KISS

KALINGA INSTITUTE OF SOCIAL SCIENCES

CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMME

BACHELOR OF SCIENCE (B.SC.) IN CHEMISTRY

(As per NEP-2020, NCrF, NHEQF)

Academic Session 2026-2027



DEPARTMENT OF CHEMISTRY

SCHOOL OF INDIGENOUS KNOWLEDGE, SCIENCE AND TECHNOLOGY

KALINGA INSTITUTE OF SOCIAL SCIENCES (KISS)

DEEMED TO BE UNIVERSITY

Higher Education Campus, KISS Campus-3, Bhubaneswar, Odisha, 751024

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		Semester - VI	**168**
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I. About the School and Department

i) About the School

The School of Indigenous Knowledge, Science and Technology, KISS Deemed to be University, was established in 2017-18 with a view of Indigenous scientific knowledge and technological development in a symbiotic relationship with Nature. Indigenous people have an innate understanding of natural resources available in our ecosystem which was in a supine state over the years. In the age of globalization, the tribes who are the real custodians of indigenous knowledge are far behind in the race of technological advancement.

Gradual developments of such people in varied facets of life enable them to explore their traditional knowledge for human welfare. As the over-exploitation of natural resources threatens the ecological balance and sustainable livelihood of tribal people, it is imperative to study our time-tested indigenous knowledge and tribal technology with greater vigour.

Hence, an innovative School – **School of Indigenous Knowledge, Science and Technology** – has been set up to promote, preserve and protect indigenous knowledge and implement it for sustainable development.

The importance of this School is to disseminate advanced knowledge by providing instructional and research facilities in tribal medicinal systems through physiochemical analysis, geosciences and their impact on the health conditions. The importance of gemology in their culture, Sutras and sub-sutras of Vedic mathematics, a nutritional component of the food habit of tribes, intellectual property rights to preserve and conserve the biodiversity of indigenous people and advancement in technologies relating to the natural resources of the tribal areas as well as in other branches of learning as it may deem fit.

This could be possible by teaching innovative courses in *Indigenous Knowledge and Intellectual Property Rights, Tribal Sports, Nutrition and Health Management, Indigenous People and the Science of Gemology and Vedic Mathematics*. The courses attempt to examine indigenous knowledge and technology, blending both traditional and modern scientific methods from interdisciplinary and multidisciplinary approaches.The School of Indigenous Knowledge, Science and Technology constantly endeavors to improve the knowledge and practice content of its academic programme to match the local, regional, national and international standards.

This School has introduced four innovative interdisciplinary programmes viz. Physics, Chemistry, Mathematics and Computer Science with specialization in Indigenous Knowledge, Science and Technology in the first phase with the approval of UGC to provide impetus to research in Indigenous Knowledge, Science and Technology with multi-disciplinary education facility free of cost. Besides implementing Sustainable Development Goals of the United Nation, the school has been able to bring about the much needed socio-economic changes in the tribal hinterland of Odisha and its neighbouring states.

Because of the school's unique excellence to help the tribal students develop their vocational, entrepreneurial and life skills, it has been trying to break the vicious cycle of poverty and social isolation of tribal communities. The school also seeks to raise the consciousness of the tribal students that the people of their communities have a right to access varied indigenous resources and opportunities in order to live a self- sufficient, adequate and dignified life.

ii) About the Department

The Department of Chemistry, under the School of Indigenous Knowledge, Science and Technology (IKST)**,** KISS Deemed to be University**,** Bhubaneswar was established in 2017–18 with the vision of providing quality education, promoting innovative research and addressing contemporary scientific and societal challenges through interdisciplinary and multidisciplinary approaches. The department functions in alignment with the mission and vision of the School of IKST, which is dedicated to integrating modern scientific knowledge with indigenous knowledge systems for sustainable development and the empowerment of tribal communities. Since its inception, the department has been committed to excellence in teaching, research, innovation and community engagement. It offers Undergraduate (B.Sc.), Postgraduate (M.Sc.) and Doctoral (Ph.D.) programmes designed in accordance with the National Education Policy (NEP) 2020 and Outcome-Based Education (OBE) principles. The curriculum is regularly revised to incorporate recent advances in chemical sciences, including nanotechnology, materials chemistry, environmental chemistry, analytical chemistry, green chemistry, and computational chemistry. The department provides a strong foundation in theoretical concepts complemented by extensive laboratory training using modern analytical techniques and scientific instrumentation. It is supported by a dedicated team of qualified

faculty members actively engaged in teaching, research and academic administration. Faculty members regularly publish research articles in reputed national and international journals and participate in conferences, seminars, workshops and faculty development programmes. The department promotes interdisciplinary research by collaborating with scientists and researchers from various academic institutions and research organizations. Research activities focus on areas such as nanomaterials, water quality assessment, photocatalysis, advanced functional materials and sustainable technologies. Special emphasis is placed on research related to indigenous resources, natural products, traditional knowledge systems and environmentally sustainable practices that benefit tribal communities and society at large. The department possesses well-equipped teaching and research laboratories that provide students with hands-on experience in synthesis, characterization, instrumental analysis and advanced experimental techniques. Students are encouraged to undertake research projects, internships, industrial training, and dissertation work to enhance their practical skills and scientific temperament. The department also organizes seminars, guest lectures, workshops, industrial visits and outreach programmes to expose students to emerging trends in chemical sciences. The department encourages multidisciplinary collaborations across various schools of the University to develop innovative solutions to regional and global challenges. The department maintains a learner-centric environment supported by ICT-enabled teaching, continuous assessment, mentoring and career guidance. Students are motivated to participate in national and international conferences, science exhibitions, competitive examinations and innovation programmes. The department also encourages publication of student research, intellectual property generation and collaborative projects with industry and research laboratories. By integrating modern chemical sciences with indigenous knowledge and sustainable practices, the department contributes significantly to achieving the Sustainable Development Goals (SDGs) and national priorities. With its strong commitment to academic excellence, innovation and community engagement, the department continues to uphold the vision of the School of Indigenous Knowledge Science and Technology and the mission of KISS Deemed to be University in serving local, regional, national and global needs.

iii) Vision & Mission of the School

Vision:

Be an internationally acclaimed School, recognized for excellence in teaching, research, consultancy and outreach; skill development and social entrepreneurship for tribal youth by promoting Indigenous Science and Technology.

Mission:

- Foster all-round development of students through multi-faceted education.
- Focus on Indigenous Science and Technology with the help of innovative courses like Vedic Mathematics, Indigenous people and the Science of Gemology, Tribal Sports, Nutrition and Health Management, Indigenous Knowledge and Intellectual Property Rights.
    - Engage with local, national and global communities to get ideas about Indigenous Science and Technological applications for contemporary needs and problems and become successful in life.
    - Manage resources for self employment and create employment for others.

II. UG Programme in Chemistry

The UG Programme in Chemistry is a four-year under graduate programme (FYUGP) introduced in the Academic Session 2024-25, designed in alignment with the National Education Policy 2020 and the UGC Curriculum and Credit Framework for Undergraduate Programmes (CCFUP). The programme follows a comprehensive eight-semester curriculum and credit framework that emphasizes flexibility, multidisciplinary learning, skill development and research orientation. This programme offers single-major and double-major pathways, integrating core chemistry courses with minor courses, multidisciplinary courses (MDCs), ability enhancement courses (AECs), skill enhancement courses (SECs), value-added courses (VACs), internships, seminars, and a research dissertation**.** This four-year UG programme (introduced in 2024–25) follows the multiple entry–exit structure with certificate, diploma, degree and honours with research options as per NEP-2020 and NCrF. Across eight semesters, the curriculum ensures a balanced progression from foundational concepts in inorganic, organic and physical chemistry to advanced and application-oriented areas

such as nanotechnology, spectroscopy, electrochemistry, green chemistry, agrochemistry and industrial chemistry**,** thereby equipping graduates with strong theoretical knowledge, practical skills, interdisciplinary exposure and research competence suitable for higher education, industry and societal needs.

In line with the syllabus, students also complete minor courses, internships and interdisciplinary/open courses offered under the MDC/SEC framework to broaden their exposure. Learning experiences are enriched through labs attached to major theory papers, mini-projects, internships, guest lectures, SWAYAM and presentations that expose learners to current industry practices, emerging technologies. The overall design follows an outcome-based approach with clearly articulated Programme Outcomes (POs) and Course Outcomes (COs), mapped across all listed courses in the structure and aligned with national qualification and credit frameworks.

III. Process of Curriculum Development

The department of Chemistry under the School of Indigenous Knowledge, Science and Technology follow consultative process in the development of the course curriculum.

Following are the stages of curriculum development:

(i) Formation of syllabus Committee with members having specialized domain knowledge.

(ii) Consultation with stakeholders comprising alumni, students, employers etc.

(iii) Review and approval by all faculty members of the Department.

(iv) Scrutiny and approval by Board of Studies (Experts from Outside).

(v) Final approval by Academic Council of the University.

(vi) Integration of NEP-2020, NCrF, and NHEQF

IV. Definition of Components

i) Ability Enhancement Courses (AEC): It refers to the courses enhancing competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills not literature, prose, poetry and novel etc.

ii) Academic Bank of Credits (ABC): The ABC has been envisaged by the UGC to facilitate the academic mobility of students with the freedom to study across the HEIs in the country with

an appropriate 'credit transfer' mechanism from one programme to another, leading to attain a Degree/Diploma/Certificate, etc.

iii) **Academic Year**: Two consecutive semesters constitute one academic year.

iv) **Choice Based** : The students select courses from the prescribed courses i.e., Major, Minor, Multidisciplinary, Ability Enhancement Course (AEC), Skill Enhancement Course (SEC), Value Added Course (VAC), Summer Internship/ Lab/Research.

v) **Major is the subject of main focus.**

vi) **Credit Based Semester System (CBSS):** Under the CBSS, the requirement for awarding a degree/diploma/Certificate is prescribed in terms of number of credits to be earned.

vii) **Credit:** A unit by which the course work is measured. One credit is equivalent to one hour of lecture or tutorials or two hours of practical work/field work per week in a semester.

viii) **Minor Course** helps a student to gain a broader understanding beyond the major discipline. The subjects mentioned in the minor (in the course structure table) will be offered only if a minimum of 10 students opt for that particular subject.

ix) **Multidisciplinary:** It refers to the courses that a student can opt from other disciplines in order to broaden the intellectual experience.

x) **Skills Enhancement Courses (SEC):** It refers to the courses aiming at imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students.

xi) Summer Internship/Apprenticeship/Summer Project: It refers to experiential exposure of a student. Summer Internship of 6-8 weeks duration after the completion of the fourth semester, followed by a project report and viva-voce examination during the fifth semester has been made compulsory to enable the students to have hands on experience of real-life business situations.

xii) Research has been provided in the Eighth semester (for students securing 7.5 CGPA or above) involving application of knowledge in exploring/critical analysis/solving issues related to a real-life situation.

xiii) **Value Added Courses:** It refers to the courses enabling the students to acquire and demonstrate the knowledge and understanding of contemporary society.

V. NCrF Aligned Components (National Credit Framework)

1. Operational Definition of Credit (NCrF Standard)

"1 Credit = 30 Notional Learning Hours."

A standard 4 credit course = 120 Notional Learning Hours.

i) NCrF-Compliant Course Engagement Table

Component	Operational Definition	Hours (Example for 4-credit course)
Face-to-Face Lectures	Concept delivery, interactive instruction	45
Tutorials / Labs / Field	Hands-on practice, experimentation	30
Independent Self-Study	Pre-reading, journal review	20
Continuous Assessment	Assignments, quizzes, mid-term	12
Final Semester Exam Preparation	Revision, project completion	13
Total Notional Hours	**Must equal 30 hours × credits**	**120**

MOOC Courses (SWAYAM and SWAYAM Plus)

According to the UGC guidelines integrated into the new curriculum structures, Higher Education Institutions (HEIs) are permitted to allow students to take up to 40% of their total courses in a semester through the national MOOC platform, SWAYAM (or SWAYAM Plus for industry-aligned courses).

Credits earned via SWAYAM are mapped directly against the appropriate NHEQF academic level and digitally stored in the student's Academic Bank of Credits (ABC) to count toward their final degree, diploma, or certificate.

ii) NCrF Category Wise Credit Distribution (UGC CCFUP Compatible)

The course is of 162 Credits and for the award of degree a student will be required to complete the credits as per the University norm.

Course Credit Scheme

Semester	Discipline Specific courses- core		Minor		MDC/IDC		AEC		SEC/ Seminar/ Internship/ Dessertation		VAC		Grand Total Credits
	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credit	

I	1	4	1	4	1	3	1	2	1	3	1	4	20
II	1	4	1	4	1	3	1	2	1	3	2	4	20
III	2	8	1	4	1	3	1	2	1	3			20
IV	3	12	1	4			1	2	1	2			20
V	4	16	1	4					1	2			22
VI	4	16	1	4									20
VII	4	16	1	4									20
VIII	1	4	1	4					1	12			20
Total Credits for the Course		80		32		9		8		25		8	162

These exit awards correspond to progressive NHEQF / NSQF levels and are fully NCrF-compliant for credit accumulation, mobility and re-entry through the Academic Bank of Credits.

Skill Enhancement Courses (SEC), Multidisciplinary Courses (MDC), value-added courses and internships are credited as per NCrF, recognising vocational, experiential and community-based learning alongside academic coursework. These courses are designed at appropriate NSQF levels, with clear competency descriptors and notional hours.

VI. Eligibility for Admissions with number of Seats:

As per the admission guidelines and brochure of the KISS Deemed to be University.

VII. Examination Pattern: As per NEP 2020

The medium of examination is English which will be reflected in their final grade sheet/certificate.Provided that for a language subject answers are to be in that language. Sanskrit may be written in Odia script but language has to be Sanskrit.

i. Duration of the Examinations-Mid Semester & End Semester:

Duration of examination for all term End examination shall be for 2.5 hours and for all Mid Term examination for 1 hour irrespective of full marks in the course/subjects and irrespective of credit. The practical examinations shall be of 2 hours duration.

Each School shall have a designated faculty as Examination Coordinator to be decided by the Vice Chancellor in addition to the Controller of Examinations of the University.

Continuous Evaluation and Mid Semester Examination:

a) Mid semester examination will be of 1-hour duration for 20/10 marks (20 for subjects having no practical and 10 for subject with practical papers). There shall be no pass mark in Mid Semester examination.

b) The Mid-Semester Examination shall be conducted and valued by the Faculty who are teaching the corresponding paper. A student who fails to appear in a Mid-Semester Examination **will be allowed one more chance to** take the same examination before appearing the concerned term-end examination. There will be no provision to re-appear in the Mid-Semester Examination for improvement.

c) For subjects with practical there will be a Mid-Semester practical examination carrying 10 marks.

d) The University authority of the valuation zones will preserve the answer Script of the End Semester examination for 06 months from the date of publication of result for reference.

e) A student has to appear the mid semester examination positively. Absence in the mid semester examination will be considered as fail however the candidate may be allowed to appear the mid semester examination before commencement of the concerned Term-End examination under special case duly considered by the HoD (for the ***candidates who represent the University or State for Inter- University or inter-state competitions in Games and Sports or attending different recognized National level camps/any critical medical case duly certified by the designated medical officer).***

ii. Distribution of Marks in End Semester and Continuous Evaluation:
(Irrespective of credit in a course/Paper)

Course Type	Maximum Marks	Semester-End theory Mark	Continues Evaluation Marks /Sessional	Mid Semester theory Mark	Semester-End and Practical mark	Mid Semester Practical Mark
Without Practical	**100**	**60**	**20**	**20**	**----**	**--**
With Practical	**100**	**50**	**10**	**10**	**20**	**10**
Thesis/ Dissertation/ Seminar/Field Work	**100**	**------**	**-------**	**-------**	**-------**	**-------**

The **modes of evaluation** of **Thesis/ Dissertation/ Seminar/Field Work** shall be as follows:
Literature Review
Synopsis Presentation
Field Work / Data Collection and Data Analysis
Findings and Conclusions

Presentation and Viva-Voce

iii. Distribution of Sessional Marks:(Continuous Evaluation)

Course Type	Maximum Mark	Mid Semester	Attendance	Surprise Test/Quiz/Viva	Assignment/ Presentation
Without Practical	**40**	**20**	**Above 95%- 5 Marks** **85%-94%- 4 Marks** **75%-84%- 3 Marks**	**10**	**05**
With Practical	**30**	(Theory 10 + Practical 10)=20		**05**	**Nil**

iv. Examination Question Pattern of End Term Examination and Mark Distribution:

The evaluation process may cover summative and formative aspects and assess understanding applications, articulation, program and course outcome.

Question Pattern		With Practical	Without Practical
Part-I –Objective	**Answer in MCQ/ in one word/in one sentence as directed**	**1x5=5**	**1x6=6**
Part-II- Very Short Type	**Answer within 50 words. Answer any 3 out of 5 questions (with practical) and Answer any 5 out of 7 question (without practical)**	**2x3=6**	**2x5=10**
Part-III- Short Type	**Answer within 250 words Answer any 3 out of 5 questions (with practical) and Answer any 4 out of 6 question (without practical)**	**5x3=15**	**5x4=20**
Part-IV- Long Type	**Answer within 800 words. Answer any 3 out of 5 questions**	**8x3=24**	**8x3=24**
Total		**50**	**60**
For Practical Paper		**One Major Experiment-10 Record-05 Viva voce-05**	---------

v. Examination Question Pattern of Mid Semester Examination and Mark Distribution

Question Pattern		With Practical	Without Practical
Part-I –Objective	Answer in MCQ/ in one word/in one sentence as directed	1x3=3	1x6=6
Part-II- Very Short Type	Answer within 50 words. Answer any 1out of 2 questions (with practical) and Answer any 2 out of 3 question (without practical)	2x1=2	2x2=4
Part-III- Short Type	Answer within 250 words Answer any 1 out of 2 questions (with practical) and Answer any 2 out of 3 question (without practical)	5x1=5	5x2=10
Total		10	20
For Practical Paper		One Major Experiment-5 Record- 02 Viva voce-03	---------

VIII. Duration and Types of Courses and Process of Multiple Entry and Exit

NHEQF-Aligned Components (National Higher Education Qualifications Framework)

1. NHEQF Level Mapping for Multi-Entry / Multi-Exit

"This programme is structured according to the multi-entry, multi-exit parameters defined by UGC. The progressive qualification bands map directly onto the National Higher Education Qualifications Framework (NHEQF)."

Insert the following table:

Milestone / Year Completed	Exit Award	NHEQF Level	Standard Credit Range
Year 1 (Sem I–II)	UG Certificate	Level 4.5	40 + 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.
Year 2 (Sem III–IV)	UG Diploma	Level 5.0	80 + 4 credit in skill based vocational courses offered during first year or second year summer term

Year 3 (Sem V–VI)	UG Degree (3-Year)	Level 5.5	122
Year 4 (Sem VII–VIII)	UG Honours / Honours with Research	Level 6.0	162

IX. Programme Educational Objectives (PEOs):

The Objective of this program is to ensure career path of the students. Students can be self-employed in the tribal community or elsewhere; or becomes a social entrepreneur; or can adopt research studies to enhance their skills for sustainable livelihood and become a researcher; they can pursue higher studies; or become a professional for policy making and its execution.

PEO1: Aim of this unique program is to enable the students to learn, evaluate and develop analytical ability mainly in the field of science and technology and to ensure preservation of tribal resources. They should be able to highlight the philosophical approach of the tribes towards economic life.

PEO2: To explore and innovate scientific knowledge through the application of indigenous knowledge by utilizing the treasured indigenous knowledge of Professors of Practice and collaborate with national and international universities and organizations, especially for undertaking spiritual studies and research on tribal communities.

PEO3: To offer online and offline certificate courses for enrichment and refinement of their skills and computer literacy for attaining global competency and formulate tribal centric development models, publish reports and organize conferences and seminars on issues relating to indigenous science and technology.

PEO4: To create ample scope for the researchers in the field of science and technology from a tribal perspective by integrating relevant aspects of indigenous knowledge with traditional subjects like Physics, Chemistry, Mathematics and computer science and To make proper use of natural resources and indigenous knowledge for sustainable environmental development.

PEO5: To equip the students with knowledge in indigenous science and technology and turn them into agents of social transformation in their respective communities and promote culture of credibility, transparency and reliability for continuous quality enhancement of academic and institutional governance.

X. Programme Outcomes(POs)

The expected attributes for a undergraduate in Chemistry shall be expert disciplinary knowledge with communication skills, critical thinking, problem solving, research related skills, digital literacy, self-directed lifelong learning with high social

commitment and ethical awareness.

PO1	Moral & Ethical Values	Apply ethical principles and commit to professional ethics and responsibilities and norms of the scientific practice.
PO2	Disciplinary Knowledge	Acquire an understanding of the nature, practice and application of the chosen area of study
PO3	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 different groups/audiences. • Express thoughts and ideas effectively in writing and orally and communicate with others using appropriate media. • Confidently share views and express themselves. • Construct logical arguments using correct technical language related to a field of learning, work/vocation, or professional practice and convey ideas, thoughts, and arguments using respectful and sensitive language regarding gender and other minority groups.
PO4	Critical Thinking, Complex problem-solving and Analytical reasoning	The graduates should be able to demonstrate the capability to: • Apply analytic thought to a body of knowledge, including the analysis and evaluation of policies and practices, as well as evidence, arguments, claims, beliefs and the reliability and relevance of evidence. • Identify relevant assumptions or implications; and formulate coherent arguments. • Identify logical flaws and holes in the arguments of others. • Analyze and synthesise data from various sources, draw valid conclusions, and support them with evidence and examples. • Solve problems in familiar and nonfamiliar contexts and apply the learning to real-life situations. • Evaluate the reliability and relevance of evidence. Identify logical flaws in the arguments of others. • Analyse and synthesise data from various sources; draw valid conclusions, support them with evidence and examples, and address opposing viewpoints.
PO5	Indian knowledge Systems	• Integrates traditional Indian scientific knowledge with modern chemical sciences. • Connects ancient practices with areas such as medicinal chemistry, dyes, ceramics and materials science. • Promotes understanding of traditional methods of natural products and indigenous technologies. • Encourages sustainable and eco-friendly approaches in chemical processes and resource utilization.

		• Develops interdisciplinary learning by linking chemistry with Ayurveda, environmental science, and material applications. • Enhances ethical scientific practices and awareness of India's historical contributions to chemistry and allied sciences.
PO6	Research-related skills	The graduates should be able to demonstrate: • A keen sense of observation, inquiry, and capability for asking relevant/appropriate questions. • The ability to problematize, synthesise, and articulate issues and design research proposals. • The ability to 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. • The capacity to develop appropriate methodology and tools for data collection. • The appropriate use of statistical and other analytical tools and techniques. • The ability to plan, execute and report the results of an experiment or investigation. • The ability to understand basic research ethics and skills in practising/doing ethics in the field/ personal research work, regardless of the funding authority or field of study.
PO7	Cooperative/ Teamwork	The graduates should be able to demonstrate the ability to: • 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 member of a team.
PO8	Digital Literacy	The graduates should be able to demonstrate the capability to: • Apply ICT in a variety of learning and work situations. • Access, evaluate, and use various relevant information sources and appropriate software for data analysis.
PO9	Experimental and Lifelong learning	The graduates should be able to demonstrate the ability to: • Acquire new knowledge and skills, including learning how to learn skills, that are necessary for pursuing learning activities throughout life through self paced and self-directed learning aimed at personal development, meeting economic, social, and cultural objectives, and adapting to changing trades and demands of the workplace, including adapting to the changes in work processes in the context of the fourth industrial revolution, through knowledge/ skill development/reskilling. • Work independently; identify appropriate resources required for further learning.

		• Acquire organisational skills and time management to set self-defined goals and targets with timelines. • Inculcate a healthy attitude to be a lifelong learner
PO10	Leadership qualities	• The graduates should be able to demonstrate the capability for: • Mapping out a team's or an organisation's tasks and setting 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.
PO11	Professional and decision making skills	The graduates should be able to demonstrate the ability to: • Apply knowledge, understanding, and skills with an appropriate degree of independence relevant to the level of the qualification. • Work independently, identify appropriate resources required for a project, and manage a project through to completion. • Exercise responsibility and demonstrate accountability in applying knowledge and skills in work and learning contexts appropriate for the qualification's level, including ensuring workplace safety and security. •
PO12	Environmental awareness and Sustainability	The graduates should be able to demonstrate the acquisition of and ability to apply the knowledge, skills, attitudes, and values required to take appropriate actions for: • Mitigating the effects of environmental degradation, climate change, and pollution. • • Effective waste management, conservation of biological diversity, management of biological resources and biodiversity, forest and wildlife conservation, and sustainable development and living.

XI. Programme Specific Outcomes(PSOs)

Graduates should be able to demonstrate the acquisition of:

PSO1	Broad and Deep Knowledge of Chemistry	Comprehensive knowledge and coherent understanding of Chemistry in a broad multidisciplinary context, its different learning areas, its linkages with related fields of study, and current and emerging developments associated with the chosen disciplinary/interdisciplinary areas of learning.
PSO2	Comprehensive Skillset for Success in Chemistry	Practical, professional, and procedural knowledge required for carrying out professional or highly skilled work/tasks related to Chemistry, including expertise required for undertaking self-employment initiatives and knowledge and mind set necessary

		for entrepreneurship involving enterprise creation, improved product development, or a new mode of organisation.
PSO3	Developing Adaptable Expertise: Specializing in Chemistry within a Multidisciplinary Framework	Skills in areas related to specialisation in Chemistry in a broad multidisciplinary context, including wide-ranging practical skills involving variable routine and non-routine contexts relating to the chosen field(s) of learning.
PSO4	Applying Knowledge for Real World Problem-Solving	Capacity to extrapolate from what has been learned, translate concepts to real-life situations and apply acquired competencies in new/unfamiliar contexts, rather than merely replicate curriculum content knowledge, to generate solutions to specific problems.

XII. Course Structure of the Undergraduate Programme(Chemistry)

The Programme comprises of Eight Semesters

SEMESTER-I (With Single Major)							
Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-1	CY10001	Inorganic Chemistry-I	3	0	1	4
Minor	M-1	CY12001	Basic Inorganic Chemistry	3	0	1	4
Multidisciplinary Course (MDC) (Opted by other Department)	MD-1	CY13001	Indian Chemistry Through the Ages	2	1	0	3
Ability Enhancement Course(AEC) (M.I.L) (Choose any one)		AE14001	Modern Indian Language (Odia)	2	0	0	2
		AE14003	Modern Indian Language (Hindi)	2	0	0	2
		AE14005	Modern Indian Language (Sanskrit)	2	0	0	2
		AE14007	Modern Indian Language (Santali)	2	0	0	2
		AE14009	Alternative English	2	0	0	2
Skill Enhancement Course (SEC)	SE-1	CY15001	Chemistry of Food Flavours and Colourants	2	0	1	3
Value Added Course(VAC)		VA16201	Environment Education and Disaster Management	3	1	0	4
			Total				**20 Credits**
SEMESTER-II (With Single Major)							
Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-2	CY10002	Physical Chemistry-I	3	0	1	4

Minor	M-2	CY12002	Basic Physical Chemistry	3	0	1	4
Multidisciplinary (MDC) (Opted by other Department)	**MD-2**	CY13002	Chemistry and Its Impact on Life	2	1	0	3
Ability Enhancement Course (AEC)(M.I.L) (Choose any one)		AE14002	Translation Studies (Odia)	2	0	0	2
		AE14004	Translation Studies (Hindi)	2	0	0	2
		AE14006	Translation Studies (Sanskrit)	2	0	0	2
		AE14008	Translation Studies (Santali)	2	0	0	2
		AE14010	Translation Studies (English)	2	0	0	2
Skill Enhancement Course(SEC)	SE-2	CY15002	Soil Chemistry	2	0	1	3
Value Added Course(VAC) (Choose any Two)		VA16148	Indian Mathematical Heritage and Knowledge Systems	2	0	0	2
		VA16156	Physics in Indian Knowledge Systems	2	0	0	2
		VA16158	Indian Knowledge System and Computing	2	0	0	2
		VA16202	Renewable Energy and Sustainable Technologies	2	0	0	2
		VA16204	Water Pollution and Treatment Technologies	2	0	0	2
		VA16302	Introduction to Methods of Applied Mathematics	2	0	0	2
		VA16394	Flutter Application Development	1	0	1	2

		VA16432	Chemistry of Medicines and Everyday Health	2	0		2
			Total				**20 Credits**

Exit Point: Undergraduate Certificate

Students exiting the programme after securing 40 credits will be awarded a UG Certificate in the relevant Discipline /Subject provided they secure 4 credits in work-based vocational courses offered during the summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semester

SEMESTER-III (With Single Major)

Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-3	CY20001	Organic Chemistry-I	3	0	1	4
	C-4	CY20003	Inorganic Chemistry-II	3	0	1	4
Minor (Opted by other Department)	M-3	CY22001	Basic Organic Chemistry	3	0	1	4
Multidisciplinary (MDC) (Opted by other Department)	MD-3	CY23001	Basics of Polymer Chemistry	2	1	0	3
Ability Enhancement Course(AEC) (M.I.L)		AE24001	Communicative English	2	0	0	2
Skill Enhancement Course(SEC)	SE-3	CY25001	Basic Nanotechnology	2	0	1	3
			Total				**20 Credits**

SEMESTER-IV (With Single Major)

Course Category	**COURSE CODE**			**CREDITS**

			NAME OF THE COURSE	L	T	P	TOTAL
Core Course (Major)	C-5	CY20002	Physical Chemistry-II	3	0	1	4
	C-6	CY20004	Organic Chemistry-II	3	0	1	4
	C-7	CY20006	Inorganic Chemistry-III	3	0	1	4
		SE20082	Seminar	0	0	2	2
Minor (Opted by other Department)	M-4	CY22002	Halogenated Hydrocarbons and Oxygen Containing Functional Groups	3	0	1	4
Ability Enhancement Course (AEC)		AE24002	Professional Communication	2	0	0	2
			Total				**20 Credits**

Exit Point: Undergraduate Diploma

Students exiting the programme after securing 80 credits will be awarded a UG Diploma in the relevant Discipline /Subject provided they secure an additional 4 credits in skill-based vocational courses offered during the first year or second year Summer term

SEMESTER-V (With Single Major)

Course Category	COURSE CODE		NAME OF THE COURSE	CREDITS			
				L	T	P	TOTAL
Core Course(Major)	C-8	CY30001	Organic Chemistry-III	3	0	1	4
	C-9	CY30003	Physical Chemistry-III	3	0	1	4
	C-10	CY30005	Inorganic Chemistry-IV	3	0	1	4
	C-11	CY30007	Organic Chemistry-IV	3	0	1	4
Minor (Opted by other Department)	M-5	CY32001	Equilibria, Chemical Kinetics and Catalysis	3	0	1	4
Internship		IP37081	Internship	0	0	2	2
			Total				**22 Credits**

SEMESTER-V (With Double Major)

Course Category	COURSE CODE		NAME OF THE COURSE	CREDITS			
				L	T	P	TOTAL
Core Course (Major)	C-8	CY30001	Organic Chemistry-III	3	0	1	4
	C-9	CY30003	Physical Chemistry-III	3	0	1	4
	C-10	CY30005	Inorganic Chemistry-IV	3	0	1	4
	C-11	CY30007	Organic Chemistry-IV	3	0	1	4
Minor (Opted by other Department)	M-5	CY32001	Equilibria, Chemical Kinetics and Catalysis	3	0	1	4
Double Major (Opted by other Department)	DM-1	CY32003	Chemical Thermodynamics and its Applications	3	0	1	4
	DM-2	CY32005	Coordination Chemistry and Reaction Mechanism	3	0	1	4
	DM-3	CY32007	Biomolecules	3	0	1	4
Internship		IP37081	Internship	0	0	2	2
			Total				**34 Credits**

SEMESTER-VI(With Single Major)

Course Category	COURSE CODE		NAME OF THE COURSE	CREDITS			
				L	T	P	TOTAL
Core Course(Major)	C-12	CY30002	Physical Chemistry-IV	3	0	1	4
	C-13	CY30004	Organic Chemistry-V	3	0	1	4
	C-14	CY30006	Physical Chemistry-V	3	0	1	4
	C-15	CY30008	Chemistry of Polymers and Fibres	3	0	1	4
Minor (Opted by other Department)	M-6	CY32002	s, p, d and f-Block Elements	3	0	1	4
			Total				**20 Credits**

SEMESTER-VI(With Double Major)							
Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-12	CY30002	Physical Chemistry-IV	3	0	1	4
	C-13	CY30004	Organic Chemistry-V	3	0	1	4
	C-14	CY30006	Physical Chemistry-V	3	0	1	4
	C-15	CY30008	Chemistry of Polymers and Fibres	3	0	1	4
Minor (Opted by other Department)	M-6	CY32002	s, p, d and f-Block Elements	3	0	1	4
Double Major (Opted by other Department)	DM-4	CY32004	Basics of Organometallic Chemistry	3	0	1	4
	DM-5	CY32006	Organic Reaction Mechanisms	3	0	1	4
	DM-6	CY32008	Industrial Chemicals and Environment	3	0	1	4
			Total				**32 Credits**

Exit Point: Bachelor's Degree with Hons.

Students who want to undertake a 3-year UG programme will be awarded a UG Degree in the relevant Discipline /Subject upon securing 120 credits

SEMESTER-VII(With Single Major)							
Core Course (Major)	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-16	CY40001	Photochemistry and Pericyclic Reaction	3	0	1	4
	C-17	CY40003	Fundamentals of Agro Chemistry	3	0	1	4
	C-18	CY40005	Bio-inorganic and Supramolecular Chemistry	3	0	1	4
	C-19	IK40051	Scientific Research Methods	3	0	1	4
Minor	M-7	CY42001	Electrochemistry	3	0	1	4

(Opted by other Department)							
			Total				**20 Credits**
SEMESTER-VII(With Double Major)							
Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-16	CY40001	Photochemistry and Pericyclic Reaction	3	0	1	4
	C-17	CY40003	Fundamentals of Agro Chemistry	3	0	1	4
	C-18	CY40005	Bio-inorganic and Supramolecular Chemistry	3	0	1	4
	C-19	IK40051	Scientific Research Methods	3	0	1	4
Minor (Opted by other Department)	M-7	CY42001	Electrochemistry	3	0	1	4
Double Major (Opted by other Department)	DM-7	CY42003	Basics of Drug Design and Medicinal Chemistry	3	0	1	4
			Total				**24 Credits**
SEMESTER-VIII (With Single Major)							
Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**			
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-20	CY40002	Molecular Spectroscopy	3	0	1	4
Minor (Opted by other Department)	M-8	CY42002	Basic Spectroscopy in Chemistry	3	0	1	4
		RD40082	Research and Dissertation	0	0	12	12
If not going for Research work		CY40004	Organic Synthesis	3	0	1	4
		CY40006	Green Chemistry	3	0	1	4
		CY40008	Inorganic Materials of Industrial Importance	3	0	1	4

		Total				**20 Credits**
Grand Total with Single Major (With or without Research)						**162 Credits**
SEMESTER-VIII(With Double Major)						
Course Category	**COURSE CODE**		**NAME OF THE COURSE**	**CREDITS**		
				L	**T**	**P**	**TOTAL**
Core Course (Major)	C-20	CY40002	Molecular Spectroscopy	3	0	1	4
Minor (Opted by other Department)	M-8	CY42002	Basic Spectroscopy in Chemistry	3	0	1	4
Double Major (Opted by other Department)	DM-8	CY42004	Advanced Organic Chemistry	3	0	1	4
		RD40082	Research and Dissertation	0	0	12	12
If not going for Research work		CY40004	Organic Synthesis	3	0	1	4
		CY40006	Green Chemistry	3	0	1	4
		CY40008	Inorganic Materials of Industrial Importance	3	0	1	4
			Total				**24 Credits**
		Grand Total with Double Major (With or without Research)		**194 Credits**			
	Exit Point: Bachelor's Degree with Hons. and Research **Students will be awarded UG Degree (Honours) with Research in the relevant Discipline /Subject provided they secure 162credits** **Honours students not undertaking research will do 3 courses for 12 credits in lieu of a research project / Dissertation.**						

SEMESTER- I

Course Code: CY10001
Course Title: Inorganic Chemistry – I (C-1)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

On completion of this course, the students will be able

- To understand atomic theory and its evolution.
- To learn scientific theory of atoms, concept of wave functions.
- To learn elements in periodic table, periodicity, physical and chemical properties of elements.
- To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
- To understand atomic theory of matter, composition of atom.
- To define isotopes, isobar and isotone.
- To predict hybridization and shapes of atomic and molecular orbitals, bond parameters, bond- distances and energies.
- To know valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- To know oxidation-reductions and their uses in metallurgy

Course Learning Outcomes: At the end of the course students will be able to:

CO1 : Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and

angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.

CO2: Draw the plausible structures and geometries of molecules using Radius Ratio Rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

CO3: Interprit the concept of lattice energy using Born-Landé and Kapustinskii expression.

CO4: Rationalize the conductivity of metals, semiconductors and insulators based on the Band theory.

CO5: Remember the importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect on melting points, boiling points, solubility and energetics of dissolution.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	1	2	–	1	–	–	2	–	1	–	3	2	2	2
CO2	–	3	1	3	–	2	–	–	2	–	1	–	3	2	3	2
CO3	–	2	–	2	–	2	–	–	1	–	1	–	2	2	2	3
CO4	–	3	1	2	–	2	–	1	2	–	1	1	3	2	2	3
CO5	1	3	1	2	–	1	–	–	2	–	1	2	3	2	2	2

Course Content:

UNIT-I: Atomic Structure: (10 Lectures)

Recapitulation of Bohr's theory and its limitations, atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Schrödinger's wave equation, significance of ψ and ψ2 .Quantum mechanical treatment of H-atom, Quantum numbers and their significance.Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves, Shapes of s, p, and d orbitals, Relative energies of orbitals, Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations.

UNIT-II: Periodicity of Elements: (10 Lectures)

Brief discussion of the following properties of the elements, with reference to s- & p-block and the trends shown:

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic and ionic radii

(c) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods.

(d) Electron gain enthalpy and trends in groups and periods.

(e) Electronegativity, Pauling's/ Allred Rochow's scales.Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

UNIT-III: Chemical Bonding: (20 Lectures)

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals.Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy.Madelung constant, Born-Haber cycle and its application, Solvation energy.Covalent character in ionic compounds, polarizing power and polarizability.Fajan's rules and consequences of polarization.

Covalent bond: Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N2, O2, C2, B2, F2, CO, NO, and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

VSEPR Theory: Lewis structure, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H2O, NH3, PCl3, PCl5, SF6, ClF3, I3 - , BrF2 + , PCl6 - ,ICl2 - ICl4 - , and SO4 2- . Multiple bonding (σ and π bond approach) and bond lengths.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors, insulators and defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of weak chemical forces, melting and boiling points, solubility, energetics of dissolution process.

UNIT-IV: Oxidation-Reduction: (5 Lectures)

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Principles involved in volumetric analysis to be carried out in class.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Titrimetric Analysis**

   i) Calibration and use of apparatus.

   (ii) Preparation of solutions of different Molarity/Normality of titrants.

   (iii) Use of primary and secondary standard solutions.

2. **Acid-Base Titrations**

   (i) Estimation of carbonate and hydroxide present together in mixture.

   (ii) Estimation of carbonate and bicarbonate present together in a mixture.

   (iii) Estimation of free alkali present in different soaps/detergents

3. **Oxidation-Reduction Titrimetry**

   (i) Estimation of Fe (II) using standardized KMnO4 solution.

   (ii) Estimation of oxalic acid using standardized KMnO4 solution.

   (iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

   (iv) Estimation of Fe (II) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) and external indicator.

Essential readings:

Theory:

1. Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India.

2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009),Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J.(1994),Concepts and Models of Inorganic Chemistry,John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010),Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.
- Flipped Classroom teaching

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens scientific reasoning, analytical skills, and foundational chemical knowledge
SDG 6	Clean Water and Sanitation	Understanding redox reactions and chemical bonding relevant to water purification

SDG 7	Affordable and Clean Energy	Band theory, semiconductors and electrochemical principles
SDG 9	Industry, Innovation and Infrastructure	Atomic structure, bonding and materials chemistry for industrial applications
SDG 12	Responsible Consumption and Production	Concepts of green chemistry, efficient resource utilization
SDG 13	Climate Action	Chemical understanding of pollution, energy materials, and sustainability

Course Code: CY12001
Course Title: Basic Inorganic Chemistry (M-1)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

On completion of this course, the students will be able

- To understand atomic theory and its evolution.
- To learn scientific theory of atoms, concept of wave functions.
- To learn elements in periodic table, periodicity, physical and chemical properties of elements.
- To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
- To understand atomic theory of matter, composition of atom.
- To define isotopes, isobar and isotone.
- To predict hybridization and shapes of atomic and molecular orbitals, bond parameters, bond- distances and energies.
- To know valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- To know oxidation-reductions and their uses in metallurgy.

Course Learning Outcomes: At the end of the course students will be able to:

CO1: Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.

CO2: Draw the plausible structures and geometries of molecules using Radius Ratio Rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

CO3: Interpret the concept of lattice energy using Born-Landé and Kapustinskii expression.

CO4: Rationalize the conductivity of metals, semiconductors and insulators based on the Band theory.

CO5: Remember the importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect on melting points, boiling points, solubility and energetics of dissolution.

CO-PO –PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	1	2	–	2	–	1	2	–	1	–	3	2	2	2
CO2	–	3	1	3	–	2	–	1	2	–	1	–	3	3	3	2
CO3	–	2	–	3	–	2	–	–	1	–	1	–	2	2	2	3
CO4	–	3	1	3	–	2	–	2	2	–	1	2	3	2	2	3
CO5	1	3	1	2	–	1	–	–	2	–	1	2	3	2	2	2

Course Content:

UNIT-I: Atomic Structure: (10 Lectures)

Recapitulation of Bohr's theory and its limitations, atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Schrödinger's wave equation, significance of ψ and ψ2 .Quantum mechanical treatment of H-atom, Quantum numbers and their significance.Normalized and orthogonal wave functions. Sign

of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, and d orbitals, Relative energies of orbitals. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations.

UNIT-II: Periodicity of Elements: (10 Lectures)

Brief discussion of the following properties of the elements, with reference to s- & p-block and the trends shown:

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic and ionic radii

(c) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods.

(d) Electron gain enthalpy and trends in groups and periods.

(e) Electronegativity, Pauling's/ Allred Rochow's scales.Variation of electronegativity with bond order, partial charge and hybridization.

UNIT-III: Chemical Bonding: (20 Lectures)

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals.Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy.Madelung constant, Born-Haber cycle and its application, Solvation energy.Covalent character in ionic compounds, polarizing power and polarizability.Fajan's rules and consequences of polarization.

Covalent bond: Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N2, O2, C2, B2, F2, CO, NO, and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

VSEPR Theory: Lewis structure, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H2O,

NH3, PCl3, PCl5, SF6, ClF3, I3 - , BrF2 + , PCl6 - ,ICl2 - ICl4 - , and SO4 2- . Multiple bonding (σ and π bond approach) and bond lengths.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of weak chemical forces, melting and boiling points, solubility, energetic of dissolution process.

UNIT-IV: Oxidation-Reduction: (5 Lectures)

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Principles involved in volumetric analysis to be carried out in class.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Titrimetric Analysis

i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality of titrants.

(iii) Use of primary and secondary standard solutions.

2. Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents.

3. Oxidation-Reduction Titrimetry

(i) Estimation of Fe (II) using standardized KMnO4 solution.

(ii) Estimation of oxalic acid using standardized KMnO4 solution

(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iv) Estimation of Fe (II) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) and external indicator.

Essential readings:

Theory:

1. Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009),Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J.(1994),Concepts and Models of Inorganic Chemistry,John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens scientific reasoning, analytical skills, and foundational chemical knowledge
SDG 6	Clean Water and Sanitation	Understanding redox reactions and chemical bonding relevant to water purification
SDG 7	Affordable and Clean Energy	Band theory, semiconductors, and electrochemical principles
SDG 9	Industry, Innovation and Infrastructure	Atomic structure, bonding, and materials chemistry for industrial applications
SDG 13	Climate Action	Chemical understanding of pollution, energy materials, and sustainability

Course Code: CY13001
Course Title: Indian Chemistry Through the Ages (MD-1)
Total Credits: 03 (Credits: Theory-02, Tutorial-01)
Total Lectures: Theory- 30 and Tutorial-15

Course Learning Objectives:

On completion of this course, the students will be able

- To understand atomic theory and its evolution.
- To learn scientific theory of atoms, concept of wave functions.

Course Learning Outcomes: At the end of the course students will be able to:

CO1: Remember the fundamental concepts in chemistry, such as matter, elements, atoms, molecules, metals, non-metals, and types of chemical bonding (covalent, ionic and coordinate), including Lewis structural representation, melting and boiling points, and scientific notation.

CO2: Students will be able to understand about the the significant contributions of ancient Indian alchemists like Acharya Nagarjuna, Govind Bhagwatpad, Vagbhatta, Siddha Nityanatha, Somadeva, and Yasodhara to the field of alchemy and iatrochemistry, as well as the categorization of chemical substances in Rasasastra.

CO3: Illustrate the processes and techniques used in historic Indian chemical arts and crafts, including glass making, soap production, dyeing, cosmetics and perfume creation, ink production, and metallurgy (iron, steel, copper, bronze).

CO4: Analyze the scientific and practical advancements in chemistry made by modern Indian chemists such as Sir Acharya Prafulla Chandra Ray, Prof. Har Govind Khorana, Prof. C N R Rao,

CO5: Interpret the impact of ancient and modern Indian contributions to the field of chemistry, particularly in terms of chemical research, development of the chemical industry, and the broader scientific community, including the environmental impact of chemical reactions such as acid rain, the greenhouse effect, and global warming.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO\ 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	–	2	–	–	–	–	1	–	1	–	3	2	2	1
CO2	2	3	1	2	3	2	–	1	2	–	1	2	3	2	2	2
CO3	1	3	1	3	3	2	–	1	2	–	1	2	3	3	3	2
CO4	1	3	1	3	2	2	–	1	2	–	1	–	3	2	2	3
CO5	2	3	1	3	3	2	–	1	2	–	1	3	3	2	2	3

Course Content:

UNIT-I: Basic Concepts in Chemistry (5 Lectures)

Matter, elements, atoms and molecules, Metal and Non-Metals, structure of the atom, Chemical Bonding (covalent, Ionic, co-ordinate) with examples, Lewis structural representation, Melting and boiling points, Scientific Notation. Chemical reactions in atmosphere: Acid rain, Greenhouse effect and global warming.

UNIT-II: Chemistry in Ancient India (10 Lectures)

Alchemy, Alchemy and Iatrochemistry in India, Rasasastra, Catagorization of chemical substances: mahārasas, uparasas, navaratnas, dhātus. Special position of mercury in Indian alchemy, Noted alchemical texts from Acharya Nagarjuna, Govind Bhagwatpad, Vagbhatta, Siddha Nityanatha, Somadeva, and Yasodhara. Contributions of Nagarjuna, General layout of the laboratory and apparatus used in ancient chemistry, the mūsa yantra or crucible, the koṣṭhi yantra, the pātana yantra (sublimation or distillation), the dhūpa yantra (for fumigation)

UNIT-III: Chemical Arts and Crafts in Historic period (8 Lectures)

Glass making, Soap, Dyeing, Cosmetics and Perfumes, Ink, Metallurgy: Iron, Steel, Copper, Bronze. Modern Indian Chemistry Sir Acharya Prafulla Chandra Ray – Father of Indian Chemistry: His contributions in chemical research, and development of Indian chemical industry, Ray's classification of five stages in development of Chemistry in India.

UNIT-IV: Lives of Some Chemists from Modern India and Their Contributions in Chemistry (7 Lectures)

Works and Contribution of Nobel laureate Professor Har Govind Khorana, Prof C N R Rao, Dr. Shanti Swarup Bhatnagar, Dr.Asima Chatterjee, Nobel laureate Venkatraman Ramakrishnan, Dr. Kamala Sohonie, Dr.Yellapragada Subba Rao, Dr. Darshan Ranganathan.

Essential Readings:

1. Basic Chemistry, 5th Edn. K. Timberlake and W. Timberlake, Pearson.

2. History of Chemistry in Ancient and Medieval India, P. C. Ray, Editor P. Ray and B.G. Guha.

3. Ancient Indian Metallurgy, Ashoka Kumar Mishra, 2009.

4. Copper and its Alloys in Ancient India, D. K.Chakrabarti, N. Lahiri, 1996.

5. Chemical Research of Sir P. C. Ray, S. Goswami and S. Bhattacharya, Resonance, 2001.

6. Life and Experiences of a Bengali Chemist, Vol I and II, P. C. Ray.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	**SDG Title**	**Nature of Contribution**
SDG 4	Quality Education	Promotes scientific literacy through historical and conceptual understanding
SDG 9	Industry, Innovation and Infrastructure	Highlights development of chemical industry and indigenous technologies
SDG 11	Sustainable Cities and Communities	Preservation of traditional chemical knowledge and heritage
SDG 12	Responsible Consumption and Production	Indigenous sustainable chemical practices and resource use
SDG 13	Climate Action	Awareness of atmosphere

Course Code: AE14001 (AEC)
Course Title: Modern Indian Language (Odia)
(ଆଧୁନିକ ଭାରତୀୟ ଭାଷା)
Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30
(Refer to the Odia Department,SCTLL)

Course Code: AE14003 (AEC)
Course Title: Modern Indian Language (Hindi)
Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30
(Refer to the Hindi Department, SCTLL)

Course Code: AE14005 (AEC)
Course Title: Modern Indian Language (Sanskrit)
Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30
(Refer to the Sanskrit Department, SCTLL)

Course Code: AE14007 (AEC)
Course Title: Modern Indian Language (Santali)
Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30
(Refer to the Santali Department, SCTLL)

Course Code: AE14009 (AEC)
Course Title: Alternative English
Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30

Course Learning Objectives:

- Develop critical reading and analytical skills through the study of prose, poetry, and short fiction.
- Understand myriad literary forms, themes, and stylistic features of English literature of different
  cultural and historical contexts.
- Enhance appreciation of literary texts by examining human core values, ethics, social issues, and
  aesthetic expression.
- Sharpen English language proficiency through the study and practice of grammar, vocabulary, comprehension, and writing skills.
- Refine communication skills, enabling students to express ideas effectively in both written and
  spoken English.

Course Learning Outcomes:

CO1: Analyze and interpret prose, poetry, and short fiction by identifying their themes, literary techniques, and cultural significance.
CO2: Evaluate the ideas and perspectives presented in literary texts and relate them to contemporary social, ethical, and human concerns.
CO3: Demonstrate an understanding of major literary forms, including essays, short stories, sonnets,and modern poetry.
CO4: Apply the rules of English grammar, including tenses, articles, prepositions, subject–verb agreement,and sentence transformations, in effective communication.
CO5: Develop proficiency in reading comprehension, précis writing, and coherent written expression for academic and professional contexts.

<u>Course Conent:</u>

Unit I: Prose

- Francis Bacon- *Of Studies, Of Truth*
- A. P. J. Abdul Kalam – *My Vision for India*

Unit II: Short Fiction

- O. Henry – *The Gift of the Magi*
- *Mahasweta Devi* – ***Draupadi*** (translated by Gayatri Chakravorty Spivak)

Unit III: Poetry

- William Shakespeare – *Sonnet 116, 138*
- Jayanta Mahapatra – *Hunger*

Unit IV: Language and Communication Skills

- Tenses, Articles, Prepositions, Subject–Verb Agreement Transformation of Sentences (Active–Passive, Direct–Indirect) Comprehension and Precis Writing

Recommended Learning Resources

- Bacon, Francis. *Essays of Francis Bacon* (Oxford World's Classics or Penguin Classics), 1625.
- Kalam, A. P. J. Abdul. *Wings of Fire* and *My Vision for India: Ideas for the New Millennium.* (Universities Press / Penguin India),1999.
- O. Henry. *The Gift of the Magi and Other Stories.* (Signet Classics / Dover Publications), 1906.
- Devi, Mahasweta. *Breast Stories.* Translated by Gayatri Chakravorty Spivak. (Seagull Books, Kolkata), 2002.
- Mahapatra, Jayanta. *A Rain of Rites: Poems.* (Oxford University Press / Harper Collins India), 1976**.**
- Shakespeare, William. *Sonnets.* (Edited by Katherine Duncan-Jones, Arden Shakespeare Series / Oxford University Press), 1997.
- Ram, M. & Singh, K. *English Language and Communication Skills: A Practical Approach.* (PHI Learning / Cambridge India), 2012.
- Iyengar, K. R. Srinivasa. *Indian Writing in English.* (Sterling Publishers / Asia Publishing House),1962.
- Parija, Ratnaprava. Communicative English (REST Publisher, Tamil Nadu), 2018.
- Murphy, Raymond. *English Grammar in Use.* (Cambridge University Press),1985

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	2	1	2	2	1	2	2	3	2	2	2
CO2	3	3	3	3	3	2	2	2	2	1	2	3	3	2	3	3
CO3	2	3	3	3	3	3	2	3	3	2	3	3	3	3	3	3
CO4	2	3	2	3	3	2	2	2	3	2	3	3	3	3	2	3

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO5	2	3	3	3	2	2	2	2	2	3	2	3	3	3	3	3

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Enhances literary competence, grammar, communication, and critical thinking skills
SDG 5	Gender Equality	Encourages critical engagement with gender representation and women's experiences
SDG 8	Decent Work & Economic Growth	Strengthens language proficiency and professional communication skills
SDG 10	Reduced Inequalities	Promotes empathy, inclusion, and understanding of marginalized communities
SDG 16	Peace, Justice & Strong Institutions	Encourages ethical values, cultural awareness, and responsible communication

Course Code: CY15001
Course Title: Chemistry of Food Flavors and Colourants (SE-1)
Total Credits: 03 (Credits: Theory-02, Practical-01)
Total Lectures: Theory- 30 and Practical-30

Course Learning Objectives:

The learning objectives of this course are as follows:

• To provide introduction to quality attributes of food such as appearance and flavour.

• To impart an understanding of the chemistry of the flavour as well as colour constituents of foods

Course Learning Outcomes:

By the end of the course, the students will be able to:

CO1: Can recall the importance, classification, taste and flavor of food.

CO2: Describe mechanisms of flavor perception

CO3: Demonstrate various mechanisms of flavor formation

CO4: Discuss the chemical dimension of flavour.

CO5: Recognize off-flavor defects in foods and strategies to control it.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT-1: Flavors (10 Lectures)

Introduction and importance of flavors in food, Taste & Odour: Structure and physiology of taste organs- tongue, papillae, taste buds, salivary glands, Mechanism of taste and odour perception.

Basic Types of taste : Salty, Sweet, Bitter, Sour, Umami taste, Chemical dimensions of basic tastes (sweet, salt, sour, bitter and umami), odour and other sensations (like astringency, coolness, pungency/pungency), Non-nutritive and nutritive sweeteners (including structures of aspartame, saccharin, sucralose, Stevioside), Molecular Theory of Sweetness, Taste Inhibition and enhancement, Chemical dimension of Flavors (peppers, peppermint, coriander, cinnamon, onion),

UNIT-II: Chemistry of food flavorings (5 Lectures)

Maillard browning, enzymic browning reactions, caramelisation browning, Off-Flavour in Food (Rancidity in Fats/Oils, Non Enzymic Browning), Control of enzymic browning (acidulants, chelating agents, heat treatment etc)

UNIT-III: Food Colours (7 Lectures)

Introduction, importance, classification: Natural food colourants (Anthocyanins, Carotenoids, Chlorophyll), Examples of Pigments in common food (turmeric, tomato, carrot, orange); Natureidentical colourants (β-Carotene, Canthaxanthin and Riboflavin)

UNIT-IV: Artificial/synthetic colourants (8 hours)

Azo dyes (e.g. amaranth dye, tatrazine, citrous red); Quinoline (e.g. quinoline yellow); Phthalein (e.g. erythrosine); Triarylmethanes and indigoid (e.g. indigo carmine), FD&C Dyes and Lakes.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Determination of the taste threshold for the different sensations – sweet, salty, sour.
2. Extraction of limonene from orange peels using supercritical carbon dioxide.
3. Quantitative determination of food dyes in powdered drink mixes by spectrophotometric method.
4. Extraction and separation of pigments present in spinach by Thin Layer Chromatography (TLC).
5. Experiment to demonstrate the enzymic browning and its prevention.
6. Determination of rancidity of edible oils by Kriess Test.
7. Estimation of carotenoids in sample by colorimetric method.

Essential readings:

Theory:

1. DeMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), Principles of Food Chemistry, 4th Edition, Springer.
2. Msagati, T.A.M. (2013), Chemistry of Food Additives and Preservatives, WileyBlackwell.
3. Fennema, O.R. (2017), Food Chemistry, 5th Edition, CRC Press.
4. Attokaran, M. (2017), Natural Food Flavors and Colorants, 2nd Ed., Wiley-Blackwell.

5. Potter, N.N., Hotchkiss, J.H, (1995) Food Science, 5th Ed., Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), Food Additives, 2nd Edition, CRC Press.
7. Coultate, T. (2016), Food: The Chemistry of its Components, 6th Edn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), Food Chemistry, Springer.
9. Course: FOOD CHEMISTRY (iasri.res.in)

Practicals:

1. Ranganna, S. (2017). Handbook of analysis and quality control for fruits and vegetable products, 2nd Edn., McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), Introductory Practical Biochemistry, Narosa Publishing House

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 2	Zero Hunger	Quality, safety and sensory appeal of food
SDG 3	Good Health and Well-being	Understanding food additives, off-flavors and food safety
SDG 4	Quality Education	Applied chemistry knowledge in food science
SDG 9	Industry, Innovation and Infrastructure	Food processing, flavour and colourant industries
SDG 12	Responsible Consumption and Production	Safe additives, reduced food spoilage, sustainable practices

Course Code: VA16201
Course Title: Environment Education and Disaster Management
Total Credits: 04 (Theory-03 and Tutorial-01)

Total Lectures: Theory- 45 and Practical-15

Course Learning Objectives:

The objective is to make students aware about the environmental functions and issues.

Learning Outcomes:

CO1: Students will develop a comprehensive understanding of the complex interactions between humans and the environment, tracing historical developments, analyzing contemporary challenges, and exploring sustainable solutions.

CO2: Students will be able to critically analyze the impact of human activities on natural resources, biodiversity, ecosystems, and the climate, evaluating the effectiveness of conservation efforts and mitigation strategies.

CO3: Students will gain an interdisciplinary perspective by integrating knowledge from fields such as ecology, geography, sociology, economics, and policy studies to address environmental issues holistically.

CO4: Students will cultivate problem-solving skills by applying scientific principles, analytical tools, and ethical considerations to devise innovative solutions for environmental challenges at local, regional, and global scales.

CO5: Students will develop the capacity for active engagement and advocacy in environmental stewardship, recognizing their role as responsible global citizens and agents of positive change in promoting sustainability and resilience.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT-I: Humans and the Environment (4 Lectures)

The man-environment interactions: Human as hunger-gatherers; Origin of agriculture; Great ancient civilizations and the environment; Industrial revolution and its impact on the environment; Population growth and natural resource exploitation; Concept of sustainable development, Sustainable Development Goals (SDGs).

UNIT-II: Natural Resources and Sustainable Development (8 Lectures)

Overview of natural resources, renewable and non-renewable resources. Biotic resources: Major type of biotic resources-forests, grassland, wetlands, wildlife. Water resources: Types of water resources-fresh water and marine; Availability and use of water resources; Environmental impact of over-exploitation, issues and challenges; Conflicts over water.Soil and mineral resources: Energy resources: Renewable and non-renewable sources of energy; Non-conventional energy sources-solar, wind, tidal, hydro, geothermal, biomass, hydrogen and fuel cells; Implications of energy use on the environment.

UNIT-III: Conservation of Biodiversity and Ecosystems (6 Lectures)

Biodiversity as a natural resource; Biodiversity in India and the world; Biodiversity hotspots; Endangered species, Red data book. Threats to biodiversity and ecosystems: Commercial exploitation of species; Invasive species. Major conservation policies: in-situ conservation approaches; Major protected areas; National and International initiatives for biodiversity conservation; the role of traditional knowledge, community-based conservation. Land use and Land cover change: deforestation, desertification, urbanization, Loss of Biodiversity and it's impact.

UNIT-IV: Environmental Pollution (8 Lectures)

Environmental issues at local, regional, and global levels. Air, noise, water, soil, thermal and radioactive pollution. Point sources and non-point sources of pollution.

Air pollution: Sources of air pollution; Primary and secondary pollutants; particulate matter and sulphur dioxide; Volatile Organic compounds (VOCs), Polycyclic aromatic hydrocarbons (PAHs) and Persistent organic pollutants (POPs); acid rain; smog, Ozone hole. National Ambient Air Quality Standards.

Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality, Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life.

Soil pollution: Soil pollutants and their sources; Solid waste and their recycling. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Mineral exploitation; Environmental problems due to extraction of minerals and use; Degradation of soil quality and impact on agriculture productivity.

Noise pollution; Noise standards; adverse impact of noise on human health.

Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.

UNIT-V: Climate Change: Impacts, Adaptation and Mitigation (5 Lectures)

Understanding climate change, Projections of global climate change with reference to temperature, rainfall, climate variability and extreme events; Climate change projections for the Indian sub-continent.

Impacts of climate change on ocean and land systems; Sea level rise, changes in marine and costal ecosystems; Impacts on forests and natural ecosystem; Impacts on animal species, agriculture, health, urban infrastructure; Climate-resilient development; Indigenous knowledge for adaption to climate change.

Mitigation of climate change: Green House Gas (GHG) Reduction vs. sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; Energy efficiency measures; Renewable energy sources; Carbon capture and storage.

UNIT-VI: Environmental Management (6 Lectures)

Introduction to environmental laws and regulations: Constitutional provisions- Article 48A, Article 51A (g) and other environmental rights, Environmental legislations on the forest, wildlife and pollution control.Environmental audit and impact assessment; Waste Management- Concept of 3R (Reduce, Recycle and Recycle) and sustainability.

UNIT-VII: Environmental Treaties and Legislation (8 Lectures)

Major International Environmental Agreements: UN Conference on Human Environment 1972, Convention on Biological Diversity (CBD); Cartagena Protocol on Biosafety; Nagoya Protocol on Access and Benefit-sharing ; Convention on International Trade in Endangered Species of Wild Flora and Fauna(CITES); Ramsar Convention on Wetlands of International Importance; United Nations Convention to Combat Desertification (UNCCD); Vienna Convention for the Protection of the Ozone Layer; Montreal Protocol on Substances that Deplete the Ozone Layer and the Kigali Amendment; Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and their Disposal; Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; Stockholm Convention on Persistent Organic Pollutants; Minamata Convention on Mercury; United Nations Framework Convention on Climate Change (UNFCCC); Kyoto Protocol; Paris Agreement; India's status as a party to major conventions

Major Indian Environmental Legislations: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air(Prevention and Control of Pollution) Act, 1981 The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; Noise Pollution (Regulation and Control) Rules, 2000; Industry-specific environmental standards; Waste management rules, National Green Tribunal.

Major International organizations and initiatives: United Nations Environment Programme(UNEP), International Union for Conservation of Nature (IUCN), World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC), and Man and the Biosphere(MAB) programme.

UNIT-VIII: Disaster Management (15 Lectures)

Concept of Hazards, Disasters, Natural and man made hazards, Types of hazards, Concept of disaster management, Vulnerability and risk. Nature and characteristics of hazards: Flood, Cyclone, Drought, and Earthquake. Man made hazards – Industrial and Fire.

Disaster management cycle, Pre disaster management, during disaster management, Post Disaster review and management, Preventing, mitigation, preparedness, Adaptation. Disaster Management Plan at National Level, State Level, District Level and Community Level.

Essential readings:

1. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. *Ecology, Environmental Science and Conservation*. S. Chand Publishing, New Delhi.
2. Das, M.C. Text Book of Ecology, Tata Mc Graw Hills, New Delhi
3. Central Pollution Control Board Web page for various pollution standards. https://cpcb.nic.in/standards/
4. Chiras, D. D and Reganolds, J.P. (2010) . Natural Resource Conservation : Management for a Sustainable Future. 10th edition, Upper Saddle River, N.J. Benjamin/Cummins/Person.
5. Fisher, Michael H. (2018) An Environmental History of India-Form Earliest Times to the Twenty-First Century, Cambridge University Press.
6. Harris, France (2012) Global Environmental Issues, 2nd Edition. Wiley-Blackwell.
7. John W. Twidell and Anthony D. (2015). Renewable Energy Sources, 3rd Edition, Weir Publisher (ELBS)
8. Kanchi Kohli and Manju Menon (2021) Development of Environment Laws in India, Cambridge University Press.
9. Krishnamurthy, K.V.(2003) Textbook of Biodiversity, Science Publishers, Plymouth, UK
10. Ministry of Environment, Forest and Climate Change (2019) A Handbook on International Environment Conventions & Programmes.
https://moef.govt.in/wp-content/uploads/2020/02/convention-V-16-CURVE-web.pdf
11. Rajagopalan, R. (2011). Environmental Studies: From Crisis to Cure. India: Oxford University Press.
12. Annual Reports of Ministry of Env., Forests and Climate Change, Govt of India, New Delhi

Note: Latest edition of the text books should be used.

Teaching Learning Process:

Lectures, Power Point Presentation, Industrial Visit/Practical, Assignments, Case discussion, Projects and Seminars

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

SEMESTER- II

Course Code: CY10002

Course Title: Physical Chemistry-I (C-2)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

- To develop basic and advance concepts regarding the three states of matter.
- To derive the expressions for determining the physical properties of gases, liquids and solids.
- To study the concept of ionization in aqueous solution, pH, buffers and various applications of ionization.

Course Learning Outcomes: By the end of the course, students will be able to:

CO1: Derive mathematical expressions for different properties of gas, liquid and solids and understand their physical significance.

CO2: Explain the crystal structure and calculate related properties of cubic systems.

CO3: Apply the concepts of gas equations, pH and electrolytes while studying other chemistry courses and everyday life.

CO4: Determination of lattice parameters of given salt.

CO5: Study of X-Ray diffraction pattern and finding out reference from JCPDS file.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	1	3	–	2	–	1	2	–	1	–	3	2	2	2
CO2	–	3	1	3	–	2	–	2	2	–	2	–	3	3	3	2
CO3	–	3	1	3	–	2	–	1	2	–	2	–	3	3	2	3
CO4	–	3	–	3	–	3	–	2	2	–	2	–	3	3	3	3
CO5	–	3	1	3	–	3	–	3	2	–	2	–	3	3	3	3

Course Content:

UNIT-I: Gaseous state: (15 Lectures)

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure and temperature for different gases. Causes of deviation from ideal behaviour.Equation of states for real gases; van der Waals equation of state, its derivation and application in explaining real gas behaviour, Virial coefficients, calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

UNIT-II: Liquid state (6 Lectures)

Liquid state: Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity.Explanation of cleansing action of detergents.Temperature variation of viscosity of liquids and comparison with that of gases.

UNIT-III: Solid State (12 Lectures)

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

UNIT-IV: Ionic equilibria (12 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.Buffer solutions; derivation of Henderson equation and its applications.Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Surface tension measurements.**

   a .Determine the surface tension by (i) drop number (ii) drop weight method.

   b. Study the variation of surface tension of detergent solutions with concentration.

2. **Viscosity measurements using Ostwald's viscometer.**

   a. Determination of viscosity of aqueous solution of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

   b. Viscosity of sucrose solution with the concentration of solute.

3. **pH metry**

   a. Effect on pH of addition of HCl/ NaOH to solutions of acetic acid, sodium acetate and their mixtures.

   b. Preparation of buffer solutions of different pH i. Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide

   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

Essential readings:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.

2. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthening quantitative, analytical, and experimental skills
SDG 6	Clean Water and Sanitation	pH, buffers, and ionic equilibria relevant to water quality
SDG 9	Industry, Innovation and Infrastructure	Crystallography, materials characterization, gas laws
SDG 12	Responsible Consumption and Production	Understanding chemical equilibria and material efficiency
SDG 13	Climate Action	Gas behaviour, atmospheric chemistry concepts

Course Code: CY12002
Course Title: Basic Physical Chemistry (M-2)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

- To develop basic and advance concepts regarding the three states of matter.
- To derive the expressions for determining the physical properties of gases, liquids and solids.
- To study the concept of ionization in aqueous solution, pH, buffers and various applications of ionization.

Course Learning Outcomes: By the end of the course, students will be able to:

CO1: Derive mathematical expressions for different properties of gas, liquid and solids and understand their physical significance.

CO2: Explain the crystal structure and calculate related properties of cubic systems.

CO3: Apply the concepts of gas equations, pH and electrolytes while studying other chemistry courses and everyday life.

CO4: Determination of lattice parameters of given salt.

CO5: Study of X-Ray diffraction pattern and finding out reference from JCPDI file.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	1	3	–	2	–	1	2	–	1	–	3	2	2	2
CO2	–	3	1	3	–	2	–	2	2	–	2	–	3	3	3	2
CO3	–	3	1	3	–	2	–	1	2	–	2	–	3	3	2	3
CO4	–	3	–	3	–	3	–	2	2	–	2	–	3	3	3	3
CO5	–	3	1	3	–	3	–	3	2	–	2	–	3	3	3	3

Course Content:

UNIT-I: Gaseous state: (15 Lectures)

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure and temperature for different gases. Causes of deviation from ideal behaviour.Equation of states for real gases; van der Waals equation of state, its derivation and application in explaining real gas behaviour, Virial coefficients, calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

UNIT-II: Liquid state (6 Lectures)

Liquid state: Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

UNIT-III: Solid State (12 Lectures)

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

UNIT-IV: Ionic equilibria (12 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.Buffer solutions; derivation of Henderson equation and its applications.Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Surface tension measurements.**
    a. Determine the surface tension by (i) drop number (ii) drop weight method.
    b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurements using Ostwald's viscometer.**
    a. Determination of viscosity of aqueous solution of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
    b. Viscosity of sucrose solution with the concentration of solute.

pH metry

3. Effect on pH of addition of HCl/ NaOH to solutions of acetic acid, sodium acetate and their mixtures.

4. Preparation of buffer solutions of different pH
i. Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide

5. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

Essential readings:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthening quantitative, analytical, and experimental skills
SDG 6	Clean Water and Sanitation	pH, buffers, and ionic equilibria relevant to water quality
SDG 9	Industry, Innovation and Infrastructure	Crystallography, materials characterization, gas laws
SDG 12	Responsible Consumption and Production	Understanding chemical equilibria and material efficiency
SDG 13	Climate Action	Gas behaviour, atmospheric chemistry concepts

Course Code: CY13002
Course Title: Chemistry and Its Impact on Life (MD-2)
Total Credits: 03 (Credits: Theory-02, Tutorial-01)
Total Lectures: Theory- 30 and Tutorial-15

Course Learning Objectives:

- To provide students with a foundational understanding of basic chemical concepts and their relevance to matter, atoms, molecules, and bonding.
- To introduce students to the role of chemistry in medicine, healthcare, and the pharmaceutical industry, with a focus on the chemical basis of drugs and their action.
- To explore the applications of chemistry in various industries such as energy, food, ceramics, agriculture, and agrochemistry, while promoting an understanding of eco-friendly and sustainable practices.

Course Learning Outcomes: By the end of the course, students will be able to:

CO1: Demonstrate an understanding of the basic concepts in chemistry, including matter, elements, compounds, mixtures, atomic structure, and chemical bonding.
CO2: Describe the role of chemistry in medicine and healthcare, and classify different types of medicinal compounds and their chemical functions.
CO3: Identify and explain the industrial applications of chemistry in areas such as energy production, food chemistry, ceramics, and cosmetics.
CO4: Analyze the chemical composition of soils, understand nutrient requirements for plants, and evaluate the impact of fertilizers and pesticides on agriculture.

CO5: Apply the principles of green chemistry to agrochemical practices, promoting sustainability through eco-friendly agricultural solutions

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT-I: Basic Concepts in Chemistry (12 Lectures)

General introduction to matter, element, compound and mixture. Dalton's atomic theory: concept of atoms and molecules, Metals and Non-Metals. Basic concept on electron, proton, neutron and atomic models. Concept of Chemical Bonding (covalent, Ionic, co-ordinate) with examples. Basic idea about periodic classification of element.

UNIT-II: Chemistry in Medicine and Healthcare (10 Lectures)

Definition and Scope of Medicinal Chemistry, classes of medicinal compounds: analgesics and anti-inflammatory drugs, antibiotics, antimicrobials, antivirals, antiseptics, disinfectants, chemotherapeutic agents, antifertility drugs, antacids, cardiovascular drugs. Antihistamines, Natural Products and Traditional Medicine (Role of Natural Compounds in Medicine, Traditional Medicines and Herbal Drugs), vitamins and hormones.

UNIT-III: Industrial applications of chemistry (13 Lectures)

Elementary idea about glass, soap and detergent, dyeing, cosmetics and perfumes, chemistry in energy production (fossil fuels: coal, petroleum, and natural gas, solar energy), chemistry in food: preservatives, artificial sweetening agent, anti-oxidants, definition and classification of ceramics, properties, applications and environmental impact of ceramics.

UNIT-IV: Agrochemistry and Its Applications (10 Lectures)

Chemical composition of soil. Essential nutrients and their roles in plant growth, Soil pH and its impact on nutrient availability. Fertilizers and Their Role in agriculture, and environmental impacts, Insecticides, herbicides, fungicides, role of green chemistry in developing eco-friendly agricultural practices. biodegradable chemicals and bio-pesticides in agriculture, Organic farming and its chemical implications.

Essential Readings:

1. *Chemistry for Today: General, Organic, and Biochemistry* by Spencer L. Seager and Michael R. Slabaugh. Cengage Learning.
2. *Medicinal Chemistry: A Molecular and Biochemical Approach* by Thomas Nogrady and Donald F. Weaver. Oxford University Press.
3. *Industrial Chemistry: For Advanced Students* by R. Norris Shreve and Joseph A. Brink, Jr. McGraw Hill Education.
4. *Agrochemicals and Pest Management* by T.S. Thind. New India Publishing Agency.
5. *Introduction to Chemistry* by Susan A. Zumdahl and Donald J. DeCoste. Cengage Learning.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 2	Zero Hunger	Soil chemistry, fertilizers, sustainable agriculture
SDG 3	Good Health and Well-being	Medicinal chemistry, drugs, healthcare applications
SDG 4	Quality Education	Applied chemical literacy for daily life
SDG 7	Affordable and Clean Energy	Chemistry of fossil fuels and solar energy
SDG 9	Industry, Innovation and Infrastructure	Industrial chemistry and materials
SDG 12	Responsible Consumption and Production	Green chemistry, eco-friendly practices
SDG 13	Climate Action	Sustainable agriculture and reduced chemical pollution

Course Code: AE14002
Course Title: Translational Studies (Odia)

(ଅନୁବାଦ ସାହିତ୍ୟ)

Total Credits: 02 (Theory-02)

Total Lectures: Theory- 30

(Refer to the Odia Department,SCTLL)

Course Code: AE14004

Course Title: Translational Studies (Hindi)

(अनुवाद साहित्य)

Total Credits: 02 (Theory-02)

Total Lectures: Theory- 30

(Refer to the Hindi Department, SCTLL)

Course Code: AE14006

Course Title: Translational Studies (Sanskrit)

Total Credits: 02 (Theory-02)

Total Lectures: Theory- 30

(Refer to the Sanskrit Department, SCTLL)

Course Code: AE14008

Course Title: Translational Studies (Santali)

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Total Credits: 02 (Theory-02)

Total Lectures: Theory- 30

(Refer to the Santali Department, SCTLL)

Course Code: AE14010

Course Title: Translational Studies (English)

Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30
(Refer to the English Department, SCTLL)

Course Learning Objectives

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

- Understand the fundamental concepts, scope, functions, and significance of translation studies.
- Develop knowledge of major translation theories, methods, and practical translation strategies.
- Examine the linguistic, cultural, and contextual aspects involved in translating different types of texts.
- Apply translation techniques to literary and non-literary texts with accuracy and cultural sensitivity.
- Explore the role of translation in professional fields and the use of technology in contemporary translation practices.

Course Learning Outcomes

CO1: Explain the basic concepts, scope, functions, and importance of translation in diverse social and cultural contexts.
CO2: Demonstrate knowledge of major translation theories, methods, and strategies for effective translation.
CO3: Analyze linguistic, cultural, and contextual challenges while translating literary and non-literary texts.
CO4: Produce accurate, coherent, and culturally appropriate translations using suitable translation techniques.
CO5: Evaluate translation quality and recognize the professional applications of translation in media, publishing, education, administration, tourism, and digital communication.

Course Content:

Unit I: Foundations of Translation Studies

- Meaning, nature, scope and significance of translation
- Functions of translation in literature, education, media, governance and global communication

Unit II: Translation Theories and Techniques

- Major approaches to translation: Literal, Free, Semantic, Communicative and Functional translation
- Translation methods and strategies: Borrowing, Calque, Modulation, Transposition, Compensation, and Cultural substitution

Unit III: Language, Culture and Practice of Translation

- Linguistic, cultural and contextual challenges in translation

- Translation of prose, poetry, drama and non-literary texts (news reports, advertisements, official documents, speeches etc.)

Unit IV: Translation, Technology and Professional Applications

- Translation in the contemporary world: Publishing, media, administration, tourism, education and digital communication
- Principles of translation quality assessment: Accuracy, readability, consistency and cultural appropriateness

Recommended Learning Resources

- Bassnett, Susan. *Translation Studies* London: Routledge, 2014.
- Munday, Jeremy. *Introducing Translation Studies: Theories and Applications.* London: Routledge, 2022.
- Nida, Eugene A., and Charles R. Taber. *The Theory and Practice of Translation.* Leiden: Brill, 1969.
- Newmark, Peter. *A Textbook of Translation.* London: Prentice Hall, 1988.
- Hatim, Basil, and Jeremy Munday. *Translation: An Advanced Resource Book.* London: Routledge, 2004.
- Venuti, Lawrence (Ed.). *The Translation Studies Reader.* London: Routledge, 2021.
- Catford, J. C. A *Linguistic Theory of Translation.* Oxford: Oxford University Press, 1965.
- Lefevere, André. *Translation, Rewriting, and the Manipulation of Literary Fame.* London: Routledge, 1992.
- Gentzler, Edwin. *Contemporary Translation Theories.* Clevedon: Multilingual Matters, 2001.
- Baker, Mona. *In Other Words: A Coursebook on Translation.* London: Routledge, 2018.
- Mukherjee, Sujit. *Translation as Discovery and Other Essays on Indian Literature in English Translation.* Hyderabad: Orient Blackswan, 2006.
- Ramakrishna, Shantha. *Translation and Multilingualism: Post-Colonial Contexts.* New Delhi: Pencraft International, 1997.
- Devy, G. N. (Ed.). *Indian Literary Criticism: Theory and Interpretation.* Hyderabad: Orient Blackswan, 2002.
- Kothari, Rita. *Translating India: The Cultural Politics of English.* Manchester: St. Jerome Publishing, 2003.
- Singh, Harish Trivedi, and Susan Bassnett (Eds.). *Post-colonial Translation: Theory and Practice.* London: Routledge, 1999.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	2	2	–	–	–	–	1	–	–	–	2	1	2	1
CO2	–	3	2	2	–	1	–	1	1	–	–	–	3	2	2	1

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO3	–	2	3	3	–	2	–	–	1	–	–	–	2	2	3	2
CO4	1	3	3	2	–	2	–	1	2	–	2	–	3	3	2	3
CO5	2	2	3	3	–	2	1	2	2	1	2	–	2	3	2	3

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Enhances translation competence, multilingual literacy, and intercultural communication skills
SDG 5	Gender Equality	Encourages inclusive representation and critical understanding of gendered narratives
SDG 10	Reduced Inequalities	Promotes accessibility of regional literatures and cross-cultural understanding
SDG 11	Sustainable Cities & Communities	Preserves linguistic and literary heritage through translation and dissemination
SDG 16	Peace, Justice & Strong Institutions	Encourages intercultural dialogue, ethical communication, and cultural sensitivity
SDG 17	Partnerships for the Goals	Supports global cultural exchange and collaborative knowledge sharing

Course Code: CY15002
Course Title: Soil Chemistry (SE-2)
Total Credits: 03 (Credits: Theory-02, Practical-01)
Total Lectures: Theory- 30 and Practical-30

Course Learning Objectives:

The learning objectives of this course are as follows:

Students develop a comprehensive understanding of soil chemistry, from its physical properties and micronutrient cycles to the basic chemical processes and practical applications in soil management and composting.

Course Learning Outcomes:

By the end of the course, the students will be able to:

CO1: Students will remember the basic physical properties of soil, including its texture, structure, density, pore space, and components, both organic and inorganic.
CO2: They can explain the key biogeochemical cycles (carbon, nitrogen, phosphorus, and sulfur) and their roles in soil health and fertility, including the processes of mineralization and oxidation of sulfur compounds.
CO3: Students can demonstrate the ability to determine soil pH and interpret its effects on nutrient availability and plant preferences, applying this knowledge to real-world soil management scenarios.
CO4: They can analyze the chemical composition of soil and the processes of ion exchange, as well as the sources and effects of soil acidity, including the impact of acid rain and toxicities in acid soils.
CO5: They can evaluate the methods and benefits of composting in improving soil fertility, comparing different composting techniques and their effectiveness in enhancing soil health.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	1	2	–	1	–	–	1	–	1	1	3	2	2	2
CO2	–	3	1	2	–	2	–	–	2	–	1	2	3	2	2	2
CO3	–	3	1	3	–	2	–	2	2	–	2	2	3	3	3	3
CO4	–	3	1	3	–	3	–	1	2	–	2	2	3	3	3	3
CO5	1	3	1	3	–	2	–	1	2	–	2	3	3	3	3	3

Course Content:

UNIT-I: Physical Properties of Soil (8 Lectures)

Brief introduction about soil and its formation; texture; structure; density and weight relationship, pore space and porosity, color and components [organic and inorganic].

UNIT-II: Soil Micronutrients (8 Lectures)

Carbon cycle, Nitrogen cycle, and Terrestrial phosphorous cycle. Sulfur cycle, the role of sulfur in the environment, forms of sulfur in nature, mineralization of organic sulfur, and oxidation of inorganic sulfur compounds.

UNIT-III: Basic Chemistry of Soil (12 Lectures)

Chemical composition, ion exchange, organic components [fulvic acids and humic acid] Sources of acidity, effects of acid rain, toxicities in acid soils, the influence of pH, determination of soil pH, nutrient availability with pH, pH preferences of plants, soil buffer capacity, and management of pH.

UNIT-IV: Soil Compost (2 Lectures)

Preparation, examples of compost soil, Composting to increase soil fertility.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Determination of pH of different types of soil.

2. Preparation of Compost.

3. Field visit to any nearby Composting unit and Project Report submission.

Essential readings:

Theory:

• Foth, H.D. Fundamentals of Soil Science, 8th Ed., Wiley, 2016.

• McLaren, A.D. & Skujins, J. Soil Biochemistry, Vol.2, Marcel Dekker, INC, New York, 1971.

• Paul, E.A. & Clark, F.E. Soil Microbiology and Biochemistry, 2nd Ed., Academic Press, 1996.

Practical:

• White, R.E. Principles and Practice of Soil Science, 4th Ed., Wiley, 2005.

• Rachelle, S. Compost, 8th Ed., Flame Tree Publishing, 2009.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 2	Zero Hunger	Soil fertility, nutrient cycles, composting for sustainable agriculture
SDG 3	Good Health and Well-being	Reduction of soil toxicity, safe agricultural practices
SDG 4	Quality Education	Applied understanding of soil chemistry and environmental science
SDG 12	Responsible Consumption and Production	Composting, sustainable soil management practices

SDG 13	Climate Action	Carbon cycle in soil, mitigation of soil degradation
SDG 15	Life on Land	Soil conservation, ecosystem sustainability, biodiversity protection

Course Code: VA16148
Course Title: Indian Mathematical Heritage and Knowledge Systems
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory- 30

Course Learning Objectives

This course aims to introduce students to the rich heritage of Indian mathematics within the framework of Indian Knowledge Systems (IKS) and to familiarize them with the pioneering contributions of eminent Indian mathematicians to mathematics, astronomy, science, and technology. It develops computational and problem-solving skills through the study of Vedic Mathematics and traditional Indian mathematical methods while fostering an appreciation of their relevance in contemporary education, research, and innovation. The course also promotes ethical values, scientific temper, critical thinking, and the preservation of India's intellectual heritage in alignment with the objectives of NEP 2020.

Course Learning Outcomes

CO1 Explain the historical development of Indian mathematics, including the concepts of the decimal place-value system, zero, Sulba Sutras, and the mathematical traditions of Ancient India.

CO2 Describe the major contributions of eminent Indian mathematicians such as Aryabhata, Brahmagupta, Bhaskaracharya, Mahavira, and Madhava to mathematics and astronomy.

CO3 Apply the principles of Vedic Mathematics and traditional computational techniques to perform rapid calculations and solve mathematical problems efficiently.

CO4 Analyze the significance of Indian mathematical concepts in modern science, engineering, computational sciences, architecture, astronomy, and calendar systems.

CO5 Evaluate the relevance of Indian Knowledge Systems in mathematics for contemporary education, research, innovation, and the preservation of India's scientific heritage.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	1	2	3	1	–	–	2	–	–	1	3	–	2	1
CO2	1	3	2	2	3	2	–	–	2	–	–	–	3	1	2	2
CO3	–	2	1	3	2	1	–	2	2	–	1	–	2	3	2	3
CO4	–	3	2	3	3	2	–	2	2	1	1	1	3	2	3	3
CO5	2	2	2	2	3	3	1	1	3	2	2	2	2	1	2	2

Course Contents

UNIT I: Indian Knowledge Systems and Mathematical Heritage (8 Lectures)

- Introduction to Indian Knowledge Systems (IKS): Concept and philosophy
- Historical development of mathematics in Ancient India
- Mathematics in the Vedas and Vedangas
- Sulba Sutras and geometric constructions
- Decimal place-value system and invention of zero
- Ancient Indian education and mathematical traditions

UNIT II: Contributions of Indian Mathematicians (8 Lectures)

- Aryabhata and the *Aryabhatiya*
- Brahmagupta and *Brahmasphutasiddhanta*
- Bhaskaracharya (Bhaskara II) and *Lilavati*
- Mahavira and *Ganita Sara Sangraha*
- Madhava and the Kerala School of Mathematics
- Contributions to algebra, trigonometry, infinite series, astronomy, and computational mathematics

UNIT III: Vedic Mathematics and Traditional Computational Methods (Lectures)

- Introduction to Vedic Mathematics
- Sixteen Sutras and selected Sub-Sutras
- Rapid multiplication and division
- Squaring, square roots, cubes, and cube roots
- Mental arithmetic techniques
- Applications in competitive examinations and computational thinking

UNIT IV: Contemporary Relevance of Indian Mathematical Knowledge (7 Lectures)

- Applications of Indian mathematics in modern science and engineering
- Mathematics in temple architecture, art, astronomy, and calendars
- Indian mathematical ideas and computational sciences
- Indian Knowledge Systems under NEP 2020
- Future research opportunities and preservation of India's mathematical heritage

Essential readings:

- **K.S. Shukla & K.V. Sarma (Eds.)** – *Aryabhatiya of Aryabhata* (Critical Edition with English Translation), Indian National Science Academy (INSA), New Delhi.

- **Bibhutibhusan Datta & Avadhesh Narayan Singh** – *History of Hindu Mathematics* (Vol. I & II), Asia Publishing House / Motilal Banarsidass.
- **Tirthaji Maharaj (Bharati Krishna Tirtha)** – *Vedic Mathematics*, Motilal Banarsidass Publishers, New Delhi.

- **C.K. Raju** – *Cultural Foundations of Mathematics: The Nature of Mathematical Proof and the Transmission of the Calculus from India to Europe in the 16th Century*, Pearson Longman.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	**Quality Education**	Promotes understanding of Indian Knowledge Systems, mathematical heritage, logical reasoning, computational thinking, and lifelong learning in accordance with NEP 2020.
SDG 9	**Industry, Innovation and Infrastructure**	Develops analytical and problem-solving skills through Indian mathematical innovations, algebra, trigonometry, infinite series, and their applications in science, engineering, and computational technologies.
SDG 11	**Sustainable Cities and Communities**	Preserves and promotes India's mathematical and cultural heritage, including applications in temple architecture, astronomy, traditional calendars, and indigenous knowledge systems.
SDG 8	**Decent Work and Economic Growth**	Enhances mental arithmetic, computational efficiency, and quantitative aptitude through Vedic Mathematics, improving employability and competitive examination preparedness.
SDG 17	**Partnerships for the Goals**	Encourages interdisciplinary research, collaboration, and global dissemination of Indian mathematical knowledge, fostering academic partnerships and preservation of indigenous scientific heritage.

Course Code: VA16156
Course Title: Physics in Indian Knowledge Systems
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory- 30

Course Learning Objectives:

This course aims to introduce students to selected concepts of physical science and technological practices rooted in Indian Knowledge Systems. It familiarizes them with India's contributions to astronomy, measurement, timekeeping, materials, and traditional technologies while relating these practices to the fundamental principles of modern physics. The course also fosters an appreciation

of sustainable, locally adapted indigenous technologies and promotes evidence-based scientific inquiry to understand their relevance in the contemporary world.

Course Learning Outcomes:

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

CO1 Explain the fundamental concepts of Indian Knowledge Systems (IKS), traditional scientific methods, and the contributions of ancient Indian scholars to physics, mathematics, and astronomy.

CO2 Describe the basic principles of Indian astronomy, traditional timekeeping systems, astronomical instruments, and the scientific contributions of Aryabhata, Varahamihira, and Bhaskara.

CO3 Analyze the physical principles underlying traditional Indian technologies, materials, agricultural tools, water-management systems, pottery, metalworking, and musical instruments.

CO4 Apply the concepts of physics to explain indigenous practices related to energy conservation, traditional architecture, water harvesting, and sustainable resource utilization.

CO5 Evaluate the relevance of traditional Indian scientific knowledge and indigenous technologies in promoting sustainable development and addressing contemporary environmental challenges.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	3	1	2	3	1	–	–	2	–	–	–	3	–	2	–
CO2	–	3	1	3	3	2	–	1	2	–	–	–	3	1	2	1
CO3	–	3	1	3	3	2	–	1	2	–	1	1	2	3	3	3
CO4	1	2	1	3	3	2	–	2	3	–	2	3	2	2	3	3
CO5	3	2	1	3	3	3	–	1	3	1	2	3	2	2	3	3

Course Contents

UNIT I: Introduction to Physics and Indian Knowledge Systems (7 Lectures)

Introduction to Indian Knowledge Systems (IKS); nature and scope of scientific knowledge in Indian traditions; observation, measurement, and experimentation; traditional units of length, mass, and time; overview of contributions of selected Indian scholars to mathematics, astronomy,

and physical thought; importance of critically studying historical scientific knowledge using evidence and modern scientific methods.

UNIT II: Indian Astronomy and Timekeeping (8 Lectures)

Introduction to Indian astronomical traditions; observation of the Sun, Moon, stars, and planets; basic concepts of day, month, year, and seasons; traditional calendars and timekeeping; sundials and shadow-based measurement of time; basic idea of astronomical instruments; selected contributions associated with Aryabhata, Varahamihira, and Bhaskara; introduction to Jantar Mantar as an example of observational astronomy.

UNIT III: Physics in Traditional Technologies and Materials (8 Lectures)

Physics principles in traditional Indian technologies; simple machines and traditional agricultural tools; water-lifting and water-management systems; basic physics of pottery and metalworking; heat transfer in traditional cooking methods; thermal properties of commonly used natural materials; acoustics of selected Indian and tribal musical instruments; principles of sound, vibration, and resonance in traditional instruments.

UNIT IV: Indigenous Knowledge, Energy and Sustainable Living (7 Lectures)

Traditional approaches to natural lighting, ventilation, heating, and cooling; basic physics of traditional and vernacular architecture; use of locally available materials; traditional water harvesting and conservation systems; solar energy in everyday practices; energy-efficient traditional practices; indigenous technologies and sustainable use of natural resources; relevance of traditional knowledge to contemporary sustainable living.

Suggested References

1. Mahadevan, B., Bhat, V. R. & Pavana, N., *Introduction to Indian Knowledge System: Concepts and Applications*, PHI Learning.
2. Subbarayappa, B. V., *Indian Astronomy: An Historical Perspective*, Nehru Centre.
3. Bose, D. M., Sen, S. N. & Subbarayappa, B. V. (Eds.), *A Concise History of Science in India*, Indian National Science Academy.
4. Selected resources on Indian Knowledge Systems from the IKS Division, Ministry of Education, Government of India.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	**Quality Education**	Promotes understanding of Indian Knowledge Systems by integrating traditional scientific knowledge with modern physics, fostering scientific inquiry and critical thinking.
SDG 7	**Affordable and Clean Energy**	Introduces traditional energy-efficient practices, natural lighting, ventilation, and the use of solar energy, encouraging sustainable energy utilization.
SDG 9	**Industry, Innovation and Infrastructure**	Highlights indigenous technologies, traditional engineering practices, materials, and astronomical instruments, inspiring innovation through traditional scientific knowledge.
SDG 11	**Sustainable Cities and Communities**	Explores vernacular architecture, traditional water management, and locally adapted technologies that contribute to sustainable communities and preservation of cultural heritage.
SDG 12	**Responsible Consumption and Production**	Encourages the sustainable use of natural resources, indigenous technologies, and environmentally responsible traditional practices for resource conservation.
SDG 13	**Climate Action**	Emphasizes environmentally sustainable practices, energy conservation, and indigenous knowledge that support climate resilience and sustainable living.

Course Code: VA16158
Course Title: Indian Knowledge System and Computing
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory- 30
Total Teaching Hours: 30 Hours

Course Learning Objectives:

1. Understand the foundations of Indian Knowledge Systems.
2. Recognize India's contributions to mathematics, astronomy, logic, and linguistics.
3. Relate ancient Indian concepts to modern computing technologies.
4. Appreciate the role of Indian knowledge in solving contemporary technological challenges.

5. Develop critical thinking by comparing traditional and modern computational approaches.

Course Learning Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of the Indian Knowledge System (IKS), its historical evolution, contributions to mathematics, science, logic, linguistics, and their relevance to computing.
- **CO2 (Understanding):** Explain and interpret the principles of Indian mathematical and computational traditions, ethical values, knowledge representation, and their influence on modern computing and interdisciplinary applications.
- **CO3 (Application):** Apply concepts from the Indian Knowledge System to analyze computational problems, mathematical reasoning, algorithmic thinking, and sustainable technology solutions in diverse application domains.
- **CO4 (Analysis):** Analyze the contributions of ancient Indian scholars and knowledge systems in relation to modern computing, artificial intelligence, data science, cybersecurity, and digital technologies.
- **CO5 (Synthesis/Evaluation):** Evaluate and propose innovative computing solutions by integrating Indian Knowledge System principles, ethical practices, and contemporary technologies to address societal and sustainable development challenges.

CO-PO-PSO Mapping

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	-	-	-	2	1	2	-	–	–	–	2	–	-	–
CO2	2	3	-	1	-	3	2	1	2	–	–	–	2	1	-	-
CO3	2	3	-	2	2	2	2	1	2	–	-	2	2	2	2	1
CO4	2	2	2	3	2	2	2	2	3	–	-	2	2	2	2	2
CO5	2	2	3	2	3	3	2	1	3	2	2	3	3	2	3	2

UNIT-I: Indian Mathematics and Computing [8 Classroom Contact Hours]

What is Indian Knowledge System, Evolution of science and technology in ancient India, Major knowledge traditions, Nalanda, Takshashila, Vikramashila, Contributions of Indian scholars.

UNIT-II: Indian Astronomy and Timekeeping [8 Classroom Contact Hours]
Decimal number system, Zero and place value, Aryabhata's mathematical contributions, Brahmagupta's rules, Bhaskara's algorithms, Pingala's binary representation and combinatorics, Ancient algorithms and computational thinking

UNIT-III: Sanskrit, Logic and Artificial Intelligence [8 Classroom Contact Hours]
Panini's grammar, Rule-based systems, Formal language theory, Sanskrit and Natural Language Processing, Nyaya logic, Knowledge representation, AI inspired by Indian logic.

UNIT-IV: Computing, Ethics and Sustainable Development [6 Classroom Contact Hours]
Ethics in Indian philosophy, Responsible AI, Indigenous knowledge and digital preservation, AI for Indian languages, Preservation of manuscripts using digital technologies, Future of IKS in Computer Science

- Text Books

1. B. Mahadevan, Vinayak Rajat Bhat, and Nagendra Pavana R., **Introduction to Indian Knowledge System: Concepts and Applications,** PHI Learning, 2022.
2. B. Mahadevan and Vinayak Rajat Bhat, **Indian Knowledge Systems**, PHI Learning.
3. Kapil Kapoor and Avadesh Kumar Singh (Eds.), **Indian Knowledge Systems: Knowledge Traditions and Practices**, Indian Institute of Advanced Study (IIAS), Shimla.
4. S. Balachandra Rao, **Indian Mathematics and Astronomy: Some Landmarks**, Jnana Deep Publications.

- **Reference Books:**

1. Michel Danino, The Lost River: On the Trail of the Sarasvati, Penguin Random House India.

2. Subhash Kak, The Astronomical Code of the Rigveda, Munshiram Manoharlal Publishers.
3. Dharampal, Indian Science and Technology in the Eighteenth Century, Other India Press.
4. D. P. Chattopadhyaya (Ed.), History of Science, Philosophy and Culture in Indian Civilization, Centre for Studies in Civilizations.
5. B. B. Chaudhuri (Ed.), History of Science, Philosophy and Culture in Indian Civilization, Pearson/CSC (selected volumes).
6. V. Lakshmikantham and S. Leela, Indian Scientific Heritage, Universities Press.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	**Quality Education**	Promotes interdisciplinary learning by integrating Indian Knowledge Systems with modern computing, fostering critical thinking, innovation, and lifelong learning.
SDG 8	**Decent Work and Economic Growth**	Develops ethical, computational, and problem-solving skills that enhance employability and support innovation-driven economic growth.
SDG 9	**Industry, Innovation and Infrastructure**	Encourages the application of traditional knowledge and computational techniques to develop innovative, sustainable, and technology-driven solutions.
SDG 10	**Reduced Inequalities**	Promotes inclusive education by recognizing diverse knowledge traditions and encouraging equitable access to scientific and technological learning.
SDG 11	**Sustainable Cities and Communities**	Highlights the relevance of indigenous knowledge and computational tools in preserving cultural heritage and supporting sustainable community development.

Course Code: VA16202
Course Title: Renewable Energy and Sustainable Technologies
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory- 30

Total Teaching Hours: 30 Hours

Course Learning Objectives:

This course aims to introduce students to the rich heritage of Indian mathematics and its significant contributions to the development of mathematical knowledge and scientific thought. It provides an understanding of the pioneering works of renowned Indian mathematicians and their contributions to algebra, geometry, trigonometry, astronomy, and computational mathematics. The course familiarizes students with the principles and techniques of Vedic Mathematics to enhance mental calculation, logical reasoning, and problem-solving abilities. It also highlights the relevance of Indian mathematical knowledge in modern science, engineering, computational sciences, and technology while fostering an appreciation of India's intellectual heritage and encouraging its preservation and application in contemporary education and research.

Course Learning Outcomes:

CO1 Explain the various forms of energy, classify conventional and non-conventional energy resources, and describe the principles of sustainable development and clean energy.

CO2 Describe the principles, components, applications, advantages, and limitations of solar thermal and photovoltaic energy systems used in everyday life.

CO3 Compare the working principles, benefits, limitations, and applications of different renewable energy sources, including wind, hydropower, biomass, geothermal, tidal, and wave energy.

CO4 Apply the concepts of energy conservation, energy efficiency, green technologies, and energy storage to promote sustainable energy management in homes and communities.

CO5 Evaluate the importance of renewable energy technologies and sustainable practices in addressing environmental challenges and supporting sustainable development.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

UNIT I: Energy Resources and Sustainability (7 Lectures)

Introduction to energy and its forms; conventional and non-conventional energy sources; renewable and non-renewable resources; fossil fuels and their environmental impacts; need for renewable energy; basic concept of sustainable development; role of clean energy in sustainable living.

UNIT II: Solar Energy (8 Lectures)

Sun as a source of energy; solar radiation—basic concept; solar thermal and solar photovoltaic energy; basic principle of solar cells; solar panels; solar cooker; solar water heater; advantages and limitations of solar energy; common applications of solar energy in daily life.

UNIT III: Renewable Energy Sources (8 Lectures)

Wind energy—basic principle and wind turbines; hydropower—principle and types; biomass and biogas energy; basic concepts of geothermal, tidal and wave energy; advantages, limitations and applications of different renewable energy sources.

UNIT IV: Energy Conservation and Sustainable Technologies (7 Lectures)

Energy conservation and energy efficiency; energy-efficient lighting and appliances; basic concept of energy audit; green buildings; electric vehicles—basic concept; energy storage and batteries—basic introduction; smart energy use; role of individuals and communities in energy conservation and sustainable development.

Suggested References

1. Rai, G. D., *Non-Conventional Energy Sources*, Khanna Publishers.
2. Khan, B. H., *Non-Conventional Energy Resources*, McGraw Hill Education.
3. Twidell, J. & Weir, T., *Renewable Energy Resources*, Routledge.
4. Boyle, G., *Renewable Energy: Power for a Sustainable Future*, Oxford University Press.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Develops fundamental knowledge of energy resources, renewable energy technologies, energy conservation, and sustainable development while promoting scientific awareness and responsible decision-making.
SDG 7	Affordable and Clean Energy	Provides comprehensive understanding of renewable energy sources including solar, wind, hydropower, biomass, geothermal, tidal, and wave energy, emphasizing clean, affordable, and sustainable energy solutions.

SDG 9	Industry, Innovation and Infrastructure	Introduces modern energy technologies such as solar photovoltaic systems, energy storage, green buildings, electric vehicles, and energy-efficient technologies that support sustainable industrial development and innovation.
SDG 11	Sustainable Cities and Communities	Promotes sustainable urban development through energy-efficient buildings, smart energy use, clean transportation, and community participation in energy conservation.
SDG 12	Responsible Consumption and Production	Encourages efficient utilization of energy resources, energy audits, conservation practices, and responsible consumption through the adoption of sustainable technologies.
SDG 13	Climate Action	Highlights the environmental impacts of fossil fuels, the importance of renewable energy, clean energy technologies, and energy conservation strategies to mitigate climate change and reduce greenhouse gas emissions.

Course Code: VA16204
Course Title: Water Pollution and Treatment Technologies
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory- 30

Course Learning Objective

This course aims to provide students with a fundamental understanding of water resources, water quality, and the importance of safe and sustainable water use. It introduces the causes, effects, and control measures of water pollution, along with the basic principles of water treatment and purification technologies. The course develops awareness of water conservation techniques, including rainwater harvesting, groundwater recharge, and water reuse for sustainable management. It also highlights the role of traditional and indigenous water conservation practices in India and encourages students to adopt responsible water management practices for environmental protection and sustainable development.

Course Learning Outcome:

- **CO1** Explain the sources, properties, and quality parameters of water, and describe their importance in ensuring safe and sustainable water resources.
- **CO2** Describe the causes, types, and impacts of water pollution on human health, aquatic ecosystems, and the environment, along with measures for its prevention and control.
- **CO3** Analyze the principles and applications of various water treatment and purification methods used for drinking water and wastewater management.
- **CO4** Apply the concepts of water conservation, rainwater harvesting, groundwater recharge, and water reuse for sustainable management of water resources.
- **CO5** Evaluate the significance of sustainable water management practices, including traditional and indigenous water conservation methods, in addressing present and future water challenges.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

UNIT I: Water Resources and Water Quality (7 Lectures)

Sources and importance of water; surface water and groundwater; basic physical and chemical properties of water; water quality parameters—pH, turbidity, hardness, dissolved oxygen (DO), BOD and COD; importance of clean and safe water.

UNIT II: Water Pollution (8 Lectures)

Meaning and types of water pollution; sources—domestic, industrial and agricultural; common water pollutants; effects of water pollution on human health, aquatic life and environment; groundwater contamination; prevention and control of water pollution.

UNIT III: Water Treatment Methods (8 Lectures)

Basic principles of water treatment; screening, sedimentation, coagulation and filtration; disinfection methods—chlorination, UV treatment and ozonation; basic concept of reverse osmosis (RO); domestic water purification methods; introduction to wastewater and sewage treatment.

UNIT IV: Water Conservation and Sustainable Management (7 Lectures)

Importance of water conservation; rainwater harvesting; groundwater recharge; reuse and recycling of water; traditional and indigenous water conservation practices in India; sustainable water management; individual and community roles in protecting water resources.

Essential readings

1. **Peavy, H. S., Rowe, D. R., & Tchobanoglous, G.** *Environmental Engineering*. McGraw-Hill Education.
2. **Sawyer, C. N., McCarty, P. L., & Parkin, G. F.** *Chemistry for Environmental Engineering and Science*. McGraw-Hill Education..
3. **Rao, C. S.** *Environmental Pollution Control Engineering*. New Age International (P) Ltd., New Delhi.
4. **P. Aarne Vesilind, Susan M. Morgan, & Lauren G. Heine.** *Introduction to Environmental Engineering*. Cengage Learning.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	**Quality Education**	Develops fundamental knowledge of water resources, water quality, pollution, treatment technologies, and sustainable water management while promoting environmental awareness and scientific literacy.
SDG 6	**Clean Water and Sanitation**	Provides understanding of water quality assessment, water pollution, water treatment methods, wastewater management, rainwater harvesting, groundwater recharge, and safe access to clean water.
SDG 11	**Sustainable Cities and Communities**	Promotes sustainable urban and rural water management through water conservation, reuse, recycling, and community participation in protecting water resources.
SDG 12	**Responsible Consumption and Production**	Encourages efficient use of water resources, water conservation, recycling, and sustainable consumption practices to minimize water wastage and environmental impact.
SDG 13	**Climate Action**	Highlights the role of sustainable water resource management, groundwater conservation, and climate-resilient water practices in addressing the impacts of climate change.
SDG 15	**Life on Land**	Emphasizes the protection of freshwater ecosystems, prevention of groundwater contamination, and conservation of natural water resources to support terrestrial biodiversity and ecosystem health.

Course Code: VA16302
Course Title: Introduction to Methods of Applied Mathematics
Total Credits: 02 (Theory-02)
Total Lectures: Theory-30

Course Learning Objectives:

Students will be able to articulate and describe:

- To introduce fundamental mathematical tools used in real-world problem solving
- To develop analytical and quantitative thinking skills
- To apply mathematical methods to physical, biological, economic, and engineering problems
- To enhance problem-solving and modeling skills

Course Learning Outcomes:

CO1:. Remember the concepts, and basic ideas

CO2: Formulate simple mathematical models.

CO3: Apply mathematical techniques to practical problems.

CO4: Solve basic differential equations and matrix problems.

CO5: Use mathematical tools in applied domains

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	–	2	–	–	–	–	–	–	–	–	1	1	_	2
CO2	2	3	–	3	3	--	–	–	–	–	–	–	3	2	1	1
CO3		2	–	3	3	2	–	–	–	–	–	–	2	3	2	2
CO4	–	3	2	–	--	--	2	–	–	2	–	–	2	3	2	2
CO5	–	2	_	2	2	--	–	–	–	–	–	2	2	3	2	2

Course Content:

UNIT-I Mathematical Modeling (10 Hours)

Meaning and importance of applied mathematics, Mathematical modeling: formulation and validation, Linear and nonlinear models, Applications in population growth, finance, and science

UNIT-II Linear Algebra Techniques (10 hours)

Systems of linear equations, Matrix operations and inverse of a matrix, Determinants and applications, Introduction to eigenvalues and eigenvectors, Applications in engineering and data analysis

UNIT-III Calculus for Applications (10 Hours)

Functions and limits, Differentiation and its applications, Maxima and minima, Optimization problems in economics and science

UNIT-IV Differential Equations (10 hours)

Formation of differential equations, First-order differential equations, Applications: growth and decay, Newton's law of cooling, Introduction to second-order differential equations

UNIT V:Basics of Probability and Statistics (5 hours)

Elementary probability concepts, Random variables and distributions, Mean, variance, and standard deviation, Correlation and regression, Applications in real-life data analysis

Tutorial:-30 hours

Textbook:

1."Kreyszig, E. – *Advanced Engineering Mathematics*

Reference Books:

1. Stewart, J. – *Calculus* "Learning Python" by Mark Lutz
2. Edwards & Penney – *Differential Equations and Linear Algebra*
3. Gupta, S.C. & Kapoor, V.K. – *Fundamentals of Mathematical Statistics*

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Develops analytical, quantitative, and problem-solving skills through mathematical modeling, linear algebra, calculus, differential equations, and statistics.
SDG 8	Decent Work and Economic Growth	Strengthens employability by building mathematical competencies applicable in finance, economics, engineering, data analysis, and industrial problem-solving.
SDG 9	Industry, Innovation and Infrastructure	Promotes the use of mathematical models, optimization techniques, matrix methods, and statistical analysis for engineering, innovation, and technological development.
SDG 10	Reduced Inequalities	Applies mathematical and statistical tools to analyze socio-economic, demographic, and public policy data, supporting evidence-based decision-making for inclusive development.

Course Code: VA16394
Course Title: Flutter Application Development
Total Credits: 02 (Theory-01, Practical-01)
Total Lectures: Theory-15, Practical-30

Course Learning Objective:

1. To empower students with the skills to design, develop, and deploy cross-platform mobile applications using Flutter.

2. Fostering critical thinking, problem-solving, and digital literacy aligned with current industry standards.

Course Learning Outcomes:

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

CO 1: Remember Flutter development principles to create innovative solutions for real-world mobile application challenges.
CO 2: Understand and optimize Flutter applications by applying analytical reasoning to enhance performance and user experience.

CO 3: Apply and integrate the latest Flutter development trends and plugins to extend app functionality and maintain relevance in a rapidly evolving digital landscape.

CO 4: Analyze in diverse teams to manage Flutter projects, demonstrating leadership and effective communication throughout the development lifecycle.

CO5: Evaluate and disseminate comprehensive documentation for Flutter applications, demonstrating clear communication of technical concepts to varied audiences

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	–	–	–	–	–	–	–	–	–	–	–	1	1	_	2
CO2	–	3	–	3	3	--	–	–	–	–	–	–	1	2	1	1
CO3	–	–	–	3	–	3	–	–	–	–	–	–	1	2	2	2
CO4	–	–	2	–	--	--	3	–	–	–	–	–	1	2	2	2
CO5	–	–	3	–	–	--	–	3	–	–	–	–	1	2	2	2

Course Content:

Unit 1: Introduction to Flutter and Dart(04 Classroom contact Hours)

Flutter architecture, Dart programming language, Setting up the development environment Basic widgets , Layout design

Unit 2: State Management and Navigation (04 Classroom contact Hours)

Stateful vs. stateless widgets, State management techniques, Navigation and routing,Data passing between screens.

Unit 3: Advanced Flutter Concepts (04 Classroom contact Hours)
Asynchronous programming in Dart, Advanced UI components, third-party integrations, Package management, Deployment strategies.

Exercises:

1. Set up a Flutter development environment and create a "Hello World" application.
2. Design a login screen with form validation.
3. Implement a to-do list application with state management.
4. Create a multi-page application with bottom navigation.
5. Integrate a REST API to fetch and display data in a Flutter app.

(15 more exercises covering the units)

Recommended Learning Resources
Textbook:

1. "Beginning Flutter: A Hands-On Guide to App Development" by Marco L. Napoli

Reference Books:

1. "Flutter for Beginners: An introductory guide to building cross-platform mobile applications with Flutter and Dart 2" by Alessandro Biessek
2. "Flutter Recipes: Mobile Development Solutions for iOS and Android" by Fu Cheng

Mapping with Sustainable Development Goals (SDGs)

SDG No.	Title	Nature of Contribution
SDG 4	Professional Ethics	App permissions, data privacy, dark patterns
SDG 8	Gender	Inclusive UX personas, accessibility
SDG 9	Human Values	Apps for community benefit (health, education, local info)
SDG 10	Environment & Sustainability	Apps that support SDGs (e.g., disaster alerts, agri advisory)

Course Code: VA16432
Course Title: Chemistry of Medicines and Everyday Health
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory- 30

Course Learning Objectives

The course aims to introduce students to the basic chemistry of medicines and their vital role in maintaining human health and healthcare systems. It provides fundamental knowledge of commonly used medicines, their classification, and their therapeutic functions. The course also

helps students understand the importance of antiseptics, disinfectants, antibiotics, vitamins, and minerals in the prevention and treatment of diseases. In addition, it creates awareness about the safe, rational, and responsible use of medicines, emphasizing the importance of avoiding misuse and promoting good health practices.

Course Learning Outcomes

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

- **CO1** Explain the basic concepts of medicinal chemistry, sources of medicines, different dosage forms, and the role of chemistry in the development of medicines.
- **CO2** Describe the classification, functions, and appropriate uses of commonly used medicines, including analgesics, antipyretics, antacids, antihistamines, and antibiotics, while distinguishing between generic and branded medicines.
- **CO3** Analyze the role of antiseptics, disinfectants, soaps, detergents, sanitizers, vitamins, minerals, and antioxidants in promoting health, hygiene, and disease prevention.
- **CO4** Apply the principles of safe medicine use, including correct dosage, proper storage, interpretation of medicine labels, and appropriate disposal of expired or unused medicines.
- **CO5** Evaluate the importance of responsible medication practices, the risks of self-medication and antibiotic resistance, and the role of chemistry in improving healthcare and quality of life.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT I: Introduction to Chemistry of Medicines (7 Lectures)

Introduction to medicines and drugs; sources of medicines—natural and synthetic; basic concept of medicinal chemistry; active ingredients and excipients; different forms of medicines—tablets, capsules, syrups, creams and injections; basic concept of drug action; importance of chemistry in the development of medicines.

UNIT II: Common Medicines and Their Uses (8 Lectures)

Introduction and general uses of analgesics and antipyretics; antacids; antihistamines; basic concept of antibiotics and their role; examples of commonly used medicines such as aspirin and paracetamol; importance of correct dosage; generic and branded medicines—basic concept; over-the-counter and prescription medicines.

UNIT III: Chemistry for Health and Hygiene (8 Lectures)

Antiseptics and disinfectants—basic concepts and differences; common examples and their uses; soaps and detergents in personal hygiene; sanitizers and their basic composition; vitamins and minerals and their importance for health; basic concepts of antioxidants; role of chemistry in maintaining health and hygiene.

UNIT IV: Safe Use of Medicines (Lectures)

Importance of proper use and storage of medicines; expiry date and medicine labels; basic awareness of side effects and allergic reactions; risks of self-medication; misuse and overuse of medicines; basic awareness of antibiotic resistance; importance of consulting qualified healthcare professionals; proper disposal of unused and expired medicines; role of chemistry in improving healthcare and quality of life.

Suggested References

1. NCERT, *Chemistry, Class XII, Part II*, Unit on Chemistry in Everyday Life.
2. Patrick, G. L., *An Introduction to Medicinal Chemistry*, Oxford University Press.
3. Chatwal, G. R., *Medicinal Chemistry*, Himalaya Publishing House.
4. Selected educational resources on medicines, health, and pharmaceutical chemistry.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	**Good Health and Well-being**	Provides fundamental knowledge of medicines, their therapeutic uses, safe medication practices, disease prevention, hygiene, and the responsible use of antibiotics to promote public health and well-being.

SDG 4	**Quality Education**	Develops scientific understanding of medicinal chemistry, drug action, healthcare practices, and rational medicine use, fostering health literacy and lifelong learning.
SDG 9	**Industry, Innovation and Infrastructure**	Introduces the role of chemistry in the discovery, development, formulation, and production of medicines, supporting innovation in the pharmaceutical and healthcare industries.
SDG 12	**Responsible Consumption and Production**	Promotes the rational use of medicines, proper storage, correct dosage, and environmentally safe disposal of expired and unused medicines to minimize waste and environmental contamination.
SDG 13	**Climate Action**	Encourages environmentally responsible disposal of pharmaceutical waste and sustainable healthcare practices that help reduce environmental pollution.

SEMESTER- III

Course Code: CY20001
Course Title: Organic Chemistry-I (C-3)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course learning Objectives:

The core course Organic Chemistry I isdesigned in a manner that it forms a cardinal part of the learning of organic chemistry for the subsequent semesters. The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, the functional groups- alkanes, alkenes, alkynes and aromatic hydrocarbons are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Course Learning Objectives:

On completion of the course, the student will be able to:

CO1: Understand and explain the different nature and behavior of organic compounds based on fundamental concepts learnt.

CO2: Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.

CO3: Learn and identify many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution.

CO4: Design and syntheses of organic molecules.

CO5: Structure identification through IR, NMR and Mass spectroscopic data.

Lab/ Instrumentation techniques used for analysing reaction mechanisms.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	1	2	–	1	–	–	1	–	1	–	3	2	2	1
CO2	–	3	1	3	–	2	–	–	2	–	1	–	3	3	3	2

CO3	**–**	**3**	**1**	**3**	**–**	**2**	**–**	**1**	**2**	**–**	**2**	**–**	**3**	**3**	**3**	**3**
CO4	**–**	**3**	**2**	**3**	**–**	**3**	**–**	**2**	**2**	**–**	**2**	**–**	**3**	**3**	**3**	**3**
CO5	**–**	**3**	**2**	**3**	**–**	**3**	**–**	**3**	**2**	**–**	**2**	**–**	**3**	**3**	**3**	**3**

Course Content:

UNIT-I: Basics of Organic Chemistry (12 Lectures)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples.Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT-II: Stereochemistry (11 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

UNIT-III: Chemistry of Aliphatic Hydrocarbons (15 Lectures)

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

UNIT-IV: Aromatic Hydrocarbons (7Lectures)

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Calibration of a thermometer.
2. Organic Preparation (any one of the following):
   a. Bromination of acetanilide/aniline/phenol
   b. Nitration of nitrobenzene/toluene

3. Purification of organic compounds by crystallization using the following solvents:
   a. Water
   b. Alcohol
   c. Alcohol-Water
4. Determination of the melting points of prepared organic compounds (Kjeldahl method and electrically heated melting point apparatus)
5. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.

6. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
7. Chromatography
   a. Separation of a mixture of two amino acids by ascending and radial paper chromatography
   b. Separation of a mixture of two sugars by ascending paper chromatography.
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Essential readings:

Theory:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

Practical:

1. Mann, F. G.; Saunders, B. C. (2009), Practical Organic Chemistry, Pearson Education.

2. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson.

4. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in organic chemistry concepts and skills
SDG 9	Industry, Innovation and Infrastructure	Organic synthesis, reaction mechanisms, and materials relevance
SDG 12	Responsible Consumption and Production	Safer laboratory practices, efficient synthesis and purification

Course Code: CY20003
Course Title: Inorganic Chemistry-II(C-4)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The course reviews the general principles of metallurgy and s-, p-block elements. It reviews the terms minerals, ores, concentration, benefaction, calcination, roasting, refining, etc. and explains the principles of oxidation and reduction as applied to the extraction procedures. Methods of purification of metals, such as electrolytic, oxidative refining, Van Arkel-De Boer process and Mond's process are discussed and applications of thermodynamic concepts like that of Gibbs energy and entropy to the extraction of metals are reviewed. It further discusses the patterns and trends exhibited by s and p block elements and their compounds with emphasis on synthesis, structure, bonding and uses of noble gases along with synthesis and structural aspects of inorganic polymers.

Course Learning Outcomes:

By the end of the course, the students will beable to:

CO1: Learn the fundamental principles of metallurgy and understand the importance of recovery of byproducts during extraction.

CO2: Understand the basic and practical applications in various fields of metals and alloy behavior and their manufacturing processes.

CO3: Apply the thermodynamic concepts like that of Gibbs energy and entropy to the principles of extraction of metals.

CO4: Understand vital role of sodium, potassium, calcium and magnesium ions in biological systems and the use of cesium in devising photoelectric cells.

CO5: Explain the hardness and softness of acid and bases and its applications.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	1	2	–	2	–	–	1	–	1	–	3	2	2	2
CO2	–	3	1	2	–	2	–	1	2	–	1	–	3	3	2	2
CO3	–	3	1	3	–	3	–	1	2	–	2	–	3	3	3	3
CO4	1	3	1	2	–	2	–	–	2	–	2	1	3	2	2	3
CO5	–	3	1	3	–	2	–	1	2	–	2	–	3	3	3	3

Course Content:

UNIT-I: General Principles of Metallurgy (10 Lectures)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

UNIT-II: Acids and Bases (10 Lectures)

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

UNIT-III: Chemistry of s and p Block Elements (15 Lectures)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation.Complex formation tendency of s and p block elements.Hydrides and their classification ionic, covalent and interstitial.Basic beryllium acetate and nitrate.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

UNIT-IV: Noble Gases (10 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes.Borazines, silicates and phosphazenes and polysulphates.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

(A) Iodo / Iodimetric Titrations

1. Estimation of Cu(II) and K2Cr2O7 using sodium thiosulphate solution (Iodometrically).
2. Estimation of antimony in tartar-emetic iodimetrically
3. Estimation of Iodine Content in iodized salt

(B) **Complexometric titrations using disodium salt of EDTA**

1. Estimation of Mg2+,Zn2+
2. Estimation of Ca2+ by substitution method
3. Estimation of Calcium content in milk.

(C) Inorganic preparations

1. Cuprous Chloride, Cu2Cl2

2. Aluminium potassium sulphate KAl(SO4)2.12H2O (potash alum) or Chromium potassium sulphate KCr(SO4)2.12H2O (chrome alum).

Essential readings:

Theory:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, ButterworthHeinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010. • Shriver & Atkins, Inorganic Chemistry 5th Ed.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in inorganic chemistry and laboratory skills
SDG 7	Affordable and Clean Energy	Metallurgy and materials relevant to energy technologies
SDG 9	Industry, Innovation and Infrastructure	Metallurgical processes, alloys, inorganic materials
SDG 12	Responsible Consumption and Production	Efficient extraction, refining, recovery of metals
SDG 13	Climate Action	Environmentally responsible metallurgical practices

Course Code: CY22001

Course Title: Basic Organic Chemistry (M-3)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The core course Organic Chemistry I isdesigned in a manner that it forms a cardinal part of the learning of organic chemistry for the subsequent semesters. The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, the functional groups- alkanes, alkenes, alkynes and aromatic hydrocarbons are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Course Learning Objectives:

On completion of the course, the student will be able to:

CO1: Understand and explain the different nature and behavior of organic compounds based on fundamental concepts learnt.

CO2: Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.

CO3: Learn and identify many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution.

CO4: Design and syntheses of organic molecules.

CO5: Lab/ Instrumentation techniques used for analysing reaction mechanisms.

CO-PO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	2	-	-	-	-	2	-	1	-	3	2	2	1
CO2	-	3	-	3	-	2	-	-	2	-	1	-	3	2	3	3
CO3	-	3	-	3	-	2	-	-	2	-	1	-	3	2	3	3
CO4	-	3	1	3	-	3	-	1	2	-	2	-	3	3	3	3

CO5	-	3	1	2	-	3	-	2	2	-	2	-	3	3	3	3

Course Content:

UNIT-I: Basics of Organic Chemistry (12 Lectures)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples.Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT-II: Stereochemistry (11 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

UNIT-III: Chemistry of Aliphatic Hydrocarbons (15 Lectures)

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions.Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and

1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

UNIT-IV: Aromatic Hydrocarbons (7 Lectures)

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism, Directing effects of the groups.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Calibration of a thermometer.

2. Organic Preparation (any one of the following):

   a. Bromination of acetanilide/aniline/phenol

   b. Nitration of nitrobenzene/toluene

3. Purification of organic compounds by crystallization using the following solvents:
a. Water

   b. Alcohol

   c. Alcohol-Water

4. Determination of the melting points of prepared organic compounds (Kjeldahl method and electrically heated melting point apparatus)

5. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.

6. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

7. Chromatography

a. Separation of a mixture of two amino acids by ascending and radial paper chromatography

b. Separation of a mixture of two sugars by ascending paper chromatography.

c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Essential readings:

Theory:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

Practical:

1. Mann, F. G.; Saunders, B. C. (2009), Practical Organic Chemistry, Pearson Education.

2. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson.

4. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in organic chemistry concepts and skills
SDG 9	Industry, Innovation and Infrastructure	Organic synthesis, reaction mechanisms, and materials relevance

SDG 12	Responsible Consumption and Production	Safer laboratory practices, efficient synthesis and purification

Course Code: CY23001
Course Title: Basics of Polymer Chemistry (MD-3)
Total Credits: 03 (Credits: Theory-02, Tutorial-01)
Total Lectures: Theory- 30 and Tutorial-15

Course Learning Objectives:

The Learning Objectives of this course are as follows:

• To help the student to know about the synthesis, properties and applications of polymers.

• To give glimpse of polymer industry to the student and help them to choose their career in the field of polymer chemistry.

Course Learning Outcomes:

By the end of this course, students will be able to:

CO1: Know about history of polymeric materials and their classification

CO2: Learn about different mechanisms of polymerization and polymerization techniques

CO3: Learn about different methods of finding out average molecular weight of polymers

CO4: Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm)

CO5: Determine Tg and Tm. Learn properties and applications of various useful polymers in our daily life.

CO-PO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	-	3	-	1	-	-	-	-	2	-	1	-	3	1	2	1

CO2	-	3	-	3	-	2	-	-	2	-	1	-	3	2	3	2
CO3	-	3	-	3	-	3	-	-	2	-	1	-	3	3	3	2
CO4	-	3	-	3	-	1	-	-	2	-	1	-	3	2	2	3
CO5	-	3	1	3	-	2	-	1	2	-	2	1	3	3	3	3

Course Content:

UNIT-I: Introduction to Polymeric Materials (10 Lectures)

History of polymeric materials, Different schemes of classification of polymers, Polymer nomenclature Molecular forces and chemical bonding in polymers, Physical and chemical properties of polymers Solubility and Criteria for polymer solubility, Texture of Polymers, modification of polymers, Structure and property relationships, Introduction to conducting and biodegradable polymers.

UNIT-II: Characterization of Polymers (10 Lectures)

Thermal characterisation of polymer: Glass transition temperature (Tg), thermal stability and decomposition of polymers, Molecular weight of polymers (Mn, Mw, etc.) by end group analysis, viscometry, light scattering technique and osmotic pressure methods. Structural characterisation of polymers by IR and NMR spectroscopy.

UNIT-III: Preparation, Properties and Uses of Polymers (10 Lectures)

Brief introduction to polymerisation, mechanism, properties and application of the following polymers: polyolefins, polystyrene, poly(vinyl chloride), poly(vinyl acetate), polyurethanes, acrylic polymers and polyamides. Phenol formaldehyde and urea formaldehyde, Silicone polymers, Conducting Polymers: polyacetylene, polyaniline, polypyrrole, polythiophene., Biopolymer: Cellulose and Chitosan.

UNIT-IV: Biodegradable polymers(15 Lectures)

Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soya protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, polyvinyl alcohol, polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: Natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Practicals:

1. Preparation of nylon 6,6.

2. Redox polymerization of acrylamide.

3. Polymerization of acrylonitrile.

4. Preparation of urea-formaldehyde resin.

5. Preparations of phenol-formaldehyde resin.

6. Determination of molecular weight of different polymers in water by viscometry.

7. Estimation of the amount of HCHO in the given solution by sodium sulphite method.

8. Demonstration for chemical structure and functional group in polymers using IR spectroscopy.

9. Purification of monomer and polymerisation of Styrene and Polymethylmethacrylate using BPO (Benzoyl Peroxide).

10. Polymerization of aniline and pyrrole by chemical polymerisation method.

11. Preparation of poly methylacrylate by emulsion and bulk polymerisation and compare the results.

12. Characterisation of polymers by IR spectroscopy.

Essential Readings:

Theory:

1. Ahluwalia V.K. & Mishra A. Polymer Science: ATextbook (2009) Anne Books.

2. Odian, G. (2004), Principles of Polymerization, John Wiley.

3. Billmeyer, F.W. (1984), Text Book of Polymer Science, 3rd Ed., John Wiley.

4. Ghosh, P. (2001), Polymer Science & Technology, Tata Mcgraw-Hill.

5. Lenz, R.W. (1967), Organic Chemistry of Synthetic High Polymers, Interscience (Wiley).

6. P. J. Flory, Principle of polymer chemistry, Cornell University Press.

7. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.

Practical:

1. Hundiwale ,D.G.,Athawale V.D ,Kapadi, U.R.& Gite V.V, Experiments in Polymer Science ,New Age International Publishers .

2. Allcock, H.R.; Lampe, F. W.; Mark, J. E. (2003), Contemporary Polymer Chemistry, Prentice-Hall.

3. Fried, J.R. (2003), Polymer Science and Technology, 2nd Ed, Prentice-Hall.

4. Munk, P.; Aminabhavi, T. M. (2002), Introduction to Macromolecular Science, John Wiley & Sons.

5. Sperling, L.H. (2005), Introduction to Physical Polymer Science, John Wiley & Sons.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Biomedical polymers, artificial organs, dental and contact lens materials
SDG 4	Quality Education	Applied polymer science and laboratory competence
SDG 9	Industry, Innovation and Infrastructure	Industrial polymers, fibers, elastomers, conducting polymers
SDG 12	Responsible Consumption and Production	Biodegradable polymers and sustainable material design
SDG 13	Climate Action	Reduction of plastic pollution through biodegradable materials
SDG 15	Life on Land	Eco-friendly polymers and reduced environmental burden

Course Code: AE24001 (AEC)
Course Title: Communicative English
Total Credits: 02 (Theory-02)
Total Lectures: Theory- 30

Course Learning Objectives:

- Understand the concepts, principles, types, and importance of communication in academic, social, and professional contexts.
- Develop effective verbal and non-verbal communication skills by understanding communication

processes, barriers, and strategies for successful interaction.

- Improve reading, listening, speaking, and writing skills through comprehension exercises, group discussions, presentations, and language practice.
- Acquire professional writing skills by preparing CVs, résumés, summaries, notes, compositions, and other functional documents.
- Build confidence, interpersonal skills, critical thinking, and employability through effective communication and collaborative learning activities.

Course Learning Outcomes:

CO1: Explain the concepts, types, functions, and barriers of communication and apply appropriate communication strategies in different contexts.

CO2: Demonstrate effective listening, speaking, pronunciation, presentation, and interpersonal communication skills with confidence and clarity.

CO3: Apply appropriate reading strategies and produce coherent, well-organized academic, professional, and creative written texts.

CO4: Prepare professional documents such as business letters, emails, resumes/CVs, cover letters, and statements of purpose using appropriate formats and language.

CO5: Exhibit job readiness skills through effective participation in interviews, group discussions, presentations, and professional digital communication practices.

Course Content:

Unit I: Foundations of Communicative English

(i) Nature, Scope and Importance of Communicative English
(ii) Process and Elements of Communication
(iii) Types of Communication: Verbal, Non-verbal, Written and Digital
(iv) Barriers to Communication and Strategies for Effective Communication

Unit II: Listening and Speaking Skills

(i) Active Listening: Principles, Techniques and Listening Comprehension
(ii) Pronunciation, Stress, Intonation and Fluency
(iii) Speaking Skills: Conversation, Public Speaking and Presentation Skills
(iv) Group Discussion, Debate, Interview and Interpersonal Communication

Unit III: Reading and Writing Skills

(i) Reading Skills: Skimming, Scanning, Intensive and Extensive Reading

(ii) Reading Comprehension and Critical Interpretation

(iii) Writing Skills: Paragraph, Essay, Report and Email Writing

(iv) Creative and Academic Writing: Summarising, Note-making and Paragraph Writing

Unit V: Professional Communication and Employability Skills

(i) Professional and Business Communication: Letters, Emails and Official Correspondence

(ii) Resume/CV Writing, Cover Letter and Statement of Purpose

(iii) Interview Skills, Group Discussion and Presentation Techniques

(iv) Digital Etiquette and Career Readiness

Recommended Learning Resources

- A. Ganeshan & P. Lovely Viniliya Pual: *Communicative English*, Charulata Publications, 2020.
- Clampitt, Phillip G. *Communicating for Managerial Effectiveness*. Sage Publications, 2012.
- Adler, Ronald B., and George Rodman. *Understanding Human Communication*. Oxford University Press, 2015.
- Peters, Robert. *English Reading Comprehension Skills for Business*. Cambridge University Press, 2018.
- Rao, P.K. *Business Communication*. Himalaya Publishing, 2017.
- Adler, Ronald B., *Communicating at Work: Principles and Practices for Business and the Professions*. McGraw-Hill, 2012.
- Locker, Kitty O., and Donna Kaczmarek. *Business Communication: Building Critical Skills*. McGraw-Hill, 2016.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
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CO2	2	3	3	3	3	3	2	3	2	2	3	3	3	2	3	3
CO3	2	3	3	3	3	3	2	3	3	2	3	3	3	3	3	3
CO4	3	3	3	3	2	2	2	1	2	3	2	3	3	3	2	3
CO5	2	2	2	3	3	3	3	3	2	2	2	3	3	3	3	3

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Develops communication competence, language proficiency, and employability skills
SDG 5	Gender Equality	Promotes inclusive and gender-sensitive communication
SDG 8	Decent Work & Economic Growth	Enhances professional communication for workplace readiness
SDG 9	Industry, Innovation & Infrastructure	Encourages digital communication and modern workplace tools
SDG 16	Peace, Justice & Strong Institutions	Promotes ethical communication, transparency, and responsible discourse

Course Code: CY25001
Course Title: Basic Nanotechnology (SE-3)
Total Credits: 03 (Credits: Theory-02, Practical-01)
Total Lectures: Theory- 30 and Practical-30

Course Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce nanomaterials and their applications.
- To provide an insight into bottom-up and top-down-approach, the methods of synthesis of nanoparticles, simple characterization techniques and applications of nanomaterials.

Course Learning Outcomes

By studying this course, students will be able to:

CO1: Recall the key concepts and historical milestones in the development of nanotechnology, including the classification and types of nanostructured materials and the principle of quantum confinement.

CO2: Illustrae the importance of size-dependent properties at the nanoscale and how these properties influence the behavior and applications of nanomaterials.

CO3: Utilize various synthesis methods for nanomaterials, including both top-down (mechanical milling, lithography, etc.) and bottom-up (chemical vapor deposition, sol-gel method, etc.) approaches, through practical examples or laboratory experiments.

CO4: Examine the techniques used for the characterization of nanomaterials, such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM), and interpret the data obtained from these techniques to determine the properties and structure of nanomaterials.

CO5: Evaluate the applications of different nanomaterials in various fields such as electronics, biology, and energy, assessing their current status and future trends. For example, assess the efficiency and potential of nanomaterials in solar energy conversion systems or their role in developing quantum electronic devices and biochemical sensors.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	2	-	-	-	-	2	-	1	-	3	1	2	1
CO2	-	3	-	3	-	1	-	-	2	-	1	-	3	2	2	3
CO3	-	3	-	3	-	3	-	1	2	-	2	-	3	3	3	3
CO4	-	3	1	3	-	3	-	2	2	-	2	-	3	3	3	3
CO5	-	3	1	3	-	2	-	1	3	-	2	2	3	3	3	3

Course Content:

UNIT-I: Introduction to Nanotechnology (5 Lectures)

Introduction to the concept of nanotechnology, Historical milestones in the development of nanotechnology, Nature and Nanotechnology, understanding nanoscale, Classification of nanostructured materials, one dimensional nanomaterials, two dimensional nanomaterials, three dimensional nanomaterials, quantum confinement, Importance of size-dependent properties at the nanoscale.

UNIT-II: Synthesis of Nanomaterials (7 Lectures)

Top-down approaches- Mechanical milling, Electrospinning, Lithography, Sputtering, Laser ablation

Bottom-up approaches- Chemical vapour deposition method, hydrothermal method,sol-gel method, solvothermal method

UNIT-III: Characterization of Nanomaterials (8 Lectures)

X-ray Diffraction(XRD),Scanning Electron Microscopy(SEM),Atomic Force Microscopy (AFM), Transmission Electron Microscopy(TEM),Field Ion Microscope(FIM), Small Angle X-ray scattering(SAXS),Three Dimensional Atom Probe(3DAP)

UNIT-IV: Applications of Nanomaterials (10 Lectures)

Carbon Nanotube, Nanocrystalline ZnO, Nanocrystalline TiO_2,Molecular electronics and nanoelectronics – Quantum electronic devices - CNT based transistor and Field Emission Display - Biological applications - Biochemical sensor - Membrane based water purification. Nanomaterials for Solar Energy Conversion Systems.Principles of photovoltaic energy conversion (PV), Dye-Sensitized Solar Cells, Organic-Inorganic Hybrid solar cells.Current status and future trends.Conducting and ferroelectric materials, structure and features of ferroelectric materials, ceramic materials, organic/inorganic hybrid materials and their applications.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer. a. Turkevich Method b. Burst Method

2. Synthesis of silver nanoparticles by green approach methods (using soluble starch, glucose or cinnamon bark) and characterization using UV-visible spectrophotometer.

3. Synthesis of metal sulphide nanoparticles and characterization using UV-visible spectrophotometer. a. MnS b. ZnS c. CuS

4. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.

5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

6. Phytochemicals mediated synthesis of gold nanoparticles (AuNPs) using tea leaves and to study the effect of size on color of gold/silver nanoparticles.

7. Preparation of magnetic nanoparticles (MNPs) of Fe3O4 using green tea leaf extract.

8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

Essential readings:

Theory:

1. Introduction to Nanoscience and Nanotechnology by Chris Binns. 1.2. Scale of Nanotechnology
2. Nanotechnology: Understanding Small Systems by Ben Rogers, Jesse Adams, and Sumita Pennathur.
3. Environmental Nanotechnology: Applications and Impacts of Nanomaterials by Mark R. Wiesner and Jean-Yves Bottero.
4. Textbook of Nanoscience and Nanotechnology by B S Murty,P Shankar,Baldev Raj, B B Rath, James Murday,Universities Press,Springer,2013.
5. The chemistry of nanomaterials: Synthesis, properties and applications, C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), by Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.
6. Naostructures and Nanomaterials: Synthesis, properties and applications, by G.Cao, Imperical College Press, 2004.

Practical:

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory, J. Chem. Educ. 2015, 92, 339−344.

2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution

SDG 4	Quality Education	Strong foundation in nanoscience and experimental skills
SDG 7	Affordable and Clean Energy	Nanomaterials for solar energy conversion systems
SDG 9	Industry, Innovation and Infrastructure	Nanoelectronics, CNT devices, advanced materials
SDG 6	Clean Water and Sanitation	Nanomaterial-based membrane water purification
SDG 12	Responsible Consumption and Production	Green synthesis, sustainable nanomaterial development

SEMESTER-IV

Course Code: CY20002
Course Title: Physical Chemistry-II(C-5)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The aim of this course is to make students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry and make them able to apply thermodynamic concepts to the system of variable compositions, equilibrium and colligative properties.

Course Learning Outcomes:

By the end of the course, students will be able to:

CO1: Understand the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties.

CO2: Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for ideal gases under different conditions.

CO3: Explain the concept of partial molar properties.

CO4: Explain the thermodynamic basis of colligative properties and applications in surroundings.

CO5: Determine the different practical applications of thermodynamics.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT-I: Chemical Thermodynamics (15 Lectures)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's

equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

UNIT-II: Systems of Variable Composition (5 Lectures)

Partial molar quantities, dependence of thermodynamic parameters on composition; GibbsDuhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

UNIT-III: Chemical Equilibrium (15 Lectures)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity.Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient.Coupling of exoergic and endoergic reactions.Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

UNIT-IV: Dilute Solutions and Colligative Properties (10 Lectures)

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of

solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Determination of heat capacity of a calorimeter for different volumes using (i) change of enthalpy data of a known system and (ii) heat gained equal to heat lost by cold water and hot water respectively
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of the enthalpy of ionization of ethanoic acid.
4. Determination of integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity of a diprotic acid by the thermochemical method for different additions of a base.
6. Determination of enthalpy of hydration of salt.
7. To study the effect of concentration of solute on elevation of boiling point of water.
8. To study the elevation in boiling point on adding same concentrations of electrolyte and nonelectrolyte to a specific volume of water.

Essential readings:

Theory:

1. Peter, A.; Paula, J. de. (2011), Physical Chemistry, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
3. Kapoor, K.L.(2015),A Textbook of Physical Chemistry,Vol 2, 6th Edition, McGraw Hill Education.
4. Kapoor, K.L.(2013),A Textbook of Physical Chemistry,Vol 3, 3rd Edition, McGraw Hill Education.
5. McQuarrie, D. A.; Simon, J. D. (2004), Molecular Thermodynamics, Viva Books Pvt. Ltd.
6. Levine, I.N.(2010),Physical Chemistry, Tata Mc Graw Hill.

7. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A.; Will, S.(2011),Commonly asked Questions in Thermodynamics. CRC Press.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.

2. Kapoor, K.L. (2019),A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong conceptual foundation in thermodynamics and physical chemistry
SDG 7	Affordable and Clean Energy	Thermodynamic principles underlying energy conversion and efficiency
SDG 9	Industry, Innovation and Infrastructure	Applications of thermodynamics in chemical industries and process design
SDG 12	Responsible Consumption and Production	Energy-efficient processes, equilibrium control, minimization of waste
SDG 13	Climate Action	Understanding energy balance, entropy, and thermodynamics of environmental systems

Course Code: CY20004
Course Title: Organic Chemistry-II (C-6)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives: The core course Organic Chemistry-II is designed in a manner that gives a better understanding of the organic functional groups, which include halogenated hydrocarbons and oxygen containing functional groups and their reactivity patterns. The detailed reactions mechanistic pathways for each functional group will be discussed to unravel the spectrum of organic chemistry and the extent of organic transformations.

Course Learning Outcomes: On completion of the course, the student will be able to:

CO1: Understand preparation, properties and reactions of haloalkanes, haloarenes and oxygen containing functional groups.

CO2: Use the synthetic chemistry learnt in this course to do functional group transformations.

CO3: To propose plausible mechanisms for any relevant reaction.

CO4: **Analyze** the structure, reactivity, and preparation methods of carboxylic acids and their derivatives, comparing the mechanisms of nucleophilic substitution at the acyl group, such as acidic and alkaline hydrolysis of esters, and reactions like the Claisen condensation and Reformatsky reaction.

CO5: **Evaluate** the use of organometallic compounds, such as Grignard reagents, in the synthesis of organic compounds, and assess their effectiveness in various synthetic applications, considering factors like reactivity and reaction conditions.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	2	–	1	–	1	2	–	1	–	3	2	2	1
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO3	–	3	2	3	–	3	–	2	2	–	2	–	3	3	3	3
CO4	–	3	2	3	–	3	–	2	2	–	2	1	3	3	3	3
CO5	1	3	2	3	–	3	1	2	3	1	2	1	3	3	3	3

Course Content:

UNIT-I: Chemistry of Halogenated Hydrocarbons: (8 Lectures)

Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination. Aryl halides: Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.

UNIT-II: Alcohol, Phenol, Ether and Epoxides (10 Lectures)

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouveault–Blanc Reduction;Oxidation of diols by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. Phenols: Preparation and properties; Acidity and affecting factors, Ring substitutionreactions, Reimer– Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements and their mechanism. Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia and LiAlH4.

UNIT-III: Carbonyl Compounds: (12 Lectures)

Structure, reactivity, preparation and properties; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism. Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, WolffKishner, LiAlH4, NaBH4, MPV, PDC) Addition reactions of α, β- unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT-IV: Carboxylic Acids and their Derivatives: (15 Lectures)

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group

2. Organic Preparations

a) Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, panisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method:

a) Using conventional method.

b) Using green approach

b) Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β -naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.

c) Oxidation of ethanol/ isopropanol (Iodoform reaction).

d) Selective reduction of meta dinitrobenzene to m-nitroaniline.

e) Hydrolysis of amides and esters.

f) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone.

g) S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

h) Aldol condensation using either conventional or green method. The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

Essential readings:

Theory:

1. Morrison, R. N.; Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K.International.
4. Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.
5. Chandra, R.; Singh, S.; Singh, A. (2019), Organic reactions and their nomenclature, Arcler Press.

Practical:

1. Mann, F. G.; Saunders, B. C. (2009), Practical Organic Chemistry, Pearson Education.

2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook ofPractical Organic Chemistry, Pearson.

3. Ahluwalia, V.K.; Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press.

4. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Organic synthesis relevant to pharmaceuticals and bioactive molecules
SDG 4	Quality Education	Strong conceptual and practical training in organic chemistry
SDG 9	Industry, Innovation and Infrastructure	Organic reactions and materials relevant to chemical industries
SDG 12	Responsible Consumption and Production	Green synthesis, sustainable laboratory practices
SDG 13	Climate Action	Reduced environmental impact through greener organic reactions

Course Code: CY20006
Course Title: Inorganic Chemistry-III(C-7)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The course introduces the students to coordination compounds which find manifold applications in diverse areas like qualitative and quantitative analysis, metallurgy, as catalysts in industrial processes as medicines, paints and pigments as well as in life. The students are also familiarized with the d and f block elements and get an idea about horizontal similarity in a period in addition to vertical similarity in a group.

Course Learning Outcomes:

By the end of the course, the students will beable to:

CO1: Understand the terms, ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds. Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.

CO2: Discuss the various types of isomerism possible in such compounds and understand the types of isomerism possible in a metal complex.

CO3: Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes

CO4: Explain the meaning of the terms Δo., Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy. Explain magnetic properties and colour of complexes on basis of Crystal Field Theory.

CO5: Understand the important properties of transition metals like variable oxidation states, colour, magneticand catalytic properties and use Latimer diagrams to predict and identify species which are reducing, oxidizing and tend to disproportionate and calculate skip step potentials .

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	2	–	1	–	1	2	–	1	–	3	2	2	1
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO3	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO4	–	3	2	3	–	3	–	2	2	–	2	1	3	3	3	3
CO5	1	3	2	3	–	3	1	2	3	1	2	1	3	3	3	3

Course Content:

UNIT-I: Coordination Chemistry (15 Lectures)

Recapitulation of Werner's Coordination theory

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. with coordination numbers 4 and 6. A brief idea about chelate effect and labile and inert complexes.

Valence bond theory and its application to complexes of coordination numbers 4 and 6. Examples of inner and outer orbital complexes.

Crystal field theory, measurement of Δo. Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δo. Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory (for octahedral σ-donor, π- acceptor and π-donor complexes).

UNIT-II: Transition Elements (14 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic properties (no temperature dependence), catalytic properties, and ability to form complexes. Latimer diagrams of Mn, Fe and Cu in acidic and basic media A brief discussion of differences between the first, second and third transition series.Some important compounds of Cr, Mn, Fe and Co and their roles as laboratory reagents; Potassium dichromate, potassium permanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside and sodium cobaltinitrite.

UNIT-III: Lanthanoids and Actinoids (6 Lectures)

A brief discussion of electronic configuration, oxidation states, colour, spectral and magnetic properties.Lanthanoid contraction (causes and effects) separation of lanthanoids by ion exchange method.

UNIT-IV: Inorganic Reaction Mechanism (10 Lectures)

Introduction to inorganic reaction mechanisms. Concept of reaction pathways, transition state, intermediate and activated complex.Substitution reactions in square planarcomplexes, Trans-effect, theories of trans-effect. Thermodynamic and Kinetic stability (using VBT).

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Estimation of Ni(II) using dimethylglyoxime (DMG).

2. Estimation of copper as CuSCN.

3. Estimation of iron as Fe2O3 by precipitating iron as Fe(OH)3.

4. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)3 (aluminium oxinate).

Inorganic Preparations

1. Tetraamminecopper (II) sulphate, [Cu(NH3)4]SO4.H2O

2. Acetylacetonate complexes of Cu2+/Fe3+

3. Potassium tri(oxalato)ferrate(III)

Properties of Complexes

1. Measurement of 10Dq/ Δo by spectrophotometric method.

2. Verification of spectrochemical series.

3. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Essential readings:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
3. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009),Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.

4. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.

5. Cotton, F.A.; Wilkinson, G.(1999), Advanced Inorganic Chemistry Wiley-VCH

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Conceptual understanding of coordination chemistry and inorganic reaction mechanisms
SDG 9	Industry, Innovation and Infrastructure	Coordination compounds as catalysts, pigments, reagents and industrial materials
SDG 3	Good Health and Well-being	Role of metal complexes in medicinal chemistry and diagnostics
SDG 12	Responsible Consumption and Production	Efficient use of transition metals, laboratory waste minimization
SDG 7	Affordable and Clean Energy	Understanding catalytic properties of transition metals in energy-related processes

Course Code: SE20082
Course Title: Seminar
Total Credits: 02 (Credits: Practical-02)
Total Lectures: Practical-60

Course Learning Objectives:

1. Develop technical presentation and communication skills.
2. Identify, review, and analyze current research topics using scholarly literature.
3. Improve critical thinking, problem-solving, and analytical abilities.
4. Prepare technical reports following academic writing and citation standards.
5. Enhance teamwork, professional ethics, and lifelong learning.

Course Learning Outcomes:

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

CO1: Identify and understand recent developments, emerging technologies, and research trends in the selected domain.

CO2: Explain and interpret the concepts, methodologies, and significance of the selected seminar topic through an effective literature review.

CO3: Apply appropriate research, analytical, and presentation techniques to prepare a well-structured seminar report and technical presentation.

CO4: Analyze research findings, compare different approaches, and critically evaluate the strengths and limitations of existing solutions.

CO5: Demonstrate effective communication, technical presentation, ethical practices, and critical thinking by delivering the seminar confidently and responding to questions professionally.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	2	-	2	2	-	-	-	-	-	-	2	2	-	2	3
CO 2	3	3	-	2	-	-	-	2	-	-	-	-	-	2	-	2
CO 3	2	2	2	-	2	-	-	2	-	2	-	-	-	-	2	-
CO 4	-	-	2	-	-	-	-	-	-	2	-	2	-	2	-	2
CO 5	-	2	3	-	-	2	2	-	-	-	2	-	2	-	2	3

Course Content:

Unit 1: Seminar Topic Selection and Literature Review [9 Classroom Contact Hours]

Identification and selection of seminar topic, research problem identification, literature survey, search of scholarly resources using IEEE Xplore, Springer, ACM Digital Library, Scopus, Google Scholar, and other digital databases.

Unit 2: Technical Report Writing and Research Ethics [9 Classroom Contact Hours]

Technical report preparation, organization of seminar report, plagiarism awareness, citation and referencing styles (APA/IEEE), academic integrity, research ethics, and use of reference management tools.

Unit 3: Presentation Design and Communication Skills [10 Classroom Contact Hours]

Planning and organizing seminar presentations, PowerPoint preparation, data visualization techniques, effective communication skills, presentation delivery, time management, and audience engagement.

Unit 4: Seminar Presentation and Evaluation [9 Classroom Contact Hours]

Seminar presentation, question-and-answer session, peer review, expert feedback, report submission, self-assessment, and evaluation of presentation performance.

Reference Books:

1. Alley, M. The Craft of Scientific Presentations. Springer.
2. Day, R. A., & Gastel, B. How to Write and Publish a Scientific Paper. Cambridge University Press.
3. Kumar, R. Research Methodology: A Step-by-Step Guide for Beginners. Sage Publications.
4. Turabian, K. L. A Manual for Writers of Research Papers, Theses, and Dissertations. University of Chicago Press.
5. IEEE Editorial Style Manual (latest edition).

SDG Mapping for this Course

SDG	Title	Contribution
SDG 4	Quality Education	Enhances lifelong learning, research aptitude, critical thinking, technical communication, and presentation skills through independent learning and scholarly inquiry.
SDG 8	Decent Work and Economic Growth	Develops employability skills, professional communication, teamwork, leadership, and problem-solving abilities required for higher education, research, and industry careers.

SDG 9	Industry, Innovation and Infrastructure	Encourages students to explore emerging technologies, innovative research, and industry-oriented solutions through seminars on current trends and technological advancements.
SDG 16	Peace, Justice and Strong Institutions	Promotes academic integrity, ethical research practices, plagiarism awareness, proper citation, and responsible dissemination of knowledge.
SDG 17	Partnerships for the Goals	Fosters collaboration, peer learning, knowledge sharing, constructive feedback, and interdisciplinary interaction among students, faculty, and researchers.

Course Code: CY22002
Course Title: Halogenated Hydrocarbons and Oxygen Containing Functional Groups (M-4)

Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives: The core course Organic Chemistry-II is designed in a manner that gives a better understanding of the organic functional groups, which include halogenated hydrocarbons and oxygen containing functional groups and their reactivity patterns. The detailed reactions mechanistic pathways for each functional group will be discussed to unravel the spectrum of organic chemistry and the extent of organic transformations.

Course Learning Outcomes: On completion of the course, the student will be able to:

CO1: Understand preparation, properties and reactions of haloalkanes, haloarenes and oxygen containing functional groups.

CO2: Use the synthetic chemistry learnt in this course to do functional group transformations.

CO3: To propose plausible mechanisms for any relevant reaction.

CO4: **Analyze** the structure, reactivity, and preparation methods of carboxylic acids and their derivatives, comparing the mechanisms of nucleophilic substitution at the acyl group, such as acidic and alkaline hydrolysis of esters, and reactions like the Claisen condensation and Reformatsky reaction.

CO5 **Evaluate** the use of organometallic compounds, such as Grignard reagents, in the synthesis of organic compounds, and assess their effectiveness in various synthetic applications, considering factors like reactivity and reaction conditions.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	2	–	1	–	1	2	–	1	–	3	2	2	1
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO3	–	3	2	3	–	3	–	2	2	–	2	–	3	3	3	3
CO4	–	3	2	3	–	3	–	2	2	–	2	1	3	3	3	3
CO5	1	3	2	3	–	3	1	2	3	1	2	1	3	3	3	3

Course Content:

UNIT-I: Chemistry of Halogenated Hydrocarbons (8 Lectures)

Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination. Aryl halides: Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.

UNIT-II: Alcohol, Phenol, Ether and Epoxides (10 Lectures)

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouveault–Blanc Reduction;Oxidation of diols by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. Phenols: Preparation and properties; Acidity and affecting factors, Ring substitutionreactions, Reimer– Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements and their mechanism. Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia and LiAlH4.

UNIT-III: Carbonyl Compounds (12 Lectures)

Structure, reactivity, preparation and properties; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism. Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, WolffKishner, LiAlH4, NaBH4, MPV, PDC) Addition reactions of α, β- unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT-IV: Carboxylic Acids and their Derivatives (15 Lectures)

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

2. Organic Preparations

i) Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, panisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method:

a) Using conventional method.

b) Using green approach

3. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β -naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.

4. Oxidation of ethanol/ isopropanol (Iodoform reaction).

5. Selective reduction of meta dinitrobenzene to m-nitroaniline.

6. Hydrolysis of amides and esters.

7. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone.

8. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

9. Aldol condensation using either conventional or green method. The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

Essential readings:

Theory:

1.Morrison, R. N.; Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K.International.

4.Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.

5. Chandra, R.; Singh, S.; Singh, A. (2019), Organic reactions and their nomenclature, Arcler Press.

Practical:

1. Mann, F. G.; Saunders, B. C. (2009), Practical Organic Chemistry, Pearson Education.
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook ofPractical Organic Chemistry, Pearson.
3. Ahluwalia, V.K.; Aggarwal, R.(2004),Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press.

4. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Organic synthesis relevant to pharmaceuticals and bioactive molecules
SDG 4	Quality Education	Strong conceptual and practical training in organic chemistry
SDG 9	Industry, Innovation and Infrastructure	Organic reactions and materials relevant to chemical industries
SDG 12	Responsible Consumption and Production	Green synthesis, sustainable laboratory practices
SDG 13	Climate Action	Reduced environmental impact through greener organic reactions

Course Code: AE24002 (AEC)
Course Title: Professional Communication
Total Credits: 02 (Theory-02)
Total Lectures: Theory-30

Course Learning Objectives:

- Understand the fundamental principles of the writing process and the conventions of academic and professional writing.
- Develop the ability to summarize and paraphrase texts accurately using their own words while maintaining the original meaning.
- Enhance critical thinking skills through the synthesis, analysis, interpretation, and evaluation of ideas and information.
- Learn to structure coherent and logical arguments with effective introductions, supporting points, and conclusions.
- Apply professional communication skills to produce clear, organized, ethical, and audience-appropriate written communication.

Course Learning Outcomes:

CO1: Explain and apply the fundamental principles of the writing process and conventions of academic writing.

CO2: Summarize and paraphrase academic and professional texts accurately, clearly, and ethically in their own words.

CO3:Demonstrate critical thinking through the synthesis, analysis, interpretation, and evaluation of information and arguments.

CO4:Construct well-organized arguments with effective introductions, logical development of ideas, appropriate transitions, and meaningful conclusions.

CO5: Produce coherent, concise, grammatically appropriate, and audience-oriented written communication for academic and professional purposes.

Course Content:

Unit I: Fundamentals of Professional Communication

- Nature, Scope, and Importance of Professional Communication.
- Principles and Barriers of Effective Communication.
- Verbal and Non-verbal Communication Skills.
- Listening Skills and Professional Etiquette.

Unit II: Written Professional Communication

- Business Letters and Official Correspondence.
- Email Writing and Digital Communication Etiquette.
- Report Writing, Memos, and Notices.
- Résumé/CV, Cover Letter, and Job Application Writing.

Unit III: Oral Communication and Presentation Skills

- Public Speaking and Presentation Techniques.
- Group Discussion and Team Communication.
- Interview Skills and Professional Interaction.
- Meeting Management and Minute Writing.

Unit IV: Workplace Communication and Employability Skills

- Workplace Ethics and Cross-cultural Communication.
- Leadership, Teamwork, and Conflict Resolution.
- Negotiation and Interpersonal Communication Skills.
- Professional Networking and Career Development Skills.

Recommended Learning Resources

- Liz Hamp-Lyons and Ben Heasley, *Study writing: A Course in Writing Skills for Academic Purposes* (Cambridge: CUP, 2006).
- Renu Gupta, *A Course in Academic Writing* (New Delhi: Orient Black Swan, 2010).
- Ilona Leki, *Academic Writing: Exploring Processes and Strategies* (New York: CUP,
- 2nd edn, 1998).
- Gerald Graff and Cathy Birkenstein, *They Say/I Say: The Moves That Matter in Academic Writing* (New York: Norton, 2009).
- Graff, Gerald, and Cathy Birkenstein. *They Say / I Say: The Moves That Matter in Academic Writing*. 4th Edition, W.W. Norton, 2018.
- Cottrell, Stella. *The Study Skills Handbook*. 5th Edition, Macmillan, 2019.
- Purdue Online Writing Lab (OWL). *Paraphrasing and Summarizing*. Purdue University, 2020.
- Paul, Richard, and Linda Elder. *Critical Thinking: Tools for Taking Charge of Your Learning and Your Life*. 2nd Edition, Pearson, 2012.
- Kirkman, Thomas W. *Academic Argument: Writing, Reading, and Thinking Critically*. Longman, 2013.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	3	3	2	2	3	2	2	2	3	3	2	2	3
CO2	2	3	3	3	3	3	2	3	2	2	3	3	3	2	3	3
CO3	2	3	3	3	3	3	2	3	3	2	3	3	3	3	3	3
CO4	3	3	3	3	2	1	1	1	2	3	1	3	3	3	2	3
CO5	3	2	2	2	2	1	1	1	2	3	2	3	3	3	3	3

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	**Quality Education**	Develops advanced writing, analytical, and communication skills
SDG 5	**Gender Equality**	Encourages inclusive and equitable communication practices
SDG 8	**Decent Work & Economic Growth**	Enhances employability through professional communication skills
SDG 9	**Industry, Innovation & Infrastructure**	Promotes digital and organizational communication competence
SDG 16	**Peace, Justice & Strong Institutions**	Supports ethical communication, accountability, and transparency

SEMESTER-V

Course Code: CY30001
Course Title: Organic Chemistry-III(C-8)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The Core Course Organic Chemistry III is infused with the details of Nitrogen containing functional groups and introduction of polynuclear hydrocarbons, heterocyclic systems and natural compounds viz. terpenes and alkaloids. A comprehensive understanding of these topics will be developed by taking examples of representative members of each class. The chemical synthesis, properties and reactions of these compounds will be discussed in detail. This course will also discuss some of the key applications of each class of compounds in diverse fields.

Course Learning Outcomes:

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

CO1: Gain theoretical understanding of chemistry of compounds having nitrogen containing functional groups, heterocyclics, polynuclear hydrocarbons, alkaloids and terpenes which include various methods for synthesis through application of the synthetic organic chemistry concepts learnt so far.

CO2: Become familiar with their particular properties, chemical reactions, criterion of aromaticity with reference to polynuclear hydrocarbons and heterocyclic compounds, trends in basicity of amines and heterocyclic compounds and their behaviour at different pH.

CO3: Learn practical approach to structural elucidation of organic compounds with specific examples of terpenes and alkaloids.

CO4: Predict the carbon skeleton of amines and heterocyclic compounds via use of Hoffmann's exhaustive methylation and Emde's modification methods.

CO5: Understand the applications of these compounds including their medicinal applications through their reaction chemistry.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	2	–	2	–	1	2	–	1	–	3	3	2	2
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO3	–	3	2	3	–	3	–	2	2	–	2	–	3	3	3	3
CO4	–	3	2	3	–	3	–	2	2	–	2	–	3	3	3	3
CO5	1	3	2	3	1	2	1	2	3	1	2	2	3	3	3	3

Course Content:

UNIT-I: Nitrogen Containing Functional Groups (8 Lectures)

Preparation and important reactions of nitro and compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications.

UNIT-II: Polynuclear Hydrocarbons (12 Lectures)

Introduction, Classification, Structure, Nomenclature and uses. Aromaticity of polynuclear hydrocarbons, structure elucidation of Naphthalene and general methods of preparation of naphthalene, phenanthrene and anthracene(including Haworth method,Friedel Craft acylation, Diels Alder reaction,Elbs reaction and Pschorr Synthesis).Relative reactivity of naphthalene, phenanthrene and anthracene in comparison to benzene.

Properties: Physical properties, discussion on the following reaction (with mechanism) for Naphthalene, Anthracene and Phenanthrene: Addition reactions, Oxidation, Electrophilic substitution- Friedel Craft reaction, Chloromethylation, Halogenation, Formylation, Nitration and sulphonation. Reduction reaction and Diels Alder reaction.

UNIT-III: Heterocyclic Compounds (12 Lectures)

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, DoebnerMiller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

Derivatives of furan: Furfural and furoic acid.

UNIT-IV: Alkaloids (13 Lectures)

Introduction, Natural occurrence, Classification, Uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method.Structure elucidation, synthesis and physiological action of Nicotine.

Terpenes: Introduction, Occurrence, Uses, classification, isoprene and special isoprene rule; general methods of structure elucidation including distinction between isopropylidene and isopropenyl group, Elucidation of structure, synthesis and industrial applicationof Citral.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols, carbonyl compounds and esters).
2. Isolation of caffeine from tea leaves.
3. Estimation of aniline by any one of thefollowing methods:a) Acetylation b) Bromate-bromide method.

Essential readings:

Theory:

1. Morrison, R. T.; Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education). 2. Finar, I. L. Organic Chemistry (Volume 1& 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.

2. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P. (2013), Organic Chemistry, Oxford University Press.

3. Gilchrist, T.L. (1997), Heterocyclic Chemistry, Pearson Education.

4. Ram V. J.; Sethi, A.; Nath, M.; Pratap, R.; (2019), The Chemistry of Heterocycles (Nomenclature and Chemistry of three to five membered Heterocycles), Elsevier publication.

5. Ram V. J.; Sethi, A.; Nath, M.; Pratap, R.; (2019), The Chemistry of Heterocycles (Chemistry of six to eight membered N, O, S, P and Se heterocycles), Elsevier publication.

Practical:

1. Mann, F. G.; Saunders, B. C. (2009),Practical Organic Chemistry, Pearson Education.

2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook ofPractical Organic Chemistry, Pearson.

3. Ahluwalia, V.K.; Aggarwal, R.(2004),Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong conceptual foundation in advanced organic chemistry
SDG 3	Good Health and Well-being	Medicinal relevance of alkaloids, amines, heterocycles
SDG 9	Industry, Innovation and Infrastructure	Organic synthesis, heterocycles and natural products used in pharmaceuticals and fine chemicals
SDG 12	Responsible Consumption and Production	Emphasis on laboratory safety, efficient synthesis and isolation methods
SDG 15	Life on Land	Study of plant-derived natural products such as alkaloids and terpenes

Course Code: CY30003
Course Title: Physical Chemistry-III(C-9)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The aim of this course is to make students understand phase, co-existence of phases, phase diagram, CST and distribution law and concepts of electrochemical cells, electrode potential, electrochemical series and learn about surface phenomenon, adsorption isotherms, BET Equation.

Course Learning Outcomes:

By the end of the course, students will be able to:

CO1: Understand the concepts of chemical kinetics, including reaction order, molecularity, rate laws, and the Arrhenius equation, as well as the basics of catalysis and surface chemistry.

CO2: Explain the principles behind phase diagrams, including those for one-component systems (e.g., H2O and S) and systems involving solid-liquid equilibria with eutectic, congruent, and incongruent melting points.

CO3: Apply the concepts of catalysis to understand the mechanisms of catalyzed reactions at solid surfaces and enzyme catalysis, as well as the factors affecting catalytic efficiency.

CO4: Analyze the mechanisms and factors influencing adsorption processes, including physical and chemisorptions, adsorption isotherms, surface area determination, and adsorption in solution.

CO5: Evaluate the efficiency of nanoparticles as catalysts based on their particle size and surface properties, and assess the specificity, selectivity, and mechanisms of various catalyzed reactions.

CO-PO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	2	2	–	2	–	2	2	–	1	–	3	2	2	2
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	2	2
CO3	–	3	2	3	–	3	–	2	2	–	2	1	3	3	3	3
CO4	–	3	2	3	–	3	–	2	2	–	2	1	3	3	3	3
CO5	1	3	2	3	–	3	1	2	3	1	2	2	3	3	3	3

Course Content:

UNIT-I: Phase Equilibria (15 Lectures)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solidliquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems (H2O and S), with applications. A comparison between the phase diagram of CO2 and H2O. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-II: Chemical Kinetics (15 Lectures)

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-III: Catalysis (8 Lectures)

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts.Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

UNIT-IV: Surface chemistry (7 Lectures)

Physical adsorption, chemisorptions, adsorption isotherms (Freundlich, Temkin, derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

a. Determination of critical solution temperature and composition at CST of the phenol water system and to study the effect of impurities of sodium chloride and succinic acid on it.

b. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems.

c. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane.

d. Study of equilibrium of any one of the following reactions by distribution method:
   i) I_2 (aq) + I^- (aq) → I^{3-}(aq)
   ii) Cu^{2+} (aq) + nNH_3→ $[Cu(NH_3)n]^{2+}$

e. Study the kinetics of the following reactions.
   a) Initial rate method: Iodide-persulphate reaction
   b) Integrated rate method:

i) Acid hydrolysis of methyl acetate with hydrochloric acid.
ii) Saponification of ethyl acetate.

f. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

g. Adsorption: Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Essential readings:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014),Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Castellan, G. W. (2004),Physical Chemistry, 4th Edition, Narosa.
3. Kapoor, K.L.(2013),A Textbook of Physical Chemistry,Vol 3, 3rd Edition, McGraw Hill Education.
4. Kapoor, K.L.(2015),A Textbook of Physical Chemistry,Vol 5, 3rd Edition, McGraw Hill Education.
5. McQuarrie, D. A.; Simon, J. D. (2004),Molecular Thermodynamics, Viva Books Pvt. Ltd.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019),A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.
4. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
5. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).

6. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

7. Rogers, D. W. Concise Physical Chemistry Wiley (2010). • Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

8. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in reaction mechanisms, phase equilibria, catalysis, and adsorption processes
SDG 9	Industry, Innovation and Infrastructure	Basis for pharmaceutical, polymer, nanomaterials, and fine chemical industries
SDG 12	Responsible Consumption and Production	Green chemistry approaches, minimization of hazardous waste, and sustainable laboratory practices
SDG 13	Climate Action	Awareness of environmental impact of chemical processes, eco-friendly experimental approaches
SDG 15	Life on Land	Sustainable use of chemical resources and responsible handling of nanomaterials and chemicals

Course Code: CY30005
Course Title: Inorganic Chemistry-IV(C-10)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The course introduces some important topics of Inorganic Chemistry in a compact way. Unit 1 of the course introduces students to the basic principles of qualitative inorganic analysis. The influence of solubility products and the common ion effect on the separation of cations is made clear. Interfering anions are identified and their removal is studied. Unit 2, an introduction to the very important area of organometallic chemistry including classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species. Specific organometallic compounds are studied in detail to further understand the basic concepts: metal carbonyls, metal alkyls, Zeise's salt and ferrocene. Unit 4 takes this a step further by covering catalysis, an important application of organometallic compounds. Under Unit 3, bioinorganic chemistry, the student learns the importance of inorganic chemical species, especially metals, in biological systems, through discussions on metal-

containing enzymes, the sodium-potassium pump and the applications of iron in physiology, including iron transport and storage system.

Course Learning Outcomes:

By the end of the course, the students will be able to:

CO1: Identify important structural features of the metal alkyls tetrameric methyl lithium and dimeric trialkyl aluminium and explain the concept of multicenter bonding in these compounds

CO2: Understand and explain the basic principles of qualitative inorganic analysis

CO3: Apply 18-electron rule to rationalize the stability of metal carbonyls and related species

CO4: Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it and understand and describe the active sites and action cycles of the metalloenzymes carbonic anhydrase and carboxypeptidase

CO5: Explain the sources and consequences of excess and deficiency of trace metals and learn about the toxicity of certain metal ions, the reasons for toxicity and antidotes also explain the use of chelating agents in medicine and, specifically, the role of cisplatin in cancer therapy and explain the applications of iron in biological systems with particular reference to haemoglobin, myoglobin, ferritin and transferrin.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT-I: Theoretical Principles in Qualitative Analysis (8 Lectures)

Basic principles involved in analysis of cations and anions. Solubility products, common ioneffect. Principles involved in separation of cations into groups and choice of group reagents.Interfering anions (fluoride, borate, oxalate and phosphate), need to remove them afterGroup II and methods of removal. Analysis of insoluble substances.

UNIT-II: Organometallic Compounds (15 Lectures)

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity.Comparison of aromaticity and reactivity with that of benzene.

UNIT-III: Catalysis by Organometallic Compounds (7 Lectures)

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis (catalytic steps, examples and industrial applications), deactivation and regeneration of catalysts, catalytic poison, promoter.

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)

2. Synthetic gasoline (Fischer Tropsch reaction)

3. Polymerisation of ethene using Ziegler-Natta catalyst

UNIT-IV: Nuclear and Radiochemistry (15 Lectures)

Nuclear structure and nuclear stability, nuclear models, Radioactivity and nuclear reactions (including nuclear fission and fusion reactions). Hot atom chemistry, nuclear fission and fusion reactors. The interaction of nuclear radiations with matter.Radiation hazards and therapeutics.Detectors and their principles.The direction of radioactivity.The counting errors and their corrections.Tracer techniques and their applications.Isotope dilution and radio-activation methods of analysis.Fission product analysis (e.g., the technique of isolating two or three different fission products of U or Th and determining the yields).

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Qualitative semi-micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}

2. Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot tests should be done whenever possible.

Essential readings:

Theory:

1. Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall.
2. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K.(2009),Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.

3. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), Inorganic Chemistry 2nd Ed., Oxford University Press.

4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010),Shriver and Atkins Inorganic Chemistry, 5th Edition, W. H. Freeman and Company.

5. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. Basic Inorganic Chemistry, 3rd Edition,Wiley India. 6. Greenwood, N.N.; Earnshaw, A.(1997), Chemistry of the Elements, 2nd Edition, Elsevier (Ziegler Natta Catalyst and Equilibria in Grignard Solution).

6. Powell, P.(1988), Principles of Organometallic Chemistry, Chapman and Hall.

Practical:

1. Vogel, A.I,(1972),Qualitative Inorganic Analysis, Longman.

2. Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis, Prentice Hall.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in qualitative inorganic analysis, organometallic chemistry, bioinorganic applications, and nuclear chemistry
SDG 9	Industry, Innovation and Infrastructure	Knowledge of organometallic catalysis, industrial processes (Wilkinson, Ziegler-Natta, Fischer-Tropsch), and nuclear applications
SDG 12	Responsible Consumption and Production	Green chemistry approaches, handling and disposal of toxic metals, and responsible laboratory practices
SDG 13	Climate Action	Awareness of environmental impact of radioactive and toxic chemicals

Course Code: CY30007
Course Title: Organic Chemistry-IV(C-11)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

This core course aims to introduce the learner to the fascinating chemistry of some biomolecules,i.e., amino acids, peptides, proteins, carbohydrates, lipids andnucleic acidsthat work within biological systems. It aims to build the concept of metabolism by the study of chemistry and energetics of biological system.

Course Learning Outcomes:

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

CO1: Understand and demonstrate how structure of biomolecules determines their reactivity and biological functions.

CO2: Gain insight into concepts of heredity through the study of genetic code, replication, transcription and translation.

CO3: Demonstrate understanding of metabolic pathways, their inter-relationship, regulation and energy production from biochemical processes.

CO4: Analyze the metabolic pathways involved in carbohydrate catabolism, including glycolysis, fermentation, and the Krebs cycle, and understand the role of ATP as the universal currency of cellular energy.

CO5: Evaluate the importance of nucleic acids, enzymes, carbohydrates, and lipids in biological systems, and assess the significance of their structures and functions in various biochemical processes.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	**3**	2	**3**	1	2	–	1	2	–	2	1	**3**	**3**	2	2
CO2	–	**3**	2	**3**	–	**3**	–	1	2	–	2	–	**3**	2	**3**	2
CO3	–	**3**	1	**3**	–	**3**	–	1	2	–	2	2	**3**	**3**	**3**	**3**
CO4	–	**3**	1	**3**	–	2	–	1	2	–	2	2	**3**	**3**	**3**	**3**
CO5	1	**3**	2	**3**	1	2	–	1	2	–	**3**	**3**	**3**	2	2	**3**

Course Content:

UNIT-I: Nucleic Acids (10 Lectures)

Structure of components of nucleic acids: Bases, Sugars, Nucleosides and Nucleotides. Nomenclature of nucleosides and nucleotides, structure of polynucleotides (DNA and RNA),

concept of DNA duplex formation and its characterization.Biological roles of DNA and RNA. Concept of heredity:Genetic Code, Replication, Transcription and Translation.

UNIT-II: Amino Acids, Peptides and Proteins (10 Lectures)

Amino acids, Peptides and their classification.α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structure-end group analysis. Synthesis of peptides using N-protecting, C-protecting and Cactivating groups, Solid-phase synthesis; primary, secondary and tertiary structures of proteins, Denaturation of proteins.

UNIT-III: Enzymes (05 Lectures)

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking chymotrypsin as an example), factors affecting enzyme action, coenzymes and cofactors (NAD,FAD), specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance.

UNIT-IV: Carbohydrates and lipids (20 Lectures)

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, Haworth projection and conformational structures; Interconversion of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Concept of Energy in Biosystems

Introduction to metabolism (catabolism, anabolism), ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD+, FAD. Outline of catabolic pathways of carbohydrate-glycolysis, fermentation, Krebs cycle. Caloric value of food, standard caloric content of food types.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Estimation of glucose by Fehling's solution.

2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch under optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Isolation and estimation of DNA using cauliflower/onion.
7. Saponification value of the given oil.
8. Determination of Iodine number of the given oil.

Essential Readings:

Theory:

1. Berg, J.M.; Tymoczko, J.L.; Stryer, L. (2006),Biochemistry. W.H. Freeman and Co.
2. Nelson, D.L.; Cox, M.M.; Lehninger, A.L.(2009),Principles of Biochemistry. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A.; Rodwell, V.W.(2009),Harper's Illustrated Biochemistry.Lange Medical Books/McGraw-Hill.
4. Brown, T.A. (2018) Biochemistry, (First Indian addition 2018) Viva Books.

Practical:

1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
2. Kumar, A.; Garg, S.; Garg, N. (2012), Biochemical Tests: Principles and Protocols.Viva Books.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Comprehensive understanding of biomolecules, metabolism, and enzyme action for strong foundation in biochemistry

SDG 3	Good Health & Wellbeing	Understanding metabolism, enzyme action, and biomolecule function; relevance to nutrition, pharmaceuticals, and health sciences
SDG 12	Responsible Consumption and Production	Safe laboratory practices and proper disposal of reagents and biological materials
SDG 9	Industry, Innovation & Infrastructure	Basis for biotechnology, pharmaceutical, and food industries
SDG 13	Climate Action	Awareness of environmentally safe lab practices

Course Code: CY32001
Course Title: Equilibria, Chemical Kinetics and Catalysis (M-5)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The Objectives of this course are as follows:

• To get an understanding of the kinetics of simple and complex chemical reactions

• To give basic concept about catalysts and enzymes.

• To explain the experimental study of kinetics of simple reactions

Course Learning Outcomes:

By the end of the course, students will be able to:

CO1: Understand the concepts of chemical kinetics, including reaction order, molecularity, rate laws, and the Arrhenius equation, as well as the basics of catalysis and surface chemistry.

CO2: Explain the principles behind phase diagrams, including those for one-component systems (e.g., H2O and S) and systems involving solid-liquid equilibria with eutectic, congruent, and incongruent melting points.

CO3: Apply the concepts of catalysis to understand the mechanisms of catalyzed reactions at solid surfaces and enzyme catalysis, as well as the factors affecting catalytic efficiency.

CO4: Analyze the mechanisms and factors influencing adsorption processes, including physical and chemisorptions, adsorption isotherms, surface area determination, and adsorption in solution.

CO5: Evaluate the efficiency of nanoparticles as catalysts based on their particle size and surface properties, and assess the specificity, selectivity, and mechanisms of various catalyzed reactions.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	**3**	2	**3**	1	2	–	1	2	–	2	1	**3**	**3**	2	2
CO2	–	**3**	2	**3**	–	**3**	–	1	2	–	2	–	**3**	2	**3**	2
CO3	–	**3**	1	**3**	–	**3**	–	1	2	–	2	2	**3**	**3**	**3**	**3**
CO4	–	**3**	1	**3**	–	2	–	1	2	–	2	2	**3**	**3**	**3**	**3**
CO5	1	**3**	2	**3**	1	2	–	1	2	–	**3**	**3**	**3**	2	2	**3**

Course Content:

UNIT-I: Phase Equilibria (15 Lectures)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solidliquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems (H2O and S), with applications. A comparison between the phase diagram of CO2 and H2O. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-II: Chemical Kinetics (15 Lectures)

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-III: Catalysis (8 Lectures)

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts.Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

UNIT-IV: Surface chemistry (7 Lectures)

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

a. Determination of critical solution temperature and composition at CST of the phenol water system and to study the effect of impurities of sodium chloride and succinic acid on it.

b. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems.

c. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane.

h. Study of equilibrium of any one of the following reactions by distribution method:
i) I_2 (aq) + I^- (aq) → I^{3-}(aq)
ii) Cu^{2+} (aq) + nNH_3→ $[Cu(NH_3)n]^{2+}$

d. Study the kinetics of the following reactions.
a) Initial rate method: Iodide-persulphate reaction
b) Integrated rate method:
i) Acid hydrolysis of methyl acetate with hydrochloric acid.
ii) Saponification of ethyl acetate.

e. Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis of methyl acetate.

f. Adsorption:
i) Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

ii) Preparation of Fe(OH)3 sols.
iii) Study of adsorption of acetic acid on charcoal.

Essential readings:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.

2. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.

3. Kapoor, K.L.(2013),A Textbook of Physical Chemistry,Vol 3, 3rd Edition, McGraw Hill Education.

4. Kapoor, K.L.(2015),A Textbook of Physical Chemistry,Vol 5, 3rd Edition, McGraw Hill Education.

5. McQuarrie, D. A.; Simon, J. D. (2004), Molecular Thermodynamics, Viva Books Pvt. Ltd.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.

2. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

3.Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.

4. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).

5. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).

6. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

7. Rogers, D. W. Concise Physical Chemistry Wiley (2010). • Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

8. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in kinetics, catalysis, and surface chemistry for further studies and research
SDG 3	Good Health & Wellbeing	Understanding enzyme action and catalysis in biological and industrial systems
SDG 12	Responsible Consumption and Production	Green chemistry practices and proper waste management in laboratory experiments
SDG 9	Industry, Innovation & Infrastructure	Application of catalysis, nanoparticles, and adsorption in industry and research
SDG 13	Climate Action	Adoption of environmentally safe lab practices and sustainable approaches

Course Code: IP37081
Course Title: Internship
Total Credits: 02 (Practical-60)

Course Learning Objectives:

The internship provides students with practical exposure to professional work environments by applying academic knowledge to real-world problems. It develops technical competence, problem-solving ability, communication, teamwork, ethical practices, and project management skills while fostering industry readiness, professional responsibility, lifelong learning, and experiential understanding of organizational practices.

Course Learning Outcomes:

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

CO1: Recall and describe the organizational structure, professional practices, workplace ethics, safety regulations, and operational procedures followed in the internship organization.

CO2: Explain and interpret industry requirements, project workflows, organizational processes, professional responsibilities, and the application of theoretical concepts in real-world environments.

CO3: Apply domain knowledge, technical skills, modern tools, and problem-solving techniques to complete assigned tasks and projects effectively in a professional setting.

CO4: Analyze real-world problems, evaluate alternative solutions, interpret project outcomes, and recommend appropriate improvements based on technical and organizational requirements.

CO5: Demonstrate professional competence by planning, executing, documenting, and presenting internship work while exhibiting effective communication, teamwork, ethical conduct, project management, and lifelong learning skills.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

1. **Internship Orientation and Workplace Induction**
   - Introduction to the organization
   - Workplace policies, ethics, and safety guidelines
   - Understanding organizational structure and work culture
2. **Technical Skill Development**
   - Training on organization-specific software, tools, or technologies
   - Familiarization with development environments, databases, cloud platforms, or hardware (as applicable)
3. **Assignment and Task Execution**
   - Participation in project-related activities
   - Requirement analysis and task planning
   - Problem identification and solution implementation
   - Testing and validation of assigned work
4. **Documentation and Reporting**
   - Maintenance of daily work diary/logbook
   - Weekly progress reports
   - Preparation of technical documentation
5. **Professional Skills Development**

- Team collaboration
- Technical communication
- Time management
- Professional ethics and workplace responsibility

6. **Project Demonstration**
   - Presentation of completed work
   - Demonstration of developed solution or assigned tasks
   - Interaction with industry/faculty mentor
7. **Internship Report and Viva Voce**
   - Submission of internship report
   - Seminar presentation
   - Viva voce examination

Suggested Assessment Scheme

Component	**Weightage (%)**
Industry/Supervisor Evaluation	30
Faculty Mentor Evaluation	20
Daily Logbook and Attendance	15
Internship Report	20
Presentation and Viva Voce	15

SDG Mapping for this Course

SDG	Title	Contribution
SDG 4	Quality Education	Experiential learning
SDG 8	Decent Work and Economic Growth	Work-readiness, industry exposure
SDG 9	Industry, Innovation and Infra	Understanding real-world systems
SDG 10	Reduced Inequalities	Application in tribal/rural/NGO contexts

DOUBLE MAJOR

Course Code: CY32003 (DM-1)
Course Title: Chemical Thermodynamics and its Applications
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The aim of this course is to make students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry and make them able to apply thermodynamic concepts to the system of variable compositions, equilibrium and colligative properties.

Course Learning Outcomes:

By the end of the course, students will be able to:

CO1: Understand the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties.

CO2: Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for ideal gases under different conditions.

CO3: Explain the concept of partial molar properties.

CO4: Explain the thermodynamic basis of colligative properties and applications in surroundings.

CO5: Determine the different practical applications of thermodynamics.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	3	–	2	–	1	2	–	2	1	3	2	2	2
CO2	–	3	2	3	–	3	–	1	2	–	2	–	3	3	3	2
CO3	–	3	1	3	–	3	–	2	2	–	2	–	3	3	2	2
CO4	–	3	2	3	1	2	–	1	2	–	2	3	3	2	3	3
CO5	1	3	2	3	1	3	–	2	3	–	3	3	3	3	3	3

Course Content:

UNIT-I: Chemical Thermodynamics (15 Lectures)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of ideal gases under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) on enthalpy of reactions.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules from heat capacity data.

Free Energy Functions: Gibbs and Helmholtz energy; variation of G, A with T, V, P; Free energy change and spontaneity. Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

UNIT-II Systems of Variable Composition (5 Lectures)

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures.

UNIT – III Chemical Equilibrium (15 Lectures)

Types of Chemical equilibrium, Criteria of thermodynamic equilibrium, chemical equilibria in ideal gases, concept of fugacity.Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient.Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier's principle (quantitative treatment).

UNIT – IV Solutions and Colligative Properties (10 Lectures)

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molarmasses of normal, dissociated and associated solutes in solution.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of copper sulphate.

(g) Study of the solubility of benzoic acid in water and determination of ΔH

Essential Readings:

Theory:

1. Peter, A. & Paula, J. de. Physical Chemistry 10th Ed., Oxford University Press (2014).

2. Castellan, G. W. Physical Chemistry 4 th Ed., Narosa (2004).

3. Engel, T. & Reid, P. Physical Chemistry 3 rd Ed., Prentice-Hall (2012).

4. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.:New Delhi (2004).

5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).

6. Levine, I .N. Physical Chemistry 6 th Ed., Tata Mc Graw Hill (2010).

7. Metz, C.R. 2000 solved problems in chemistry, Schaum Series(2006).

Practical:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).

2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New AgeInternational: New Delhi (2001)

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong understanding of thermodynamic concepts for foundational knowledge in physical chemistry
SDG 7	Affordable and Clean Energy	Thermochemistry and energy calculations relate to energy applications and efficiency
SDG 9	Industry, Innovation & Infrastructure	Applications in chemical industries, process efficiency, and equilibrium systems
SDG 12	Responsible Consumption & Production	Efficient use of chemicals in labs, minimizing waste, green chemistry principles
SDG 13	Climate Action	Understanding energy transfer and heat management in reactions to promote sustainability

Course Code: CY32005
Course Title: Coordination Chemistry and Reaction Mechanism (DM-2)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The Objectives of this course are as follows:
• To familiarize the students with coordination compounds which find manifold applications in diverse areas.
• To acquaint the student with the concept of Inorganic reaction mechanism.

Course Learning Outcomes

By studying this course, the students will be able to:

CO1: Explain the terms- ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds.

CO2: Discuss the various types of isomerism possible in such compounds.

CO3: Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.

CO4: Explain the meaning of the terms Δo, Δt, pairing energy, CFSE, high spin and low spin complexes and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.

CO5: Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory. Can explain the reaction mechanism of coordination compounds and differentiate between kinetic and thermodynamic stability.

CO-PO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	3	–	2	–	1	2	–	2	–	3	3	2	2
CO2	–	3	2	3	–	2	–	1	2	–	2	–	3	2	3	2
CO3	–	3	2	3	–	3	–	1	2	–	2	1	3	3	3	3
CO4	–	3	2	3	–	3	–	2	2	–	2	2	3	3	3	3
CO5	1	3	2	3	1	3	–	2	3	–	3	2	3	3	3	3

Course Content:

UNIT-I: Coordination Chemistry (10 Lectures)

Werner's Coordination theory, simple problems based on this theory

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds (coordination numbers 4 and 6). Valence bond theory and its application to complexes of coordination numbers 4 and 6.

UNIT-II: Crystal field theory (15 Lectures)

measurement of Δo. Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δo. Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry: Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory (for octahedral σ-donor, π- acceptor and π- donor complexes).

UNIT-III: Stability of complexes (10 Lectures)

Brief discussion of thermodynamic and kinetic stability, Factors affecting stability of complexes, such as chelate effect, macrocyclic effect, resonance effect etc., trends in step wise formation constant, interpretation of lability and inertness based on VBT and CFT

UNIT-IV: Inorganic Reaction Mechanism (10 Lectures)

Introduction to inorganic reaction mechanisms, concept of reaction pathways, transition state, intermediate and activated complex. Substitution reactions in square planar complexes, factors affecting the rate of Substitution reactions in square planar complexes- such as charge effect, solvent effect and Trans- effect (Theories of trans-effect).

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

(A) Argentometry Estimation of Cl^{-1}

(i) By Mohr's method (ii) By Vohlard's method and (iii) By Fajan's method

(B) Complexometric Titrations:

(i) Complexometric estimation of Mg2+/ Zn2+ using EDTA

(ii) Estimation of total hardness of water samples

(iii) Estimation of Ca2+ in solution by substitution method

(iv) Estimation of Ca/Mg in drugs or biological samples.

(C) Properties of Complexes Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, dimethyl glyoxime, glycine) by substitution method.

Essential Readings

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, Fifth Edition, Pearson.

3. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic ChemistryPrinciples of Structure and Reactivity, Pearson Education.

4. Pfennig, B. W. (2015), Principles of Inorganic Chemistry, John Wiley & Sons.

5. Cotton, F.A.; Wilkinson, G.(1999), Advanced Inorganic Chemistry, Wiley-VCH.

6. Sodhi G.S. (2018), Principles of Inorganic Chemistry, Viva Books India.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons,

2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.

3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, Sixth Edition, PHI Learning Private Limited. 4. Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in coordination chemistry, reaction mechanisms, and practical titrations
SDG 9	Industry, Innovation and Infrastructure	Basis for metallurgical, pharmaceutical, and materials science applications

SDG 12	Responsible Consumption and Production	Safe chemical usage, minimizing hazardous waste, responsible laboratory practices
SDG 13	Climate Action	Awareness of environmental impact of chemical processes and eco-friendly laboratory practices

Course Code: CY32007
Course Title: Biomolecules (DM-3)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The objectives of this course are as follows:

1. To familiarize students with the fascinating chemistry and biology of biomolecules, i.e., nucleic acids and proteins etc.
2. To develop the interest of students in the basic concepts of heredity, which are imparted through replication, transcription, and translation processes.
3. To discuss basic fundamentals of enzyme action and inhibition, this forms the basis of drug action.
4. To familiarize students with the chemistry of carbohydrates and lipids.

Course Learning Outcomes

By studying this course, the students will be able to:

CO1: Demonstrate how structure of biomolecules determines their reactivity and biological role.

CO2: Gain insight into concepts of heredity through the study of genetic code, replication, transcription, and translation

CO3: Demonstrate basic understanding of enzyme action and role of inhibitors

CO4: Use knowledge gained to solve real world problems.

CO5: Use the knowledge gained from study of carbohydrates and lipids to propose greener and better synthetic routes. Use the chemistry and biology of carbohydrates and lipids to better serve the mankind.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	2	3	1	2	–	1	2	–	2	1	3	3	2	2
CO2	–	3	2	3	–	3	–	1	2	–	2	–	3	2	3	2
CO3	–	3	2	3	–	3	–	1	2	–	2	–	3	3	3	2
CO4	1	3	2	3	–	3	–	2	3	–	3	2	3	3	3	3
CO5	1	3	2	3	3	2	–	2	3	–	3	3	3	3	3	3

Course Content:

UNIT-I: Nucleic Acids (8 Lectures)

Structure of components of nucleic acids: Bases, Sugars, Nucleosides and Nucleotides. Nomenclature of nucleosides and nucleotides, structure of polynucleotides (DNA and RNA) and factors stabilizing them, biological roles of DNA and RNA; Concept of heredity: Genetic Code, Replication, Transcription and Translation.

UNIT-II: Amino Acids, Peptides and Proteins (14 Lectures)

Amino acids and their classification; α-amino acids - Synthesis, ionic properties, and reactions.zwitterions, pKa values, isoelectric point, and electrophoresis; Study of peptides: determination of their primary structure-end group analysis; Synthesis of peptides using Nprotecting, C-protecting and C-activating groups, Solid-phase synthesis; Overview of primary, secondary and tertiary structures of proteins, protein denaturation.

UNIT-III: Enzymes (8 Lectures)

Introduction, classification, and characteristics of enzymes, Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as an example), factors affecting enzyme action, coenzymes, and cofactors (including ATP, NAD, FAD), specificity of enzyme action (including stereospecificity).Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive, and non-competitive inhibition including allosteric inhibition).

UNIT-IV: Carbohydrates & Lipids (15 Lectures)

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projection and conformational structures; Interconversion of aldoses and ketoses; KillianiFischer synthesis and Ruff degradation; Linkage between monosaccharides: Comparative study of the structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch, cellulose and glycogen) excluding their structure elucidation.

Lipids: Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

Practical: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Study of the titration curve of glycine.
2. Estimation of glycine by Sorenson Formol Titration
3. Qualitative analysis of proteins- Ninhydrin test, Biuret test, Millon's reagent test, Xanthoproteic test.
4. Estimation of proteins by Lowry's method.
5. Study of the action of salivary amylase on starch at room temperature.
6. Effect of temperature on the action of salivary amylase.
7. Effect of pH on the action of salivary amylase
8. Study the inhibition of α-Amylase by copper sulphate
9. Isolation and estimation of DNA using cauliflower/onion
10. Estimation of sugars by using Fehling solution.
11. Determination of saponification value of the given oil.
12. Determination of iodine number of the given oil.

Essential Readings

Theory:

1. Berg, J.M., Tymoczko, J.L., Stryer, L. (2019), Biochemistry, Nineth Edition W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), Principles of Biochemistry. W.H. Freeman and Co., International Edition.
3. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2009), Harper's Illustrated Biochemistry. Lange Medical Books/McGraw-Hill.
4. Brown, T.A. (2018), Biochemistry, (First Indian Edition) Viva Books.
5. Kuashik, S., Singh, A. (2023), Biomolecules: From Genes to Proteins, First Edition, Berlin, Boston: De Gruyter.
6. Voet, D., Voet, J.G. (2010), Biochemistry, Fourth Edition, Wiley.
7. Singh J, Awasthi S K, Singh J, Fundamentals of Organic Chemistry, Pragati Prakashan Meerut.

Practical:

1. Manual of Biochemistry Workshop (2012), Department of Chemistry, University of Delhi.
2. Kumar, A., Garg, S., Garg, N. (2015), Biochemical Tests: Principles and Protocols. Viva Books.
3. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong foundation in biomolecules, genetics, enzymes, carbohydrates, and lipids
SDG 3	Good Health and Well-Being	Understanding biomolecules and enzyme action relevant to human health and drug design
SDG 9	Industry, Innovation and Infrastructure	Basis for biotechnology, pharmaceuticals, and food industry applications
SDG 12	Responsible Consumption and Production	Green approaches in biochemical experiments and responsible use of oils, fats, and biological materials
SDG 13	Climate Action	Awareness of eco-friendly laboratory practices and sustainable use of biological resources

SEMESTER-VI

Course Code: CY30002 (C-12)
Course Title: Physical Chemistry-IV
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurement of conductance and its applications, measurement of emf and its applications.

Course Learning Outcomes

By studying this course, students will be able to:

CO1: Define key concepts related to electrolytic dissociation, conductivity, and molar conductivity for both weak and strong electrolytes, and recall fundamental theories such as the Arrhenius theory and Kohlrausch's law of independent migration of ions.

CO2: Stufents will be able to explain the principles and equations governing ionic velocities, mobilities, and their determination, including the Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect etc.

CO3: Demonstrate the use of conductance measurements in practical applications such as determining the degree of dissociation of weak electrolytes, ionic product of water, solubility and solubility product.

CO4: They can analyze the quantitative aspects of Faraday's laws of electrolysis and the rules for oxidation/reduction based on half-cell potentials. Evaluate the applications of electrolysis in metallurgy and industry, and assess the principles and measurements related to electromotive force (EMF) of cells, including the Nernst equation and standard electrode potentials.

CO5: Determinethe impact of concentration cells, liquid junction potentials, and the determination of activity coefficients and transference numbers on electrochemical systems. Discuss the significance of potentiometric titrations, dipole moment, molecular polarizabilities.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	-	1	-	-	2	-	-	-	3	2	2	-
CO2	-	3	2	3	-	2	-	1	2	-	-	-	3	2	3	1
CO3	-	3	2	3	-	3	-	2	2	-	1	-	3	3	2	3
CO4	1	3	2	3	-	2	-	1	2	-	1	1	3	3	2	3
CO5	-	3	2	3	-	2	-	2	2	-	1	-	3	2	3	3

Course Content:

UNIT-I: Conductance-I (08 Lectures)

Arrhenius theory of electrolytic dissociation, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Molar conductivity at infinite dilution.Kohlrausch law of independent migration of ions.Debye-Huckel-Onsagar equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

UNIT-II: Conductance-II (10 Lectures)

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-III: Electrochemistry-I (12 lectures)

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells.Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes.

UNIT-IV: Electrochemistry-II (10 Lectures)

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers.Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).Dipole moment and molecular polarizabilities and their measurements.Diamagnetism, paramagnetic, magnetic susceptibility and its measurement, molecular interpretation.

Electrical & Magnetic Properties (05 Lectures)

Electrical & Magnetic Properties of Atoms and Molecules Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, LorenzLaurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement by Gouy's method.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

Conductometry:

1. Determination of cell constant
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
    a) Strong acid vs. strong base
    b) Weak acid vs. strong base

Potentiometry:

Perform the following potentiometric titrations:
a) Strong acid vs. strong base
b) Weak acid vs. strong base
c) Dibasic acid vs. strong base
d) Potassium dichromate vs. Mohr's salt.

Essential readings:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
3. Kapoor, K.L.(2013),A Textbook of Physical Chemistry,Vol 3, 3rd Edition, McGraw Hill Education.
4. Kapoor, K.L.(2015),A Textbook of Physical Chemistry,Vol 5, 3rd Edition, McGraw Hill Education.
5. McQuarrie, D. A.; Simon, J. D. (2004), Molecular Thermodynamics, Viva Books Pvt. Ltd.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019),A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.
4. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
5. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
6. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
7. Rogers, D. W. Concise Physical Chemistry Wiley (2010). • Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
8. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution

SDG 4	Quality Education	Strong conceptual and experimental foundation in electrochemistry and physical chemistry
SDG 7	Affordable and Clean Energy	Understanding electrochemical cells relevant to batteries and energy storage
SDG 9	Industry, Innovation and Infrastructure	Applications in electroplating, metallurgy, corrosion, and electrochemical industries
SDG 12	Responsible Consumption and Production	Efficient electrochemical processes, minimization of chemical waste
SDG 13	Climate Action	Awareness of sustainable energy technologies and electrochemical solutions

Course Code: CY30004
Course Title: Organic Chemistry-V(C-13)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The objective of this course is to understand the structure, stereochemistry and reaction pathways of organic molecules**.**

Course Learning Outcomes: At the end of the course the students will be able to:

CO1: Enumerate thermodynamics and kinetics of chemical reactions.

CO2: Classify different types of reactive intermediates, their property and reactivity. They can also be able to interpret configuration and conformational analysis of organic compounds.

CO3: Demonstrate an understanding of the effect of the electronic structuture on chemical bonding and aromaticity and predict the mechanism of different reactions.

CO4: Explain nucleophilic, electrophilic and free radical addition and substitution reactions and elimination reactions.

CO5: Discriminate stereospecificity, regioselectivity and stereoselectivity of elimination reactions.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4

CO1	-	3	-	2	-	1	-	-	2	-	-	-	3	2	2	1
CO2	-	3	1	3	-	2	-	-	2	-	-	-	3	2	3	2
CO3	-	3	1	3	-	2	-	1	2	-	-	-	3	3	3	2
CO4	-	3	2	3	-	2	-	-	2	-	1	-	3	3	2	3
CO5	-	3	1	3	-	2	-	-	2	-	1	-	3	2	3	3

Course Content:

UNIT-I: Nomenclature (5 Lectures)

Basic nomenclature of bicyclic compounds: Spirocyclic, Polycyclic compounds and heterocyclic compounds.

UNIT-II: Stereochemistry (10 Lectures)

Molecular symmetry and chirality: symmetry operations, elements, point group, symmetry number. Stereoisomerism: Classification, molecules with one, two, more stereocenters, configuration, nomenclature: D, L, R, S, E, Z, axial, planar chirality, helicity, Stereochemistry and R, S, configuration of allene, spirane, adamentane, catenane, biphenyl, ansa compounds, cyclophens, topicity and pro-stereoisomerism, cyclostereoisomerism, asymmetric induction, Crams, Prelogs rule, Felkin-Anh model, Chelation effect, Dynamic stereochemistry. Problem oriented approach.

UNIT– III: Reactive intermediates (15 Lectures)

Synthesis, Structure, stability and reactivity of Carbocations, Carbanions, Free Radicals. Carbenes, benzynes, enamines, and Nitrenes. Few important Name Reactions: Pinacol-pinacolone rearrangement, Demjanov rearrangement, Wagner-Meerwein rearrangement, Benzyl benzylic acid rearrangement, Dienone phenol rearrangement, Favorski rearrangement, Wittig reaction, Reformatsky reaction, benzoin condensation, Stobbe condensation, diazomethane reaction, swernoxidation.Problem oriented approach.

UNIT–IV: Reaction mechanism (15 Lectures)

Electrophiles, nucleophiles and radicals, Determination of reaction pathway, Substitution Reaction: Classification, Aliphatic nucleophilic substitution reaction: S_N1, S_N2, S_Ni reactions, solvent effect, neighbouring group participation (NGP) reactions. Aromatic Nucleophilic substitution reactions, benzyne mechanism.Aliphatic Electrophilic substitution reactions, aromatic electrophilic substitution reaction, orientation and reactivity in substituted benzene ring ortho-para ratio.Addition to Carbon-Carbon Multiple Bonds, addition to carbon-hetero multiple bonds.Electrophilic, nucleophilic and free radical addition reactions.Elimination Reactions E^1, E^2, E^i and E^1CB mechanisms.Stereospecificity, regioselectivity and stereoselectivity of elimination reactions. Relative reactivity of distereoisomers in ionic elimination, intramolecular rearrangements, Few important reaction of each reactions, Problem oriented approach.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Qualitative analysis of functional groups in organic molecule.
2. Qualitative analysis of N& S in an organic molecule.
3. Quantitative analysis of N in a molecule by Kjeldhal method.
4. Preparation of *p*-nitroaniline from acetanilide.
5. Preparation of pyridinium dichromate and its use in oxidation of benzyl alcohol.
6. Cannizzaro reaction of an aromatic aldehyde (*p*-nitrobenzaldehyde).

Essential Readings:

Theory:

1. Advanced Organic Chemistry, Part-A, F.A. Carey and R.J. Sundburg.
2. Advanced Organic Chemistry, Part-B, F.A. Carey and R.J. Sundburg
3. March‟s Advanced Organic Chemistry, Michael B. Smith and Jerry March
4. Modern Methods of Organic Synthesis: William Carruthers and Iain Coldham.
5. Basic Organic Stereochemistry, Eliel, Wilen, Doyle. Willey
6. Stereochemistry of Organic Compounds, D. Nashipuri, 3rdEdn, New age International.
7. S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.

8. R. T. Morison, and R. N. Boyd, Organic Chemistry, 6th Edn, Prentice-Hall India Pvt Ltd, New Delhi, 1992.

Practical:

1. Experiments and Techniques in Organic Chemistry, D.Pasto, C.Johnson, & M. Miller, Prantice Hall.

2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).

3. Hand Book of Organic Analysis, Qualitative & Quantitative, M.T.Clarke, Edward Arnold (Publisher).

4. Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.

5. A Text Book of Practical Organic Chemistry (Qualitative). Arthur I.Vogel.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong conceptual understanding of stereochemistry, reaction mechanisms, and organic synthesis
SDG 9	Industry, Innovation and Infrastructure	Foundation for pharmaceutical, fine chemical, polymer, and agrochemical industries
SDG 12	Responsible Consumption and Production	Efficient reaction pathways, minimization of hazardous reagents and waste
SDG 3	Good Health and Well-Being	Understanding reactions relevant to drug synthesis and biologically active molecules
SDG 13	Climate Action	Awareness of environmentally responsible chemical processes and sustainable practices

Course Code: CY30006
Course Title: Physical Chemistry-V(C-14)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course learning objectives

The objectives of this course are as follows:

- To make students understand the limitations of classical mechanics and the need of quantum chemistry
- To familiarize the students with the postulates of quantum chemistry

- To explain how to apply the postulates to derive equations for various models and extend to hydrogen atom and hydrogen like atoms.
- To explain the valence bond and molecular orbital theories and their applications to simple molecules
- To explain the use of some computational software

Course learning outcomes

By studying this course, students will be able to:

CO1: Explain the limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.

CO2: Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle

CO3: Set up Schrodinger equations for different types of systems

CO4: Explain the concept of covalent bonding based on valence bond theory and molecular orbital theory.

CO5: Perform calculations using different software and plot different wavefunctions and probability distribution curves. Perform simple calculations using appropriate quantum mechanical methods in different computational software.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	-	1	-	-	2	-	-	-	3	2	2	1
CO2	-	3	1	3	-	2	-	1	2	-	-	-	3	2	3	2
CO3	-	3	1	3	-	2	-	1	2	-	-	-	3	3	3	2
CO4	-	3	2	3	-	2	-	-	2	-	1	-	3	3	2	3
CO5	-	3	2	3	-	3	-	3	2	-	1	-	3	3	3	3

Course Content:

UNIT-I: Quantum Chemistry-I (10 Lectures)

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

UNIT-II: Quantum Chemistry-II (12 Lectures)

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule.Schrödinger equation, transformation to spherical polar coordinates.Separation of variables.Spherical harmonics.Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

UNIT-III: Hydrogen atom (08 Lectures)

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Zeeman effect, Introduction of spin quantum number and magnetic spin quantum number Setting up of Schrödinger equation for many electron atoms (He, Li), Indistinguishability of electrons and Pauli exclusion principle, Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

UNIT-IV: Covalent Bonding (15 Lectures)

Setting up of Schrödinger equation, Born-Openheimer approximation, LCAO-MO treatment of H_2^+ and its qualitative extension to H_2, Valence bond (VB) treatment of H_2, Comparison of LCAO-MO and VB wave functions of H_2 and their refinements, Qualitative description of LCAO-MO of homonuclear and heteronuclear diatomic molecules-HF and LiH.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbital using software like EXCEL.

2. Using a software such as ArgusLab, plot HOMO, LUMO and ESP maps of various molecules.

3. Draw probability plots for a particle in a 1-dimensional box for different values of quantum number n - commenting on the number of points of zero probability and then correlate them with the correspondence principle.

4. Plot the electron density contour maps of sigma molecular orbitals for diatomic homonuclear molecules.

5. Plotting of the wave function and probability curve for simple harmonic motion and interpret the results for first two levels.

6. Plotting energy as a function of distance for simple harmonic motion - parabolic curve.

7. Using software such as ArgusLab calculate properties such as dipole moment and Mulliken charges using quantum mechanical methods.

Essential Readings:

Theory:

1. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.

2. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier.

3. McQuarrie, D.A. (2016), Quantum Chemistry, Viva Books.

4. Chandra, A. K. (2001), Introductory Quantum Chemistry, Tata McGraw-Hill.

5. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier

Practical:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).

5. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
6. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong theoretical and computational foundation in quantum chemistry
SDG 9	Industry, Innovation and Infrastructure	Basis for materials science, molecular modelling, and computational research
SDG 12	Responsible Consumption and Production	Promotion of computational approaches reducing chemical consumption

Course Code: CY30008
Course Title: Chemistry of Polymers and Fibres(C-15)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

After completion of the course, the learner can be able to understand understand:

- The mechanism of polymer material formation.
- Molecular weight and structure property relationship
- Polymerization procedure and Zigler-Natta catalysis.
- Characterization of polymers

Course Learning Outcomes:

On successful completion of this course the student should be able to understand:

CO1: Enumerate the principle routes to isolate fibre from biomass feedstock and possess expertise in natural fibres.

CO2: Articulate deeply with a solid fundamental knowledge of polymers, their structure, processing and properties.

CO3: Customize the knowledge how polymers are synthesised from bio-based as well as fossil-based precursors.

CO4: Examine how molecular structure controls the material properties of polymers derived there from.

CO5: Interpret the number- and weight-average molecular masses of polymer samples given the degree of polymerisation and mass fraction of chains present.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	2	1	-	-	2	-	-	2	3	2	2	2
CO2	-	3	1	2	-	2	-	-	2	-	-	-	3	3	2	2
CO3	-	3	1	3	1	2	-	1	2	-	-	2	3	3	3	3
CO4	-	3	1	3	-	2	-	-	2	-	1	1	3	3	3	3
CO5	-	3	1	3	-	3	-	2	2	-	1	-	3	3	3	3

Course Content:

UNIT-I: Introduction (4 Classes)

Introduction and classification of Polymers, Biopolymers, Synthetics polymers.polymerization process, degree of polymerization, condensation and addition polymers, kinetics of addition polymerization process.

UNIT-II: Polymeric Structure and Property Relationship (8 Classes)

Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average and weight average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume, Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

UNIT-III: Polymerization Chemistry (20 classes)

Industrial methods of polymerization such as a bulk, solution, emulsion, suspension.Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

Characterization of Polymers: Molecular Weight Determination by Light scattering, End-group analysis, Viscosity, Applications of FTIR, UV-visible, NMR and Mass Spectroscopy for identification of polymers.

Properties of Polymers: (Physical, thermal, Flow & Mechanical Properties). Brief introduction to 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, polyurethanes, silicone polymers, polydienes, Polycarbonates.

UNIT-IV: Frontier areas of polymer science and technology (13 Classes)

Conducting polymers: Basic principles of conducting polymers delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soya protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, polyvinyl alcohol, polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: Natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Free radical solution polymerization of any one: Styrene, methylmethacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (purification of monomer should be taught)
2. Preparation of phenol-formaldehyde resins
3. Emulsion polymerization of polymethylmethacrylate.
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$ solution) by viscometry.

(students should be explained regarding principles and use of Ubblohde/Ostwald viscometer).

5. Estimation of amount of HCHO in a given solution by sodium bisulphite method.
6. Determination of exchange capacity of cation exchange resins and anion exchange resins.
7. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
8. Determination of composition of dolomite (by complexometric titration).

Essential readings:

Theory:

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork. 1990.
2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt, 1996.
3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987
4. Odian, George, Principles of Polymerization, McGraw-Hill Book Co., New York (1970).
5. W. Billmeyer, Text book of polymer science, 3rd Edn., 2007, Wiley.
6. J.R.Fried, Polymer Science and Technology, (2005), PHI publication.
7. Billmeyer Jr., Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers, New York (1962).
8. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
9. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
10. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
11. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int. Publication, 2019.

Practical:

1. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002).
2. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
3. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strong conceptual and practical understanding of polymer science
SDG 9	Industry, Innovation and Infrastructure	Industrial polymerization methods, fibres, rubbers, and advanced materials
SDG 12	Responsible Consumption and Production	Biodegradable polymers, sustainable polymer processing
SDG 13	Climate Action	Reduction of plastic pollution through bio-based and degradable polymers

Course Code: CY32002
Course Title: s, p, d and f-Block Elements (M-6)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

After completion of the course, the learner shall be able to understand understand:

- Chemistry of s and p-block elements.
- Chemistry of noble gases.
- Structure, bonding of s and p block materials and their oxides/compounds.

- Understanding chemistry of boron compounds and their structures.
- Chemistry of noble gases and their compounds, application of VSEPR theory in explaining structure and bonding.
- Lanthanides, Actinides – separation, colour, spectra and magnetic behaviour
- Understanding the transition metals stability in reactions, origin of colour and magnetic properties.
- Understanding the separation of Lanthanoids and Actinoids, its colour, spectra and magnetic behaviour.

Course Learning Outcomes:

On successful completion of this course the student should know:

CO1: Extraction of metals through metallurgical operations and their uses.

CO2: Bonding of various s and p block elements.

CO3: Chemistry of inorganic polymers and their uses.

CO4: Prediction of structure of complexes using various theories, colour and magnetic properties of different complexes.

CO5: Use of lanthanide/actinide compounds in industries.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	1	2	-	-	2	-	-	2	3	2	2	2
CO2	-	3	1	3	-	2	-	-	2	-	-	-	3	2	3	2
CO3	-	3	1	2	-	2	-	-	2	-	-	-	3	3	2	2
CO4	-	3	2	3	-	2	-	1	2	-	1	-	3	3	3	3
CO5	-	3	1	2	-	2	-	1	2	-	1	1	3	2	2	3

Course Content:

UNIT-I: Chemistry of s and p Block Elements: (15 Lectures)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification: ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, phosphorus and chlorine.Per-oxo acids of Sulphur inter-halogen compounds, poly-halide ions, pseudo-halogens.

UNIT-II: Noble Gases: (10 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6, Bonding in noble gas compounds (Valence bond and MO treatment for XeF2), Shape of noble gas compounds (VSEPR theory).

UNIT-III: Transition Elements: (10 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams).Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

UNIT-IV: Lanthanides and Actinides: (10 Lectures)

Electronic configuration, oxidation states, colour, spectra and magnetic behaviour, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

Iodo / Iodimetric Titrations

i) Estimation of Cu(II) and K2Cr2O7 using sodium thiosulphate solution (Iodimetrically).

ii) ii) Estimation of available chlorine in bleaching powder iodometrically.

Inorganic preparations

i) Cuprous Chloride, Cu2Cl2

ii) ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.

Qualitative semimicro analysis of mixtures

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on the understanding of chemistry of different reactions. Following radicals may be analyzed:

CO3 2-, NO2 - , S 2-, SO4 2- , SO3 2- , CH3COO- , F- , Cl- , Br- , I- , NO3 - , BO3 3- , C2O4 2-, PO4 3-, NH4 + , K + , Pb2+, Cu2+, Cd2+, Bi3+, Sn2+, Sb3+, Fe3+, Al3+, Cr3+, Zn2+, Mn2+, Co2+, Ni2+, Ba2+, Sr2+, Ca2+, Mg2+

Mixtures should preferably contain:

i. one interfering anion, or

ii. insoluble component (BaSO4, SrSO4, PbSO4, CaF2 or Al2O3) or

iii. combination of anions e.g. CO3 2-and SO3 2-, NO2 - and NO3 - . Note: Spot analyses/tests should be done wherever possible.

Essential readings:

Theory:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.

2. Douglas, B.E, Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed. John Wiley Sons, N.Y. 1994.

3. Greenwood, N.N., Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.

4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.

5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry Fourth Ed., Pearson, 2010

6. Atkins, P. W and Shriver D. N. Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

7. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.

8. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.

Practical:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition Pearson, 2009.

2. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla. Pearson Education, 2002.

3. Marr & Rockett Practical Inorganic Chemistry. John Wiley & Sons 1972.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthening foundational knowledge in inorganic chemistry, analytical thinking, laboratory skills, and scientific literacy
SDG 6	Clean Water and Sanitation	Understanding iodometric estimation, chlorine content in bleaching powder, and relevance of inorganic chemistry in water treatment
SDG 9	Industry, Innovation and Infrastructure	Role of transition metals, lanthanides, and actinides in catalysts, alloys, electronics, and advanced materials
SDG 12	Responsible Consumption and Production	Safe handling of chemicals, waste minimization, responsible laboratory practices, and sustainable use of inorganic compounds
SDG 13	Climate Action	Awareness of chemical pollutants, environmental impact of inorganic compounds, and sustainable chemical practices

DOUBLE MAJOR

Course Code: CY32004

Course Title: Basics of Organometallic Chemistry (DM-4)

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the interactions of metal atom with organic molecules (or not so typical organic molecule), which is in an entirely different fashion as compared to coordination compounds.
- To familiarize the students with the structure and bonding in organometallic compounds
- To familiarize the student with how organometallic compounds can act as good catalysts for organic transformations and hencehave industrial importance associated with medicines, bioorganic synthesis, and energy production.

Course Learning Outcomes

By studying this course, the students will be able to:

CO1: Identify and classify organometallic compounds of different types.

CO2: Explain the stability of organometallic compounds and hence the requirement of special experimental conditions for their synthesis.

CO3: Explain the bonding modes through VBT and MOT in these compounds.

CO4: Explain the chemical nature of these compounds through various reactions thus acquiring skills to understand their applications.

CO5: Explain the mechanism of catalysis by these compounds. This may prepare the student to predict the catalytic pathways for new reactions.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	-	1	-	-	2	-	-	-	3	2	2	1
CO2	-	3	1	3	-	2	-	-	2	-	-	-	3	2	3	2
CO3	-	3	1	3	-	2	-	-	2	-	-	-	3	3	3	2
CO4	-	3	2	3	-	2	-	1	2	-	1	-	3	3	3	3
CO5	-	3	2	3	-	3	-	1	2	-	1	1	3	3	3	3

Course Content:

UNIT-I: Introduction to Organometallic Chemistry (6 Lectures)

Definition, brief history, classification of organometallic compounds on the basis of bond type. Common notation used in organometallic chemistry, concept of hapticity of organic ligands, importance of organometallic chemistry, organometallic compounds as reagents, additives, and catalysts. Introduction to the 18-electron rule or effective atomic number rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series and finding metal-metal bonds.

UNIT-II: Structure and Bonding in Organometallic Compounds (12 Lectures)

Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. Molecular orbital theory applied to organometallic compounds, description of bonding of two electron ligands to transition metals. π-acceptor behavior of CO (MO diagram of CO to be discussed), π-bonding of CO with metal (synergic effect) and use of IR data to explain extent of back bonding, bonding modes of CO, symmetry of metal carbonyls. Bonding between metal atoms and organic π- systems: linear (ethylene, allyl, butadiene) and cyclic (cyclopentadiene, benzene), Zeise's salt and comparison of synergic effect with that in carbonyls. Metal alkyls and Metal-carbene complexes.

UNIT-III: Synthesis, Reactions and Applications of Organometallic Compounds (16 Lectures)

General methods of synthesis of metal carbonyls: direct carbonylation, reductive carbonylation, thermal and photochemical decomposition, of mono and binuclear carbonyls of 3d series. Reaction of metal carbonyls: reduction, oxidation, photochemical substitution, migratory insertion of carbonyls, and nucleophilic addition of CO. Synthesis of metal-alkene complexes through ligand addition, reduction and substitution and reaction of metal bound alkenes, Zeise's salt Metal–sandwich compounds: Ferrocene: synthesis, physical properties and reactions: acylation, sulfonation, alkylation metallation, acetylation, chloromercuration, Mannich reaction, comparison of aromaticity and reactivity of ferrocene with that of benzene. Synthesis and reactions of Metal alkyls and Metal-carbenes.

UNIT-IV: Catalysis by Organometallic Compounds (11 Lectures)

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis.(Catalytic steps, examples and industrial applications), deactivation and regeneration of catalysts, (catalytic poisons and promoter). Organometallic catalysis of the following reactions of commercial importance and their mechanism: 1. Alkene hydrogenation (using Wilkinson's Catalyst) 2. Synthetic gasoline preparation (Fischer Tropsch reaction) 3.Polymerisation of ethene using Ziegler-Natta catalyst 4.Wacker oxidation process (Smidth process) 5.Hydroformylation reaction (Oxo-process) 6. Monsanto Acetic Acid process

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. To study and compare the UV-Vis spectrum of ferrocene (in methanol or acetonitrile) and potassium ferrocyanide (in water).

2. To study the cyclic voltammogram of ferrocene.

3. Preparation of Bis(acetylacetonato)copper (II) complex and characterisation through UV-Visible spectrum of its aqueous solution.

4. Preparation of tris(acetylacetonato)manganese (III) complex.

5. Preparation of Potassium tris(oxalato)ferrate (III) complex.

6. Preparation of Tetraamminecopper (II) sulphate monohydrate complex.

7. Preparation of Pentaamminechloridocobalt (III) chloride.

8. Preparation of Hexaamminecobalt (III) chloride

9. Determination of number of chloride ions in ionisation sphere to confirm the formula of complexes prepared in (6) and (7) through potentiometric titration or conductance measurements. (See reference 5 & 6 of Practicals)

10. Compare and interpret the visible spectrum of complexes prepared in (6) and (7) for shifts in wavelength maxima.

Essential Readings

Theory:

1. Gary L Miesler, Paul J Ficsher, and Donald A Tarr, Inorganic Chemistry 5th Edition , Pearson.

2. Shriver & Atkins Inorganic Chemistry, Edn V, W.H. Freeman and Company.

3. F.A. Cotton & G. Wilkinson, Advanced Inorganic Chemistry, 5th Edition.

4. William W. Porterfield, Inorganic Chemistry, Ist Edition.

5. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), Inorganic ChemistryPrinciples of Structure and Reactivity, Pearson Education.

6. Principles of Organometallic Chemistry by M.L.H Green, Coward, G.E Coates and K.Wade 3rd Edition. 7. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. Basic Inorganic Chemistry, 3rd Edition, Wiley India.

8. Greenwood, N.N.; Earnshaw, A. (1997), Chemistry of the Elements, 2nd Edition, Elsevier.

9. Gupta, B. D., Elias, A. J., (2013) Basic Organometallic Chemistry: Concepts, Syntheses and Applications, 2nd Edition, Universities Press.

Practical:

1. ChemTexts (2020) 6:22, https://doi.org/10.1007/s40828-020-00119-6

2. J. Chem Education: 1971, Volume 48(2), 133

3. Front. Chem. Sci. Eng. 2013, 7(3): 329–337, DOI 10.1007/s11705-013-1339-0

4. Orbital: Electron. J. Chem. 2019, 11 (6): 348-354

5. Vogel's text book of quantitative chemical analysis. Edn V

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthening conceptual understanding of organometallic chemistry, analytical reasoning, reaction mechanisms, catalysis, and laboratory skills essential for higher education and research
SDG 7	Affordable and Clean Energy	Understanding the role of organometallic catalysts in energy-related processes such as fuel synthesis, hydrogenation reactions, and sustainable energy production
SDG 9	Industry, Innovation and Infrastructure	Application of organometallic compounds in industrial catalysis, polymerisation, petrochemical processes, pharmaceuticals, and material synthesis
SDG 12	Responsible Consumption and Production	Promoting efficient catalytic processes, reduced energy consumption, waste minimization, responsible handling of metal complexes, and sustainable chemical practices
SDG 13	Climate Action	Awareness of environmentally friendly catalytic pathways, role of catalysis in reducing emissions, and understanding chemical solutions to climate-related challenges

Course Code: CY32006
Course Title: Organic Reaction Mechanisms (DM-5)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The objective of this course is to understand the structure, stereochemistry and reaction pathways of organic molecules.

Course Learning Outcomes:

At the end of the course the students will be able to:

CO1: Enumerate thermodynamics and kinetics of chemical reactions.

CO2: Classify different types of reactive intermediates, their property and reactivity. They can also be able to interpret configuration and conformational analysis of organic compounds.

CO3: Demonstrate an understanding of the effect of the electronic structuture on chemical bonding and aromaticity and predict the mechanism of different reactions.

CO4: Explain nucleophilic, electrophilic and free radical addition and substitution reactions and elimination reactions.

CO5: Discriminate stereospecificity, regioselectivity and stereoselectivity of elimination reactions.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	-	1	-	-	2	-	-	-	3	2	2	1
CO2	-	3	1	3	-	2	-	-	2	-	-	-	3	2	3	2
CO3	-	3	2	3	-	2	-	1	2	-	-	-	3	3	3	2

CO4	-	**3**	**2**	**3**	-	**2**	-	**1**	**2**	-	**1**	-	**3**	**3**	**3**	**3**
CO5	-	**3**	**2**	**3**	-	**3**	-	**1**	**2**	-	**1**	-	**3**	**3**	**3**	**3**

Course Content:

UNIT-I: Nomenclature (5 Lectures)

Basic nomenclature of bicyclic compounds: Spirocyclic, Polycyclic compounds and heterocyclic compounds.

UNIT-II: Stereochemistry (10 Lectures)

Molecular symmetry and chirality: symmetry operations, elements, point group, symmetry number. Stereoisomerism: Classification, molecules with one, two, more stereocenters, configuration, nomenclature: D, L, R, S, E, Z, axial, planar chirality, helicity, Stereochemistry and R, S, configuration of allene, spirane, adamentane, catenane, biphenyl, ansa compounds, cyclophens, topicity and pro-stereoisomerism, cyclostereoisomerism, asymmetric induction, Crams, Prelogs rule, Felkin-Anh model, Chelation effect, Dynamic stereochemistry. Problem oriented approach.

UNIT– III: Reactive intermediates (15 Lectures)

Synthesis, Structure, stability and reactivity of Carbocations, Carbanions, Free Radicals. Carbenes, benzynes, enamines, and Nitrenes. Few important Name Reactions: Pinacol-pinacolone rearrangement, Demjanov rearrangement, Wagner-Meerwein rearrangement, Benzyl benzylic acid rearrangement, Dienone phenol rearrangement, Favorski rearrangement, Wittig reaction, Reformatsky reaction, benzoin condensation, Stobbe condensation, diazomethane reaction, swernoxidation.Problem oriented approach.

UNIT–IV: Reaction mechanism (15 Lectures)

Electrophiles, nucleophiles and radicals, Determination of reaction pathway, Substitution Reaction: Classification, Aliphatic nucleophilic substitution reaction: S_N1, S_N2, S_Ni reactions, solvent effect, neighbouring group participation (NGP) reactions. Aromatic Nucleophilic substitution reactions, benzyne mechanism.Aliphatic Electrophilic substitution reactions, aromatic electrophilic substitution reaction, orientation and reactivity in substituted benzene ring ortho-para ratio.Addition to Carbon-Carbon Multiple Bonds, addition to carbon-hetero multiple bonds.Electrophilic, nucleophilic and free radical addition reactions.Elimination Reactions E^1, E^2, E^i and E^1CB mechanisms. Stereospecificity, regioselectivity and stereoselectivity of elimination reactions. Relative reactivity of distereoisomers in ionic elimination, intramolecular rearrangements, few important reactions of each reactions, Problem oriented approach.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Qualitative analysis of functional groups in organic molecule.
2. Qualitative analysis of N& S in an organic molecule.
3. Quantitative analysis of N in a molecule by Kjeldhal method.
4. Preparation of *p*-nitroaniline from acetanilide.
5. Preparation of pyridinium dichromate and its use in oxidation of benzyl alcohol.
6. Cannizzaro reaction of an aromatic aldehyde (*p*-nitrobenzaldehyde).

Essential Readings:

Theory:

1. Advanced Organic Chemistry, Part-A, F.A. Carey and R.J. Sundburg.
2. Advanced Organic Chemistry, Part-B, F.A. Carey and R.J. Sundburg
3. March‟s Advanced Organic Chemistry, Michael B. Smith and Jerry March
4. Modern Methods of Organic Synthesis: William Carruthers and Iain Coldham.
5. Basic Organic Stereochemistry, Eliel, Wilen, Doyle. Willey
6. Stereochemistry of Organic Compounds, D. Nashipuri, 3rdEdn, New age International.
7. S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.
8. R. T. Morison, and R. N. Boyd, Organic Chemistry, 6th Edn, Prentice-Hall India Pvt Ltd, New Delhi, 1992.

Practical:

1. Experiments and Techniques in Organic Chemistry, D.Pasto, C.Johnson, & M. Miller, Prantice Hall.
2. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
3. Hand Book of Organic Analysis, Qualitative & Quantitative, M.T.Clarke, Edward Arnold (Publisher).

4. Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
5. A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthening conceptual understanding of organic reaction mechanisms, stereochemistry, and structure–reactivity relationships, promoting analytical thinking and problem-solving skills
SDG 9	Industry, Innovation and Infrastructure	Understanding reaction mechanisms and intermediates relevant to pharmaceuticals, polymers, fine chemicals, and industrial organic synthesis
SDG 12	Responsible Consumption and Production	Promotion of efficient reaction pathways, reduced waste generation, responsible handling of organic chemicals, and awareness of sustainable laboratory practices
SDG 13	Climate Action	Awareness of environmentally benign reaction mechanisms, reduction of hazardous reagents, and understanding chemistry-based approaches to mitigating environmental impact

Course Code: CY32008
Course Title: Industrial Chemicals and Environment (DM-6)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

These learning objectives aim to provide a comprehensive understanding of industrial chemicals, environmental impacts, and sustainable practices, preparing students to address industrial and environmental challenges effectively.

Course Learning Outcomes:

CO1: Identify the major industrial gases and inorganic chemicals, their large-scale production methods, uses, storage, and associated hazards. List the preparation methods for ferrous and non-ferrous metals and ultrapure metals for semiconductor technology.

CO2: Explain the biogeochemical cycles of carbon, nitrogen, and sulfur, and describe the chemical and photochemical reactions occurring in the atmosphere. Discuss the types, sources, and environmental effects of various air and water pollutants.

CO3: Demonstrate methods for estimating air pollutants (CO, NOx, SOx) and apply techniques for measuring water pollution. Use these methods to analyze pollution levels and the effectiveness of control procedures.

CO4: Analyze the impact of various pollutants on ecosystems and human health. Evaluate the efficiency of different water purification methods and effluent treatment plants in removing contaminants from industrial waste.

CO5: Assess the environmental and safety implications of handling industrial chemicals and gases. Critically evaluate the sustainability and environmental impact of different energy sources, including coal, petroleum, natural gas, nuclear, solar, and renewable energies.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	3	1	2	-	2	-	1	2	-	1	3	3	3	2	2
CO2	1	3	1	3	1	2	-	1	2	-	1	3	3	2	3	3
CO3	1	3	2	3	-	3	-	2	2	-	1	3	3	3	3	3
CO4	2	3	2	3	-	3	-	2	2	-	2	3	3	3	3	3
CO5	2	3	2	3	1	3	-	2	3	-	2	3	3	3	3	3

Course Content:

UNIT-I: Industrial Gases and Inorganic Chemicals (15 Lectures)

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate

UNIT-II: Industrial Metallurgy (5 Lectures)

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

UNIT-III: Environment and its segments (17 Lectures)

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its

constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO2, CO2, CO, NOx, H2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures.Effects of air pollution on living organisms and vegetation.Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal.Control of particulates.
Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.
Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.
Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

UNIT-IV: Energy & Environment (8 Lectures)
Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO3 and potassium chromate).
6. Estimation of total alkalinity of water samples (CO3 2- , HCO3 -) using double titration method.
7. Measurement of dissolved CO2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples. 10. Preparation of borax/ boric acid.

Essential Readings

Theory:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.

2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi. • J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
3. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
4. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
5. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
6. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
7. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
8. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

Practical:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi. • J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
3. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
4. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
5. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-Being	Understanding health impacts of air and water pollutants, toxic industrial chemicals, and pollution control measures
SDG 4	Quality Education	Strengthening environmental chemistry knowledge, analytical skills, sustainability awareness, and applied laboratory competence
SDG 6	Clean Water and Sanitation	Water quality assessment, pollution measurement, purification methods, and effluent treatment technologies
SDG 7	Affordable and Clean Energy	Evaluation of conventional and renewable energy sources, nuclear energy, and sustainable alternatives
SDG 9	Industry, Innovation and Infrastructure	Industrial chemical processes, metallurgy, pollution control technologies, and environmental compliance
SDG 12	Responsible Consumption and Production	Industrial waste management, safe chemical handling, pollution reduction, and sustainable industrial practices
SDG 13	Climate Action	Climate change awareness, greenhouse effect, ozone depletion, clean energy transition, and emission control

SEMESTER-VII

Course Code: CY40001
Course Title: Photochemistry and Pericyclic Reaction(C-16)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

To have an exposure in the understanding and mechanisms of organic oxidations, reductions, the generation and reactions of organic reaction intermediates, organic photochemistry and pericyclic reactions.

Course Learning Outcomes: At the end of this course students will able to:

CO1: Describe the theory and practice of common photochemical and photophysical methods, and be able to execute these experimentally.

CO2: Distinguish the different types of pericyclic reactions, the stereochemistry of the same and simple rules and also the Fundamentals of the NMR phenomenon, relationship between NMR spectraand molecular structure.

CO3: Employing thePrinciples photochemical reactions in organic chemistry, Woodward-Hofmann symmetry rules for pericyclic reactions.

CO4: Correlating the macroscopic and quantum laws of the absorption of light by molecules and solids· Describe the basis of photochemistryas well as different types of spectroscopy.

CO5: Determine the magnetic behaviour of complexes and its application.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	-	3	1	2	-	2	-	2	2	-	-	-	3	2	2	1
CO2	-	3	1	3	-	2	-	2	2	-	-	-	3	2	3	2
CO3	-	3	2	3	-	3	-	2	2	-	1	-	3	3	3	3
CO4	-	3	2	3	-	2	-	3	2	-	1	-	3	3	3	3
CO5	-	3	1	3	-	2	-	2	2	-	1	-	3	2	3	3

Course Content:

Unit-I: Photochemical reactions (6 Lectures)

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

Unit-II: Photochemistry (13 Lectures)

Introduction, Photochemical energy, Franck-Condon, Jablonski diagram, photosensitisation and quenching, Norrish Type-I and Type-II processes, Paterno-Buchi reaction, di-pi methane rearrangement, Barton reaction, Hofmann-Loeffler-Freytag reaction, photochemistry of unsaturated compounds: rearrangement of unsaturated compounds; photo-induced reactions in aromatic compounds. Problem oriented approach.

Unit-III: Pericyclic Reactions (13 Lectures)

Electrocyclisation, cycloaddition, sigmatropic rearrangements, chelatropic reaction, Ene reaction and group transfer reactions. Principles and applications of photochemical reactions in organic chemistry, Rationalisation of different example with the basis of frontier orbital interaction, Woodward-Hofmann symmetry rules for pericyclic reactions, exceptions to symmetry rules, correlation diagram of different perecyclic reactions. Problem oriented approach

Unit-IV: Chemistry of Important Reagents (13 Lectures)

Hydride transfer reagent: Boranes, trialkylborohydrides, Diimide, Baker's yeast, trialkyl tin hydride; DIBAL, Na(CN)BH3, Woodward and Prevost hydroxylation, Sharplessepoxidation, dihydroxylation, PCC, PDC, Mn(IV) oxide, RuO4 (TPAP), Moffat oxidation, Swern oxidation, Dess-Martin Periodinane (DMP); Shapiro reaction, Peterson reaction, OsO4, SeO2. Problem oriented approach.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Photoreduction of Benzophenone to Benzopinacol.**
2. **Sunlight-Induced Cis–Trans Isomerization of Azobenzene.**
3. Comparative Oxidation of Secondary Alcohols (MnO_2 vs PCC).
4. Sharpless Asymmetric Epoxidation of an Allylic Alcohol.

5. **Photodegradation of methylene blue.**

6. **Baker's-yeast reduction of acetophenone → (S)-1-phenylethanol**

Essenial Readings:

Theory:

1. Spectroscopic Identification of Organic Compounds, Robert M. Silverstein and Francis X. Webster

2. Introduction to Spectroscopy, 3rd Ed, Pavia, Lampmann and Kriz. Thomson Learning.

3. R. B. Woodward and R. Hoffman, The Conservation of Orbital Symmetry, VerlagChemie GmbH, 1970

4. I. Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley, New York, 1980

5. H. O. House, Modern Synthetic Reactions, 2nd Ed, Benjamin, 1971

6. T. L. Gilchrist and R. C. Storr, Organic Reactions and Orbital Symmetry, 2nd Edn, Cambridge University Press, Cambridge, 1979.

7. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, 3rd Edn, ELBS, 2003.

8. Spectroscopy of Organic Compounds—P. S. Kalsi, New Age International Publishers, 6th Ed.

Practical:

1. B. B. Dey, M. V. Sitaraman and T. R. Govindachar, Laboratory *manual of organic chemistry,* New Delhi: Allied Publishers, 1996.

2. A. I. Vogel, *Text book of practical organic chemistry*, 1996.

3. V. K. Ahluwalia and R. Aggarwal, Comprehensive *practical organic chemistry*

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthening advanced understanding of photochemistry, pericyclic reactions, spectroscopy, and experimental skills essential for higher education and research
SDG 9	Industry, Innovation and Infrastructure	Application of photochemical and pericyclic reactions in pharmaceuticals, materials science, polymers, and fine chemical industries
SDG 12	Responsible Consumption and Production	Promotion of efficient reaction pathways, use of selective reagents, reduction of waste, and greener photochemical processes
SDG 13	Climate Action	Understanding photochemical processes relevant to atmospheric chemistry, pollutant degradation, and environmentally sustainable chemical practices

Course Code: CY40003
Course Title: Fundamentals of Agro Chemistry(C-17)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The course is designed to develop a scientific understanding of the diverse approaches used to classify agrochemicals, enabling students to recognize their categories and significance. It aims to familiarize learners with the chemical structures, modes of action and practical uses of pesticides, thereby providing a strong foundation in their application. In addition, the course imparts knowledge about pesticide formulations, their various types, along with their advantages and limitations, to highlight their role in agricultural practices. Furthermore, it seeks to create awareness about the hazards associated with agrochemicals and their potential impact on human health, encouraging responsible and safe usage.

Course Learning Outcomes:

CO1 Learn classification of pesticides

CO2 Analyze the impact of stereochemical aspects on pesticidal activity

CO3 Carry out preparation of formulations and analysis

CO4 Handle pesticides safely in view of human health and environment

CO5 Know the experimental details and laboratory practices

CO-PO-PSO Mapping (Strong-3, Moderate-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	–	2	–	–	–	–	2	–	–	2	–	2	2	–
CO2	–	3	–	3	–	2	–	–	2	–	2	2	2	3	3	–
CO3	–	3	2	3	–	3	2	2	2	–	3	–	2	3	3	2
CO4	3	3	–	3	–	2	–	–	2	–	3	3	–	2	3	–
CO5	2	3	2	2	–	3	2	2	3	–	3	2	2	2	3	3

Course Content:

UNIT-I: Pesticides (8 Lectures)

Different classes of pesticides based on use or target pests (Only definitions and examples- no structural requirement): Herbicides, Fungicides, Insecticides, Rodenticides, Acaricides, Bactericides, Chemosterillant, Molluscicide, Nematicides, Plant growth regulators, Repellents, Antifeedants, Sex attractants, Classification of pesticides based on chemical nature, mode of entry, mode of action and toxicity.

UNIT-II: Herbicides (10 Lectures)

Structure, uptake, mode of action and uses along with key points on human toxicity with special reference to the individual compounds mentioned (synthesis excluded):

a) Aryl alkanoic acids: 2, 4 D, 2,4DB, MCPA and other acid derivatives: dicamba, dichlorobenil, dalapon {along with structure-activity relationship (SAR)}

b) Aromatic carbamates: Barban and asulam

c) Triazines: Simazine, Atrazine

d) Bipyridinium: Paraquat

e) Organophosphorous: Glyphosate

f) Sulfonylurea: Chlorosulfuron

g) Uracils: Bromacil

h) Ureas: Monuron and Isoproturon

UNIT-III: Fungicides (7 Lectures)

Structure, mode of action and uses along with key points on human toxicity with special reference to the individual compounds mentioned (synthesis excluded):

a) Copper and mercury derivatives

b) Dithiocarbamates: Thiram, Ziram, Nabam

c) Dinitro phenols: 2, 4-Dinitro o-Cresol (DNOC)

d) Quinines: Dichlone

e) Benzimidazoles: Benomyl
f) Organophosphorus fungicides: Kitazine
g) Phenyl amides: Metalaxyl
h) Triazoles: Propiconazole
i) Thiophanates: Thiophanates

UNIT-IV: Conventional Pesticides (20 Lectures)

With special reference to the individual compounds mentioned (synthesis excluded): Structure, pesticidal properties and stereochemical aspects (if any), mode of action, uses and comments on human toxicity

a) Carbamate insecticides: Carbaryl, Methomyl
b) Organophosphorus insecticides: Malathion, Parathion
c) Organochlorine Insecticides: Chlordane, Heptachlor, DDT

Introduction to other Pesticides: Structure, stereochemical aspects (if any), use and toxicity of the following (synthesis excluded):

a) Alkaloid family: Nicotine
b) Pyrethrins: Pyrethrin-I and II
c) Fumigants: Example of Halogenated Hydrocarbons
d) Rodenticides: Inorganic and organic (Two examples each)
e) Repellents: DEET, Diethylphthalate

Pesticide Formulations:

1. Definition and purpose of formulations.
2. Brief discussion on the following type of formulations:

a) Solid formulations: dusts (D), granules (G), pellets (P), wettable powders (WP or W), dry flowable (DF), soluble powders (SP); poison baits (B)

b) Liquid formulations: emulsified concentrates (EC or E), solutions, flowing suspensions (F or L), Suspension Concentrate (SC), aerosols (A)

c) Other type of formulations: fumigants (F); microencapsulated product (M) for controlled-release.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Preparation of Bordeaux mixture and Bordeaux paste.
2. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.
3. Preparation of homemade rodent bait.
4. Preparation of Emulsifiable concentrate (EC) formulation of given organic compound as oil in water emulsion (O/W).
5. Preparation of EC formulation: Emulsifiable concentrate of neem oil.
6. Determination of total hardness of a water sample by EDTA method.
7. To determine the emulsion stability of given EC formulation.

8. Determination of bulk density of WP formulation.
9. Project Writing: For project work pesticides to be selected from the theory portion (a) Use of Globally Harmonized System (GHS) of classification and labelling of chemicals (b) The impact of pesticides on the environment (c) Pesticide exposure and its impact on human health.

Essential Readings:

1. Buchel, K. H., (1983) Chemistry of Pesticides, John Wiley & Sons Inc ISBN 13 978-0471056829.
2. Melnikov,N.N. (1971) Chemistry of Pesticides, Edited By: Frances A. Gunther, Jane Davies Gunther, Springer, ISBN: 978-1-4684-6253-1.
3. Cremlyn, R. (1978) Pesticides: Preparation and mode of action, 1st edition (October 19, 1978) John Wiley & Sons., 0471996319.
4. Kenneth, A., Hessall (2013) The chemistry of Pesticides, their Metabolism, Mode action and uses in crop, Bio-Green Books, ISBN13: 978-9386237118.
5. Sree Ramulu, U. S. (1979) Chemistry of insecticides and fungicides, 3rd Edition, Scientific Publishers; Edition: 2020, ISBN: 9789389832020.
6. Roberts, T.R., Hutson, D.H., Jewess P.J., (1998) Metabolic pathways of agrochemicals: insecticides and fungicides. Royal Society of Chemistry.
7. Handa, S.K., (2008) Principles of Pesticide Chemistry, Ed. By Agrobios (India) ISBN-13: 9788177542165 8. Singh Anupama et. al (2022) Basics of Agrochemical Formulations, Brillion Publishing; ISBN: 9789392725128.
8. Parmar, B.S., Tomar, S.S., (2010) Pesticide Formulation-Theory and practice, CBS Publisher; ISBN 13: 9788123911243.

Mapping with Sustainable Development Goals (SDGs)

SDG	SDG Title	Rationale
SDG 2	Zero Hunger	Role of agrochemicals in crop protection and food security
SDG 3	Good Health and Well-being	Understanding health hazards of pesticides and safe handling practices
SDG 4	Quality Education	Scientific training in agrochemistry, laboratory skills, and research awareness
SDG 12	Responsible Consumption and Production	Safe formulation, controlled pesticide use, waste reduction
SDG 13	Climate Action	Minimizing environmental impact and promoting sustainable agricultural chemistry
SDG 15	Life on Land	Protecting soil health, biodiversity, and ecosystems from pesticide misuse

Course Code: CY40005
Course Title: Bio-inorganic and Supramolecular Chemistry(C-18)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

After successful completion of Master degree, students will be provided knowledge about the advanced bioinorganic chemistry also inculcating supramolecular aspects which form the firm basis for the development of luminescent sensors and supramolecular devices.

Course Learning Outcomes: At the end of this course student will be able to:

CO1: Enumerate the basic principles of bio-inorganic chemistry in/to different biological and medicinal relevant systems (metal-biomolecules, bioactive metal-complexes, etc.)

CO2: Describe basic bioinorganic chemical experiments and be able to suggest potential experiments to solve a metal-related biological relevant question and also the concepts related to supramolecular chemistry and molecular recognition processes.

CO3: Employ the role of metal ions in the active sites, structure and functions of metalloproteins and enzymes containing Mg, Ca, V, Mn, Fe, Co, Ni, Cu and Zn ions

CO4: Investigate unknown supramolecular complexes and systems and to extract relevant parameters controlling the formation of individual molecular complexes and extended architectures.

CO5: Summarizing the different application of supramolecules.

CO-PO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	3	1	2	-	2	-	-	2	-	1	-	3	2	2	2
CO2	1	3	1	3	-	3	-	1	2	-	1	-	3	3	3	2
CO3	1	3	1	3	-	3	-	1	2	-	1	-	3	3	3	3
CO4	-	3	2	3	-	3	-	2	2	-	1	-	3	3	3	3
CO5	-	3	1	2	-	2	-	1	2	-	1	-	3	2	3	3

Course Content:

UNIT-I: Bio-inorganic chemistry (15 Lectures)

Metalloproteins and enzymes– Role of metal ions in the active sites, structure and functions of metalloproteins and enzymes containing Mg, Ca, V, Mn, Fe, Co, Ni, Cu and Zn ions. Detailed structure and mechanistic studies of the following–Mn-photosystem-II, catalase, pseudocatalase, oxygen carriers, haemoglobin, myoglobin, non-porphyrin oxygen carriers, hemerythrin, hemocyanin, Fe-ribonucleotide reductase, cytochrome c oxidases, cytochrome P-

450s, Ni-urease, hydrogenase, nitrogen fixation, Cu-blue copper protein, tyrosinase, galactose oxidase, superoxide dismutases, Zn-carbonicanhydrase, carboxypeptidase, alcohol dehydrogenase.Biological importance of Vitamin B12 and coenzymes, and their biomimetic studies.Toxic chemicals in the environment, toxic effects of arsenic, cadmium, lead, mercury, carbon monoxide, cyanide and other carcinogens, metal containing drugs in therapy, interaction of heavy metal ions with DNA, DNA cleavage, structure-activity relationship and mode of action. Organometallic compounds as therapeutic drugs and enzyme inhibitors.

UNIT-II: Fundamentals of supramolecules (15 Lectures)

Definitions, brief overview and examples; types of non-covalent interactions (H-bonding, electrostatic (ion-ion, iondipole, dipole-dipole), hydrophobic and steric, van der Waals), concepts of hostguest complexation with examples from ionophore chemistry, complexation of ions, molecular baskets, chalices and cages– podands, crown ethers, cryptands, calixarenes, macrocyclic effect, complexation of neutral molecules, self-assembly, molecular boxes and capsules, self-complementary species and self-replication.

UNIT-III: Methods for synthesis of supramolecules (8 Lectures)

Synthesis of macrocycles, synthesis of receptors for cations anions, and neutral molecules, non-covalent synthesis, metal directed selfassemblyof complex supramolecular architecture– rotaxanes, catenanes.

UNIT-IV: Application of supramolecules (7 Lectures)

Supramolecules in catalysis, asmembrane transport, sensors, phase-transfer catalysts, supramolecular devices and switches, memories, logic gates and related systems, molecular scale machines (mechanical rotors, gears and brakes), conversion of light into fuels and light intoelectricity.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Preparation of coordination complexes and their characterization by magnetic susceptibility measurements and IR, UV -Vis, TGA techniques.
2. Synthesis and structural characterization (IR, electronic spectra and magnetic susceptibility) of [Ni(py)4(NCS)2].
3. Synthesis and structural characterization (IR, Electronic spectra) of the cis- and trans isomers of [Co(en)2Cl2].
4. Synthesis and characterization (IR and PMR & CMR) of [Al(acac)3].
5. Preparation of N, Nbis (salicyldehyde) ethylenediamine, salenH2 and Co(Salen) complex.
6. Preparation of copper glycine complex-cis and trans bis (glycinato Copper (II).
7. Catalase activity from potato: effect of added metal ions.
8. Test of carbonic anhydrase (CA) inhibition by simple metal ions using pH-change assay.

Essential Readings:

Theory:

1. Steed, J.W. and Aswood, J.L., "Supramolecular Chemistry", Wiley.

2. Beer, P.D., Gale, P.A. and Smith, D.K., "Supramolecular Chemistry", Oxford Chemistry Printers, ISBN-10: 0-19-850447-0.
3. Dodziuk,,H., "Introduction to Supramolecular Chemistry", Springer, ISBN 1402002149
4. Schneider, H.J. and Yatsimirsky, A., "Principles and Methods in Supramolecular Chemistry", Wiley-VCH, ISBN: 0-471-97253-3.
5. Cragg, P., "A Practical Guide to Supramolecular Chemistry", Wiley-VCH, ISBN: 0-470-86654-3.

Practical:

1. Inorganic Experiments, J. Derck Woollins., VCH.
2. Microscale Inorganic Chemistry, Z. Szafran, R. M. Pike and M. M. Singh, Wiley.
3. Practical Inorganic Chemistry, G. Marr and B. W. Rockett, Van Nostrand.
4. Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed., Person (2007).

5. J. Chem. Educ., 1977, 54, 443, 1973, 50,670; Acc. Chem. Res., 1975, 8, 384.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-Being	Understanding metallodrugs, enzyme inhibitors, metal-based therapeutics, and biochemical mechanisms
SDG 4	Quality Education	Advanced interdisciplinary education in bioinorganic and supramolecular chemistry
SDG 9	Industry, Innovation and Infrastructure	Development of sensors, supramolecular devices, molecular machines, and functional materials
SDG 12	Responsible Consumption and Production	Awareness of toxic metals, safer chemical design, and responsible use of metal-containing compounds
SDG 13	Climate Action	Concepts related to light-to-energy conversion and sustainable molecular systems

Course Code: IK40051
Course Title: Scientific Research Methods (C-19)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

This course introduces students to the principles and methodologies of scientific research. It develops skills in research design, literature review, hypothesis formulation, data collection, statistical analysis, ethical research practices, scientific writing, and publication, enabling students to conduct independent, rigorous, and high-quality research in interdisciplinary scientific and technological domains.

Course Learning Outcomes:

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

CO1: Recall and describe the fundamental concepts of scientific research, research methodologies, research ethics, literature review, hypothesis formulation, research design, and data collection techniques.

CO2: Explain and interpret the principles of qualitative and quantitative research methods, sampling techniques, statistical analysis, experimental design, research ethics, intellectual property rights, and scholarly communication.

CO3: Apply appropriate research methodologies, statistical tools, and data analysis techniques to formulate research problems, conduct scientific investigations, and interpret research findings.

CO4: Analyze research literature, evaluate experimental results, assess the validity and reliability of data, and critically examine scientific findings using appropriate analytical and statistical methods.

CO5: Design and conduct independent research by integrating scientific methodologies, ethical practices, statistical analysis, and academic writing skills to prepare research proposals, technical reports, dissertations, and research publications.

CO-PO-PSO Mapping (Strong-3, Moderate-2, Low-1)

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

Course Content:

Unit 1: Scope of Research [5 Classroom Contact Hours]

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

Unit 2: Literature Survey, Databases and Research metrics [15 Classroom Contact Hours]

Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase,

Field, Boolean, Proximity, Concept, Limiting/Refining Search Results. Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index. Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN.

Unit 3: Communication in Science [13 Classroom Contact Hours]

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis. Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

Unit 4: Ethical Practices in Research and Publication [12 Classroom Contact Hours]

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS).

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
2. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.

3. Collection of chemical structure using ChemSpider and creating a database.
4. Curve fitting using freely available softwares/apps (any one)
5. Making of power point presentation
6. Technical writing on topics assigned.
7. Demonstration for checking of plagiarism using recommended software

Reference Book:

1. Kothari, C. R. & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th Edition). New Age International Publishers, New Delhi.
2. Day, R. A. & Gastel, B. (2024). *How to Write and Publish a Scientific Paper* (9th Edition). Cambridge University Press..
3. Gopalakrishnan, S. (2019). *Patent Law and Intellectual Property*. Eastern Book Company, Lucknow.
4. Bird, A. (2020). *Understanding Scientific Method*. Routledge, London..
5. Wallwork, A. (2020). *English for Writing Research Papers* (2nd Edition). Springer Nature, Cham.
6. Resnik, D. B. (2020). *The Ethics of Research with Human Subjects: Protecting People, Advancing Science, Promoting Trust*. Springer Nature, Cham.

SWAYAM Course

Research Methodology - https://onlinecourses.nptel.ac.in/noc24_ge41/preview

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Strengthens research skills, ethical awareness and scientific communication for higher education
SDG 9	Industry, Innovation & Infrastructure	Supports innovation through responsible research, data analysis and publication practices
SDG 16	Peace, Justice & Strong Institutions	Encourages integrity, transparency, accountability and trust in scientific research

Course Code: CY42001
Course Title: Electrochemistry (M-7)

Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurement of conductance and its applications, measurement of emf and its applications.

Course Learning Outcomes

By studying this course, students will be able to:

CO1: Define key concepts related to electrolytic dissociation, conductivity, and molar conductivity for both weak and strong electrolytes, and recall fundamental theories such as the Arrhenius theory and Kohlrausch's law of independent migration of ions.

CO2: Stufents will be able to explain the principles and equations governing ionic velocities, mobilities, and their determination, including the Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect etc.

CO3: Demonstrate the use of conductance measurements in practical applications such as determining the degree of dissociation of weak electrolytes, ionic product of water, solubility and solubility product.

CO4: They can analyze the quantitative aspects of Faraday's laws of electrolysis and the rules for oxidation/reduction based on half-cell potentials. Evaluate the applications of electrolysis in metallurgy and industry, and assess the principles and measurements related to electromotive force (EMF) of cells, including the Nernst equation and standard electrode potentials.

CO5: Determinethe impact of concentration cells, liquid junction potentials, and the determination of activity coefficients and transference numbers on electrochemical systems. Discuss the significance of potentiometric titrations, dipole moment, molecular polarizabilities.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	-	1	-	-	2	-	-	-	3	2	2	-
CO2	-	3	2	3	-	2	-	1	2	-	-	-	3	2	3	1
CO3	-	3	2	3	-	3	-	2	2	-	1	-	3	3	2	3
CO4	1	3	2	3	-	2	-	1	2	-	1	1	3	3	2	3
CO5	-	3	2	3	-	2	-	2	2	-	1	-	3	2	3	3

Course Content:

UNIT-I: Conductance-I (08 Lectures)

Arrhenius theory of electrolytic dissociation, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Molar conductivity at infinite dilution.Kohlrausch law of independent migration of ions.Debye-Huckel-Onsagar equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

UNIT-II: Conductance-II (12 Lectures)

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-III: Electrochemistry-I (13 lectures)

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells.Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes.

UNIT-IV: Electrochemistry-II (12 Lectures)

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers.Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).Dipole moment and molecular polarizabilities and their

measurements.Diamagnetism, paramagnetic, magnetic susceptibility and its measurement, molecular interpretation.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

Conductometry:

1. Determination of cell constant
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
    a) Strong acid vs. strong base
    b) Weak acid vs. strong base

Potentiometry:

Perform the following potentiometric titrations:
a) Strong acid vs. strong base
b) Weak acid vs. strong base
c) Dibasic acid vs. strong base
d) Potassium dichromate vs. Mohr's salt.

Essential readings:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin’s Physical Chemistry Ed., 10th Edition, Oxford University Press.

2. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.

3. Kapoor, K.L.(2013),A Textbook of Physical Chemistry,Vol 3, 3rd Edition, McGraw Hill Education.

4. Kapoor, K.L.(2015),A Textbook of Physical Chemistry,Vol 5, 3rd Edition, McGraw Hill Education.

5. McQuarrie, D. A.; Simon, J. D. (2004), Molecular Thermodynamics, Viva Books Pvt. Ltd.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.

2. Kapoor, K.L. (2019),A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

3.Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.

4. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).

5. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).

6. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

7. Rogers, D. W. Concise Physical Chemistry Wiley (2010). • Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

8. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens conceptual clarity, laboratory competence, analytical skills, and research readiness.
SDG 7	Affordable and Clean Energy	Electrochemical foundations of batteries, fuel cells, and energy conversion technologies.
SDG 9	Industry, Innovation and Infrastructure	Applications of electrolysis, EMF, and conductance in metallurgy and chemical industries.
SDG 12	Responsible Consumption and Production	Promotes efficient electrochemical processes and sustainable industrial practices.
SDG 13	Climate Action	Supports low-emission technologies and renewable energy systems through electrochemical knowledge.

DOUBLE MAJOR

Course Code: CY42003
Course Title: Basics of Drug Design and Medicinal Chemistry (DM-7)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

These objectives aim to provide students with a comprehensive understanding of drug design and medicinal chemistry, encompassing both synthetic and herbal approaches.

Course Learning Outcomes

By studying this course, students will be able to:

CO1: Explain the fundamental concepts and principles of drug design, including the role of physiochemical factors in drug activity.

CO2: Apply molecular modeling techniques to design and optimize drug molecules, and understand the interactions between ligands and receptors.

CO3: Synthesize and evaluate the effectiveness of analgesic and antimalarial drugs, understanding their chemical structures and therapeutic uses.

CO4: Analyze the synthesis, properties, and applications of antibacterial and antibiotic drugs, including sulphonamide drugs and their significance.

CO5: **Assess the importance of herbal medicine in drug design, and identify key Indian medicinal plants and their uses.**

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	1	2	1	1	-	-	1	-	-	-	3	2	2	1
CO2	-	3	1	3	-	2	-	2	1	-	-	-	3	3	3	2
CO3	-	3	1	2	-	2	-	-	1	-	-	-	3	3	2	3
CO4	-	3	1	3	-	2	-	-	1	-	-	-	3	3	2	3
CO5	1	2	1	2	3	1	-	-	1	-	-	2	3	2	2	2

Course Content:

UNIT-I: Basic Concept of Drug Design & Physiochemical Factors (10 Lectures)

Introduction; Basics of drug design; analog and Prodrug; Cocept of lead; Factors governing drug design; Rational approach to drug design. Physical-Chemical factors and biological activities; Factors governing ability of drug to reach active site.

UNIT-II: Molecular Modeling & Ligand Design Concept (15 Lectures)

Concept of structure of drug molecules and its optimization; Molecular modeling and drug design; Basic concept of Protein and its structure; Structure based drug design; Ligand receptor recognition; Active site of a target molecules; Characterization of site and design of ligands.

UNIT-III: Analgesic & Antimalerial Drugs (10 Lectures)

Concept of Analgesics drug; Synthesis and use of analgesics drugs: Paracetamol, Phenacetine, Acetanilide, Aspirin, Salol, Cinchophene, and Phenazone. Antimalerial Drugs: Synthesis and use of Chloroquine phosphate.

UNIT-IV: Antibacterial & Antibiotic (10 Lectures)

Sulphonamide drugs, Antibacterial properties. Synthesis and use of Sulphonamide drugs: Sulphanilide, Sulphapyridine, Sulphathiazole, Sulphadiazine, Concept of Antibiotics with its application.

Herbal medicine

Herbal Drug: Its importance Ethanobotanical survey methods; introduction to ayurveda, pharmacopia; plants as source of drugs; Indian medicinal plants and uses - Tulasi, Neem, Pili, Mango, Sarpagandhi, Gulbakavali, Shyma Haldi, Vanchana, Safed Musli, Aswagandha, Satavar, Pipalendi, Digitalis, Senna, Clove, Cardamom, Plantago, Artemisia annua, Coleus forskoli, Aloe Patal Kumhda, Banpyaz.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

(a) Drawing of different organic molecules using ChemDraw and ChemSketech software.

(b) Synthesis and characterization of following drugs:

1. Paracetamol, 2. Acetanilide, 3. Aspirin, 4. Phenazone 5. Ibuprofen

Essential Readings:

1. Asutosh Kar, Medicinal Chemistry, New Age Publication.
2. P. D. Sethi, Dilip Charegaonkar: Identification of Drugs and PharmaceuticalFormulations by Thin Layer Chromatography –2nd Edition.
3. G.E. Trease, W.C. Evans: Pharmacognosy, ELBS.
4. Varro E.Tyler, Lynn. R.Brady, James E.Robbers: Pharmacognosy.
5. T.E. Wallis: Text Book of Pharmacognosy, CBS Pub. Delhi.
6. Kirthikar, Basu: Indian Medicinal Plants.
7. K.M. Nalkarni: Indian Meteria Medica,
8. W. Dymock: Pharmacographia Indica

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Enhances understanding of drug design, synthesis, and evaluation of analgesic, antimalarial, antibacterial, and antibiotic drugs contributing to improved healthcare outcomes.
SDG 4	Quality Education	Strengthens conceptual clarity in medicinal chemistry, promotes laboratory competence, molecular 218odelling skills, and research-oriented learning.
SDG 9	Industry, Innovation and Infrastructure	Supports pharmaceutical innovation through rational drug design, molecular 218odelling, and synthesis of therapeutically important compounds.
SDG 12	Responsible Consumption and Production	Encourages sustainable drug synthesis practices, responsible use of chemicals, and awareness of green and ethical pharmaceutical production.
SDG 15	Life on Land	Promotes conservation and sustainable use of medicinal plants through the study of herbal drugs and traditional knowledge systems.

SEMESTER-VIII

Course Code: CY40002
Course Title: Molecular Spectroscopy(C-20)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The objective of this course is to provide students with a comprehensive understanding of the fundamental principles of absorption, emission, and scattering of electromagnetic radiation by molecules. It aims to introduce them to the theoretical and practical aspects of rotational, vibrational, Raman, and electronic spectroscopies, enabling them to analyze and interpret molecular spectra for structural and functional characterization. In addition, the course is designed to equip students with hands-on laboratory experience in commonly used spectroscopic techniques, thereby bridging theoretical concepts with practical applications in chemistry and related fields.

Course Learning Outcomes: At the end of this course, the students will be able to:

CO1: **Explain the fundamental principles of spectroscopy** and describe the interaction of electromagnetic radiation with matter across different regions of the spectrum.

CO2: **Interpret rotational and vibrational spectra** of diatomic and polyatomic molecules to determine molecular parameters such as bond lengths, force constants, vibrational frequencies, and modes of vibration.

CO3: **Analyze Raman spectra** using classical and quantum approaches, apply polarizability and selection rules, and evaluate the applications of Raman spectroscopy in chemical and biological systems.

CO4: **Differentiate between electronic transitions and photophysical processes,** applying concepts such as the Franck–Condon principle, singlet and triplet states, fluorescence, and phosphorescence.

CO5: **Apply spectroscopic techniques for molecular characterization,** including identifying dissociation and predissociation phenomena, and utilize spectroscopy as a tool in chemical, physical, and biological research.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4

CO1	–	3	2	2	–	1	–	1	2	–	1	–	3	2	2	1
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO3	–	3	2	3	–	3	1	2	2	–	2	1	3	3	3	3
CO4	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO5	1	3	2	3	–	3	1	2	3	1	2	1	3	3	3	3

Course Content:

UNIT-I: Fundamentals of Spectroscopy (8 Lectures)

Historical development and importance of spectroscopy in chemical sciences, Definition and scope: absorption, emission and scattering processes. Electromagnetic spectrum: classification of regions (microwave, IR, visible, UV, X-ray) and corresponding energy transitions in molecules. Concept of quantization of energy: rotational, vibrational and electronic energy levels. Born-Oppenheimer approximation.

UNIT-II: Rotational and Vibrational spectroscopy (18 Lectures)

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, degrees of freedom for polyatomic molecules, modes of vibration.

UNIT-III: Raman Spectroscopy: (12 Lectures)

Classical and quantum theories of Raman Effect, Rotational and vibrational Raman spectra, Polarizability and selection rules, Resonance Raman spectroscopy, applications in chemical and biological system.

UNIT-IV: Electronic Spectroscopy: (7 Lectures)

Electronic transitions,Franck-Condon principle, singlet and triplet states, fluorescence and phosphorescence, dissociation, predissociation and their spectroscopic significance.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Study of the UV–Vis absorption spectrum of $KMnO_4$ / $K_2Cr_2O_7$** and determination of λmax.
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of K2Cr2O7.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
4. Verification of Beer Lambert's law.
5. Functional group identification of unknown organic solid by IR spectroscopy.
6. Electronic spectra of organic dyes (methylene blue, crystal violet, rhodamine).
7. Spectroscopic study of biomolecules (proteins, amino acids, nucleic acids) using UV/IR/Raman.
8. **Determination of molar absorptivity** and concentration of an unknown solution using absorption spectroscopy.

Essential readings:

Theory:

1. C.N. Banwell & E.M. McCash – Fundamentals of Molecular Spectroscopy
2. J.M. Hollas – Modern Spectroscopy
3. G. Aruldhas – Molecular Structure and Spectroscopy
4. P.S. Sindhu – Molecular Spectroscopy
5. Pavia et al. – Introduction to Spectroscopy
6. P. S. Kalsi – Spectroscopy of Organic Compounds (New Age International)

Practical:

1. G. M. Khopkar – *Basic Concepts of Analytical Chemistry*
2. D. A. Skoog, D. M. West, F. J. Holler & S. R. Crouch – *Fundamentals of Analytical Chemistry* (Cengage)

3. Willard, Merritt, Dean & Settle – *Instrumental Methods of Analysis*
4. M. Yadav – *Spectroscopy: Theory and Practice*
5. C. N. Banwell – *Practical Molecular Spectroscopy*

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Applications of molecular spectroscopy in biomolecular studies (proteins, nucleic acids) help understand biochemical processes relevant to health.
SDG 4	Quality Education	Strengthens theoretical understanding, practical laboratory skills, analytical reasoning, and research readiness in spectroscopy.
SDG 9	Industry, Innovation and Infrastructure	Spectroscopy techniques are critical in chemical, pharmaceutical, and materials industries for structural and functional analysis.
SDG 12	Responsible Consumption and Production	Promotes efficient use of chemicals and laboratory resources during spectroscopic experiments.
SDG 13	Climate Action	Indirect contribution through analytical techniques that monitor environmental pollutants and chemical processes affecting climate.

Course Code: CY42002
Course Title: Basic Spectroscopy in Chemistry (M-8)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

The objective of this course is to provide students with a comprehensive understanding of the fundamental principles of absorption, emission, and scattering of electromagnetic radiation by molecules. It aims to introduce them to the theoretical and practical aspects of rotational, vibrational, Raman, and electronic spectroscopies, enabling them to analyze and interpret molecular spectra for structural and functional characterization. In addition, the course is designed to equip students with hands-on laboratory experience in commonly used spectroscopic techniques, thereby bridging theoretical concepts with practical applications in chemistry and related fields.

Course Learning Outcomes: At the end of this course, the students will be able to:

CO1: **Explain the fundamental principles of spectroscopy** and describe the interaction of electromagnetic radiation with matter across different regions of the spectrum.

CO2: **Interpret rotational and vibrational spectra** of diatomic and polyatomic molecules to determine molecular parameters such as bond lengths, force constants, vibrational frequencies, and modes of vibration.

CO3: **Analyze Raman spectra** using classical and quantum approaches, apply polarizability and selection rules, and evaluate the applications of Raman spectroscopy in chemical and biological systems.

CO4: **Differentiate between electronic transitions and photophysical processes,** applying concepts such as the Franck–Condon principle, singlet and triplet states, fluorescence, and phosphorescence.

CO5: **Apply spectroscopic techniques for molecular characterization,** including identifying dissociation and predissociation phenomena, and utilize spectroscopy as a tool in chemical, physical, and biological research.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	2	2	–	1	–	1	2	–	1	–	3	2	2	1
CO2	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO3	–	3	2	3	–	3	1	2	2	–	2	1	3	3	3	3
CO4	–	3	2	3	–	2	–	2	2	–	1	–	3	3	3	2
CO5	1	3	2	3	–	3	1	2	3	1	2	1	3	3	3	3

Course Content:

UNIT-I: Fundamentals of Spectroscopy (8 Lectures)

Historical development and importance of spectroscopy in chemical sciences, Definition and scope: absorption, emission and scattering processes. Electromagnetic spectrum: classification of regions (microwave, IR, visible, UV, X-ray) and corresponding energy transitions in molecules. Concept of quantization of energy: rotational, vibrational and electronic energy levels. Born-Oppenheimer approximation.

UNIT-II: Rotational and Vibrational spectroscopy (18 Lectures)

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, degrees of freedom for polyatomic molecules, modes of vibration.

UNIT-III: Raman Spectroscopy: (12 Lectures)

Classical and quantum theories of Raman Effect, Rotational and vibrational Raman spectra, Polarizability and selection rules, Resonance Raman spectroscopy, applications in chemical and biological system.

UNIT-IV: Electronic Spectroscopy: (7 Lectures)

Electronic transitions, Franck-Condon principle, singlet and triplet states, fluorescence and phosphorescence, dissociation, predissociation and their spectroscopic significance.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Study of the UV–Vis absorption spectrum of $KMnO_4$ / $K_2Cr_2O_7$** and determination of λmax.
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of K2Cr2O7.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
4. Verification of Beer Lambert's law.
5. Functional group identification of unknown organic solid by IR spectroscopy.
6. Electronic spectra of organic dyes (methylene blue, crystal violet, rhodamine).
7. Spectroscopic study of biomolecules (proteins, amino acids, nucleic acids) using UV/IR/Raman.
8. **Determination of molar absorptivity** and concentration of an unknown solution using absorption spectroscopy.

Essential readings:

Theory:

9. C.N. Banwell & E.M. McCash – Fundamentals of Molecular Spectroscopy
10. J.M. Hollas – Modern Spectroscopy
11. G. Aruldhas – Molecular Structure and Spectroscopy
12. P.S. Sindhu – Molecular Spectroscopy
13. Pavia et al. – Introduction to Spectroscopy
14. **P. S. Kalsi** – Spectroscopy of Organic Compounds (New Age International)

Practical:

1. G. M. Khopkar – *Basic Concepts of Analytical Chemistry*
2. D. A. Skoog, D. M. West, F. J. Holler & S. R. Crouch – *Fundamentals of Analytical Chemistry* (Cengage)
3. Willard, Merritt, Dean & Settle – *Instrumental Methods of Analysis*
4. M. Yadav – *Spectroscopy: Theory and Practice*
5. C. N. Banwell – *Practical Molecular Spectroscopy*

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Applications of molecular spectroscopy in biomolecular studies (proteins, nucleic acids) help understand biochemical processes relevant to health.
SDG 4	Quality Education	Strengthens theoretical understanding, practical laboratory skills, analytical reasoning, and research readiness in spectroscopy.
SDG 9	Industry, Innovation and Infrastructure	Spectroscopy techniques are critical in chemical, pharmaceutical, and materials industries for structural and functional analysis.
SDG 12	Responsible Consumption and Production	Promotes efficient use of chemicals and laboratory resources during spectroscopic experiments.
SDG 13	Climate Action	Indirect contribution through analytical techniques that monitor environmental pollutants and chemical processes affecting climate.

Course Code: RD40082
Course Title: Research and Dissertation
Total Credits: 12 (Credits: Practical-180)

Course Learning Objectives:

The Objective is to enable student to identify a problem in the field of chemistry and to carry out literature survey, design an experiment, perform experiment, analyse data and write a report.

Course Learning Outcomes:

By the end of the dissertation, the students will be able to;

CO1: Do survey, study and cite published literature on a particular area of interest.

CO2: Correlate the experimental observations with theoretical understanding.

CO3: Interpret results, write a report and submit to the supervisor.

CO4: Use laboratory resources judiciously.

CO5: Work in a team under the supervision of a teacher. Develop scientific writing skills.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

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

Course Content:

UNIT-I: Identification of research problem

UNIT-II: Survey of literature

UNIT-III: Formulation of hypothesis, experimental design and methodology

UNIT-IV: Analysis of data and interpretation of results

UNIT-V: Discussion and conclusion

UNIT-VI: Writing a project report

Assessment Methods:

The assessment will be through evaluation of the dissertation, presentation and viva voce involving external and internal examiners.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Develops research skills, scientific writing, critical thinking, data analysis, and lifelong learning competencies.
SDG 9	Industry, Innovation and Infrastructure	Promotes scientific research, innovation, experimental design, and the development of new technologies and solutions.
SDG 12	Responsible Consumption and Production	Encourages systematic research for efficient resource utilization, sustainable practices, and evidence-based decision-making.
SDG 13	Climate Action	Supports research addressing environmental challenges, climate-related studies, and sustainable development strategies where applicable.
SDG 17	Partnerships for the Goals	Strengthens research collaboration, knowledge sharing, interdisciplinary studies, and dissemination of scientific findings through project reports.

Course Code: CY42004
Course Title: Advanced Organic Chemistry (DM-8)
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Objectives:

These objectives aim to provide students with a comprehensive understanding of advanced organic chemistry concepts, equipping them with the skills to analyze, design, and execute complex organic syntheses and reaction mechanisms.

Course Learning Outcomes:

By the end of the dissertation, the students will be able to;

CO1: Understand and apply the nomenclature rules for complex organic molecules including bicyclic, spirocyclic, polycyclic, and heterocyclic compounds.

CO2: Analyze stereochemical properties and determine the stereoisomeric purity of organic compounds.

CO3: Evaluate reaction mechanisms and kinetic data to determine the pathways of organic reactions.

CO4: Synthesize and interpret the outcomes of pericyclic and free radical reactions in organic synthesis.

CO5: Design and perform functional group interconversions and stereoselective reactions in organic synthesis.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	–	3	1	2	–	1	–	–	2	–	–	–	3	2	2	1
CO2	–	3	2	3	–	2	–	1	2	–	1	–	3	2	3	2
CO3	1	3	2	3	–	3	–	2	2	–	2	–	3	3	3	3
CO4	1	3	2	3	–	3	1	2	2	–	2	–	3	3	3	3
CO5	2	3	2	3	–	3	1	2	3	1	3	1	3	3	3	3

Course Content:

UNIT-I: Nomenclature (10 Lectures)

Basic nomenclature of bicyclic compounds: Spirocyclic, Polycyclic compounds and heterocyclic compounds.

UNIT-II: Stereochemistry (15 Lectures)

Definition of Stereochemistry, Properties of stereoisomers, Tartaric acid and it's various isomers, Enantiomeric purity, How do we measure enantiomeric purity, Definition of d.r.; e.r.; ee. Topism, Diastereotopic, Enantiotopic. Prochirality, Making compounds Chiral, Prochiral at sp2 carbon.

UNIT-III: Reaction Mechanism (10 Lectures)

SN2, SN1 Rate equation, Eyring equation, Linear free Energy relationship. Determining the mechanism of a reaction: Detection and trapping of intermediates, Cross-over experiments, kinetic isotopic effect-primary kinetic and secondary kinetic isotopic effect.

UNIT-IV: Introduction of Pericyclic Reaction and Free radical Chemistry (10 Lectures)

Definition of Pericyclic reaction.classification of Pericyclic reactions. Cycloaddition reaction (Diels-Alder reaction and it's application to the natural products), Sigmatropic rearrangements. Free radical initiation, Barton Reaction, Hoffmann-Loffler-Freytag reaction, Deoxygenation reaction, dehalogenation reaction.

Functional Group Interconversions: Functional Groups, Oxidation state, Markonikov-Antimarkonikov addition, Hydration, Acetal/ketal or thioketal formation, Selective reduction, Oxidation of alcohols (Swern oxidation, DMP-oxidation), Stereoselective oxidation and reduction.

Stereoselective C-C bond formation reaction: Carbon nucleophile and electrophile, LDA to make enolate, Carbonyl compound reactions, Enolate and pka, The aldol reaction. Claisen and Dieckmen condensastion reaction, Michael addition and Robinson annulations reaction.Acid Promoted reaction (Prins reaction, F-C alkylation and acylation reaction).Benzoin and acylanion equivalent.Retrosynthetic analysis for DA and Robinson annulations reaction.

Practicals: Credits: 01

(Laboratory periods:15 classes of 2 hours each)

1. Hands on experiences: a) To determine the enantiomeric purity (ee/er) by HPLC chromatogram. b) To determine the diastereoisomers ratio from NMR Spectra. c) Analyze the 1H-NMR Spectra of any organic molecules. d) Analyze the 2D-13C-NMR spectra of any organic molecules.

2. Synthesis of an Imidazolidinone Oraganocatalyst and its application in a DA Reaction: Multistep Synthesis. a) Catalyst synthesis b) Diels-Alder reaction. c) Purification step d) Spectral data analysis (1H-NMR and 13C-NMR)

3. Robinson annulations a) Two step synthesis of Wieland-Miescher ketone from 1,3-diketone and enones. b) Asymmetric synthesis by chiral proline catalyst c) HPLC Chromatogram and spectral data interpretation.

4. Rearrangement of trans-stilbene Oxide with Bi(OTf)3 and other metal triflates.

5. Oxidation and Reduction a) Oxidation of secondary alcohol to ketone b) Oxidation of primary alcohol to aldehyde c) Reduction of aldehyde/ketone by NaBH4 d) Reduction of Ester by using LialH4.

Essential readings:

Theory:

1. Advanced Organic Chemistry –by J. March 6th Edition
2. Advance Organic Chemistry (part A) –by A. Carey and R.J. Sundberg
3. Stereochemistry of carbon compound-by E.L. Eliel
4. Stereochemistry of organic compound-by Nasipuri
5. J. Singh & J.Singh, Photochemistry and Pericyclic Reactions
6. W. Carruthers, Some Modern Methods of Organic Synthesis, Cambridge University, Press, 1993.
7. Bessler and Silverstein, Spectroscopy of Organic Compounds, JOHN WILEY, 2001.
8. D. C. Pavia, G. M. Lampman, G. S. Kriz, Introduction to Spectroscopy, 3rd Edition, 2007. Organic Spectroscopy III Edition–by William Kemp.

Practical:

1. Bessler and Silverstein, Spectroscopy of Organic Compounds, JOHN WILEY, 2001.
2. J. Chem. Edu. DOI: 10.1021/acs.jchemed.5b00812
3. J. Chem. Edu. 2008, 85, 1531.
4. J. Chem. Edu. 2011, 88, 1014.
5. J. Chem. Edu. 2008, 85, 1274.
6. Practical Organic Chemistry by A. I. Vogel.
7. Practical Organic Chemistry by F. G. Mann and B. C. Saunders.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens conceptual clarity, analytical thinking, hands-on lab competence, and research readiness in organic chemistry.
SDG 9	Industry, Innovation and Infrastructure	Applications of pericyclic, free radical, and stereoselective reactions in chemical synthesis and pharmaceutical industries.
SDG 12	Responsible Consumption and Production	Promotes efficient use of reagents, green chemistry principles in multi-step synthesis, and responsible lab practices.
SDG 3	Good Health and Well-being	Understanding synthesis of biologically active molecules, drug intermediates, and organocatalysts supporting medicinal chemistry.
SDG 13	Climate Action	Encourages minimizing chemical waste and adopting sustainable synthetic protocols where possible.

If not going for Research Work

Course Code: CY40004
Course Title: Organic Synthesis
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

To gain an in-depth understanding of various functional group transformations, classical and modern techniques in synthetic chemistry, synthetic planning and targeted synthesis of complex molecules. Detailed information and analysis of common synthetic techniques and methods will be gained. Using this knowledge, exercises on the planning of synthesis of complex scaffolds and targets will be carried out. Breakdown of complex molecules into simple building blocks for synthesis will be learned. A few case studies of total synthesis to understand the actual application of synthetic methods in real life problem solving will also be learned. Students are expected to design retrosynthesis and forward synthesis of complex targets at the end of the course.

Course Learning Outcomes:

CO1 An up-to-date knowledge of modern reagents used in synthesis for FGIs and macrocycle formation.

CO2 Understanding of modern trends in synthesis such as multicomponent reactions, click chemistry, CH activation and organocatalysis.

CO3 Development of ability to consider and analyze the sustainability, economics, safety and toxicity aspects of organic synthesis.

CO4 Ability to analyze complex molecular structures to identify key structural features and devise ways of constructing them.

CO5 Understanding of strategies and tactics of organic synthesis such as protection, deprotection, umpolung, order of events etc.

CO-PO-PSO Mapping (Strong-3, Moderate-2, Low-1)

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

Course Content:

UNIT-I: Functional Group Transformations using Miscellaneous Reagents and Reactions: (10 Lectures)

Amide coupling reagents (DCC, DIC, EDC, BOP, HOBt), macrolactonization, Mukiyama reagent; Mitsunobu reaction; Silyl and stannyl hydrides, Burgess reagent, Lawesson's reagent, CH2N2, TMSCHN2, Finkelstein reaction, Eschenmoser-Tanabe, Ohira-Bestmann reagent.

UNIT-II: Classical and Modern Methods in Synthesis (12 Lectures)

Illustration of the following concepts with examples; Multicomponent reactions (Strecker, Mannich, Biginelli, Passerini and Ugi reactions), click chemistry, cascade and domino processes for multiple C-C bond forming reactions (radical cyclisations, electrocyclic cascades, polyenecyclizations), CH-activation and remote functionalization, asymmetric organocatalysis (proline, NHCs), biocatalysis, Reusable reagents, biomimetic synthesis.

UNIT-III: Asymmetric Synthesis: (08 Lectures)

Principle of asymmetric synthesis, Chiral auxiliaries, methods of asymmetric induction– substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic, application in the synthesis of simple natural products.

UNIT-IV: Retrosynthetic and Disconnection Approach: (15 Lectures)

Concept of retrosynthesis, disconnection approach, introduction to synthons and synthetic equivalents, linear and convergent synthesis, types of transforms, functional group interconversions, classification of disconnections, one group and two group disconnections for C-C bond and C-X bond. Chemo selectivity, control of stereochemistry, reversal of polarity (umploung), common building blocks, the importance of the order of events in organic synthesis, applications of alkynes, aliphatic nitro compounds, bifunctional compounds, Protection and deprotection of amine and alcohol.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. ORGANIC SYNTHESIS: Preparation of organic compound involving one-step reaction. (Prepare at least three compounds)
   [Important Note: Greener protocols to be used wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and melting points.]
2. INDUSTRIAL VISIT: In order to get an exposure on how chemical industries function, department will arrange an industrial visit. Students to prepare a report on the industrial visit.

Essential readings:

Theory:

1. S. Caron, Practical Synthetic Organic Chemistry: reactions, Principles and Technique, 2nd Edition. Wiley, 2020.
2. S. Warren, Designing Organic Synthesis, Wiley, 2011.
3. F. A. Carey and R. J. Sandburg, Advanced Organic Chemistry Part B, Plenum Press, 2009.
4. T. Hudlický and J. W. Reed, The Way of Synthesis, Wiley VCH-Weinheim 2007.
5. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis- An Introduction, W. H. Freeman & Co., 2007.
6. J. March, Advanced Organic Chemistry, Reactions Mechanisms and Structure, John Wiley, 2005.
7. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, Blackie Academic & Professional, 2002.
8. K. C. Nicolaou and E. J. Sorensen, Classics in Total Synthesis, Wiley VCH-Weinheim, 1996.
9. W. Carruthers, Some Modern Methods of Organic Synthesis, Foundation Books, 1995.
10. Fieser and Fieser, Reagents in Organic Synthesis, Wiley, 1993.
11. H. O. House, W.A. Benjamin, Modern Synthetic Reactions, 1990.

Practical:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. Cengage learning, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition, CRC Press, 2015.
3. R. K. Bansal, Laboratory Manual in Organic Chemistry, Wiley, 2006.
4. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5th Edition Paperback, Pearson, 2003.
5. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, Prentice Hall, Instructor's Edition, 1992.

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Advanced training in modern organic synthesis and research skills

SDG 8	Decent Work & Economic Growth	Skill development for chemical, pharmaceutical and research industries
SDG 9	Industry, Innovation & Infrastructure	Innovation in synthetic methodologies and industrial applications
SDG 12	Responsible Consumption & Production	Promotion of green chemistry and sustainable synthesis
SDG 13	Climate Action	Environment-friendly chemical processes and pollution control

Course Code: CY40006
Course Title: Green Chemistry
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The objectives of this course are as follows:

1. To make the society to become more and more environmentally conscious by knowing huge rise in environmental pollution, depleting resources, climate change, ozone depletion, heaps and heaps of landfills piling up has forced.
2. To improve the creative and innovative thinking in undergraduate students towards sustainable practices of Green Chemistry. has arisen from these concerns.
3. To know the Green chemistry in a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. To trained them to practice chemistry in the safest way in the laboratories as well as the chemical industry and extends to society in a sustainable future for the planet.

Course Learning Outcomes

By studying this course, students will be able to:

CO1: Understand the twelve principles of green chemistry and also build the basic understanding of toxicity, hazard and risk related to chemical substances.

CO2: Calculate atom economy, E-factor and relate them in all organic synthesis

CO3: Learn to use green solvents, renewable feedstock and renewable energy sources for carrying out safer chemistry

CO4: Learn to design safer processes, chemicals and products through understanding of inherently safer design (ISD)

CO5: Appreciate the success stories and real-world cases as motivation for them topractice green chemistry.Appreciate the use of green chemistry in problem solving skills and critical thinking to innovate and find solutions to environmental problems.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	2	2	2	–	1	2	–	2	3	3	2	2	3
CO2	1	3	1	3	–	2	–	2	2	–	1	2	3	2	2	3
CO3	2	3	2	3	2	2	1	2	2	–	2	3	3	3	3	3
CO4	3	3	2	3	1	3	1	2	2	1	3	3	3	3	3	3
CO5	3	3	2	3	2	3	1	2	3	1	2	3	3	3	3	3

Course Content:

UNIT-I: Introduction (8 Lectures)

Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry. Need of green chemistry. Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each). A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).

UNIT-II: Twelve Principles of Green Chemistry (12 Lectures)

The twelve principles of the Green Chemistry with their explanations Special emphasis on the following:

• Prevention of waste / by products, pollution prevention hierarchy.

• Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.

• Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.

•Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

• Green energy and sustainability.

• Real-time analysis for pollution prevention.

Prevention of chemical accidents, designing greener processes, principles of inherent safer design (ISD).Bhopal Gas Tragedy (safer route to carbaryl) and Flixborough accident (safer route to cyclohexanol), subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

UNIT-III: Real-world Cases in Green Chemistry (10 Lectures)

Discussion of the following Real-world Cases in green chemistry: Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Right fit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

UNIT-IV: Future Trends in Green Chemistry (15 Lectures)

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

Green Chemistry in the Fine chemicals and Pharmaceutical Industries

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Solvent-free Aldol Condensation using Grinding Technique.
2. Microwave-assisted Synthesis of Aspirin (Acetylsalicylic Acid).
3. Green Synthesis of Silver Nanoparticles using Plant Extract.
4. Green synthesis of MgO Nanoparticles using Plant Extracts.
5. Green synthesis of TiO2 Nanoparticles using Plant Extracts.
6. Synthesis of Benzylideneacetone by Solvent-free Claisen–Schmidt Condensation.
7. Biocatalytic Esterification using Lipase Enzyme in Aqueous Medium.
8. Recrystallization using Water as a Green Solvent (instead of organic solvents).
9. Green Oxidation of Alcohols using Hydrogen Peroxide as Oxidant.
10. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Essential readings:

Theory:

1. Anastas, P.T., Warner, J.C. (2014), Green Chemistry, Theory and Practice, Oxford University Press.

2. Lancaster, M. (2016), Green Chemistry: An Introductory Text, 3rd Edition, RSC Publishing.

3. Cann, M. C., Connely, M.E. (2000), Real-World cases in Green Chemistry, American Chemical Society, Washington.

4. Matlack, A.S. (2010), Introduction to Green Chemistry, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.

5. Alhuwalia, V.K., Kidwai, M.R. (2005), New Trends in Green chemistry, Anamalaya Publishers.

6. Sidhwani, I.T, Sharma, R.K. (2020), An Introductory Text on Green Chemistry, Wiley India Pvt Ltd.

Practical:

1. Kirchoff, M.; Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment, American Chemical Society, Washington DC.

2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi.

3. Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B. (2012), Introduction to organic Laboratory Technique- A Microscale approach, 4th Edition, Brooks-Cole Laboratory Series -for Organic chemistry.

4. Sindhwani I.T. (2015), Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. DU Journal of Undergraduate Research and Innovation, 1(1),131-151. ISSN: 2395- 2334.

5. Sidhwani, I.T; Sharma, R.K. (2020), An Introductory Text on Green Chemistry, Wiley India Pvt Ltd.

6. Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.

Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution

SDG 3	Good Health and Well-being	Reduces exposure to toxic chemicals, promotes safer chemical practices, and supports environmentally conscious health measures.
SDG 4	Quality Education	Builds critical thinking, problem-solving, and practical skills in students with hands-on green chemistry experiments.
SDG 6	Clean Water and Sanitation	Promotes use of safer reagents, renewable solvents, and reduces contamination of water resources.
SDG 7	Affordable and Clean Energy	Encourages the use of renewable energy and energy-efficient processes in chemical synthesis.
SDG 12	Responsible Consumption and Production	Minimizes waste generation, maximizes atom economy, and encourages sustainable chemical practices.
SDG 13	Climate Action	Reduces chemical pollution, promotes environmentally friendly reactions, and supports climate-conscious lab practices.

Course Code: CY40008
Course Title: Inorganic Materials of Industrial Importance
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The objectives of this course are as follows:

- To make students understand the diverse roles of inorganic materials in the industry and to give an insight into how these raw materials are converted into products used in day-to-day life.
- To make students learn about silicates, fertilizers, surface coatings, batteries, engineering materials for mechanical construction.
- To develop the interest of students in the frontier areas of inorganic and material chemistry.

Course Learning Outcomes

By studying this course, the students will be able to:

CO1: To learn the composition and applications of the different kinds of glasses & ceramics.
CO2: To understand the composition of cement and the mechanism of setting of cement.
CO3: To explain the suitability of fertilizers for different kinds of crops and soil.
CO4: To explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
CO5: To explain the principle, working and applications of different batteries.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	–	3	1	2	2	1	–	–	2	–	–	2	3	2	2	2
CO2	1	3	1	3	–	2	–	–	2	–	1	2	3	2	2	3
CO3	2	3	2	3	1	2	–	1	2	–	1	3	2	3	2	3
CO4	2	3	2	3	1	2	–	1	2	–	2	3	2	3	3	3
CO5	1	3	2	3	–	2	–	2	2	1	1	2	3	3	3	3

Course Content:

UNIT-I: Silicate Industries (12 Lectures)

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

Fertilizers: Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime and potassium nitrate.

UNIT-II: Surface Coatings (18 Lectures)

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC)and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing. Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

UNIT-III: Batteries (09 Lectures)

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Liion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.

UNIT-IV: Nano dimensional materials (06 Lectures)
Introduction to zero, one and two-dimensional nanomaterial: Synthesis, properties and applications of fullerenes, carbon nanotubes, carbon fibres, semiconducting and superconducting oxides.

Practicals: Credits: 01
(Laboratory periods: 15 classes of 2 hours each)
1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.
2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
4. Analysis of (Cu, Ni) in alloy or synthetic samples (methods involving Gravimetry and Spectrophotometry).
5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, and Potentiometry).
6. Synthesis and structural characterization of pure ZnO nanoparticle.
7. Synthesis of Cu doped ZnO nanoparticles by solid state method.
8. Dielectric study of a semiconducting metal oxide.

Essential readings:

Theory:
1. West, A. R. (2014),Solid State Chemistry and Its Application, Wiley
2. Smart, L. E.; Moore, E. A. (2012),Solid State Chemistry An Introduction, CRC Press Taylor & Francis.
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Mapping with Sustainable Development Goals (SDGs)

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Enhances analytical thinking, problem-solving, and practical skills through lab experiments and case studies.
SDG 7	Affordable and Clean Energy	Explains principles of batteries, fuel cells, and energy storage materials.
SDG 9	Industry, Innovation and Infrastructure	Knowledge of silicates, surface coatings, and nanomaterials supports industrial applications and innovations.
SDG 12	Responsible Consumption and Production	Encourages sustainable production practices, safer materials, and efficient use of chemical resources.
SDG 13	Climate Action	Promotes understanding of environmentally safer materials and green alternatives in industrial chemistry.

********* **End** **********



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