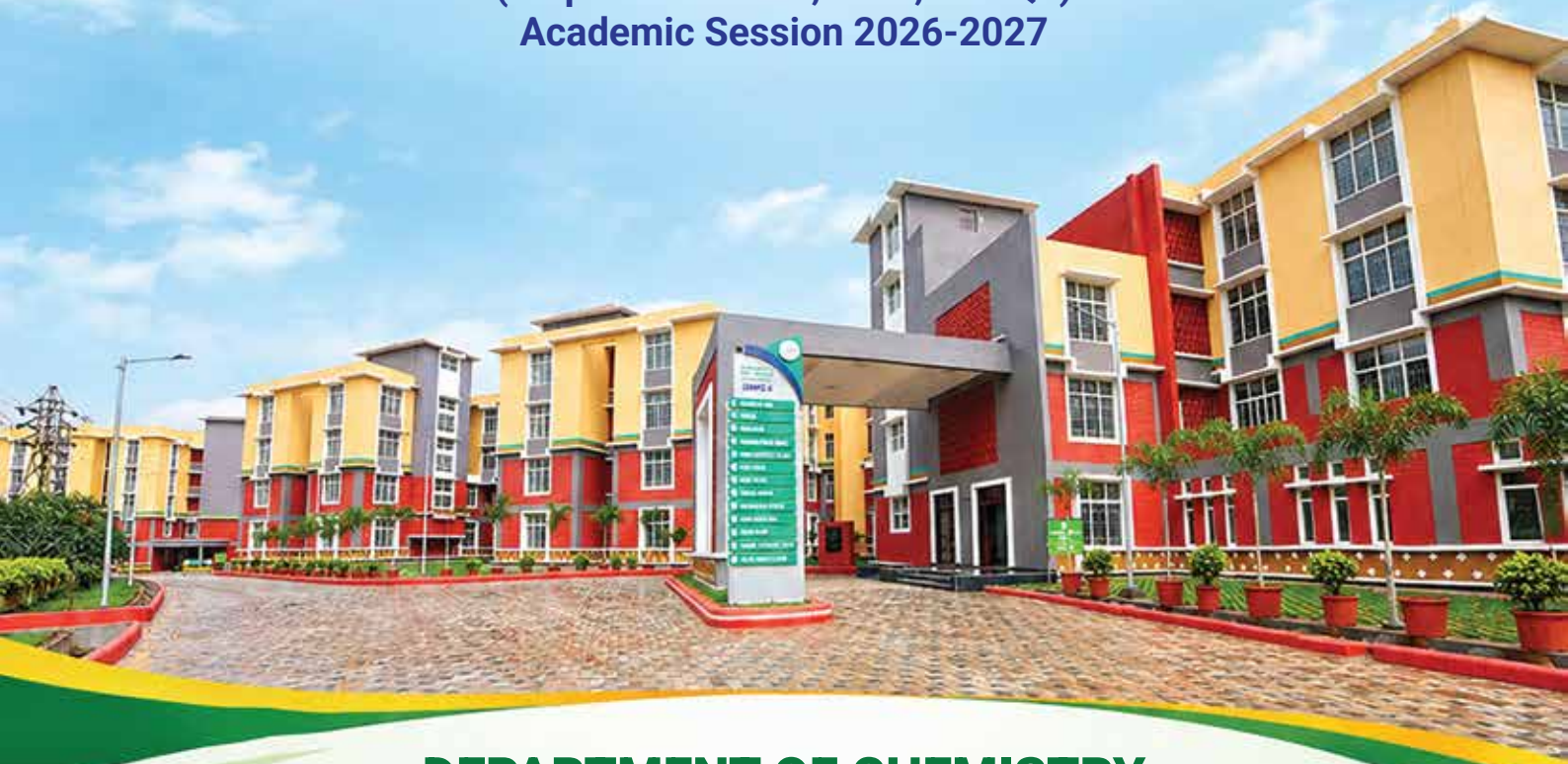
KISS

KALINGA INSTITUTE OF SOCIAL SCIENCES

CURRICULUM AND CREDIT FRAMEWORK FOR POSTGRADUATE PROGRAMME

MASTER OF SCIENCE (M.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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I. About the School and Department

i) About the School

The School of Indigenous Knowledge, Science and Technology (SIKST), 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. The School has been offering P.G and Ph.D. Programmes since inception and U.G Programme from 2024 onwards. 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 Indigenous communities who are the real custodians of traditional 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. 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.

The **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 that are Physics, Chemistry, Mathematics and Computer Science. 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.

The School has been contributing to honing the vocational, entrepreneurial and life skills of the students. In addition to this, it has also 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. It 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. Publication of student research, intellectual property generation and collaborative projects with industry and research laboratories are a regular feature at the Department. 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. M.Sc. in Chemistry Programme

M.Sc. in Chemistry is a two-year post-graduate programme designed in alignment with the National Education Policy 2020, the National Credit Framework, the National Higher Education Qualification Framework (Level 8), and the UGC Curriculum and Credit Framework for Postgraduate Programmes (2023). The programme integrates core competencies in various thrust areas of Chemistry along with Indigenous Science and Technology. In addition to innovative tribal courses this programme integrates fundamental and Applied Chemistry which includes Agro Chemistry, Materials Chemistry, Inorganic Materials of Industrial Importance, Molecular Symmetry and its Applications, Green Chemistry, Nuclear Chemistry, Spectroscopy, Photo chemistry and pericyclic reaction, Bio- inorganic and Supramolecular Chemistry, Reagent and Reaction, Solid state chemistry, computational tools, research methodology and ethical practices**.**

Students get opportunities to develop core competencies in Chemistry and build successful careers in academia, research, industry and higher education. The curriculum is a blend of lectures, case studies, field works, SWAYAM MOOC Courses, research projects and presentations are organized from time to time ensuring a holistic and experiential learning environment consistent with NEP 2020.

III. Process of Curriculum Development

The Department of Chemistry under the School of Indigenous Knowledge, Science and Technology follows a 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.

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

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

(v) Integration of NEP-2020, NCrF and NHEQF guidelines.

IV. Definition of Components

(i) '**Academic Programme'** means the entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching programme or jointly under more than one such programme.

(ii) **'Course'** means a segment of a subject that is part of an Academic Programme.

(iii) **'Course Structure'** means a list of courses (Core, Specialization, Discipline Specific Elective, MOOCs/Open Elective and skill based) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission.

(iv) **'Core Course'** means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v) **'Discipline Specific Elective'** Courses offered in the same Programme of the School.

(vi) **'Open Elective Course'** means an elective course which is available for students of all programmes, including students of the same department and the students of other programmes will opt for these courses.

(vii) **'Skill Enhancement Courses'** means the skill-based courses and are aimed at providing hands-on-training, competencies, skill- based knowledge.

(viii) **'Credit'** means the value assigned to a course which indicates the level of instruction; One hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit.

(ix) **'SGPA' means 'Semester Grade Point Average'** calculated for individual semesters and 'CGPA' is 'Cumulative Grade Points Average' calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together. To benefit the student a formula for conversion of Grand CGPA into percentage marks is given in the Transcript.

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)

This programme is a two-year course divided into four-semesters. The course is of 90 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	Core Courses		IKS		Dissertation		Grand Total Credits
	No. of Papers	Total Credits	No. of Papers	Total Credits	No. of Papers	Total Credits	
I	5	20	1	4			24
II	5	20	1	4			24
III	5	18	1	4			22
IV	-	-			1	20	20
Total Credits for the Course		58		12		20	90

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.

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 subjects 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 practicals 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 the result for reference.

e) A student has to appear for 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)

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)."

Milestone / Year Completed	Exit Award	NHEQF Level	Standard Credit Range
Year 1(Sem I-II)	Post-Graduate Diploma	Level 6.0	48 Credits
Year 2(Sem III-IV)	Master's degree in Chemistry	Level 6.5	90 Credits
	Doctoral Degree	Level 8.0	Credits for coursework and a thesis and published work

IX. Programme Educational Objectives (PEOs):

The Objective of this program is to ensure that the appropriate career path is paved for the students. Students can be self-employed and contribute to the development of tribal communities or elsewhere; or become a social entrepreneur; or can pursue research to enhance their skills for sustainable livelihood and become a researcher so that they can pursue higher studies; or become a professional contributing to 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 a culture of credibility, transparency and reliability for continuous quality enhancement of academic and institutional governance.

X. Programme Outcomes (POs):

The expected attributes for a post graduate 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 scientific practice.
PO2	Disciplinary Knowledge	Acquire an understanding of the nature, practice and application of the chosen area of study

PO3	Communication Skills	➢ Ability to speak, read, write, listen and understand clearly in person or through electronic media and make meaning of the world by connecting people, ideas, books, media and technology. ➢ Present complex chemical information clearly and concisely. ➢ Prepare laboratory reports, dissertations and seminar presentations.
PO4	Critical Thinking, Problem solving & Analytical reasoning	➢ Ability to engage in reflective and independent thinking by understanding the concepts in every area of Mathematics with Indigenous Science and Technology and take informed actions after identifying the assumptions that frame their thinking and actions, checking out the degree to which these assumptions are accurate and valid and looking at ideas and decisions from different perspectives. ➢ Ability to examine the results and apply them to various problems appearing in different branches of Mathematics with Indigenous Science and Technology. ➢ Identify assumptions and limitations and formulate coherent scientific arguments. ➢ Analyse and synthesise data from various sources and support conclusions with evidence. ➢ Ability to address scientific problems and offer a solution for the same. ➢ Capacity is to analyze synthesize data and derive influences for valid conclusions ➢ Capability to analyze the impact of chemistry on the overall development of tribal society. ➢ Identify logical flaws in chemical reasoning and interpretations.

		➢ Analyse and synthesise chemical data and address alternative viewpoints logically.
PO5	Indian knowledge Systems(IKS)	➢ 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. ➢ Provides deeper insight into the role of ancient Indian knowledge in the development of modern chemical technologies.
PO6	Research-Related Skills	➢ Ability to search for, locate, extract, organize, evaluate, and use or present information which has relevance with different Scientific issues. ➢ Ability to identify the research gaps and developments in various branches of Chemistry and Indigenous Science. ➢ Skills to design and execute experiments and dissertation work. ➢ Competence in selecting appropriate methodologies, instruments and statistical tools. ➢ Understanding of research ethics, safety norms and responsible conduct of research.

PO7	Cooperation/Team work	➢ Convey ideas and information effectively to a range of audiences for a variety of purposes and contribute in a positive and collaborative manner to achieve common goals. ➢ Participate in collaborative experiments, projects and seminars. ➢ Contribute efficiently as a team member in academic, industrial and research environments.
PO8	Digital Literacy	Capability to use various technical ICT tools (Data analytics) for exploring, analyzing, and using the information for different purposes.
PO9	Experiential & Life – long learning	Students would seek hands-on learning to perform in the real world by acquiring knowledge, skills and attitude, so that they will be able to present them effectively to their employers.
PO10	Leadership Qualities	Students are expected to have the qualities like high integrity, accountability for actions, sense of empathy, humanity, resilience, positivity, influencing and a vision. They are expected to engage in professional behaviour and have the potential to be an entrepreneur and take leadership roles in their chosen occupations or careers and communities.
PO11	Professional & Decision- making Skills	➢ Students are expected to exhibit skills that would demonstrate what they are capable of contributing to their job role and fulfill duties of the position they would seek. ➢ Ability to achieve professional integrity and professional behavior, as well as the skills and attitudes necessary to plan for one's career and to stay current in a dynamic world.
PO12	Environment Awareness and Sustainability	➢ Able to understand the issues of environment trends and would endeavor for their lasting solutions. ➢ Apply chemical knowledge to environmental protection and pollution control. ➢ Practice green chemistry and sustainable laboratory methods. ➢ Contribute to waste management, resource conservation and climate action.

XI. Programme Specific Outcomes (PSOs):

PSO1: The students will be able to do data simulation and analyze the performance of chemical data obtained from the different studies. They will also develop scientific outlook not only with respect to science subjects but also in the field of Indigenous Science and Technology.

PSO2: The student will be able to design specific methods to synthesize and analyze the novel organic and in-organic molecules in the context of different branches of chemistry. They will also acquire knowledge of Chemical Thermodynamics, Kinetics, Electrochemistry, Organic Chemistry, Spectroscopy and Skill in Industrial Chemistry.

PSO3: The students will be able to identify, analyze and solve complex problems and the data obtained by the modern instruments relating to their applied scientific knowledge of interdisciplinary branches of chemistry which includes applied organic, inorganic, physical, analytical, industrial, pharmaceutical, polymer, Nano science and technology and data obtained by the modern analytical instruments.

PSO4: The students will get training for employment in academic institutes, in projects at different research centers and Quality control laboratories of Indian chemical/pharmaceutical industries as well as multinational and forensic Laboratories.

PSO5: The students will learn how to apply appropriate techniques for the qualitative and quantitative analysis of chemicals in laboratories and in industries to pursue a career in this applied field.

XII. COURSE STRUCTURE FOR M.Sc. IN CHEMISTRY

SEMESTER DETAILS: The Programme comprises of Four Semesters

Department of Chemistry
School of Indigenous Knowledge, Science and Technology

SEMESTER-I					
COURSE CODE	**NAME OF THE COURSE**	**CREDITS**			
		L	**T**	**P**	**TOTAL**
CY40001	Photochemistry and Pericyclic reaction	3	0	1	4
CY40003	Fundamentals of Agro Chemistry	3	0	1	4
CY40005	Bio-inorganic and Supramolecular Chemistry	3	0	1	4
CY40007	Artificial Intelligence in Chemistry	3	0	1	4
IK40051	Scientific Research Methods	3	1	0	4
IK40053	Vedic Mathematics	3	1	0	4
	Total				**24 Credits**
SEMESTER-II					
COURSE CODE	**NAME OF THE COURSE**	**CREDITS**			
		L	**T**	**P**	**TOTAL**
CY40002	Molecular Spectroscopy	3	0	1	4
CY40004	Organic Synthesis	3	0	1	4
CY40006	Green Chemistry	3	0	1	4
CY40008	Inorganic Materials of Industrial Importance	3	0	1	4
CY40010	Nanotechnology in Agriculture	3	0	1	4
IK40052	Indigenous People and the Science of Gemology	3	1	0	4
	Total				**24 Credits**
Grand Total					**48 Credits**
Exit Point: Postgraduate Diploma **Students who exist at the end of 1st year shall be awarded a Postgraduate Diploma**					
SEMESTER-III					
COURSE CODE	**NAME OF THE COURSE**	**CREDITS**			
		L	**T**	**P**	**TOTAL**
RM50001	Research Methodology	3	1	0	4
RE50003	Research and Publication Ethics	2	0	0	2
CA50005	Computer Application and Data Analysis	3	0	1	4
IK50051	Indigenous Knowledge and Intellectual Property Rights	3	1	0	4

	Choose Any Two				
CY50031	Nuclear Chemistry	3	1	0	4
CY50033	Molecular Symmetry and its Applications	3	1	0	4
CY50035	Solid State Chemistry	3	0	1	4
CY50037	Reagents and Reactions	3	0	1	4
	Total				**22 Credits**

SEMESTER-IV

COURSE CODE	NAME OF THE COURSE	CREDITS			
		L	**T**	**P**	**TOTAL**
RT50082	Research Thesis	0	0	20	20
	Total				**20 Credits**
Grand Total					**90 Credits**

Exit Point: Master's Degree

Students will be awarded PG degree in Chemistry provided they secure 90 credits

Grand Total Credits = 90

*** One Credit = 1 hour for Theory classes (45 hours of lecture/tutorial)**

*** One Credit = 2 hours for Practical classes (30 hrs of practicum)**

XIII. DETAILED COURSE CONTENT FOR M.SC. IN CHEMISTRY

SEMESTER-I

Course Code: CY40001
Course Title: Photochemistry and Pericyclic Reaction
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:

CO1 Describe the theory and practice of common photochemical, photophysical methods and be able to execute these experimentally.
CO2 Distinguish the different types of *pericyclic reactions*, the stereochemistry of the same, simple rules.
CO3 Employing the Principles of 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 *photochemistry* as well as different types of spectroscopies.
CO5 To study the applications of important reagents in organic synthesis, including hydride donors, selective oxidizing agents, and stereoselective reagents.

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	3	–	3	2	–	2	–	2	–	2	3	3	–	2
CO2	–	3	–	3	–	2	–	–	2	–	2	–	–	3	3	–	–
CO3	–	3	2	3	–	3	–	–	2	–	2	–	2	3	3	–	2
CO4	–	3	2	3	–	3	–	2	2	–	2	–	2	3	3	–	3
CO5	2	3	2	3	–	3	2	–	2	–	3	2	–	3	3	2	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 principle, 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 pericyclic 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, Sharpless epoxidation, 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.

Essential 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.

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Provides advanced theoretical and experimental training in photochemistry and organic reactions
SDG 9	Industry, Innovation & Infrastructure	Supports chemical innovation and industrial applications of photochemical processes
SDG 12	Responsible Consumption & Production	Promotes sustainable synthesis and responsible use of chemical reagents
SDG 13	Climate Action	Encourages environmentally benign photochemical processes and pollution mitigation

Course Code: CY40003
Course Title: Fundamentals of Agrochemistry
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	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
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	3
CO4	3	3	–	3	–	2	–	–	2	–	3	3	–	2	3	–	3
CO5	2	3	2	2	–	3	2	2	3	–	3	2	2	2	3	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 types 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.

SDG Mapping

SDGs	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
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:

CO1 Enumerate the basic principles of bio-inorganic chemistry into 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-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	–	–
CO2	–	3	2	3	–	3	2	–	2	–	2	–	2	3	3	–	2
CO3	–	3	–	3	–	3	–	–	2	–	2	–	2	3	3	2	2
CO4	–	3	2	3	–	3	2	2	2	–	2	–	3	3	3	2	3
CO5	–	3	2	2	–	2	–	–	2	–	2	–	–	3	3	2	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 self-assembly of complex supramolecular architecture– rotaxanes, catenanes.

UNIT-IV: Application of supramolecules (7 Lectures)

Supramolecules in catalysis, as membrane 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.

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 3	Good Health and Well-being	Role of metallodrugs, enzymes, diagnostics, and bioinorganic systems
SDG 4	Quality Education	Advanced training in bioinorganic and supramolecular chemistry
SDG 9	Industry, Innovation and Infrastructure	Development of supramolecular devices, sensors, and molecular machines
SDG 12	Responsible Consumption and Production	Environment-friendly synthesis and controlled use of metal complexes
SDG 13	Climate Action	Understanding toxic metals and sustainable molecular systems
SDG 15	Life on Land	Awareness of environmental toxicity of heavy metals

Course Code: CY40007
Course Title: Artificial Intelligence in Chemistry
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objective:
To provide students with an understanding of how artificial intelligence (AI) can be applied to solve complex problems in chemistry, enabling them to analyze chemical data, develop AI models, and apply these techniques to various chemical research areas, while fostering critical thinking, analytical reasoning, and collaborative skills.

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

CO1: Analyze chemical data using AI techniques to solve complex problems (Complex problem-solving, Analytical reasoning).

CO2: Evaluate AI models and algorithms for their effectiveness in chemical research (Critical Thinking, Research-related skills).

CO3: Design and **implement** AI-based solutions for chemical data analysis using appropriate tools and programming languages (Digital Literacy, Self-Directed Learning).

CO4: Collaborate effectively in teams to develop AI applications in chemistry, demonstrating leadership and teamwork skills (Cooperative/Teamwork, Leadership readiness).

CO5: Communicate technical concepts and findings related to AI in chemistry clearly and effectively (Communication Skills, Multicultural competence and inclusive spirit).

CO-PO-PSO Mapping (Strong-3, Moderate-2, Low-1)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	–	3	–	3	–	2	–	3	2	–	2	–	3	2	3	–	2
CO2	–	3	–	3	–	3	–	2	2	–	2	–	2	2	3	–	2
CO3	–	3	–	3	–	3	–	3	3	–	3	–	3	2	3	2	3
CO4	–	2	2	2	–	2	3	–	2	3	3	–	–	–	2	3	–
CO5	–	2	3	2	–	–	2	2	2	–	2	–	–	–	2	–	–

Course Content:

UNIT-1: Introduction to AI in Chemistry (9 hours)

- Overview of AI and its importance in chemistry
- Types of AI: Machine learning, deep learning, neural networks
- Applications of AI in chemistry: Drug discovery, materials science, reaction prediction
- Basic concepts of data science and AI
- Case studies of AI applications in chemistry

UNIT-II: Data Collection and Preprocessing (9 hours)

- Sources of chemical data: Databases, experiments, simulations
- Data preprocessing techniques: Cleaning, normalization, transformation
- Feature selection and extraction
- Handling missing data and outliers
- Practical implementation using Python and R

UNIT-III: Machine Learning Techniques in Chemistry (9 hours)

- Supervised learning: Regression, classification
- Unsupervised learning: Clustering, dimensionality reduction
- Neural networks and deep learning
- Model evaluation and validation
- Practical implementation using scikit-learn and Tensor Flow

UNIT-IV: AI Applications in Chemical Research (9 hours)

- AI in drug discovery: QSAR modelling, virtual screening
- AI in materials science: Property prediction, materials design
- Reaction prediction and retrosynthesis
- AI in spectroscopy and imaging
- Practical implementation using cheminformatics tools

UNIT-V: Advanced Topics and Future Directions (9 hours)

- Explainable AI and model interpretability
- Ethical considerations and data privacy in AI research
- AI in environmental chemistry and sustainability
- Emerging trends and research directions in AI in chemistry
- Developing a personal ethical framework for AI researc

Exercises:

1. Collect and preprocess a chemical dataset.
2. Implement data normalization and transformation techniques.
3. Develop a regression model to predict chemical properties.
4. Implement a classification algorithm for a chemical dataset.
5. Perform clustering on a chemical dataset and interpret the results.
6. Develop a neural network model for a chemical prediction task.
7. Evaluate the performance of different AI models.

8. Implement a QSAR model for drug discovery.
9. Perform virtual screening using AI techniques.
10. Predict material properties using machine learning.
11. Develop a reaction prediction model using AI.
12. Implement a retrosynthesis prediction algorithm.
13. Analyze spectroscopic data using AI techniques.
14. Develop an AI model for chemical imaging analysis.
15. Evaluate the ethical implications of an AI application in chemistry.
16. Collaborate on a group project to develop an AI application in chemistry.
17. Write a report on the application of AI in a specific area of chemistry.
18. Present a case study on the use of AI in drug discovery.
19. Research and present on the future trends in AI in chemistry.
20. Participate in a debate on the ethical considerations of AI in chemical research.

Essential Readings:

Textbook:

- **"Artificial Intelligence in Chemistry: Applications and New Technologies"** by Hugh M. Cartwright.

- **"Machine Learning in Chemistry: The Impact of Artificial Intelligence"** by Jon Paul Janet and Heather J. Kulik.
- **"Data-Driven Chemistry: Machine Learning and Big Data"** by Taylor & Francis Group.
- **"Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, Drug Discovery, and More"** by Bharath Ramsundar, Peter Eastman, Patrick Walters, and Vijay Pande.

Course Code: IK40051
Course Title: Scientific Research Methods
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: IK40053
Course Title: Vedic Mathematics
Total Credits: 04 (Credits: Theory-03, Tuorial-01)
Total Lectures: Theory- 45 and Tutorial-15

Course Learning Objectives:

The course aims to introduce students to the rich heritage of Vedic Mathematics by exploring sutras, sub-sutras, and their applications in fundamental arithmetic operations. It emphasizes the problem-solving techniques of ancient Indian scholars, covering arithmetic progression, algebraic equations, and calculus concepts from a Vedic perspective. Students will gain insights into ethno-mathematics, traditional numeral systems, and the role of mathematics in folk art and tribal traditions. The course also bridges ancient methods with modern mathematical concepts such as factorization, geometry, and theorems, fostering both analytical and cultural understanding.

Course Learning Outcomes: After completing this course, the students will be able to:
CO1**:** Remember Mathematics in Vedas, different sutras and sub sutras, examples of sutras and sub sutras.
CO2: Understand Arithmetic progression in Ancient India and different techniques. Simple equations,
CO3: Apply the Factorization, H.C.F, Partial fractions, differential calculus in Vedic mathematics.
CO4: Analyze the Development and meaning of "ethno mathematics", Numerals and naming systems.
CO5: Evaluate the problems based on different sutras and sub sutras.

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	3	–	–	–	2	–	–	–	2	–	2	–	–

CO2	–	3	–	3	3	–	–	–	2	–	2	–	2	–	2	–	–
CO3	–	3	–	3	2	2	–	–	3	–	2	–	2	2	3	–	–
CO4	–	3	2	3	3	2	–	–	2	–	2	–	3	–	3	–	–
CO5	–	3	2	3	3	2	–	–	3	–	2	–	2	–	3	–	–

Course Content:

Unit-I: Introduction to Mathematics in Vedas, different sutras and sub sutras, examples of sutras and sub sutras. Basic Concepts of Ancient Arithmetic, development and their uses. Different operations in Vedic mathematics: Addition, subtraction, multiplication, division, square, square root, cube and cube root and Examples.

Unit – II: Knowledge on Arithmetic progression in Ancient India and different techniques. Simple equations, quadratic equations, Cubic equation, biquadrate equation, simultaneous equation in Vedic mathematics.

Unit – III: Mathematical numbers in Indian Tradition and different types of problems relating to Vedic sutras. Factorization, H.C.F, Partial fractions, differential calculus in Vedic mathematics.

Unit – IV: Mathematical Concept in Tribal Tradition: Ethno mathematics: development and meaning of "ethno mathematics", Numerals and naming systems, Mathematics in folk art, Informal mathematics. Pythagoras theorem, integration by partial fractions, Apollonius theorem, Analytical geometry in Vedic mathematics.

Suggested Readings:

1. Vedic Mathematics space book by S, JK. Cosmic Kapoor- 2005

2. Vedic Arithmetic and Development of basic concepts Dr. K.P. Chamola – 2006 Arithmetic

SEMESTER-II

Course Code: CY40002
Course Title: Molecular Spectroscopy
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:

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 (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	PSO 5
CO1	–	3	–	2	–	2	–	–	2	–	2	–	–	3	2	–	–
CO2	–	3	–	3	–	3	–	2	2	–	2	–	2	3	3	2	3
CO3	–	3	–	3	–	3	–	2	2	–	2	–	2	3	3	2	3
CO4	–	3	2	3	–	2	–	–	2	–	2	–	–	3	3	–	2
CO5	–	3	2	3	–	3	–	2	3	–	3	2	2	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*

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Advanced theoretical and practical training in molecular spectroscopy
SDG 3	Good Health and Well-being	Spectroscopic analysis of biomolecules and medical diagnostics
SDG 9	Industry, Innovation and Infrastructure	Spectroscopy as a core tool in chemical, pharmaceutical, and materials industries
SDG 12	Responsible Consumption and Production	Non-destructive testing and reduced chemical waste
SDG 13	Climate Action	Environmental monitoring using spectroscopic techniques

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	PO1 0	PO1 1	PO1 2	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:

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. To improve the creative and innovative thinking in undergraduate students towards sustainable practices of Green Chemistry has arisen from these concerns. 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:

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 to practice 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 (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	PSO 5
CO1	3	3	–	2	3	–	–	–	2	–	2	3	–	2	2	–	–
CO2	–	3	–	3	–	2	–	–	2	–	2	3	2	3	3	–	2
CO3	–	3	–	3	2	3	–	–	2	–	2	3	2	3	3	2	3
CO4	3	3	–	3	–	2	–	–	2	–	3	3	–	2	3	2	3
CO5	3	3	2	3	2	2	2	–	3	2	3	3	2	2	3	3	3

Course Content:

UNIT-I: Introduction (8 Lectures)

Definition of green chemistry, 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.

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Provides education and training in sustainable chemistry, green technologies, and environmentally responsible scientific practices.
SDG 8	Decent Work and Economic Growth	Develops green skills for employment in chemical, pharmaceutical, and sustainable manufacturing industries.

SDG 9	Industry, Innovation and Infrastructure	Promotes innovation in eco-friendly chemical processes and sustainable industrial technologies.
SDG 12	Responsible Consumption and Production	Encourages waste minimization, atom economy, renewable resources, and environmentally benign chemical processes.
SDG 13	Climate Action	Supports climate-friendly technologies, pollution prevention, and sustainable industrial 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:

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 :

CO1 Learn the composition and applications of different kinds of glasses and ceramics

CO2 Understand the composition and setting mechanism of cement

CO3 Explain suitability of fertilizers for crops and soil

CO4 Explain formulation of paints and surface coating protection principles

CO5 Explain principles, working and applications of batteries

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	2	–	2
CO2	–	3	–	3	–	2	–	–	2	–	2	–	–	3	3	2	2
CO3	–	3	–	3	2	2	–	–	3	–	3	3	–	3	3	2	3
CO4	–	3	2	3	–	2	–	–	2	–	3	2	–	3	3	2	3
CO5	–	3	2	3	–	3	–	–	3	–	3	3	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, Li ion 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.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, W. H. Freeman and Company.
4. Kent, J. A. (ed) (1997), Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. Poole Jr.; Charles P.; Owens, Frank J. (2003), Introduction to Nanotechnology, John Wiley and Sons.

Practical:

1. Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis, Prentice Hall.
2. Banewicz, J. J.; Kenner, C.T. Determination of Calcium and Magnesium in Limestones and Dolomites, Anal. Chem., 1952, 24 (7), 1186–1187.
3. Ghorbani, H. R.; Mehr, F.P.; Pazoki, H.; Rahmani B. M. Synthesis of ZnO Nanoparticles by Precipitation Method. Orient J Chem 2015;31(2).
4. 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.

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Provides advanced education on industrial inorganic materials, construction materials, fertilizers, batteries and nanomaterials.

SDG 8	Decent Work and Economic Growth	Builds industry-ready skills for chemical, fertilizer, cement, battery and materials industries.
SDG 9	Industry, Innovation and Infrastructure	Supports industrial development through materials for construction, energy storage and surface protection.
SDG 11	Sustainable Cities and Communities	Promotes eco-friendly cement, construction materials and sustainable infrastructure.
SDG 12	Responsible Consumption and Production	Encourages efficient use of raw materials, eco-friendly coatings and fertilizers.
SDG 13	Climate Action	Promotes sustainable materials, renewable energy storage and green industrial technologies.

Course Code: CY40010
Course Title: Nanotechnology in Agriculture
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

To create foundational knowledge of Nanotechnology. Educate students about the current green and sustainable methods of preparation of nanomaterials. To teach difference between conventional and modern agriculture. It will give idea about the importance of nanomaterials in agriculture and impart knowledge on toxicity of nanomaterials.

Course Learning Outcomes:

CO1 Explain fundamental concepts, properties, classification and synthesis of nanoparticles relevant to agriculture.

CO2 Analyze the role of nano-agrochemicals and compare modern nanotechnology-based agriculture with conventional farming methods.

CO3 Evaluate the effectiveness of nano-fertilizers and nano-pesticides in improving crop productivity and environmental sustainability.

CO4 Apply nanomaterials for soil treatment and enhancement using nanoremediation and smart pest control techniques.

CO5 Assess toxicological impacts of nanomaterials on soil ecosystems, crop yield, human health and the environment.

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	PSO 5
CO1	–	3	–	2	–	2	–	–	2	–	–	2	–	2	3	–	–
CO2	–	3	–	3	–	2	–	–	2	–	2	2	2	3	3	–	–
CO3	–	3	–	3	–	3	–	–	2	–	2	3	2	3	3	2	2
CO4	–	3	2	3	–	3	2	2	2	–	3	3	2	3	3	2	3
CO5	**3**	3	–	3	–	3	–	–	2	–	3	3	2	2	3	2	3

Course Content:

UNIT-I: Introduction (10 Lectures)

Basics of nanoscience and technology: Definition, Classification of nanoparticles based on dimension and origin, Quantum confinement, properties of nanoparticles (optical only).

Synthesis of nanoparticles: Overview of physical and chemical routes, green methods of nanoparticles synthesis, Introduction to agriculture: Limitations of conventional farming, role of nano- agrochemicals in modern agriculture, Benefits of nanomaterials in agriculture (plant growth, crop protection, crop nutrients, etc.).

UNIT-II: Application of Nanomaterials in Agriculture (20 Lectures)

Nano fertilizers: Types and synthesis: Nitrogen-based, Phosphate based and Iron based. Role towards enhancement of crop productivity, Molecular mechanism of nano-fertilizer for plant growth and mechanism, Advantages over conventional fertilizers, limitations, optimization of nutrient use efficiency (NUE) and environment sustainability.

Nano pesticides: Brief discussion about nano- insecticides, nano- herbicides and nanofungicides, role in agriculture, Advantages over conventional pesticides and limitations.

UNIT-III: Treatment of Soil using Nanomaterials (7 Lectures)

Treatment of polluted soil by nanoremediation, Utilization of nanoparticles like nanoclay and zeolites in soil boosting, smart pest control.

UNIT-IV: Nanotoxicity in Agriculture (8 Lectures)

Toxicity of nanoparticles, Toxic effects of metal nanoparticles on soil ecosystem, Toxicity of nanoparticles to crop production, Health and environmental concerns related to nanomaterials.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Basic introduction to the characterization of nanoparticles employing any of the following techniques (Data and/or images for few reference compounds will be provided for analysis):
i. UV-Visible spectroscopy
ii. Fourier transforms infrared spectroscopy (FT-IR)
iii. Powder X-ray diffraction (PXRD)
iv. Scanning electron microscopy (SEM)
2. Synthesis of nanoparticles by Sol-gel method.
3. Synthesis of metal and metal oxide nanoparticles by green methods.
4. Synthesis of Nano urea.
5. Comparative study of pH of untreated and nano fertilizer treated soil.
6. Influence of Metal Oxide Nanoparticles on Soil pH, EC and Available Phosphorus.

Essential Readings:

1. Varghese, T., Balakrishna, K.M., (2020) Nanotechnology- An Introduction to synthesis, properties and applications of nanomaterials. Atlantic Publishers & Distributors (P) Ltd; ISBN: 9788126916375.
2. Shah, M.A.; Shah, K.A., (2019) Nanotechnology-The Science of Small. Wiley; ISBN: 9788126579976.
3. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/102104069); Book download link: 102104069.pdf - Google Drive.
4. Axelos, M. A., & Van de Voorde, M. (Eds.). (2017) Nanotechnology in agriculture and food science. John Wiley & Sons, ISBN: 3527339892.
5. Chattopadhyay K.K., Banerjee A.N., (2009) Introduction to Nanoscience and Technology; PHI Learning Pvt. Ltd. ISBN: 9788120336087.
6. Jogaiah, S., Singh, H. B., Fraceto, L. F., & De Lima, R. (Eds.). (2020) Advances in NanoFertilizers and Nano-Pesticides in Agriculture: A Smart Delivery System for Crop Improvement. Woodhead Publishing; ISBN: 978-012-820092.
7. Singh, H. B., Mishra, S., Fraceto, L. F., & De Lima, R. (Eds.). (2018) Emerging trends in agrinanotechnology: fundamental and applied aspects; CABI Publishing, ISBN: 9781786391445.
8. Mallick, M. A., Solanki, M. K., Kumari, B., & Verma, S. K. (Eds.) (2021) Nanotechnology in Sustainable Agriculture, CRC Press; ISBN: 9780367369408.
9. Subramanian, K. S., Gunasekaran, K., Natarajan, N., Chinnamuthu, C. R., Lakshmanan, A., & Rajkishore, S. K. (2015) Nanotechnology in Agriculture, New India Publishing Agency; ISBN: 9789383305209.
10. Tarafdar, J. C. (2021). Nanofertilizers: challenges and prospects; Scientific Publishers (India); ISBN: 978938889696931.
11. Fraceto, L. F., De Castro, V. L. S., Grillo, R., Ávila, D., Oliveira, H. C., & Lima, R. (2020) Nanopesticides, Springer International Publishing. ISBN: 978-3-030-44873-8.

E-contents:

1. E-content on e-PG Pathshala portal of Government of India: (P08) Nanoscience and Nanotechnology (https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=5VgWkgm+I3FGq9cGlsbNmQ==).
2. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/102104069); study material, videos and other material link for course (NPTEL).

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 2	Zero Hunger	Enhances crop productivity and food security through nano-fertilizers and nano-pesticides
SDG 4	Quality Education	Provides interdisciplinary knowledge of chemistry, nanotechnology and sustainable agriculture
SDG 12	Responsible Consumption & Production	Promotes efficient nutrient use, reduced agrochemical waste and sustainable farming practices
SDG 13	Climate Action	Encourages climate-resilient agriculture and reduced environmental impact through nanotechnology
SDG 15	Life on Land	Protects soil ecosystems and biodiversity via controlled and targeted nano-applications

Course Code: IK40052
Course Title: Indigenous People and the Science of Gemology
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-15

Course Learning Objectives:

This course imparts expertise and knowledge to the world of gemstones and enables the student to get a fair idea to identify, grade and value gemstones together with the market dynamics, trends, and terminologies.

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

CO1: Recognize the terminology and nomenclature of gemology**.**

CO2: Explain the skills on gems mineralogy and genesis.

CO3: Employ the skills to identify and characterize different gem stones by means of physical and optical techniques.

CO4: Exploring the science behind different colours of gemstones and their healing effects.

CO5: Rating the physical and optical properties of gemstones and apply their knowledge for grading and engraving.

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	PSO 5
CO1	–	3	–	2	–	–	–	–	2	–	–	–	–	2	2	–	–
CO2	–	3	–	3	–	2	–	–	2	–	2	–	2	3	3	–	2
CO3	–	3	2	3	–	3	–	2	3	–	3	–	2	3	3	2	3
CO4	–	3	–	3	–	2	–	–	2	–	2	2	–	2	3	–	2
CO5	–	3	2	3	–	3	–	2	3	–	3	–	2	3	3	3	3

Course Content:

UNIT-I: Introduction to the world of Gemstones

Ancient history of Gem stones, Mythology related to Gem stones, Use of Gems among indigenous people, Crystallography, study on crystal growth, formation of atomic lattice, originand structure of gem stones, twinned crystal, rough gemstone identification, knowledge of identification process.

UNIT-II: Properties of Gemstones

Physical and optical properties of gemstones, grading parameters of gemstones, various shapes and cutting of gemstones, engraving on stones, drilled stones, interlink of beauty, rarity, durability and its effect on valuation, Internal and external factors that affects valuation.

UNIT-III: Colour and Healing Power

The healing power of Gem stones, Tribal concept on Gemstones, Scientific approach of gemstones, Top gemstones with their colours and healing qualities, Science behind different colours of gemstones and their healing effects, precious gemstones found in tribal areas. Tribal ornaments having gemstones, semi precious stones and their practical identification, organic gemstones, ornament making techniques in both traditional and modern, Ornament design, stones used in fine and fashion jewelers, rare stones collection.

UNIT-IV: Terminology and nomenclature

Terminology and nomenclature of gemstones as per Indian and International markets, weights used in the gem trade, Market system of gems buying and selling, Gems and human race, Career and jobs, Scope in Gemology, Gemology as a tool for tribal development.

Essential Readings:

1. Colour encyclopedia of Gemstones by Joel. E. Arem
2. The Gemsstones Handbook by Arthur Thomas
3. Precious Stones, Vol-I & II: Max Bauer
4. Gemstones of the World: Walter Schumann
5. Gemology: Cornelius S. Hurlbut & Robert C Kammerling
6. Popular Gemology: Richard M Pearl
7. Dictionary of Gems and Gemology: Robert M Shiplley
8. Gemmolog: Peter G Read
9. Gem: Smiths Onian
10. Stoned:Jewellery,obsession: Aja Raden
11. Rocks,Minerals and Gems: John Farndon

Note: Latest edition of the textbooks should be used

SEMESTER-III

Course Code: RM50001
Course Title: Research Methodology
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory-30 and Tutorial-15

Course Learning Objective: To equip students with the foundational principles and advanced techniques of research methodology, enabling them to conduct and evaluate scientific research effectively, with a strong emphasis on ethical practices and innovation.

Course Learning Outcomes:

CO1: Apply complex problem-solving skills to design and execute research studies, utilizing appropriate methodologies and tools.

CO2: Evaluate and **critique** research literature to foster critical thinking and develop well-reasoned arguments.

CO3: Analyze data using statistical and computational techniques to derive meaningful insights and support analytical reasoning.

CO4: Collaborate effectively in teams to conduct research, demonstrating cooperative skills and leadership readiness.

CO5: Create and **communicate** research findings clearly and effectively, showcasing digital literacy and multicultural competence.

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	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	3	–	3	–	2	2	–	2	–	3	2	3	–	2
CO2	2	3	2	3	–	2	–	–	2	–	–	–	2	–	3	–	–
CO3	–	2	–	3	–	3	–	3	–	–	2	–	3	2	3	–	3
CO4	2	–	2	–	–	2	3	–	2	3	2	–	–	–	–	3	–
CO5	2	2	3	–	–	–	2	3	2	2	3	–	2	–	–	2	3

Course Content:

Unit 1: Introduction to Research Methodology (9 hours)

- Understanding the research process
- Formulating research questions and hypotheses
- Overview of qualitative and quantitative methods

Unit 2: Literature Review and Critical Analysis (9 hours)

- Conducting a systematic literature review
- Critical appraisal of research articles
- Ethical considerations in research

Unit 3: Research Design and Data Collection (9 hours)

- Experimental, quasi-experimental, and non-experimental designs
- Sampling techniques and data collection methods
- Ensuring validity and reliability in research

Unit 4: Data Analysis and Interpretation (9 hours)

- Descriptive and inferential statistics
- Data analysis software and tools
- Interpreting research findings

Unit 5: Research Communication and Dissemination (9 hours)

- Writing research reports and papers
- Presentation skills for seminars and conferences
- Research impact and knowledge transfer

Essential Readings:

1. "Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded" by Joshua Schimel.
2. "Research Methods for Business: A Skill Building Approach" by Uma Sekaran and Roger Bougie.
3. "The Literature Review: Six Steps to Success" by Lawrence A. Machi and Brenda T. McEvoy.
4. "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" by John W. Creswell.
5. "Discovering Statistics Using IBM SPSS Statistics" by Andy Field.

Course Code: RE50003

Course Title: Research and Publication Ethics
Total Credits: 02 (Credits: Theory-02)
Total Lectures: Theory-30

Course Learning Objectives:

To provide students with a comprehensive understanding of ethical principles and issues in research, enabling them to conduct responsible and ethical research while fostering critical thinking, analytical reasoning, and collaborative skills.

Course Learning Outcomes:

After completing this course, student is expected to learn the following:

CO1: Analyze ethical dilemmas in research and apply ethical principles to resolve them (Complex problem-solving, Analytical reasoning).

CO2: Evaluate the ethical implications of research practices and policies (Critical Thinking, Research-related skills).

CO3: Design and **implement** research projects that adhere to ethical standards (Autonomy, responsibility, and accountability, Self-Directed Learning).

CO4: Collaborate effectively in teams to address ethical issues in research, demonstrating leadership and teamwork skills (Cooperative/Teamwork, Leadership readiness).

CO5: Communicate ethical considerations and solutions clearly and effectively (Communication Skills, Multicultural competence and inclusive spirit).

CO-PO-PSO Mapping (Strong-3, Moderate-2, Low-1)

CO	PO1	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	PSO 5

CO1	3	2	–	3	1	3	–	–	2	–	2	–	2	–	2	–	–
CO2	3	2	–	3	2	3	–	–	2	–	2	–	2	–	2	–	–
CO3	3	2	–	2	–	3	–	1	2	2	3	1	1	–	2	1	–
CO4	2	–	2	2	–	2	3	–	2	3	2	–	–	–	–	2	–
CO5	3	–	3	2	–	2	2	2	2	1	3	–	–	–	–	1	–

Course Contents:

UNIT-I: Introduction to Research Ethics (6 hours)

- Definition and importance of research ethics
- Historical perspectives on research ethics
- Key ethical principles: Respect for persons, beneficence, and justice
- Ethical guidelines and codes of conduct
- Case studies of ethical breaches in research

UNIT-II: Ethical Issues in Research Design and Conduct (6 hours)

- Informed consent and voluntary participation
- Privacy and confidentiality
- Risk assessment and management
- Ethical considerations in data collection and analysis
- Plagiarism and academic integrity

UNIT-III: Ethical Issues in Publication and Peer Review (6 hours)

- Authorship and contributorship
- Conflicts of interest
- Peer review process and ethical responsibilities
- Retraction and correction of published work
- Ethical considerations in open access publishing

UNIT-IV: Ethical Issues in Collaborative and Interdisciplinary Research (6 hours)

- Collaboration and communication in research teams
- Ethical issues in interdisciplinary research
- Intellectual property and data sharing
- Cultural sensitivity and inclusivity in research
- Ethical considerations in international research

UNIT-V: Emerging Ethical Issues and Future Directions (6 hours)

- Ethical implications of emerging technologies in research

- Environmental and sustainability considerations in research
- Ethical issues in big data and AI research
- Future trends and challenges in research ethics
- Developing a personal ethical framework for research

Textbook:

- **"Research Ethics: A Reader"** by Deni Elliott and Judy E. Stern

Essential Readings:

- **"The Ethics of Research with Human Subjects: Protecting People, Advancing Science, Promoting Trust"** by David B. Resnik
- **"Responsible Conduct of Research"** by Adil E. Shamoo and David B. Resnik
- **"Ethics in Research"** by Ian Gregory-Smith

Exercises:

1. Analyze a case study of an ethical breach in research and propose solutions.
2. Develop an informed consent form for a hypothetical research study.
3. Evaluate the ethical considerations in a given research design.
4. Conduct a risk assessment for a proposed research project.
5. Identify and address potential conflicts of interest in a research scenario.
6. Write a reflection on the importance of privacy and confidentiality in research.
7. Develop a plan to ensure academic integrity in a research project.
8. Analyze the ethical responsibilities of authors and reviewers in the publication process.
9. Propose solutions for ethical issues in collaborative research.
10. Evaluate the ethical implications of data sharing in a research project.
11. Develop a strategy for addressing cultural sensitivity in an international research project.
12. Analyze the ethical considerations in the use of emerging technologies in research.
13. Propose solutions for ethical issues in big data research.
14. Develop a personal ethical framework for conducting research.
15. Collaborate on a group project to address an ethical issue in research.
16. Write a report on the ethical implications of a specific research practice.
17. Present a case study on the ethical considerations in interdisciplinary research.
18. Research and present on the future trends in research ethics.
19. Participate in a debate on the ethical implications of AI in research.
20. Develop a plan to ensure sustainability and environmental responsibility in a research project.

Course Code: CA50005

Course Title: Computer Application and Data Analysis

Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory-45 and Practical-30

Course Learning Objectives:

Increase knowledge and requisite skills of participants on the use of SPSS and to enable the scholars make the most of this powerful software package while allowing them to work independently with SPSS on their own data and provide a solid foundation for advanced data analysis work. Increase proficiency of scholars on the use of Basic computer Applications and SPSS.

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

CO1: Recall and describe the fundamental concepts of computer hardware, software, operating systems, and basic computer applications.
CO2: Explain and interpret the features and applications of MS Office packages and various analytical and research software tools used for data organization, documentation, and presentation.
CO3: Apply appropriate computer applications and statistical methods to formulate research hypotheses, organize data, and perform basic computational tasks.
CO4: Analyze research data using statistical software such as SPSS and interpret the results to support evidence-based decision-making and problem-solving.
CO5: Design, implement, and evaluate data analysis workflows by integrating computer applications, MS Office tools, and SPSS to prepare professional reports and support research and organizational decision-making.

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	PSO 5
CO1	–	3	–	2	–	2	–	3	2	–	2	–	2	–	2	–	–
CO2	–	2	3	2	–	2	–	3	2	–	3	–	1	–	–	2	–
CO3	–	2	–	3	–	3	–	3	2	–	2	–	3	–	3	1	2
CO4	–	2	–	3	–	3	–	2	2	–	2	–	2	–	3	–	2
CO5	–	2	2	3	–	3	–	3	2	1	3	–	3	1	3	2	2

Course Content:

Unit – I: Computer Basic and Computer Fundamental (8 Lectures)

Hardware and Software. Functional units comprising a typical computer configuration: input/output, fixed and removable data storage, internal storage, control and arithmetic/logic unit. The concepts relating to execution speed, data access times, storage capacities and similar comparative aspects of hardware performance. Operating Systems, Windows, Linux etc. Application software, role and functions of commonly available applications. Computer Network Concept- Data communication and network terminology, IP address and its significance, Internet, Multimedia, WWW, FTP, E-mail, and Web pages. Concept of VPNs. Concept of Network security and management.

Unit-II: Microsoft word (9 Lectures)

Creating and editing documents, formatting text and paragraph, formatting documents, creating and formatting tables, illustration documents with graphics. Creating a web page, mail merge and document merging, working with styles and templates, developing multi-page documents, integrating word with other applications, exploring advance graphics, building forms. working with charts and diagrams.

Unit-III: Microsoft Excel **(9 Lectures)**

Building and editing worksheets, formatting a worksheet, working with charts, working with formulas and functions, managing workbooks and preparing them for the web, automating worksheet tasks with macros, using lists, analyzing list data, enhancing charts and worksheets Using analysis tools, analyzing data with pivot tables, exchanging data with other programs.

Unit-IV: Microsoft PowerPoint **(9 Lectures)**

Creating a presentation with Microsoft PowerPoint, modifying a presentation, inserting objects into presentation, finishing a presentation, working with advanced tools and masters, enhancing charts, inserting illustration, objects and media clips, using advanced features.

Unit–V: SPSS **(10 Lectures)**

The analysis will be done with the help of SPSS, and other statistical packages. M Descriptive Analysis: Mean, Median, Mode, Standard Deviation, Correlation. Regression Analysis, t- test, chi-square test, R-Square test, Factor Analysis, ANOVA, NVIVO, SPSS, JAMOVI, AMOS.

List of Experiments:

1. Create and format a **table** in Word with at least 5 rows × 5 columns; apply borders, shading, and sorting.
2. Perform a **Mail Merge**: prepare a personalized invitation letter using an Excel data source (name, address).
3. Build a **student mark sheet** with fields (Name, Roll, Subject Marks). Apply formulas for **Total, Average, Percentage, and Grade**.
4. Format the worksheet (merge cells, adjust column width, borders, number formatting). Apply **conditional formatting** (highlight marks <40 in red).
5. Create different **charts** (bar, pie, line) for student performance or sales data. Enhance charts with titles, legends, and labels.
6. Demonstrate **formulas and functions**:
   SUM, AVERAGE, MAX, MIN, COUNT, IF
7. Create a **PowerPoint presentation** (minimum 8 slides) on "Emerging Technologies in Computing." Include title slide, content slides, conclusion, and references.
8. Create a **PowerPoint presentation** (minimum 10 slides) on "Emerging Trends in Computer Science." Include:
   1. Slide designs, transitions, and animations
   2. Insert **images, charts, and SmartArt**
   3. Add **audio or video clips**
9. Input a dataset of student scores into SPSS. Perform **Descriptive Statistics**: Mean, Median, Mode, Standard Deviation, and Correlation. Generate graphs (histogram, scatter plot).

10. Using SPSS, perform **Hypothesis Testing**:
    - **t-test** for comparing two groups
    - **Chi-square test** for categorical data
    - **ANOVA** for comparing more than two groups
    - Report **R-square** and regression results with interpretations

Text Books:

1. Hari Shankar Asthana, Braj Bhushan, Statistics for Social Sciences (With SPSS Applications, PHI Publication.
2. Jesus Salcedo, Keith Mccormick, SPSS Statistics for Dummies, 3rd Edition (Paperback), Wiley Publication.
3. Sabine Landau and Brian S. Everitt, A Handbook of Statistical Analysis Using SPSS

Reference Materials & Digital Resources:

1. Goel, Computer Fundamentals, Pearson Education, 2010.
2. K. Kalyanaraman, Hareesh N. Ramanathan, P.N. Harikumar, Statistical Methods for Research: A Step by Step Approach Using IBM SPSS, Atlantic Publication
3. R. Panneerselvam, Research Methodology, 2nd Edition, PHI Publication.

Swayam Link-

1. https://onlinecourses.swayam2.ac.in/nou24_cm16/preview
2. https://onlinecourses.nptel.ac.in/noc24_mg70/preview

SDG Mapping for this Course

SDG	Rationale
SDG 4	Digital literacy
SDG 9	Data-driven innovation
SDG 10	Equity through unbiased data
SDG 17	Data for partnerships and policy

Course Code: IK50051
Course Title: Indigenous Knowledge and Intellectual Property Rights
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial -15

Course Learning Objectives:

The main objective of this course is to know how the Intellectual Property Rights Protect Consumers and Families of Indigenous people relating to their safety, reliability, and effectiveness of their purchases. It also gives them for local level decision-making in food security, human and animal health, education and other vital economic and social activities.

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

CO1: Define the concept meaning and theories of Property.
CO2: Describe the fundamental legal principles relating to confidential information, copyright, patents, designs, trademarks and unfair competition.
CO3: Alphabetize the knowledge for the development and reform of intellectual property right institutions and their likely impact on creativity and innovation.
CO4: Explain the current and emerging issues relating to the intellectual property protection.
CO5: Measuring knowledge about layout designs of Integrated Circuits and Protection of Plant Varieties and Farmers' Rights.

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	PS
CO1	2	3	–	2	–	–	–	–	2	–	2	–	–	–	–	–	-
CO2	3	3	2	2	–	2	–	–	2	–	3	–	–	–	1	2	-
CO3	2	3	2	3	–	2	–	–	2	1	3	–	–	–	2	2	-
CO4	3	2	2	3	–	2	–	–	2	–	3	–	–	–	2	2	-
CO5	2	3	–	2	–	2	–	–	2	–	2	–	–	–	1	2	

Course Contents:

UNIT-I: Introduction to Intellectual Property Rights: Concept and meaning.Theories of Property - An Overview, Intellectual Property as an Instrument of Development.
Introduction to Patent Law (a) Paris Convention (b) Patent Cooperation Treaty (c) WTO- TRIPS (d) Harmonisation of CBD and TRIPs.

UNIT-II: Indian Patent Law (a) The Patents Act, 1970 (b) Amendments to the Patents Act (c) Patentable Subject Matter, Patentability Criteria (d) Procedure for Filing Patent Applications, Patent Granting Procedure (e) Revocation, Patent Infringement and Remedies (f) Relevant Provisions of the Biological Diversity Act, 2002 (g) Access and Benefit Sharing Issues.

UNIT-III: Copyright, Neighbouring Rights and Industrial Designs.Introduction to Copyright.
Indian Copyright Law: (a) The Copyright Act, 1957 with its amendments (b) Copyright works (c) Ownership, transfer and duration of Copyright (d) Renewal and Termination of Copyright (e) Neighbouring Rights (f) Infringement of copyrights and remedies

Industrial Designs (a) Need for Protection of Industrial Designs (b) Subject Matter of Protection and Requirements (c) The Designs Act, 2000 (d) Procedure for obtaining Design Protection (e) Revocation, Infringement and Remedies.

UNIT-IV: Geographical Indications, Layout designs of Integrated Circuits and Protection of Plant Varieties and Farmers' Rights.
Geographical Indications: Concept of Appellations of Origin, Indication of Source and Geographical Indication, The Geographical Indications of Goods, Infringement, Penalties and Remedies. Layout-Designs of Integrated Circuits: Conditions and Procedure for Registration, Duration and Effect of Registration, Assignment and Transmission
The Protection of Plant Varieties and Farmers' Rights: The Protection of Plant Varieties and Farmer's Rights Act, 2001., Protection of Plant Varieties and Farmers' Rights, Registration of Plant Varieties and Essentially derived variety, Duration, Effect of Registration and Benefit Sharing, Farmers' Rights, Plant Varieties Protection Appellate Tribunal, Infringement, Offences, Penalties and Procedure.

Essential Readings:

1. Text Book of Intellectual Property Rights by N.K. Acharya.
2. Intellectual Property Rights-Infringement and Remedies by Ananth Padamanabhan.
3. Intellectual Property Rights (IPRS): TRIPS Agreement and Indian Laws by E.T.Lokganathan
4. Law Relating to Intellectual Property Rights by V. K. Ahuja.
5. Law Relating to Intellectual Property Right by V.L. Wadehra.
6. Arai, Hisamitsu. "Intellectual Property Policies for the Twenty-First Century: The Japanese Experience in Wealth Creation", WIPO Publication Number 834 (E). 2000. wipo.int
7. Bettig, R. V. (1996). Critical Perspectives on the History and Philosophy of Copyright. In R. V. Bettig, Copyrighting Culture: The Political Economy of Intellectual Property. (pp. 9–32). Boulder, CO: Westview Press.
8. Boldrin, Michele and David K. Levine. "Against Intellectual Monopoly", 2008. dkleving.com

Course Code: CY50031
Course Title: Nuclear Chemistry
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-15

Course learning Objectives:

To provide the basics of nuclear structures, radiations, artificial radioactivity and applications of nuclear chemistry, radiopharmacy and chelation therapy.

Course Learning Outcomes:

CO1 Understand the composition, structure, properties and binding forces of the atomic nucleus.

CO2 Explain various types of nuclear reactions including fission, fusion, reactor processes and waste management.

CO3 Measure and interpret radioactive decay processes and determine decay constants and half-life.

CO4 Describe artificial radioactivity, production of radioisotopes and their scientific applications.

CO5 Apply concepts of nuclear chemistry in medicine, agriculture, industry and chelation therapy with safety awareness.

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	PSO 5
CO1	–	3	–	2	–	–	–	–	2	–	2	–	–	2	2	–	–
CO2	2	3	–	3	–	2	–	–	2	–	2	3	–	2	3	1	2
CO3	–	3	–	3	–	3	–	2	2	–	2	–	2	–	3	–	2
CO4	–	3	2	2	–	2	–	–	2	–	2	–	2	2	3	2	2
CO5	3	3	2	3	–	2	–	–	3	–	3	3	2	2	3	2	3

Course Contents:

UNIT-I: Nuclear Structure (10 Lectures)

Composition of the nucleus, nuclear size, shape and density, theories of nuclear composition, magnetic and electric properties of nucleus, nuclear spin and parity, nuclear binding forces.

UNIT-II: Nuclear Reactions (15 Lectures)

Penetration potential, nuclear binding energy, nuclear emissions, nuclear transformations, bombardment of nuclei, nuclear fission, nuclear fusion, nuclear explosives, nuclear reactors in India, Szilard–Chalmer's effect, fuel cycle and waste management, reactor power control.

UNIT-III: Radioactivity (20 Lectures)

Radioactive decay and growth, naturally occurring and artificially produced radioactive substances, Measurement of radioactivity, group displacement law, radioactive disintegration series, rate of disintegration, half-life, average life of radioactive elements, unit of radioactivity, nuclear decay, determination of decay constants, decay rates, types of nuclear decay.

UNIT-IV: Artificial Radioactivity and Applications of Nuclear Chemistry (15 Lectures)

Discovery of artificial radioactivity, isotopes used in medicines, radiocarbon dating, age determination, effects of radiation on life, applications of tracer element in medical, agriculture and analytical fields, biological effects of radiation, radiation protections, chelation therapy.

Essential Readings:

1. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rd Edition.Willey, 2013.
2. W. D. Loveland, D. Morrissey and G. T. Seaborg, Modern Nuclear Chemistry, John Wiley & Sons, 2006.
3. C. E. Housecroft and A. G. Sharpe; Inorganic Chemistry, 2ndEdition.Pearson, 2005.
4. H. J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern, 1988.

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 3	Good Health and Well-Being	Applications in nuclear medicine, radiopharmacy and chelation therapy
SDG 4	Quality Education	Builds scientific understanding of nuclear science and its responsible use
SDG 7	Affordable and Clean Energy	Understanding nuclear reactors and energy generation
SDG 12	Responsible Consumption and Production	Emphasizes nuclear waste management and radiation safety
SDG 13	Climate Action	Nuclear energy as a low-carbon energy option when used responsibly

Course Code: CY50033
Course Title: Molecular Symmetry and its Applications
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial -15

Course Learning Objectives:

The objective of the course is to help recognize symmetry in molecules and understand its role in Chemistry. The course will explore the role of symmetry in determining molecular properties, classifying and assigning nomenclature to molecules, molecular states and molecular motion, Bringing about simplifications in representations of groups. Determining spectroscopic selection rules based on molecular symmetry. Group theory applied to the study of molecular symmetry has far reached consequences in chemistry and the course will provide an in depth appreciation of this.

Course Learning Outcomes: (COs)

CO1 Understand symmetry elements, symmetry operations and classification of molecules into point groups.
CO2 Explain group theory concepts and representations relevant to molecular symmetry.
CO3 Construct symmetry adapted linear combinations (SALCs) and apply them to molecular orbital formation.
CO4 Analyze vibrational modes of molecules using group theory and determine IR activity.
CO5 Apply symmetry principles to interpret IR and Raman spectra of polyatomic molecules.

CO-PO-PSO Mapping (Strong-3, Moderate-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	–	–	3	2	–
CO2	–	3	–	3	–	2	–	–	2	–	2	–	–	3	3	–
CO3	–	3	–	3	–	3	–	–	2	–	3	–	2	3	3	1
CO4	–	3	2	3	–	2	–	–	2	–	2	–	2	2	3	1
CO5	–	3	2	3	–	2	–	–	3	–	3	–	2	2	3	2

Course Contents:

UNIT-I: Molecular Symmetry and Symmetry Groups (16 Hours)

Symmetry elements and operations, Symmetry planes and reflections, the inversion centre, proper axes and proper rotations, improper axes and improper rotation, products of symmetry operations, equivalent symmetry elements and equivalent atoms, general relations among symmetry elements and symmetry operations, classes of symmetry operations, symmetry elements and optical isomerism, symmetry point groups, classification of molecular point groups. Defining properties of a group, group multiplication table, some examples of group, subgroups and classes.

UNIT-II: Representations of Groups (14Hours)

Matrix representation and matrix notation for geometric transformation, The Great Orthogonality Theorem and its consequence, character tables (No mathematical part), wave function as basis for irreducible representations.

UNIT-III: Symmetry Adapted Linear Combinations (12Hours)

Projection operators and their use of construct SALC (Construction of SALC for sigma bonding for molecules belonging point groups: D2h, D3h D4h, C4v, Td., Oh., normalization of SALC, transformation properties of atomic orbital, MO's for sigma bonding, ABn molecules, tetrahedral AB4 and Oh AB6 cases.

UNIT-IV: Application of Group theory to Infrared Spectroscopy and Raman Spectroscopy (18Hours)

Introduction, selection rules, polyatomic molecules, possible vibrations in a linear molecule, bending modes, symmetry of vibrations and their IR activity, Group vibration concept and its limitations, IR spectra related to symmetry of some compounds, IR spectra of complex compounds. Raman spectra of diamond and ammonia.

Essential Readings:

Theory:

1. Chemical Applications of Group Theory by F. A. Cotton
2. Symmetry and spectroscopy of molecules by K. VeeraReddy
3. Group Theory and its Chemical Application, P.K. Bhattarchrya
4. Inorganic Chemistry by Shriver and Atkins
5. Concise Inorganic Chemistry by J. D. Lee
6. Inorganic chemistry: principle of structures and reactivity by Huheey, Keiter, Medhi

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Strengthens foundational theoretical knowledge and analytical skills in chemistry
SDG 9	Industry, Innovation and Infrastructure	Supports materials science, catalysis and molecular design through symmetry principles
SDG 12	Responsible Consumption and Production	Enables rational molecular design, reducing trial-and-error in chemical processes

Course Code: CY50035

Course Title: Solid State Chemistry
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 solid-state chemistry by introducing the fundamental concepts of crystalline solids, crystal systems and structural defects, along with the methods of solid preparation such as crystallization, doping, intercalation and thin-film deposition. It aims to familiarize learners with advanced solid materials including fullerenes, nanomaterials, carbon-based materials and ceramics, focusing on their structure and applications. The course also intends to equip students with knowledge of solid-state reactions, experimental techniques and kinetic aspects, while enabling them to analyze the electrical, magnetic and superconducting properties of solids. Overall, the course is designed to build a strong foundation in solid-state materials and their technological applications in modern devices like rectifiers, transistors, switches and sensors.

Course Learning Outcomes:

CO1 Understand and classify crystalline solids based on crystal systems, defects, and lattice parameters.
CO2 Demonstrate knowledge of solid-state synthetic techniques such as doping, crystallization, thin film deposition, and intercalation.
CO3 Analyze the structure, properties, and applications of advanced solid materials including nanomaterials, fullerenes, and ceramics.
CO4 Apply principles of solid-state reactions to design and evaluate reaction mechanisms, kinetics, and precursor methods (e.g., co-precipitation).
CO5 Correlate the electrical, magnetic, and superconducting properties of solids with their practical applications in devices like rectifiers, transistors, and sensors.

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	PSO 5
CO1	1	3	2	3	1	2	1	2	2	–	1	1	2	2	3	–	2
CO2	2	3	2	3	2	3	2	2	3	1	2	2	2	3	3	2	3
CO3	2	3	2	3	2	2	1	2	2	1	2	2	2	2	3	2	2
CO4	2	3	2	3	1	3	2	2	3	1	2	2	2	3	3	2	3
CO5	2	3	2	3	1	2	1	3	2	2	3	2	2	2	3	3	2

Course Contents:

UNIT-I: Crystalline solids and Solid preparations (12 Lectures)

Basics of solids, crystalline solids, crystal systems, defects in solids, methods of crystallization, Doping, Intercalation compounds, Deposition methods: Preparation of thin films and monolayers.

UNIT-II: Advanced solid materials (8 Lectures)

Fullerenes, Nanomaterials-definition and classification, Carbon nanomaterials, Ceramics and their uses, Intercalation compounds of transition elements.

UNIT-III: Solid State Reactions (10 Lectures)

General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid-state reactions.

UNIT-IV: Electrical and magnetic properties of solids (15 Lectures)

Electrically conducting solids, Electrical properties of fullerenes and doped fullerenes, carbon nanotubes. Magnetism in inorganic and organic materials, Superconductivity in inorganic and organic compounds. Solids used in rectifiers, transistors, switches and sensors.

Practicals: Credits: 01
(Laboratory periods: 15 classes of 2 hours each)

1. Synthesis and phase identification of TiO_2 nanoparticles by hydrothermal method.
2. Characterization of TiO_2 nanoparticles by UV-Vis spectroscopy.
3. Synthesis of Ca doped ZnO nanoparticles by solid state reaction and its structural characterization by X-ray diffraction.
4. Synthesis of ZnS or CdS thin films.
5. Measurement of electrical conductivity of doped ZnO pellet.
6. Preparation of alum or copper sulfate crystals.

Essential Readings:

Theory:

1. G.W. Castellan, Physical Chemistry, 4th Ed. Narosa.
2. R.G. Mortimer, Physical Chemistry. 3rd Ed. Elsevier, NOIDA, UP.
3. Solid State Chemistry and its Applications, A.R. West. Plemum.
4. Solid State Chemistry, D.K. Chakrabarty, New Age International.

Practical:

1. The Essentials – Understanding Nanoscience and Nanotechnology by T. Pradeep (Tata McGraw-Hill, New Delhi, 2007, multiple reprints through 2020)
2. Introduction to Nanoscience and Nanotechnology by G. Louis Hornyak, Joydeep Dutta, John J. Moore, and Harry F. Tibbals (CRC Press India, 2009)
3. Thin Film Technology and Applications edited by Kasturi L. Chopra (Tata McGraw-Hill, New Delhi, 1984)

4. Structural Chemistry of Glasses by K. J. Rao (Elsevier India, 2015)
5. Practical Inorganic Chemistry Lab Manual by A. Padmanabha Rao and M. Akiful Haque (Notion Press, 2019, 1st Edition)

SDG Mapping

SDG No.	SDG Goal	Rationale
SDG 4	Quality Education	Enhances advanced knowledge in solid-state chemistry, research skills, laboratory training, and scientific literacy.
SDG 8	Decent Work and Economic Growth	Prepares students for employment in chemical, pharmaceutical, nanotechnology, and materials industries.
SDG 9	Industry, Innovation and Infrastructure	Supports innovation through development of advanced materials, nanomaterials, semiconductors, and solid-state devices.
SDG 12	Responsible Consumption and Production	Promotes green chemistry, sustainable synthesis, waste minimization, and responsible use of resources.
SDG 13	Climate Action	Encourages environment-friendly materials, pollution control, and energy-efficient solid-state technologies.
SDG 15	Life on Land	Contributes to conservation of natural resources and sustainable utilization of materials derived from the environment.

Course Code: CY50037
Course Title: Reagents and Reactions
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives:

To provide the advanced knowledge of organic synthesis in general and classical and modern reagents and methods in synthesis in particular. In-depth knowledge of metal-mediated reactions and common metal-based reagents, oxidation-reduction reactions and reagents and rearrangement reactions will be gained. At the end of the course students are expected to predict reagents and conditions needed for specific conversions.

Course Learning Outcomes:

CO1 Advanced knowledge of modern methods of manipulations of carbonyl compounds, theoretical explanations of and reactivity including stereochemistry.

CO2 In-depth understanding of the use of various transition metal-based catalysts in coupling reactions Modern, classical and green methods of oxidation of various functional groups

CO3 Common reduction methods in organic synthesis

CO4 Environmentally friendly and stereoselective modern processes in organic synthesis

CO5 Thorough understanding of various rearrangement reactions and their applications in synthesis.

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	PSO 5
CO1	1	3	2	3	–	2	1	–	2	–	2	–	2	3	3	–	2
CO2	2	3	2	3	2	3	1	1	2	–	2	3	2	3	3	2	3
CO3	1	3	2	3	–	2	1	–	2	–	2	1	2	3	3	1	3
CO4	2	3	2	3	2	3	2	1	3	1	2	3	2	3	3	2	3
CO5	1	3	2	3	–	2	1	–	2	–	2	–	2	3	3	2	2

Course Contents:

UNIT-I: Use of Metals in Organic Synthesis (12 Lectures)

Selective enolate generation using LDA, LHMDS, KHMDS; Modern aldol reactions (lithium, boron, and titanium enolates), Zimmerman-Traxler TS; McMurry and Tebbe olefinations; Gilman cuprates, Samarium Iodide, Palladium mediated reactions: Wacker process, Heck reaction, Stille coupling, Suzuki coupling, Negishi coupling, Sonagashira reaction and Buchwald-Hartwig amination.

UNIT-II: Oxidation Reactions (12 Lectures)

Common oxidizing agents (transition metal oxidant, sulphur based, peroxide and peracid, modern catalytic oxidations using TEMPO) for oxidation of alcohols, ketones and aldehydes; Oxidation of C-C bonds [ozone, KMnO4, Pb(OAc)4, dimethyldioxirane, Ce(IV) andMn(III)] and saturated carbons, hypervalent iodine reagents, DDQ, Major methods for asymmetric epoxidations and dihydroxylations.

UNIT-III: Reduction Reactions (12 Lectures)

Common reducing agents such as dissolving metal reductions (Birch reduction), various Aluminum and Boron derived hydrides, catalytic/transfer hydrogenations (Homogeneous and Heterogeneous), diimide, Bu3SnH, low valent Ti species, and Wolf-Kishner reduction. Asymmetric reduction using Corey's oxazaborolidine (CBS catalyst) and Noyori's hydrogenation.

UNIT-IV: Rearrangement Reactions (9 Lectures)

General mechanistic considerations, nature of migration, migratory aptitude and mechanistic study of the following rearrangements: Pinacol-pinacolone, WagnerMeerwin, Benzil-Benzilic acid, Favorskii, Arndt-Ester synthesis, Demyanov, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction, Dienone-Phenol, Pummerer, Smiles, Sommelet-Hauser and Achmatowicz rearrangements.

Practicals: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. **Qualitative Analysis of Binary Organic Mixtures by a Systematic Approach:**

Chemical separation using H_2O, $NaHCO_3$, NaOH, HCl, Ether or any other reagent as per required conditions of solid-solid, solid-liquid and liquid-liquid mixtures. Systematic identification of the components and preparation of at least one derivative of each.

2. **Oxidation-Reduction Titrations**:

(i) Preparation of 0.1M cerium (IV) sulphate and its standardization with ammonium iron (II) sulphate or sodium oxalate.

(ii) To determine the concentration of the nitrite ions in the sample solution using standardized cerium (IV) sulphate.

(iii)To determine the percentage purity of the NaNO2 using standardized cerium (IV) sulphate.

3. Oxidation of Benzyl Alcohol with $KMnO_4$.

Essential Readings:

Theory:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, 5 thEdition. Springer Verlag, 2012.
3. V. K. Ahluwalia, Oxidation in Organic Synthesis, CRC press, 2012.
4. J. H. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, 1stEdition. University Science Books, 2009.
5. L. Kurti and B. Czako, Strategic Applications of Name Reactions in Organic Synthesis, Elsevier Academic Press, 2005.
6. R. H. Crabtree, The Organometallic chemistry of the transition metals, John Wiley, 2005.
7. W. Carruthers and Iain Coldham, Modern Methods of Organic Chemistry, 4thEdition. Cambridge University Press, 2004.
8. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2ndEdition. Oxford University Press, 2001.
9. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7thEdition. Wiley, 2013.
10. S. Warren, Organic Synthesis, Wiley, 1982.
11. H. O. House, W. A. Benjamin, Modern Organic Synthesis, Inc., New York, 1965.

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, 1st Edition 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. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5th Edition, ELBS, 1989.
6. Marr and Rocket, Practical Inorganic Chemistry. Van Nostrand Reinhold, 1972.
7. K. Nakamoto; Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A and B, 6th Edition. Wiley, 2008.
8. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5thEdition. Cengage India, 2015.

SDG Mapping

SDG No.	SDG Goal	Rationale
SDG 4	Quality Education	Provides advanced knowledge in organic synthesis, modern reagents, catalysts, and laboratory skills.
SDG 8	Decent Work and Economic Growth	Prepares students for careers in chemical, pharmaceutical, and fine chemicals industries.
SDG 9	Industry, Innovation and Infrastructure	Encourages innovation through development of new synthetic routes, catalysts, and organic molecules.
SDG 12	Responsible Consumption and Production	Promotes green reagents, environmentally friendly synthesis, waste minimization, and sustainable processes.
SDG 13	Climate Action	Encourages eco-friendly oxidation–reduction processes and low-energy reaction pathways.
SDG 15	Life on Land	Supports reduced environmental pollution and safer chemical practices.

SEMESTER-IV

Course Code: RT50082
Course Title: Research Thesis
Total Credits: 20 (Credits: Practical-20)

Course Learning Objectives:

This course provides students with the opportunity to undertake an independent research project in their chosen area of specialization. The course is designed to develop research aptitude by guiding students through the complete research process, including the identification of a relevant research problem, comprehensive literature survey, formulation of research objectives and hypotheses, experimental design, selection of appropriate methodologies, data collection and

analysis, interpretation of results, and preparation of a scientific research report. Emphasis is placed on critical thinking, analytical skills, ethical research practices, and scientific writing. The course also requires students to effectively communicate and defend their research findings through seminar presentations and a viva voce examination, thereby enhancing their technical competence, problem-solving ability and professional communication skills.

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 (Strong-3, Moderate-2, Low-1)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	1	3	1	2	2	1	2	1	3	2	2	1	1
CO2	1	3	1	3	1	3	1	2	2	1	2	2	3	3	3	2	2
CO3	2	3	3	3	1	3	2	2	3	2	3	1	3	2	3	3	2
CO4	3	2	1	2	2	2	2	1	2	2	3	3	1	2	2	2	3
CO5	2	2	3	2	1	2	3	1	3	3	3	1	2	1	2	3	2

Course Content:

Sl. No.	Mode of Evaluation	Credits
1	Identification of research problem	4
2	Survey of literature	4
3	Formulation of hypothesis, experimental design and methodology	4
4	Analysis of data, Interpretation of results and report writing	4
5	Presentation of research work and Viva voce test	4
Total		**20**

Assessment Methods:

The assessment will be through evaluation of the dissertation, presentation and viva voce involving external and internal examiners.

SDG Mapping

SDG No.	SDG Goal	Rationale
SDG 4	Quality Education	Develops students' research aptitude, critical thinking, scientific writing, and lifelong learning skills through independent research.
SDG 8	Decent Work and Economic Growth	Enhances professional competencies, problem-solving abilities, and research skills required for careers in academia, industry, and research organizations.
SDG 9	Industry, Innovation and Infrastructure	Promotes innovation by encouraging students to investigate scientific problems, develop novel solutions, and apply modern research methodologies.
SDG 12	Responsible Consumption and Production	Encourages ethical research practices, efficient use of resources, proper data management, and sustainable approaches in research activities.
SDG 13	Climate Action	Motivates students to address environmental and climate-related challenges through sustainable and interdisciplinary research where applicable.
SDG 17	Partnerships for the Goals	Fosters collaboration with supervisors, research groups, institutions, and interdisciplinary teams to achieve meaningful research outcomes.

********** End **********

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