Tymoczko, J. L.; Gatto Jr., G. J.; Stryer, L., *Biochemistry*, 10th Ed., W. H. Freeman, New York (2023). (ISBN: 978-1319498504).
2. Voet, D.; Voet, J. G., Pratt, C. W., *Biochemistry*, 4th Ed., John Wiley and Sons, New Jersey (2012). (ISBN: 978-0071737074).
3. Campbell, M. K.; Farrell, S. O., *Biochemistry*, 9th Ed., Cenage Learning India, NOIDA (2022). (ISBN: 978-9355733832).
4. Nelson, D. L.; Cox, M. M., *Lehninger Principles of Biochemistry*, 8th Ed., W. H. Freeman, New York (2021). (ISBN: 978-1319381493).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	-	-	-	M	-	-	H	-	-	-	-	H	H	L	-
CO2	H	-	-	-	M	-	-	H	-	-	-	-	H	H	L	-
CO3	H	-	-	-	M	-	-	H	-	-	-	-	H	H	M	-
CO4	H	H	-	-	H	-	-	H	-	-	-	-	H	H	M	-
CO5	H	M	-	-	H	-	-	H	-	-	-	-	H	H	M	-

H = High; M = Medium; L = Low

SEMESTER IV

NCrF Level	6.5	
Course Code	CHE-101-CW-6230	
Title of the Course	Literature Survey	
Nature of the Course	Coursework	
Total Credits	4 (L 0 – T 0 – P 4)	
Total Contact Hours (CH)	120 (Theory – 0; Practical – 120)	
Distribution of Marks	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives
The literature survey course aims to develop skills in conducting research and collecting/compiling information for preparing reports and publications.

Course Outcomes
On completion of this course, the students will be able to:

CO1: Acquire the ability to conduct literature reviews and critically analyse existing research on a specific topic.

CO2: Gain proficiency in identifying key sources and summarising the findings to build a strong foundation for further research.

CO3: Learn to recognise gaps in the existing literature and highlight areas for potential exploration.

CO4: Enhance skills in academic writing by presenting a coherent and well-structured overview of the literature.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
Literature Survey The student will undertake a comprehensive literature survey on a topic under the guidance of a faculty member. He/she will write and present a report during the end-semester examination.	120	CO1, CO2, CO3, CO4

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO2	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO3	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO4	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-
CO5	H	H	-	-	H	-	-	-	-	-	-	-	H	H	H	-

H = High; M = Medium; L = Low

SEMESTER IV

NCrF Level	6.5	
Course Code	CHE-101-CW-6240	
Title of the Course	Advanced Laboratory Course III	
Nature of the Course	Coursework	
Total Credits	4 (L 0 – T 0 – P 4)	
Total Contact Hours (CH)	120 (Theory – 0; Practical – 120)	
Distribution of Marks	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This advanced laboratory course will enable the students to gain experimental skills in advanced material synthesis, characterisation, and study of their properties using selected examples. It introduces students to multistep organic synthesis through conventional and greener practices. Spectrophotometric techniques and green chemistry experiments will also be introduced. The course will also enable students to experimentally verify the constant and complex dissociation formation using the spectrophotometric method. It will also helps the students estimate the concentration of different components in a mixture by conductometric titration and preparation of buffer solution.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Gain experimental skills in synthesising and characterising metal, semiconductor, and metal oxide nanoparticles and investigate their properties.

CO2: Gain hands-on experience in performing multi-step organic preparations.

CO3: Learn to determine dissociation constants, study complex formations through the spectrophotometric method, and determine equilibrium constants using the distribution method.

CO4: Gain experimental skills to estimate the concentrations of various acids and salts in mixtures using conductometric titration techniques.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
1. Synthesis and characterisation of nanomaterials using suitable methods such as XRD and electron microscopy (a) Metal nanoparticles (Cu, Ag, Au, etc.) and investigation of their optical properties. (b) Semiconductor nanocrystals (CdS, ZnS, ZnO etc.). (c) Metal oxide nanoparticles such as ZnO, CeO_2, MgO, Fe_2O_3, Fe_3O_4, etc. by coprecipitation, sol-gel and hydrothermal methods.	45	CO1
2. Organic preparations involving two or more steps. (a) Benzopinacolone from benzophenone via benzopinacol (b) Benzilic acid from benzoin (c) Dibenzyl from benzoin (d) Anthranilic acid from phthalic anhydride (e) Any halogenation reaction etc.	45	CO2

3. Spectrophotometry (a) To determine the dissociation constant of an indicator (e.g. methyl red) by spectrophotometric method. (b) To study the complex formation between Fe(III) and salicylic acid and find the formula of the complex. 4. Conductometry (a) To estimate the concentration of HCl, CH_3COOH and $CuSO_4$ in a mixture by conductometric titration. (b) To estimate the concentration of H_2SO_4 and $CuSO_4$ by conductometric titration. (c) To estimate the concentration of HCl and KCl by conductometric titration. 5. Determine the equilibrium constant of the reaction $KI + I_2 = KI_3$ by distribution method. 6. Preparation of buffer solutions of different pH (i) acetic acid-sodium acetate (ii) ammonium hydroxide-ammonium chloride.	30	CO3, CO4

Other new novel syntheses and experiments reported in the literature from time to time may be included during the semester.

Recommended Books

1. Viswanathan, B.; Raghavan, P. S., *Practical Physical Chemistry*, Viva Books India (2014). (ISBN:978-8130920696).
2. Yadav, J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan, Meerut (2015). (ISBN: 978-8182839168).
3. Khosla, B. D.; Garg, V. C.; Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2018). (ISBN: 978-8180450792).
4. Sreedher, N. *A Comprehensive Guide to Physical Chemistry Experiments and Viva Questions*, Notion Press (2023). (ISBN: 979-8891861916).
5. Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education, New Delhi (2005). (ISBN: 978-8177589573).
6. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2013). (ISBN: 978-8173714757).
7. Pradeep, T., *Textbook of Nanoscience and Nanotechnology*, McGraw Hill Education, India (2012). (ISBN: 978-1259007323).

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	-	-	H	-	-	M	-	-	-	-	H	H	H	H
CO2	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO3	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO4	H	H	-	-	M	-	-	M	-	-	-	-	H	H	H	H
CO5	H	H	-	-	H	-	-	M	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low

SEMESTER IV

NCrF Level	6.5	
Course Code	CHE-101-CW-6250	
Title of the Course	Methods in Chemical Research	
Nature of the Course	Coursework	
Total Credits	4 (L 0 – T 0 – P 4)	
Total Contact Hours (CH)	120 (Theory – 0; Practical – 120)	
Distribution of Marks	Practical	80 (End Sem) + 20 (Internal Assessment)

Course Objectives

This course introduces students to essential skills in utilising modern software tools and techniques for chemical data analysis and interpretation. They will also gain proficiency in scientific writing and managing and organising references using a reference manager. The course will cover practical applications such as determining crystallite size and structure elucidation of small molecules based on UV, IR, NMR, and mass spectrometry data.

Course Outcomes

On completion of this course, the students will be able to:

CO1: Gain proficiency using advanced chemistry software tools such as Mnova, ChemDraw, Origin, and ImageJ.

CO2: Learn to efficiently manage and organise scientific references using reference manager software to streamline the research and writing process.

CO3: Analyse UV, IR, NMR, PXRD and mass spectrometry data for the structural elucidation of small molecules.

CO4: Develop the ability to present chemical data in concise and accurate scientific reports.

Contents	Contact Hour	Mapping to Course Outcomes (COs)
1. Use of Software in Chemistry for Data extraction and Analysis: Mnova, ChemDraw, Origin, Image J, etc. 2. Reference Managing Software: Endnote, Mendeley etc. 3. Determination of crystallite size using Scherrer equation from raw data of Powder XRD. 4. Structure elucidation of small molecules from UV, IR, NMR and mass raw data. 5. Preparation of a brief scientific report using the given raw data.	120	CO1, CO2, CO3, CO4

CO-PO/PSO Mapping Matrix

	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	H	H	H	H	H	-	-	M	-	-	-	-	H	H	H	H
CO2	H	H	H	H	H	-	-	M	-	-	-	-	H	H	H	H
CO3	H	H	H	H	H	-	-	M	-	-	-	-	H	H	H	H
CO4	H	H	H	H	H	-	-	M	-	-	-	-	H	H	H	H

H = High; M = Medium; L = Low