SACRED HEART COLLEGE (AUTONOMOUS), THEVARA

KOCHI, KERALA, 682013

Syllabus of Courses

Under the discipline

CHEMISTRY

(For Undergraduate(Honours) Degree Programmes)

Introduced from 2024-25 admission onwards

Prepared by

Board of Studies in Chemistry

Sacred Heart College (Autonomous), Thevara, Kochi.

BOARD OF STUDIES IN CHEMISTRY
Sacred Heart College (Autonomous)
Thevara, Kochi, Kerala

Sl. No.	Name & Address	Designation / Category
1	**Dr. Franklin J** Associate Professor & HoD Department of Chemistry Sacred Heart College, Thevara.	*Chairperson*
2	**Dr. N. Manoj** Professor Department of Applied Chemistry CUSAT, Kochi	*Expert in the subject from outside the college, nominated by the academic council.*
3	**Dr. Reji Varghese** Associate Professor, School of Chemistry, IISER Thiruvananthapuram	*Expert in the subject from outside the college, nominated by the academic council.*
4	**Dr. Sebastian Nybin Remello** Assistant Professor Department of Applied Chemistry CUSAT, Kochi	*Post Graduate meritorious alumnus nominated by the Principal*
5	**Dr. Anu Gopinath** Professor & Head Department of Aquatic Environment Management KUFOS, Panangadu, Kochi	*Expert nominated by the Vice Chancellor from a panel of six recommended by the College Principal*
6	**Dr. Tom Thomas P** Country Head (India) SNRG Pharma Consulting, Wholly Owned Subsidiary of Syner-G Pharma Consulting, MA, USA	*Representative from industry, corporate – sector or allied area.*
7	**Dr. Jinu George** Associate Professor Sacred Heart College, Thevara.	*Faculty member*
8	**Dr. Grace Thomas** Associate Professor Sacred Heart College, Thevara.	*Faculty member*
9	**Dr. Ignatious Abraham** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
10	**Dr. Midhun Dominic C. D.** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*

11	**Mr. Senju Devassykutty** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
12	**Dr. June Cyriac** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
13	**Dr. Ramakrishnan S** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
14	**Dr. Abi T. G.** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
15	**Dr. Ammu Rosin Jose** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
16	**Dr. Deepak D. Prabhu** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
17	**Dr. Jaison M. Joy** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
18	**Dr. Shalumon K T** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*
19	**Dr. Thomasukutty Jose** Assistant Professor Sacred Heart College, Thevara.	*Faculty member*

FOREWARD

I am greatly privileged in presenting the revised curricula and syllabi of B.Sc. Honours Chemistry for the approval of Faculty, Board of Studies and Academic Council of Sacred Heart College (Autonomous), Thevara.

Chemistry is a fundamental science and has contributed immensely for the improvement of human life by providing materials, methods and other essentialities. Also, chemistry is essential to solve many future problems, including sustainable energy and food production, managing our environment, providing safe drinking water and promoting human and environmental health. The advancement achieved in the field of chemical sciences in the past few decades was phenomenal. It is also seen that these developments are crossing the traditional vertical boundaries of scientific disciplines. Science is interdisciplinary. Now a chemist cannot isolate himself from other disciplines. New branches of chemistry such as computational chemistry, bioorganic chemistry, material chemistry, green chemistry etc. are emerging and gaining importance. The practise of chemistry in industry is also undergoing radical changes.

Sacred Heart College – Under Graduate Programme (Honours) offering Honours degree will be adopted from 2024-25 academic year onwards. The Board of Studies in Chemistry was entrusted with the duty of preparing new curricula and syllabi for B.Sc Honours programme in accordance with the regulations of Mahatma Gandhi University and SHC-UGP(Honours) regulations. The BoS has taken keen interest in collecting expert opinion from the renowned experts in the field as well as from the faculties of the affiliated colleges handling the subjects. We have also referred to the syllabi of various Central Universities, IISERs, IITs and the UGC model curriculum in this attempt.

The new syllabus is prepared based on Outcome Based Education (OBE). Programme Outcomes (PO) for the BSc Honours programme and Course Outcomes (CO) for each course have been prepared for the effective teaching-learning process.

The BoS prepared draft proposals of revised curricula and syllabi for B.Sc Honours Programmes in Chemistry keeping the Credit and Semester System. The syllabus has been set with the objective of training the students in all the fundamentals of the subject along with good practical exposure. Most of the advanced topics have been incorporated in the Discipline Specific Capstone and elective course baskets.

The BoS feels that appreciable updating could be done considering the current developments and latest trends in chemistry education. The task of preparing the Curricula and Syllabi and bringing it out in the present form was not a simple task but it was possible with the dedicated efforts, wholehearted support and involvement of all the members of the faculty and BoS. I would like to express my sincere thanks to all my fellow members of the BoS and faculty for all their help, cooperation and encouragement.

Dr. Franklin J
Chairperson
Board of Studies in Chemistry
Sacred Heart College (Autonomous), Thevara.

CONTENTS

1. INTRODUCTION

The National Education Policy (NEP) 2020 envisages the revision of the Choice Based Credit System (CBCS) for instilling innovation and flexibility. It emphasizes on promoting interdisciplinary studies, introducing new subjects, and providing flexibility in courses and fresh opportunities for students. It also envisages setting up of facilitative norms for issues, such as credit transfer, equivalence etc., and a criterion-based grading system that assesses student achievement based on the learning goals for each programme.

The NEP document suggests several transformative initiatives in higher education. These include:

- Introduction of holistic and multidisciplinary undergraduate education that would help develop all capacities of human beings - intellectual, aesthetic, social, physical, emotional, ethical and moral - in an integrated manner; soft skills, such as complex problem solving, critical thinking, creative thinking, communication skills; and rigorous specialization in a chosen field(s) of learning.
- Adoption of flexible curricular structures in order to enable creative combinations of disciplinary areas for study in multidisciplinary contexts in addition to rigorous specialization in a subject
- Undergraduate degree programmes of either 3 or 4-year duration.
- The students are getting a chance to determine his/her own semester-wise academic load and will be allowed to learn at his/her pace, to the extent possible.
- Increase in the number of choices of courses available to students and the students are getting an opportunity to choose the courses of their interest from all disciplines.
- Multidisciplinary and holistic education with emphasizes on research, skill development and higher order thinking,
- Promotion of innovation and employability of the student.
- Flexibility for the students to move from one institution to another as per their choice.
- Flexibility to switch to alternative modes of learning (offline, ODL, and online learning, and hybrid modes of learning).

Outcome Based Education (OBE)

Undergraduate courses in Chemistry follow the Outcome-based Education (OBE) framework. OBE is a system where all the parts and aspects of education are focused on the outcomes of the course. The students take up courses with a certain goal of developing skills or gaining knowledge and they have to complete the goal by the end of the course. Outcome-based education affirms teachers as facilitators, rather than lecturers. In this model, teachers guide the students and encourage them to develop their knowledge and skills. The undergraduate courses at the Department of Chemistry, Sacred Heart College (Autonomous), Thevara provide a learning approach in which students develop analytical ability, critical thinking and research acumen over different situations.

Programme Outcomes:

The Undergraduate Programme Outcomes (POs) are as follows:

PO 1: Critical thinking and Analytical reasoning

- Critical thinking guides the assessment and judgment of information, while analytical reasoning involves specific methods for analysis and conclusion drawing. It includes the ability to assess evidence, identify assumptions, formulate coherent arguments, understand complex relationships, and evaluate practices and theories critically. Additionally, critical sensibility involves self-awareness and reflection on personal and societal experiences.

PO 2: Scientific reasoning and Problem solving

- Capacity to interpret and draw conclusions from data, critically evaluate ideas and evidence with an open-minded perspective; ability to apply learned competencies to solve unfamiliar problems and apply knowledge to real-life situations, avoiding mere replication of curriculum content.

PO 3: Effective communication and leadership skill

- Proficiency in expressing thoughts verbally and non-verbally, utilizing appropriate communication media. Confidently sharing ideas, active listening, analytical reading and writing and presenting complex information clearly to diverse groups. Effective teamwork and leadership skills, including setting direction, inspiring vision, building and motivating teams, and guiding them efficiently towards common goals.

PO 4: Social consciousness and responsible citizenship

- Social consciousness involves an empathetic and informed perspective, extending beyond personal concerns to embrace a responsibility for the collective good in nation-building. It includes reflecting on the impact of research on conventional practices and a clear understanding of societal needs for inclusive and sustainable development. Responsible citizens contribute positively through civic engagement, environmental stewardship, and a commitment to social justice, abiding by laws and working for the advancement of society.

PO 5: Equity, Inclusiveness and Sustainability

- Promoting equity, inclusiveness, sustainability, and diversity appreciation. Developing ethical and moral reasoning with values of unity, secularism, and national integration for dignified citizenship. Understanding and appreciating diversity, managing differences, and using an inclusive approach. Emphasizing creating environments where diverse individuals feel valued, addressing present needs without compromising future generations' ability to meet their own needs, considering environmental, economic, and social factors.

PO 6: Moral and Ethical Reasoning

- Possessing the capacity to embody moral and ethical values in personal conduct, articulating positions and arguments on ethical matters from diverse perspectives, and consistently applying ethical practices in all endeavours. Proficient in recognizing and addressing ethical issues pertinent to one's work, steadfastly steering clear of any unethical behaviour.

PO 7: Networking and Collaboration

- Cultivating networking skills in education entails establishing meaningful professional connections and relationships among educators, administrators, and stakeholders. It also involves fostering cooperative efforts among individuals, institutions, and research organizations within the educational realm. These practices are indispensable for nurturing a supportive, innovative, and dynamic learning environment.

PO 8: Lifelong Learning

- Cultivating the ability to continually acquire knowledge and skills, including the art of "learning how to learn," becomes paramount for lifelong learning. This self-paced and self-directed approach serves personal development, aligns with economic, social, and cultural objectives, and facilitates adaptation to evolving workplace demands through skill development and reskilling. It equips individuals with competencies and insights, allowing them to adeptly respond to society's changing landscape and enhance their overall quality of life. Lifelong learning extends beyond formal education, embracing diverse informal and non-traditional learning experiences.

2. REGULATIONS FOR UNDERGRADUATE (HONOURS) DEGREE PROGRAMMES

PREAMBLE

Sacred Heart College (Autonomous), Thevara, Kochi is a grant-in-aid private college affiliated to Mahatma Gandhi University, Kottayam, Kerala. The College was established in 1944 as a higher educational institute for men on the basis of the minority rights. It started admitting girls in 1975 and currently serves all sections of the society without any discrimination of caste or creed.

The College was granted Autonomous Status by the University Grants Commission (UGC) in 2014.

Vision and Mission of the Institution

The vision of the College aims at the formation of holistic individuals who would champion the cause of justice, love, truth and peace. To this effect, Sacred Heart College envisions the **"Fashioning of an enlightened society founded on a relentless pursuit of excellence, a secular outlook on life, a thirst for moral values as well as an unflinching faith in God."** It seeks the creation of a world, guided by divine wisdom, governed by moral principles, inclusive by secular outlook and united by the principle of equity.

The Mission of the Institution is to provide an environment that

- facilitates the holistic development of the individual
- enables the students to play a vital role in the nation-building process and contribute to the progress of humanity
- disseminates knowledge even beyond academia
- instils in the students a feel for the frontier disciplines, and
- cultivates a concern for the environment

by setting lofty standards in the ever-evolving teacher-learner interface.

Framing of the Regulations

As part of the implementation of the National Education Policy 2020 (NEP 2020), the University Grants Commission (UGC) has issued the Curriculum and Credit Framework for Undergraduate Programmes 2023 (CCFUP) which would provide a flexible choice-based credit system, multidisciplinary approach, multiple entry and exit options, and establish three Broad Pathways, (a) 3-year UG Degree, (b) 4-year UG Degree (Honours), and (c) 4-year UG Degree (Honours with Research).

The Kerala Higher Education Reforms Commission has recommended a comprehensive reform in the undergraduate curriculum for the 2023-24 academic year, adopting 4-year undergraduate programmes to bring Kerala's undergraduate education at par with well acclaimed universities across the globe.

The Kerala State Curriculum Committee for Higher Education has been constituted, and have proposed a model Kerala State Higher Education Curriculum Framework (KSHECF) for Undergraduate Education.

Further, an Academic Committee and various sub committees were constituted for the implementation of the Regulations. The Academic Committee submitted the draft regulations on 15-03-2024, namely**: THE SACRED HEART COLLEGE (AUTONOMOUS) UNDERGRADUATE PROGRAMMES (HONOURS) REGULATIONS, 2024 {SHC-UGP (Honours)}** under the New Curriculum and Credit Framework, 2024.

REGULATIONS

Short Title and Commencement

i. These Regulations may be called THE SACRED HEART COLLEGE (AUTONOMOUS) UNDERGRADUATE PROGRAMMES (HONOURS) REGULATIONS, 2024 {SHC-UGP (Honours)} under the New Curriculum and Credit Framework 2024.
ii. These Regulations will come into effect from the academic year 2024-2025 and will have prospective effect.

Scope and Application

i. These Regulations shall apply to all Undergraduate programmes under various Faculties conducted by THE SACRED HEART COLLEGE (AUTONOMOUS) for the admissions commencing in the academic year 2024-2025.
ii. Every programme conducted under the SHC-UGP shall be monitored by an SHC-UGP Academic Committee comprising members nominated by the Principal.

Definitions

Unless used in a context otherwise specified,

i. College means THE SACRED HEART COLLEGE (Autonomous), a grant-in-aid private college affiliated to Mahatma Gandhi University, Kottayam, Kerala.
ii. 'University' means the MAHATMA GANDHI University which is the affiliating University of Sacred Heart College (Autonomous).
iii. FYUGP means Four Year Undergraduate Programme.
iv. Academic Year: Two consecutive (one odd and one even) semesters followed by a vacation in one academic year.
v. Academic Coordinator/Nodal Officer: Academic Coordinator/Nodal Officer is a faculty nominated by the college council to co-ordinate the effective conduct of the FYUGP including Continuous Comprehensive Assessment (CCA) undertaken by various departments within the college. She/ he/ they shall be the convenor for the College level Academic Committee.
vi. Academic Week: A unit of five working days in which the distribution of work is organized, with at least five contact hours of one-hour duration on each day.
vii. Academic Credit: A unit by which the course work is measured. It determines the number of hours of instructions required per week in a semester. It is defined both in terms of student efforts and teacher's efforts. A course which includes one hour of lecture or tutorial or minimum 2 hours of lab work/ practical work/ field work per week is given one credit hour. Accordingly, one credit is equivalent to one hour of lecture or tutorial or two hours of lab work/ practical work/ field work/ practicum and learner engagement in

terms of course related activities (such as seminars preparation, submitting assignments, group discussion, recognized club-related activities etc.) per week. Generally, a one credit course in a semester should be designed for 15 hours Lecture/ tutorials or 30 hours of practical/ field work/ practicum and 30 hours learner engagement.

viii. Academic Bank of Credits (ABC): An academic service mechanism as a digital/ virtual entity established and managed by Government of India to facilitate the learner to become its academic account holder and facilitating seamless learner mobility, between or within degree-granting Higher Education Institutions (HEIs) through a formal system of credit recognition, credit accumulation, credit transfers and credit redemption to promote distributed and flexible process of teaching and learning. This will facilitate the learner to choose their own learning path to attain a Degree/ Diploma/ Certificate, working on the principle of multiple entry and exit, keeping to the doctrine of anytime, anywhere, and any level of learning.

ix. Credit Accumulation: The facility created by ABC in the Academic Credit Bank Account (ABA) opened by the learner across the country in order to transfer and consolidate the credits earned by them by undergoing courses in any of the eligible HEIs.

x. Credit Recognition: The credits earned through eligible/ partnering HEIs and transferred directly to the ABC by the HEIs concerned.

xi. Credit Redemption: The process of commuting the accrued credits in the ABC of the learner for the purpose of fulfilling the credits requirements for the award of various degrees. Total credits necessary to fulfil the criteria to get a degree shall be debited and deleted from the account concerned upon collecting a degree by the learner.

xii. Credit Transfer: The mechanism by which the eligible HEIs registered with ABC are able to receive or provide prescribed credits to individual's registered with ABA in adherence to the UGC credit norms for the course(s) registered by the learner in any HEIs within India.

xiii. Credit Cap: Maximum number of credits that a student can take per semester, which is restricted to 30.

xiv. Continuous Comprehensive Assessment (CCA): The mechanism of evaluating the learner by the course faculty at the institutional level.

xv. End Semester Evaluation (ESE): The mechanism of evaluating the learner at the end of each semester.

xvi. Audit Course: a course that the learner can register without earning credits, and is not mandatory for completing the SHC-UGP. The student has the option not to take part in the CCA and ESE of the Audit Course. If the student has 75% attendance in an Audit Course, he/she/they is eligible for a pass in that course, without any credit (zero-credit).

xvii. Courses: refer to the papers which are taught and evaluated within a programme, which include lectures, tutorials, laboratory work, studio activity, field work, project work, vocational training, viva, seminars, term papers, presentations, assignments, self-study, group discussion, internship, etc., or a combination of some of these elements.

xviii. Choice Based Credit System (CBCS) means the system wherein students have the option to select courses from the prescribed list of courses.

xix. College-level Academic Committee: Is a committee constituted for the FYUGP at the college level comprising the Principal as the Chairperson, the Academic Co-ordinator/ Nodal Officer as its convenor.

xx. Academic Co-ordinator/ Nodal Officer: A senior faculty member nominated by the college council.

xxi. Course Faculty: A faculty member nominated by the Head of the Department shall be in charge of offering a particular course in a particular semester of FYUGP.

xxii. Department means any teaching department in a college offering a course of study approved by the College as per the regulations of the college and it includes a Department, Centre, or School of Teaching and Research conducted directly by the College.

xxiii. Board of Studies (BoS) means the academic body duly constituted to frame the syllabus of each department.

xxiv. Senior Faculty Advisor (SFA) is a faculty nominated by a Department Council to co-ordinate all the necessary work related to FYUGP undertaken in that department, including the continuous comprehensive assessment.

xxv. Department Council means the body of all teachers of a department in a college.

xxvi. Faculty Adviser (FA) means a teacher from the parent department nominated by the Department Council to advise students in academic matters.

xxvii. Graduate Attributes means the qualities and characteristics to be obtained by the graduates of a programme of study at the College, which include the learning outcomes related to the disciplinary areas in the chosen field of learning and generic learning outcomes. The College will specify graduate attributes for its programmes.

xxviii. Programme means the entire duration of the educational process including the evaluation leading to the award of a degree.

xxix. Programme Pathway: Combination of courses that can be chosen by a student that give options to pursue interesting and unconventional combinations of courses drawn from different disciplinary areas, like the sciences and the social sciences/ humanities. The pathways could be in terms of major- minor options with different complementary/ allied disciplines.

xxx. Regulatory Body means University Grants Commission (UGC), All India Council for Technical Education (AICTE), National Assessment and Accreditation Council (NAAC) and National Board of Accreditation (NBA) etc.

xxxi. Signature Courses: Signature courses are the specialized Discipline Specific Elective courses or skill-based courses designed and offered by the regular/ ad hoc/ visiting/ emeritus/ adjunct faculty member of a particular college with the prior recommendation of the BoS and the approval of Academic Council of the College.

xxxii. Letter Grade or simply ‘Grade’ in a course is a letter symbol (O, A+, A, B+, B, C, P, F, and Ab). Grade shall mean the prescribed alphabetical grade awarded to a student based on their performance in various examinations. The Letter grade that corresponds to a range of CGPA.

xxxiii. Grade Point: Each letter grade is assigned a ‘Grade point’ (G) which is an integer indicating the numerical equivalent of the broad level of performance of a student in each course. Grade Point means point given to a letter grade on 10-point scale.

xxxiv. Semester Grade Point Average (SGPA) is the value obtained by dividing the sum of credit points obtained by a student in the various courses taken in a semester by the total number of credits in that semester. SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.

xxxv. Credit Point (P) of a course is the value obtained by multiplying the grade point (G) by the credit (C) of the course: P = G x C

xxxvi. Cumulative Grade Point Average (CGPA) is the value obtained by dividing the sum of credit points in all the semesters earned by the student for the entire programme by the total number of credits in the entire programme and shall be rounded off to two decimal places.

xxxvii. Grade Card means the printed record of students' performance, awarded to them.

xxxviii. Words and expressions used and not defined in this regulation, but defined in the Mahatma Gandhi University Act and Statutes, being the Act and Statues of Sacred Heart College (Autonomous)'s affiliating University shall have the meaning assigned to them in the Act and Statutes.

Features and Objectives of SHC-UGP

The features and objectives of the SHC-UGP shall be:

i. The features, meaning, and purpose of FYUGP shall be as stipulated by the UGC and as adapted by the Kerala State Higher Education Curriculum Framework (KSHECF) for undergraduate education.

ii. The practice of lateral entry of students to various semesters exists, but an exit with a Degree shall be awarded only upon successful completion of 133 credits as per the conditions stipulated in this regulation.

iii. FYUGP shall have three Broad Pathways, (a) 3-year UG Degree, (b) 4-year UG Degree (Honours), and (c) 4-year UG Degree (Honours with Research).

iv. Students who choose to exit after 3 years shall be awarded UG Degree in their respective Discipline/ Disciplines after the successful completion of the required minimum Courses with 133 credits.

v. A 4-year UG Degree (Honours) in the Discipline/ Disciplines shall be awarded to those who complete the FYUGP with a specific number of Courses with 177 credits including 8 credits from a graduate project/ dissertation in their major discipline.

vi. Students who acquire minimum 75% in their graduation (upto 6th semester) are eligible for Honours with Research Programme. However if necessary, College may conduct screening test for the honours with research programme in accordance with College Regulations from time to time.

vii. 4-year UG Degree (Honours with Research): Students who aspire to pursue research as a career may opt for 4-year UG Degree Honours with Research stream under FYUGP with a specific number of Courses with 177 credits including 12 credits from a research project in their major discipline.

viii. The recognized research departments or departments with at least two faculty members having PhD shall offer the Honours with Research programme. Minimum 2 students (mentees) should be allotted to a faculty member (Mentor).

ix. Students who have chosen the honours with research stream shall do their entire fourth year under the mentorship of a mentor.

x. The mentor shall prescribe suitable advanced level/capstone level courses for a minimum of 20 credits to be taken within the institutions along with the courses on research methodology, research ethics, and research topic-specific courses for a minimum of 12

credits which may be obtained either within the institution or from other recognized institutions, including online and blended modes.

xi. Students who have opted for the honours with research should successfully complete a research project under the guidance of the mentor and should submit a research report for evaluation. They need to defend successfully the research project to obtain 12 credits under a faculty member of the College. The research shall be in the Major/ allied discipline.

xii. The research outcomes of their project work may be published in peer-reviewed journals or presented at conferences or seminars or patented.

xiii. The proposed FYUGP curriculum comprises Three Broad Parts: a) Foundation Components, b) Discipline Specific Pathway components (Major/ Minor), and c) Discipline Specific Capstone Components.

xiv. The Foundation component of the FYUGP shall consist of a Set of General Foundation Courses and a Set of Discipline Specific Foundation Courses.

xv. General Foundation Courses shall be grouped into 4 major baskets as Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC), Value Addition Courses (VAC), and Multi-Disciplinary Courses (MDC).

xvi. Ability Enhancement Courses shall be designed specifically to achieve competency in English, other languages as per the student's choice with special emphasis on language and communication skills.

xvii. English or other language courses shall be designed to enable the students to acquire and demonstrate the core linguistic skills, including critical reading, academic and expository writing skills as well as the cultural and intellectual heritage of the language chosen. Separate courses will be designed for Science, Humanities and Commerce streams.

xviii. Multi-Disciplinary Courses (MDC) shall be so designed as to enable the students to broaden their intellectual experience by understanding the conceptual foundations of Science, Social Sciences, Humanities, and Liberal Arts. Students shall not be eligible to take the MDC in the same discipline that they have studied during their +2. Third semester MDC can be Kerala specific content.

xix. Skill Enhancement Courses (SEC) shall be designed to enhance 21st century workplace skills such as creativity, critical thinking, communication, and collaboration.

xx. Discipline Specific Courses shall include Discipline Specific Pathway Courses, both Major and Minor streams, enabling students to gain basic knowledge in the chosen discipline.

xxi. Discipline Specific Foundation Courses shall focus on foundational theories, concepts, perspectives, principles, methods, and critical thinking essential for taking up advanced/ Capstone Courses. Practical courses shall be included in discipline specific foundation courses.

xxii. The curriculum of the SEC should be designed in a manner that at the end of year- 1, year-2, year-3, and year-4 students are able to meet the level descriptors for levels 5, 6, 7, and 8 of the UGC Guidelines on National Skills Qualifications Framework (NSQF). The detailed descriptors of the NSQF levels is provided as **Appendix I** below.

xxiii. Value Addition Courses (VAC) shall be so designed as to empower the students with personality development, perspective building, and self-awareness.

xxiv. Discipline Specific Pathway Components (Major/ Minor) shall provide the students with an opportunity to pursue in-depth study of a particular subject or discipline and develop competency in that chosen area, which includes Discipline Specific Core (DSC) courses and Discipline Specific Elective (DSE) courses as Major and Minor courses.

xxv. Major components consist of three types: Discipline Specific Core or the Discipline Specific Elective Courses, and the research /laboratory/ fieldwork.

xxvi. Minor Courses can be selected from any discipline that may supplement or complement the Major Courses.

xxvii. Students who complete a sufficient number of Courses in a discipline or an interdisciplinary area of study other than their chosen Major shall qualify for a Minor in that discipline or in a chosen interdisciplinary area of study.

xxviii. Major Components shall be the main focus of study. By selecting a Major, the student shall be provided with an opportunity to pursue an in-depth study of a particular discipline.

xxix. Each Board of Studies (BoS) shall identify specific Courses or baskets of Courses towards Minor Course credits. Students shall have the option to choose Courses from disciplinary/ interdisciplinary minors and skill-based courses related to a chosen programme.

xxx. Students can opt for a change of Major at the end of the second semester to any Minor discipline studied among the foundation level courses. Students also can opt for a change of Major at the end of the second semester to any MDC.

xxxi. Students should opt their 5th and 6th semester VAC and SEC from their Major disciplines only.

xxxii. Course cum Credits Certificate: After the successful completion of a semester as proof for re-entry to another institution this certificate is essential. This will help the learner for preserving the credits in the Academic Bank of Credits.

xxxiii. The Advanced Level/ Capstone Level Courses shall be designed in such a manner as to enable students to demonstrate their cumulative knowledge in their main field of study, which shall include advanced thematic specialization or internships or community engagement or services, vocational or professional training, or other kinds of work experience.

xxxiv. Advanced/ Capstone level Major Specialization shall include Courses focused on a specific area of study attached to a specific Major, which could be an Elective Course. They shall include research methodology as well.

xxxv. The student has the option to register for and attend a course without taking part in the CCA and ESE of that course. Such a course is called the Audit Course. If the student has 75% attendance in an Audit Course, he/she/they is/are eligible for a pass in that course, without any credit (zero-credit). The Audit Course will be recorded in the final grade card of the student.

xxxvi. All students shall undergo Summer Internship or Apprenticeship in a Firm, Industry or Organization; or Training in labs with faculty and researchers or other Higher Education Institutions (HEIs) or Research Institutions. The College will adhere to the guidelines on internship published by the University.

xxxvii. Students will be provided the opportunities for internships with local industries, business organizations, agriculture, health and allied sectors, Local Government institutions (such

as panchayats, municipalities), State Planning Board, State Councils/ Boards, Research Institutions, Research Labs, Library, elected representatives to the parliament/ state assembly/ panchayat, media organizations, artists, crafts persons etc. These opportunities will enable the students to actively engage with the practical aspects of their learning and to improve their employability.

xxxviii. The College will provide opportunities for field-based learning/minor projects enabling them to understand the different socio-economic and development-related issues in rural and urban settings. The College will provide the students with opportunities for Community engagement and services, exposing them to socio-economic issues to facilitate theoretical learning in real-life contexts.

xxxix. Additional Credits will be awarded for those who actively participating in Social Activities, which may include participation in National Service Scheme (NSS), Sports and Games, Arts, participation in College union related activities (for respective elected/ nominated members), National Cadet Corps (NCC), adult education/ literacy initiatives, mentoring school students, and engaging in similar social service organizations that deemed appropriate to the College.

xl. Grace marks shall be awarded to a student for meritorious achievements in co-curricular activities (in Sports/ Arts/ NSS/ NCC etc.). Such a benefit is applicable in the same academic year spreading over two semesters, in which the said meritorious achievements are earned. The Academic Council will decide from time to time the eligibility and other rules of awarding the grace marks.

xli. Options will be made available for students to earn credit by completing quality- assured remote learning modes, including Online programmes offered on the Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM) or other Online Educational Platforms approved by the competent body/university from time to time.

xlii. Students shall be entitled to gain credits from courses offered by other recognized institutions directly as well as through distance learning.

xliii. For the effective operation of the FYUGP, a system of flexible academic transaction timings shall be implemented for the students and teachers.

Eligibility for Admission and Reservation of Seats

i. The eligibility for admissions and reservation of seats for various FYUG Degree Programmes shall be in accordance with the norms/ rules made by the Government/ University from time to time.

ii. No student shall be eligible for admission to FYUG Degree Programmes in any of the disciplines unless he/she/they has successfully completed the examination conducted by a Board/University at the +2 level of schooling or its equivalent.

iii. Students shall be admitted and enrolled in the respective programmes solely based on the availability of the academic and physical facilities within the institution. The College shall provide all students with a brochure detailing the Courses offered by the various departments under the various Programmes and the number of seats sanctioned by the University for each Programme.

iv. During the time of admission each student may be provided with a unique higher education student ID which may be linked with the Aadhar number of the student so that this ID can be transferred if required to other higher education institutions as well.

v. The students at the end of second semester may be permitted to change their major programme of study to any course/ institution/ university across the state. Based on the availability of seats and other facilities, the students may be permitted to opt any discipline which he/she/they had studied during the first two semesters as Discipline Specific Foundation courses/ Multidisciplinary Foundation courses. If ranking is required it will be in the order of the highest-grade points secured in the discipline to which the switching of Major is sought.

vi. Students shall be allowed to change their major programmes, if required, to a maximum of 10% of the sanctioned strength of that particular programmes depending upon the academic and infrastructural facilities available in the Institution.

vii. Depending upon the availability of academic and infrastructural facilities, the College may also admit a certain number of students who are registered for particular programmes in each semester by transfer method, if required, from other Institutions subject to conditions as may be issued by the University.

viii. A student who has already successfully completed a First-Degree Programme and is desirous of and academically capable of pursuing another First-Degree Programme may also be admitted with the prior approval of the University as per the conditions regarding programme requirements specified by the University.

ix. A Student can also be admitted for an additional major/ second major/ additional minor and on completion of the required credits he/she/they can be awarded a second major/ additional major/ minor. He/she/they may be exempted from minor pathway and general foundation course requirement.

x. The College can also enroll students in certain courses as per their choice depending upon the availability of infrastructure and other academic facilities from other recognized HEIs who are already registered for a particular programme there either through regular/ online/ distance mode irrespective of the nature of programme (Govt./ Aided/ Self-finance/ Autonomous). On successful completion of the course the credits may be transferred through the Academic Bank of Credit.

Academic Monitoring and Student Support

The academic monitoring and student support shall be in the following manner, namely

i. The College shall appoint a Senior Faculty member as Academic Co-ordinator/ Nodal officer for the smooth conduct of FYUGP.

ii. Advisory System: There shall be one Senior Faculty Advisor (SFA) for each department and one Faculty Advisor (FA) for 20 to 30 students of the class to provide advice in all relevant matters. The Head of the Department, in consultation with the SFA, shall assign FA for each student.

iii. The documents regarding all academic activities of students in a class shall be kept under the custody of the FA/ SFA.

iv. All requests/ applications from a student or parent to higher offices are to be forwarded/ recommended by FA/ SFA.

v. Students shall first approach their FA/ SFA for all kinds of advice, clarifications, and permissions on academic matters.
vi. It is the official responsibility of the institution to provide the required guidance, clarifications, and advice to the students and parents strictly based on the prevailing academic regulations.
vii. The SFA shall arrange separate or combined meetings with FA, faculty members, parents, and students as and when required and discuss the academic progress of students.
viii. The FA/ SFA shall also offer guidance and help to solve the issues on academic and non-academic matters, including personal issues of the students.
ix. Regular advisory meetings shall be convened immediately after the commencement of the semester and immediately after announcing the marks of the Continuous Comprehensive Assessment (CCA).
x. The CCA related results shall be displayed on the department notice board/ other official digital platforms of the college at least for two working days.
   a. Any concern raised by the students regarding CCA shall be looked into in the combined meetings of advisors, HOD, course faculty, and the students concerned.
   b. If the concerns are not resolved at the advisor's level, the same can be referred to the properly constituted college-level grievance redressal committees as per the existing UGC/ University/ Government norms.
   c. The Principal/ HOD shall ensure the proper redressal of the concerns raised by the students regarding CCA.
   d. If the students raise further concerns about the issue, the principal shall refer the issue to the appropriate authorities with proper documents and minutes of all the committees.
xi. The FA/ SFA shall be the custodian of the minutes and action taken reports of the advisory meetings. The SFA shall get the minutes and action taken reports of advisory meetings approved by the Head of Department and the Principal.
xii. The Principal shall inform/forward all regulations, guidelines, communications, announcements, etc. regarding student academic and other matters to the HODs/ SFA for information and timely action.
xiii. It shall be the official responsibility of the Principal to extend the required administrative and financial support to the HODs, SFAs and FAs to arrange necessary orientation programmes for students regarding student counselling, the prevailing norms, regulations, guidelines and procedures on all academic and other related matters.
xiv. An integrated educational planning and administration software will be made available by the College to manage the academic information of all students including student admissions and registration, managing students' personal and academic information, course registrations, attendance management, all process related to assessments including regular & online examinations, grading, publishing of results, supplementary examinations, LMS, stakeholders' feedback, etc.
xv. Faculty, staff, students, and parents shall be allowed to access this software system over a highly secure authenticated mechanism from within the campus.

Course Registration

i. Each department shall publish well in advance the relevant details of courses offered, such as the name, academic level, expected outcomes, time slot, and course faculty members.

ii. Students shall be allowed to visit and interact with respective faculty members during the first week of each semester, to gather more information about the courses and the availability of seats.
iii. Based on consultations and advice from the faculty adviser, each student shall complete course registration within one week from the commencement of each semester.
iv. The number of credits that a student can take in a semester is governed by the provisions in these Regulations, subject to a minimum of 16 and a maximum of 30 Credits.
v. A student can opt out of a Course or Courses registered, subject to the minimum Credit/ Course requirement, if he/she/they feels that he/she/they has registered for more Courses than he/she/they can handle, within 30 days from the commencement of the semester.
vi. The college shall publish a list of the students registered for each course including audit course, if any, along with the chosen Programmes, repeat/ reappearance courses, if any.
vii. The higher education institutions shall admit candidates not only for programmes, but also for courses.

Re-admission and Scheme Migration

i. Students who opt out before the completion of the third year shall be provided with a 'Course cum Credits Certificate' after the successful completion of a semester as proof for re-entry to another institution.
ii. Students who have successfully completed a particular programme pathway may be permitted to take an additional minor or second major.
iii. Those students who are opting for a second major are eligible for getting certain credit transfer/ credit exemption from their previous minor programs of study, subject to the prior recommendation of the BoS that, those credits are relevant for the present major programme of study.

Duration of Programme, Credits, Requirements and Options

i. Students will be offered the opportunity to take breaks during the programme and resume after the break, but the total duration for completing the FYUG programme shall not exceed 7 years.
ii. Students who wish to complete the undergraduate programmes faster may do so by completing different courses equivalent to the required number of credits and fulfilling all other requirements in N-1 semesters, where N is the number of semesters in the FYUGP.
iii. Provided further that the students may complete the undergraduate programme in slower pace, they may pursue the three years or six semester programme in 4 to 5 years (8 to 10 semesters), and four years, or eight semester programme in 5 to 6 years (10 to 12 semesters) without obtaining readmission.
iv. For students who crossed 6 semesters at a slower space, the requirement of 16 credits per semester from the institutions where they enrolled may be relaxed.

Credit Structure

The proposed number of credits per course and the credit distribution of them for the FYUG Programmes are given below:

i. An academic year shall consist of 200 working days; one semester consists of 90 working days; and an academic year consists of two semesters.
ii. Ten working days in a semester shall be used for extracurricular activities. One semester consists of 18 weeks with 5 working days per week. In each semester, 15 days (3 weeks) should be kept aside for End Semester Evaluation (ESE) and CCA.
iii. The maximum number of available weeks for curriculum transactions should be fixed at 15 in each semester. A minimum of 5 teaching or tutorial hours could be made available for a day in a 5-day week.

iv. A course that includes one hour of lecture/ tutorial or two hours of lab work/ practical work/ field work/ practicum per week is given one credit hour.
v. One credit in a semester should be designed for 15 hours of lectures/ tutorials or 30 hours of lab work/ practical work/ field work/ practicum and 30 hours of learner engagement in terms of course-related activities such as seminar preparation, submitting assignments, etc.
vi. A one-credit seminar or internship or studio activities or field work/ projects or community engagement and service will have two-hour engagements per week (30 hours of engagement per semester).
vii. A course can have a combination of lecture credits, tutorial credits, and practicum credits.
viii. Minimum credit for one Course should be 2 (Two), and the maximum credit should be 4 (Four).
ix. All Discipline Specific Major/ Minor Courses shall be of 4 (Four) credits.
x. For all Discipline Specific Major/ Minor Courses, there may be practical/ practicum of two or four hours per week.
xi. All Courses under the Multi-Disciplinary, Ability Enhancement, Value Addition and Skill Enhancement categories are of 3 credits.
xii. Summer Internship, Apprenticeship, Community outreach activities, etc. may require sixty hours (or as appropriate) of engagement for acquiring one credit.
xiii. A student shall be able to opt for a certain number of extra credits over and above the requirements for the award of a degree.
xiv. Maximum number of credits that a student can earn per semester shall be restricted to 30. Hence, a student shall have the option of acquiring credits to a maximum of 180 credits for a 6-semester UG programmes and 240 credits for a 4-year (8-semester) programmes.
xv. Each faculty member shall offer a maximum of 16 credits per semester. However, those who are offering both practical and theory courses shall offer a maximum of 12-16 credits per semester.
xvi. For a four-credit theory course, 60 hours of lecture/ tutorial class shall be assured as a mandatory requirement for the completion of that course.

Course Structure of the SHC-UGP Programme

The SHC-UGP consists of the following categories of courses and the minimum credit requirements for pathway option-one shall be as follows;

Sl. No.	Categorization of Courses for all Programme	Minimum Number of Credit Required	
1.	Major	68	88
2.	Minor	24	24+12*
3.	Multi-Disciplinary Courses (MDC)	9	9
4.	Skill Enhancement Courses (SEC)	9	9
5.	Ability Enhancement Courses (AEC)	12	12
6.	Value Addition Courses (VAC)	9	9
7.	Summer Internship, field basedlearning etc.	2	2
8.	Research Project / Dissertation		12/8**

* The students can acquire advanced/ capstone level courses with 12 credits from their DSC/ DSE/ Minor courses depending up on their pathway choice. The Minor courses can be of level 300 or above.

** The students pursuing the 4-year honours with research have to complete a project with 12 credits and for the 4-year honours degree students have to complete a project with 8 credits and DSC/ DSE capstone/ advanced level course in the 8th semester.

i. 20% syllabus of each course will be prepared by the teacher as 'Teacher Specific Content' and will be evaluated under CCA.
ii. In case of MDC, SEC, VAC courses coming under 3rd & 4th semester, college should make necessary arrangements to give adequate preference to courses designed by language departments. MDC in the 3rd semester can be Kerala Specific Content.

Academic Levels of Pathway Courses

Semester	Difficulty level	Nature of Course
1 & 2	100-199	Foundation-level or introductory courses
3 & 4	200-299	Intermediate level courses
5 & 6	300-399	Higher level courses
7 & 8	400-499	Advanced/Capstone level courses

Signature Courses

i. With a prior recommendation of BoS and the approval of academic council, each faculty member can design and offer at least one signature course in every semester, which may be offered as DSE /SEC/ VAC.
ii. The College will publish a list of signature courses in DSE/ SEC/ VAC offered by the faculty members with a prior recommendation of BoS and the approval of academic council.
iii. The College may empanel distinguished individuals who have excelled in their field of specialization like science and technology, industry, commerce, social research, media, literature, fine arts, civil services etc. as adjunct faculty as per the UGC guidelines with the approval of the College. With a prior recommendation of BoS and the approval of academic council, the adjunct faculty can offer SEC/VAC as signature course.
iv. Ad hoc/ Guest faculty/ Visiting faculty/ Visiting Scholars can also offer DSE/ SEC/ VAC as signature courses with a prior recommendation of BoS and the approval of academic council.
v. The faculty concerned may design the particular course and it should be forwarded to the concerned BoS after the approval of the Academic Committees formed as part of this regulations.
vi. The examinations and evaluation of the signature courses designed by the faculty shall be conducted by the faculty themselves and an external expert faculty chosen by the college from a panel of experts submitted by the faculty and recommend by the BoS concerned.

Programme Pathways and Curriculum Structure

Students who have joined for any programme under these regulations shall have the option to choose the following pathways for their UG degree and Honours programme.

i. **Degree with single Major**: A student pursuing the FYUG programme in a specific discipline shall be awarded a Major degree if he secures at least 50% of the total credits

in the specific discipline required for the award of the Degree in that Discipline. Example: Physics Major/ Economics Major/ Commerce Major

ii. **Degree Major with Minor**: If a student pursuing the FYUG Programme is awarded a Major Degree in a particular discipline, he/she/they are eligible to be awarded a Minor in another discipline of his choice, if he earns a minimum of 32 credits (approximately 25% of credit required for the three-year programme) from 8 pathway courses in that discipline. Example: Physics Major with Chemistry Minor/ Chemistry Major with English Minor/ Commerce Major with Economics Minor/ English Major with Functional English Minor/ Hindi Major with Malayalam Minor etc.

iii. **Major with Multiple Disciplines** of Study: This pathway is recommended for students who wish to develop core competencies in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/ subjects. If a student pursuing FYUG Degree Programme is awarded a major Degree in a particular discipline, he/she/they are eligible to get mentioned his core competencies in other disciplines of his choice if he has earned 12 credits from the pathway courses of that discipline. Example: Physics Major with Minors in Chemistry and Mathematics, Economics Major with Minors in History and English, Commerce Major with Minors in Economics and Statistics.

iv. **Interdisciplinary Major**: For these programme pathways, the credits for the major and minor pathways shall be distributed among the constituent disciplines/subjects to attain core competence in the interdisciplinary programme. Example: Econometrics Major, Global Studies Major, Biostatistics Major.

v. **Multi-Disciplinary Major**: For multidisciplinary major pathways, the credits for the major and minor pathways will be distributed among the broad disciplines such as Life Sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc. Example: Life Science, Data Science, Nano Science.

vi. **Degree with Double Major**: A student who secures a minimum of 50% credits from the first major will be awarded a second major in another discipline if he could secure 40% of credit from that discipline for the 3-year/ 4-year UG degree to be awarded a double major degree. Example: Physics and Chemistry Major, Economics and History Major, Economics and History Major, Commerce and Management Major.

Pathway Option 1 - Degree Major or Major with Multiple Disciplines of Study

Course Components	No. of Courses											
	Semester 1	Semester 2	Semester 3	Semester 4	Internship of 2 Credits	Semester 5#	Semester 6#	Total	Remarks	Semester 7	Semester 8	Total
DSC A (4 Credit /Course)	1(P)	1(P)	3 (2P)	3 (2P)		5	4	17	7 Out of 17 can be opted as DSE	3	2	22
DSC B & C (4 Credit /Course)	2(P)	2(P)	1(P) (B or C)	1(P) (C or B)				6		3		9
Multidisciplinary Courses (MDC) (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1**	1**	3	*Recommended that the course may be offered by the English Department ** From DSC A only			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1**	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department ** From DSC A only			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC / DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Pathway Option 2 - Major with Minor

Course Components	No. of Courses											
	Semester 1	Semester 2	Semester 3	Semester 4	Internship of 2 Credits	Semester 5#	Semester 6#	Total	Remarks	Semester 7	Semester 8	Total
DSC A (4 Credit /Course)	1(P)	1(P)	3 (2P)	3 (2P)		4	3	15	7 Out of 15 can be opted as DSE	3	2	20
DSC B (4 Credit /Course)	2(P)	2(P)	1(P)	1(P)		1	1	8	1 Out of 8 can be opted as DSE	3		11
Multidisciplinary Courses (MDC)/ (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1**	1**	3	*Recommended that the course may be offered by the English Department ** From DSC A only			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1**	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department ** From DSC Aonly			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC/ DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Pathway Option 3 - Double Major

Course Components	No. of Courses											
	Semester 1	Semester 2	Semester 3	Semester 4	Internship of 2 Credits	Semester 5#	Semester 6#	Total	Remarks	Semester 7	Semester 8	Total
DSC A (4 Credit /Course)	1(P)	1 (P)	2(2P)	2(1P)		4	3	13	7 Out of 13 can be opted as DSE	3	2	18
DSC B (4 Credit /Course)	2(P)	2(P)	2(1P)	2(2P)		1	1	10	2 Out of 10 can be opted as DSE	3		13
Multidisciplinary Courses (MDC) (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1	1	3	*Recommended that the course may be offered by the English Department			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC/ DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Note: In all the above 3 tables “(P)” means courses with practical

Guidelines for Acquiring Credit from Other Institutions/Online/Distance Mode

i. A student shall register to a minimum of 16 credit per semester from the college/ department where he/she/they officially admitted for a particular programme. However, students enrolled for a particular programme in one institution can simultaneously enroll for additional credits from other HEIs within the University or outside University subject to a maximum of 30 credits per semester including the 16 institutional credits.
ii. The College shall publish a list of courses that are open for admission for students from other institutions well in advance before the commencement of each semester.
iii. Each BoS shall prepare and publish a list of online courses at different levels before the commencement of each semester offered in various online educational platforms recognized by the Academic Council of the college, which can be opted by the students for acquiring additional credits.
iv. BoS shall prepare and publish a list of allied/ relevant pathway courses before the commencement of each semester offered by other Board of Studies that can be considered as pathway course for major/ minor for their disciplines at different levels.
v. At the end of each semester the college will include the credit acquired by the student through online courses in their semester grade card subject to a maximum of 30 credits.

Attendance

i. A student shall be permitted to register for the end-semester evaluation of a specific course to acquire the credits only if he has completed 75% of the prescribed classroom activities in physical, online, or blended modes, including any makeup activities as specified by the course faculty of that particular course.
ii. A student is eligible for attendance as per the existing university and government orders which includes participation in a meeting, or events organized by the college or the university, a regularly scheduled curricular or extracurricular activity prescribed by the college or the university. Due to unavoidable or other legitimate circumstances such as illness, injury, family emergency, care-related responsibilities, bad or severe weather conditions, academic or career-related interviews students are eligible for authorized absence. Apart from this, all other eligible leaves such as maternity leave, and menstrual leave shall also be treated as authorized absences.
iii. The condonation facility can be availed as per the university norms.

Workload

i. The workload of a faculty who offers only lecture courses during an academic year shall be 32 credits.
ii. The workload of a faculty offering both practical courses and theory courses may be between 24-32 credits per academic year.
iii. An academic year shall consist of two semesters.
iv. To protect the existing language workload, college should make necessary arrangements to give adequate preference to those courses designed by language departments coming under MDC, SEC and VAC of 3rd & 4th semester. It is recommended that the MDC offered in the third semester shall be based on Indian Knowledge Systems or Nation-specific topics and may be offered by the Other Languages department or any other department as may be seen fit. Additionally, the SEC in the fourth semester may be offered by the English Department and of the VACs in the third and fourth semesters, one may be offered by the Other Languages Department and the other may be offered by the English Department. These recommendations may be modified as per the recommendations of the SHC-UGP Academic Monitoring Committee.

v. Programme wise workload calculation will be as per the FYUGP workload ordinance 2024.
vi. The teachers given the administrative responsibilities in the department and college level may give a relaxation in their work load as specified in the UGC regulations 2018.

Credit Transfer and Credit Accumulation

i. The college will establish a digital storage (DIGILOCKER) of academic credits for the credit accumulation and transfer in line with ABC.

ii. The validity of credits earned shall be for a maximum period of seven (7) years or as specified in the university/ UGC regulations.The students shall be required to earn at least 50% of the credits from the College.

iii. Students shall be required to earn the required number of credits as per any of the pathway structure specified in this regulation for the award of the degree.

Outcome Based Approach

The curriculum will be designed based on Outcome Based Education (OBE) practices. The Graduate Attributes (GA) and Programme Outcomes (PO) will be defined and specified in the syllabus of each programme.

Assessment and Evaluation

i. The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE).

ii. 30% weightage shall be given for CCA. The remaining 70% weight shall be for the ESE.

iii. Teacher Specific Content will be evaluated under CCA.

iv. CCA will have two subcomponents Formative Assessment (FA) and Summative Assessment (SA). Each of these components will have equal weightage and to be conducted by the course faculty/ course coordinator offering the course.

v. FA refers to a wide variety of methods that teachers use to conduct in-process evaluations of student comprehension, learning needs, and academic progress during a lesson, unit, module or course. FA is to encourage students to build on their strengths rather than fixate or dwell on their deficits. FA can help to clarify and calibrate learning expectations for both students. FA will help students become more aware of their learning needs, strengths, and interests so they can take greater responsibility over their own educational growth. FA will be prerogative of the course faculty/ course coordinator based on specific requirement of the student.

vi. Suggestive methods of FA are as follows: (anyone or in combinations as decided by the course faculty/ course coordinator)

a. Practical assignment
b. Observation of practical skills
c. Viva voce
d. Quiz
e. Interview
f. Oral presentations
g. Computerized adaptive testing
h. In-class discussions

i. Group tutorial work
j. Reflection writing assignments
k. Home assignments
l. Self and peer Assessments
m. Any other method as may be required for specific course/ student by the course faculty/ course coordinator.

vii. Summative Assessments (SA) are used to evaluate student learning, skill acquisition, and academic achievement at the conclusion of a defined instructional period- typically at the end of a project, unit, module, course or semester. SA may be a class tests, assignments, or project, used to determine whether students have learned what they were expected to learn. It will be based on evidence, collected using single or multiple ways of assessment. The systematically collected evidences should be kept in record by course faculty/ course coordinator and the marks should be displayed on the college notice board/ other official digital platforms of the college before the End Semester Evaluations.

viii. The method of SA will be as follows: (any one as decided by the course faculty/ course coordinator)
a. Written test
b. Open book test
c. Laboratory report
d. Problem based assignments
e. Individual project report
f. Case study report
g. Team project report
h. Literature survey
i. Standardized test
j. Any other pedagogic approach specifically designed for a particular course by the course faculty/ course coordinator.

ix. A student may repeat SA only if for any compulsive reason due to which the student could not attend the assessment.

x. The prerogative of arranging a CCA lies with the course faculty/ course coordinator with the approval of SHC-UGP Academic Committee based on justified reasons.

xi. The course faculty/ course coordinator shall be responsible for evaluating all the components of CCA. However, the college may involve any other person (External or Internal) for evaluation of any or all the components as decided by the Principal/Controller of Examinations from time to time in case any grievances are raised.

xii. Written tests shall be precisely designed using a variety of tools and processes (e.g., constructed responses, open-ended items, multiple-choice), and the students should be informed about the evaluation modalities before the commencement of the course.

xiii. The course faculty may provide options for students to improve their performance through continuous assessment mechanism.

xiv. There shall be theory and practical examinations at the end of each semester.

xv. Regarding evaluation, one credit may be evaluated for 25 marks in a semester; thus, a 4-credit course will be evaluated for 100 marks; 3-credit courses for 75 marks and 2-credit courses for 50 marks.

xvi. All examinations will be conducted by the College and will be evaluated at the College itself.

xvii. Individual Learning Plans (ILPs) and/ or specific assessment arrangements may be put in place for differently abled students. Suitable evaluation strategies including technology

assisted examinations/ alternate examination strategies will be designed and implemented for differently abled students.

Practical Examination

i. The end semester practical examination will be conducted and evaluated by the institution.

ii. There shall be a CCA for practical courses conducted by the course faculty/ course coordinator.

iii. The scheme of evaluation of practical courses will be as given below:

Components for the Evaluation of Practical Courses	Weightage
CCA of practical/practicum.	30%
ESE of practical/practicum.	70%

iv. Those who have completed the CCA alone will be permitted to appear for the ESE.

v. For grievance redressal purpose, the university shall have the right to call for all the records of CCA.

vi. Duration of Examination: Questions shall be set as per the defined Outcome .The duration of the examinations shall be as follows.

Mode	Time (in Hours)
Written Examination	2
Multiple Choice	1.5
Open Book	2
Any Other Mode	2

Evaluation of Project/Dissertation

The evaluation of project work shall be CCA with 30% and ESE 70%. The scheme of evaluation of the Project is given below:

Project type	Maximum Marks	CCA	ESE
Research Project of Honours with Research (12 credits)	200	60	140
Project of Honours (8 credits)	100	30	70

Evaluation of Internship

The evaluation of internship shall be done by a committee constituted by the Department Council. The scheme of CCA and ESE is given below:

Components of Evaluation of Internship	Weightage	Marks for Internship 2 Credits/ 50 Marks
CCA	30%	15
ESE	70%	35

The department council may decide any mode for the completion of the Internship. If in case evaluation is not specified in any of the selected internship programme, institution can adopt a proper evaluation method as per the weightage specified in the table above.

Letter Grades and Grade Points

Mark system is followed for evaluating each question. For each course in the semester, letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below,

i. The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester. The SGPA is based on the grades of the current term, while the Cumulative Grade Point Average (CGPA) is based on the grades in all courses taken after joining the programme of study.

ii. Based on the marks obtained, the weighted grade point will be mentioned in the student's grade cards.

Letter Grade	**Grade Point**	**Percentage of Marks (Both Internal & External Marks put together)**	**Class**
O (Outstanding)	10	95% and above	First Class with Distinction
A+ (Excellent)	9	85% and above but below 95%	
A (Very good)	8	75% and above but below 85%	
B+ (Good)	7	65% and above but below 75%	First Class
B (Above average)	6	55% and above but below 65%	
C (Average)	5	45% and above but below 55%	Second Class
P (Pass)	4	35% and above below 45% Aggregate (external and internal put together) with a minimum of 30% in external	Third Class
F (Fail)	0	Below an aggregate of 35%or below 30% in external evaluation	Fail
Ab (Absent)	0		Fail

iii. When students take audit courses, they may be given pass (P) or fail (F) grade without any credits.

Computation of SGPA and CGPA

The following method is recommended to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

iv. The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student in the semester, i.e.

SGPA (Si) = Σ(Ci x Gi) / ΣCi

Where Si is the SGPA in the i^{th} semester, Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

$$\textbf{SGPA} = \frac{\text{Sum of the credit points of all courses in a semester}}{\text{Total Credits in that Semester}}$$

Illustration – Computation of SGPA

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	DSC A	4	A	8	4 x 8 = 32
I	DSC B	4	B+	7	4 x 7 = 28
I	DSC C	4	B	6	4 x 6 = 24

I	MDC	3	B	6	3 x 6 = 18
I	AEC 1	3	O	10	3 x 10 = 30
I	AEC 2	3	C	5	3 x 5 = 15
	Total	21			147
	SGPA				147/21 = 7

The CGPA is also calculated in the same manner considering all the courses undergone by a student over all the semesters of a programme, i.e.

$$\textbf{CGPA} = \frac{\text{Sum of the credit points of all courses in six or eight semesters}}{\text{Total Credits in Six (133) or Eight (177) semesters}}$$

v. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Implementation and Monitoring of SHC-UGP

i. The implementation and monitoring of SHC-UGP will be carried out by duly appointed bodies/committees of the college such as the Academic Council, the various Boards of Studies and the Academic Monitoring Committee.

ii. Academic Council

Among its other functions, the Academic Council of the College shall:

i. Scrutinize and approve all the proposals submitted by the Board of Studies of each Department with regard to the SHC-UGP details such as, academic pathways, allowed syllabi enrichment/ updating, details of elective courses, Online courses, blended teaching, courses offering to the students of other HEIs, panel of examiners, summative and formative evaluation tools proposed by the course faculty concerned, new courses and syllabus proposed by the faculty members as signature courses etc.
ii. The Academic Council can differ on any proposal and it shall have the right to return the matter for reconsideration to the Board of Studies concerned or reject it, after giving sufficient reasons to do so.
iii. Undertake the scrutiny of all documents related to Teacher Specific Content.
iv. Recommend to the College Governing Council for starting innovative programmes using the flexibility and holistic nature of the SHC-UGP curriculum frame work.

iii. Board of Studies

Among its other functions, the Board of Studies of each Department shall:

i. Prepare teacher specific content of syllabi for various courses keeping in view the objectives of the SHC-UGP and submit the same for the approval of the Academic Council.
ii. Scrutinize the signature course content and its evaluation techniques.
iii. Suggest methodologies for innovative teaching and evaluation techniques.
iv. Suggest panel of examiners to the Office of the Controller of Examinations.
v. Coordinate research, teaching, extension and other academic activities in the department.

iv. SHC-UGP Academic Monitoring Committee

The SHC-UGP Academic Monitoring Committee shall be constituted under the Chairmanship of the Principal, with the Academic Coordinator as the Convenor,

shall be entrusted to oversee the implementation and monitoring of the SHC-UG programme.

i. The Academic Monitoring Committee will collect and whet the proposals submitted by the Board of Studies of each Department with regard to the SHC-UGP and duly forward them to the Academic Council.
ii. It will oversee and coordinate the activities undertaken for the successful implementation of SHC-UGP in the College and will function as an advisory body in such matters.

Power to Remove Difficulties

If any difficulty arises in giving effect to the provisions of these Regulations, the Principal may by order make such provisions which appears to him/her to be necessary or expedient for removing the difficulty. Every order made under this rule shall be subject to ratification by the appropriate authorities.

Modifications to the Regulations

Notwithstanding anything contained in these Regulations, any amendments or modifications issued or notified by the University Grants Commission or the State Government or the Mahatma Gandhi University from time to time, shall be incorporated into these Regulations by the appropriate regulatory bodies of the College and shall constitute an integral part thereof.

SYLLABUS INDEX

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
DISCIPLINE SPECIFIC COURSES (DSC)						
I	24UCHEDSC101	Fundamentals of Chemistry - I	100-199	4	3	2
II	24UCHEDSC102	Fundamentals of Chemistry - II	100-199	4	3	2
III	24UCHEDSC201	Inorganic Chemistry – I	200-299	4	3	2
	24UCHEDSC202	Organic Chemistry – I	200-299	4	3	2
	24UCHEDSC203	Physical Chemistry – I	200-299	4	4	0
IV	24UCHEDSC204	Inorganic Chemistry – II	200-299	4	3	2
	24UCHEDSC205	Organic Chemistry – II	200-299	4	3	2
	24UCHEDSC206	Physical Chemistry – II	200-299	4	4	0
V	24UCHEDSC301	Inorganic Chemistry – III	300-399	4	3	2
	24UCHEDSC302	Organic Chemistry – III	300-399	4	4	0
	24UCHEDSC303	Physical Chemistry – III	300-399	4	4	0
VI	24UCHEDSC304	Inorganic Chemistry – IV	300-399	4	4	0
	24UCHEDSC305	Organic Chemistry – IV	300-399	4	3	2
	24UCHEDSC306	Physical Chemistry – IV	300-399	4	3	2
VII	24UCHEDSC401	Inorganic Chemistry – V	400-499	4	4	0
	24UCHEDSC402	Organic Chemistry – V	400-499	4	4	0
	24UCHEDSC403	Organic Chemistry – VI	400-499	4	4	0
	24UCHEDSC404	Physical Chemistry - V	400-499	4	3	2
	24UCHEDSC405	Physical Chemistry - VI	400-499	4	4	0
	24UCHEDSC406	Spectroscopy - I	400-499	4	4	0
VIII	24UCHEDSC407	Inorganic Chemistry – VI	400-499	4	3	2
	24UCHEDSC408	Spectroscopy - II	400-499	4	3	2
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)						
V / VI	24UCHEDSE301	Instrumental Methods for Chemical Analysis	300-399	4	4	0
	24UCHEDSE302	Forensic Chemistry & Toxicology	300-399	4	4	0
	24UCHEDSE303	Food Chemistry	300-399	4	4	0
	24UCHEDSE304	Electrochemical Power Sources	300-399	4	4	0
	24UCHEDSE305	Applied Chemistry: Exploring Industrial Products and Processes.	300-399	4	4	0
	24UCHEDSE306	Materials Science and Nanochemistry	300-399	4	4	0
VIII	24UCHEDSE401	Advances in Chemistry	400-499	4	4	0
DISCIPLINE SPECIFIC COURSES (DSC) - *Minor Pathway*						
I	24UCHEDSC101	Fundamentals of Chemistry - I	100-199	4	3	2

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
II	24UCHEDSC102	Fundamentals of Chemistry - II	100-199	4	3	2
III/IV	24UCHEDSC207	Chemistry for Physical Sciences	200-299	4	3	2
	24UCHEDSC208	Elements of Biochemistry	200-299	4	3	2
	24UCHEDSC209	Bioinorganic and Agricultural Chemistry	200-299	4	3	2
MULTIDISCIPLINARY COURSES (MDC)						
I	24UCHEMDC101	Chemistry in Everyday Life	100-199	3	2	2
II	24UCHEMDC102	Environmental Chemistry	100-199	3	2	2
SKILL ENHANCEMENT COURSES (SEC)						
V	24UCHESEC301	Insilico Methods in Chemistry & Informatics	300-399	3	2	2
VI	24UCHESEC302	Preparation and Characterization of Advanced Materials.	300-399	3	2	2
VALUE ADDITION COURSES (VAC)						
VI	24UCHEVAC301	Chemicals and Hazardous Waste Management	300-399	3	3	0
SIGNATURE COURSES (SIG)						
V/VI	24UCHESIG301	Molecular Modelling and Drug Design	300-399	4	3	2
V/VI	24UCHESIG302	Rubber Products Manufacturing and Testing	300-399	4	3	2
VIII	24UCHESIG401	Cheminformatics	400-499	4	3	2
VIII	24UCHESIG402	Biochemistry	400-499	4	4	0

PROPOSED PROGRAMME STRUCTURE FOR B.Sc. (HONS.) CHEMISTRY

(*with Chemistry as Major and Minors B and C*)

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
I	24UCHEDSC101	Fundamentals of Chemistry - I	100-199	4	3	2
	-	DSC – Minor (B)	100-199	4	3	2
	-	DSC – Minor (C)	100-199	4	3	2
	-	AEC - English	100-199	3	3	0
	-	AEC – Other Languages	100-199	3	3	0
	-	MDC	100-199	3	2	2
				21	**17**	**8**
II	24UCHEDSC102	Fundamentals of Chemistry - II	100-199	4	3	2
	-	DSC – Minor (B)	100-199	4	3	2
	-	DSC – Minor (C)	100-199	4	3	2
	-	AEC - English	100-199	3	3	0
	-	AEC – Other Languages	100-199	3	3	0
	-	MDC	100-199	3	2	2
				21	**17**	**8**
III	24UCHEDSC201	Inorganic Chemistry – I	200-299	4	3	2
	24UCHEDSC202	Organic Chemistry – I	200-299	4	3	2
	24UCHEDSC203	Physical Chemistry – I	200-299	4	4	0
	-	DSC – Minor (B) / (C)	200-299	4	3	2
	-	MDC	200-299	3	3	0
	-	VAC	200-299	3	3	0
				22	**19**	**6**
IV	24UCHEDSC204	Inorganic Chemistry – II	200-299	4	3	2
	24UCHEDSC205	Organic Chemistry – II	200-299	4	3	2
	24UCHEDSC206	Physical Chemistry – II	200-299	4	4	0
	-	DSC – Minor (C) / (B)	200-299	4	3	2
	-	SEC	200-299	3	3	0
	-	VAC	200-299	3	3	0
				22	**19**	**6**
Summer Internship				**2**	**-**	**60**
V	24UCHEDSC301	Inorganic Chemistry – III	300-399	4	3	2
	24UCHEDSC302	Organic Chemistry – III	300-399	4	4	0
	24UCHEDSC303	Physical Chemistry – III	300-399	4	4	0
	-	DSE	300-399	4	4	0
	-	DSE	300-399	4	4	0

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
	24UCHESEC301	Insilico Methods in Chemistry & Informatics	300-399	3	2	2
				23	**21**	**4**
VI	24UCHEDSC304	Inorganic Chemistry – IV	300-399	4	4	0
	24UCHEDSC305	Organic Chemistry – IV	300-399	4	3	2
	24UCHEDSC306	Physical Chemistry – IV	300-399	4	3	2
	-	DSE	300-399	4	4	0
	24UCHESEC302	Preparation and Characterization of Advanced Materials.	300-399	3	2	2
	24UCHEVAC301	Chemicals and Hazardous Waste Management.	300-399	3	3	0
				22	**19**	**6**
Exit at 3rd Year with 133 Credits – BSc Degree						
VII*	24UCHEDSC401	Inorganic Chemistry – V	400-499	4	4	0
	24UCHEDSC402	Organic Chemistry – V	400-499	4	4	0
	24UCHEDSC403	Organic Chemistry – VI	400-499	4	4	0
	24UCHEDSC404	Physical Chemistry - V	400-499	4	3	2
	24UCHEDSC405	Physical Chemistry - VI	400-499	4	4	0
	24UCHEDSC406	Spectroscopy - I	400-499	4	4	0
** 3 Courses in Sem 7 can be taken from minor pathway at 300-399 level (for single minor pathway)*				**24**	**23**	**2**
VIII	24UCHEDSC407	Inorganic Chemistry – VI	400-499	4	3	2
	24UCHEDSC408	Spectroscopy - II	400-499	4	3	2
	-	12 Credit Project or 8 Credit Project + DSE	-	12	-	-
				20	-	-
Completion of the Programme at 4th Year with 177 Credits – BSc Honours Degree						

3. SYLLABUS FOR DISCIPLINE SPECIFIC COURSES IN CHEMISTRY

List of Courses in the Chemistry DSC Course Basket

No.	SEM	Course Code	Course Title	Course Level	Credit	Hours
1.	I	24UCHEDSC101	Fundamentals of Chemistry - I	100-199	4	75
2.	II	24UCHEDSC102	Fundamentals of Chemistry - II	100-199	4	75
3.	III	24UCHEDSC201	Inorganic Chemistry – I	200-299	4	75
4.		24UCHEDSC202	Organic Chemistry – I	200-299	4	75
5.		24UCHEDSC203	Physical Chemistry – I	200-299	4	60
6.	IV	24UCHEDSC204	Inorganic Chemistry – II	200-299	4	75
7.		24UCHEDSC205	Organic Chemistry – II	200-299	4	75
8.		24UCHEDSC206	Physical Chemistry – II	200-299	4	60
9.	V	24UCHEDSC301	Inorganic Chemistry – III	300-399	4	75
10.		24UCHEDSC302	Organic Chemistry – III	300-399	4	60
11.		24UCHEDSC303	Physical Chemistry – III	300-399	4	60
12.	VI	24UCHEDSC304	Inorganic Chemistry – IV	300-399	4	60
13.		24UCHEDSC305	Organic Chemistry – IV	300-399	4	75
14.		24UCHEDSC306	Physical Chemistry – IV	300-399	4	75
15.	VII	24UCHEDSC401	Inorganic Chemistry – V	400-499	4	60
16.		24UCHEDSC402	Organic Chemistry – V	400-499	4	60
17.		24UCHEDSC403	Organic Chemistry – VI	400-499	4	60
18.		24UCHEDSC404	Physical Chemistry - V	400-499	4	75
19.		24UCHEDSC405	Physical Chemistry - VI	400-499	4	60
20.		24UCHEDSC406	Spectroscopy - I	400-499	4	60
21.	VIII	24UCHEDSC407	Inorganic Chemistry – VI	400-499	4	75
22.		24UCHEDSC408	Spectroscopy - II	400-499	4	75

DSC - 01

Discipline	Chemistry
Semester	I
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC101
Course Title	Fundamentals of Chemistry - I
Course Level	100-199
Course Summary	The Fundamentals of Chemistry introduces fundamental concepts of matter, atoms, molecules, organic reagents and intermediates. Laboratory sessions enhance understanding through titration experiments. The course lays the groundwork for further study in chemistry and related fields.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4
Pre-requisite, if any	Basic understanding of general science concepts.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the system of units, its interconversions and different states of matter.	Understand	PO 1, PO 2
2	Explain the basic concepts in inorganic chemistry	Understand	PO 1, PO 2
3	Illustrate the fundamental principles of analytical chemistry	Apply	PO 1, PO 2
4	Explain the basic concepts of organic chemistry, reagents and reactive intermediates.	Apply	PO 1, PO 2
5	Analyse volumetrically the amount of substance in a given solution	Analyse	PO 1

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Fundamentals of Physical Chemistry (15 Hours)**			
	1.1	System of Units, The seven base units of the SI, Prefixes for SI units, Common metric prefixes, conversion of SI unit to non-SI units.	3	CO 1
	1.2	Atomic mass unit, Avogadro constant, Bohr magneton, Bohr radius, Faraday constant, Gas constant, Boltzmann constant, Plank constant, molar volume of ideal gas, Proton charge, electron charge, Electron rest mass, proton rest mass	2	CO 1

	1.3	Matter and its different states (7 states - elementary idea only), *Intermolecular Forces*: dipole-dipole interaction, Dipole-induced dipole interaction and induced dipole-induced dipole interaction, Ion-dipole interaction, Hydrogen bonding: intra and intermolecular hydrogen bonds - effect on physical properties.	3	CO 1
	1.4	*Gaseous state*: Concept of pressure and temperature, Gas laws, ideal gas equation and real gas equation (mention only).	3	CO 1
	1.5	*Liquid state*: Properties of liquids - vapour pressure, boiling point.	2	CO 1
	1.6	*Solid state*: Types of Solids - Crystalline and amorphous solids, Unit cell, Classification of unit cell.	2	CO 1
2	**Basic Concepts in Inorganic Chemistry (5 Hours)**			
	2.1	Atomic mass and Molecular mass. Isotopes, isobars and isotones – Mole concept – Molar volume. Oxidation and reduction – Oxidation number and valency - Variable valency - Equivalent mass.	2	CO 2
	2.2	Methods of expressing concentration: Weight percentage, molality, molarity, normality, formality, mole fraction, ppm and millimoles. Numerical Problems related to basic concepts.	3	CO 2
3	**Analytical Chemistry – I (10 Hours)**			
	3.1	Quantitative Analysis: Primary standard-secondary standard, quantitative dilution – problems. Calibration of volumetric apparatus. Acid-base titrations-titration curves – pH indicators.	5	CO 3
	3.2	Redox titrations – Titration curve, Titrations involving $KMnO_4$ and $K_2Cr_2O_7$, Redox indicators. Complexometric titrations – EDTA titrations, titration curves, metal ion indicators and characteristics.	5	CO 3
4	**Recapitulation of Basics of Organic Chemistry (15 Hours)**			
	4.1	Birth of organic chemistry, Reasons for the existence of a large number of organic compounds, Tetravalency of carbon, Hybridization, Shapes of molecules, Various representations of organic compounds,	3	CO 4
	4.2	Electronic displacements and their applications: Inductive, electromeric, resonance and mesomeric effects and hyperconjugation.	3	CO 4
	4.3	Concept of dipole moment, acidity and basicity and pKa values.	2	CO 4
	4.4	Drawing electron movements with arrows- curved arrow notation. Half-headed and double-headed arrows. Homolytic and heterolytic fissions with suitable examples.	1	CO 4
	4.5	Types of reagents – Electrophiles and Nucleophiles- Types and sub-types of following organic reactions with definition and at least one example of each - Substitution, Addition reactions,	2	CO 4

		Elimination and Rearrangement.		
	4.6	Reactive Intermediates: Formation, structure and relative stability of carbocations, carbanions, carbenes and free radicals.	4	CO 4
5	**Practical : Volumetric Analysis (30 Hours)**			
	5.1	Preparation of solutions, quantitative dilution of solutions.	4	CO 5
	5.2	Acidimetry and Alkalimetry 1. Strong acid – Weak base 2. Strong base – Weak acid 3. Estimation of Na_2CO_3 and $NaHCO_3$ in a mixture 4. Estimation of NaOH and Na_2CO_3 in a mixture	20	CO 5
	5.3	Microanalysis – Two Burette titrations 1. Strong acid – Weak base 2. Strong base – Weak acid	6	CO 5
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record, and *any other method as may be required by the course faculty*.

References:

1. H. A. Radi and J. O. Rasmussen, Principles of Physics, Undergraduate Lecture Notes in Physics, DOI: 10.1007/978-3-642-23026-4_1, Springer-Verlag Berlin Heidelberg 2013.
2. Butcher, K. S., Crown, L. D. & Gentry, E. J. The international system of units (SI) - conversion factors for general use: 2006 doi:https://doi.org/10.6028/NIST.SP.1038.
3. The IUPAC Compendium of Chemical Terminology. *IUPAC Compend. Chem. Terminol.* 2019 doi:10.1351/GOLDBOOK.
4. B. R. Puri, L. R. Sharma, M.S. Pathania, Elements of Physical Chemistry, 3rd edn. Vishal Pub. CO., 2008.
5. J. D. Lee, Concise Inorganic Chemistry, 5th edn., Blackwell Science, London (Chapter 1).
6. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press (Chapter 1)

7. D A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004
8. M.C. Day and J. Selbin, Theoretical Inorganic Chemistry, East West Press, New Delhi, 2002.
9. B.R. Puri, L.R. Sharma and K.C. Kalia, Principles of Inorganic Chemistry, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
10. Satya Prakash, Advanced Inorganic Chemistry, Volume 1, 5th Edition, S. Chand and Sons, New Delhi, 2012.
11. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
12. Finar, I. L. Organic Chemistry Volume 1. Pearson education, 2007.
13. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010
14. Jain, M.K. & Sharma, S.C. Modern Organic Chemistry, Vishal Publishing Co. 2010
15. McMurry, John E. Fundamentals of organic chemistry. Cengage Learning, 2010.
16. Clayden, Jonathan, Nick Greeves, and Stuart Warren. Organic chemistry. Oxford University Press, USA, 2012.
17. Wade, Leroy G. Organic chemistry. Pearson Education India, 2008.
18. Bruice, Paula Yurkanis. Organic chemistry. Pearson, 2017.
19. Solomons, TW Graham, and Craig B. Fryhle. Organic chemistry. John Wiley & Sons, 2008.
20. Chandra, R.; Singh, S.; Singh, A. (2019), Organic reactions and their nomenclature, Arcler Press.

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC - 02

Discipline	Chemistry
Semester	II
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC102
Course Title	Fundamentals of Chemistry - II
Course Level	100-199
Course Summary	The Fundamentals of Chemistry introduces a mathematical foundation for quantitative analysis, atomic structure, analytical chemistry, and chemistry of hydrocarbons. Laboratory sessions enhance understanding through organic chemistry experiments. The course lays the groundwork for further study in chemistry and related fields.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4
Pre-requisite, if any	Basic understanding of general chemistry concepts.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the mathematical tools for quantitative analysis	Understand	PO 1, PO 2
2	Analyse the features and limitations of various models of atomic structure.	Understand	PO 1, PO 2, PO 8
3	Explain the principle of gravimetric analysis, separation and purification techniques.	Apply	PO 1, PO 2, PO 8
4	Explain the preparation and properties of aliphatic hydrocarbons	Apply	PO 1, PO 2
5	Illustrate the purification and detection of organic compounds.	Analyse	PO 1

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Mathematical Foundation for Quantitative Analysis (15 Hours)**			
	1.1	Logarithm: Basic rules and calculations	1	CO 1
	1.2	Graph - Quadrants, drawing of linear graph Dependant and independent variables, Slopes and Intercept.	2	CO 1
	1.3	Derivative and Integration: Basic rules (Kx, e^x, x^n, logx, sinx, cosx)	2	CO 1
	1.4	Definitions of analysis, determination, measurement, techniques	2	CO 1

		and methods.		
	1.5	Classification of analytical techniques. Choice of an analytical method - accuracy, precision, sensitivity, selectivity, method validation. Significant figures.	2	CO 1
	1.6	Figures of merit of analytical methods and limit of detection (LOD), Limit of quantification (LOQ), linear dynamic range (working range).	2	CO 1
	1.7	Errors in Chemical Analysis. Types of error-absolute and relative error, methods of eliminating or minimizing errors.	2	CO 1
	1.8	Methods of expressing precision: mean, median, Measures of dispersion – Standard deviation, average deviation and coefficient of variation.	2	CO 1
2	**Atomic Structure (10 Hours)**			
	2.1	Introduction to atomic structure based on historical development – Rutherford's atom model and its limitations - Failure of classical physics – Black body radiation – Compton Effect - Planck's quantum hypothesis - Photoelectric effect – Generalization of quantum theory -Atomic spectra of hydrogen and hydrogen-like atoms – Ritz-combination principle	5	CO 2
	2.2	Bohr theory of the atom, Calculation of Bohr radius, velocity and energy of an electron - Explanation of atomic spectra – Rydberg equation – Limitations of Bohr theory – Sommerfeld's modification - Louis de Broglie's matter waves – Wave-particle duality - Electron diffraction – Davisson and Germer experiment, Heisenberg's uncertainty principle.	5	CO 2
3	**Analytical Chemistry – II (5 Hours)**			
	3.1	Gravimetric analysis: Systematic steps in gravimetric analysis. Illustrations using iron and barium estimation. Separation and purification techniques – Filtration, Crystallization and precipitation – concept of solubility product as applied in group separation of cations – problems. Fractional distillation, Solvent extraction	5	CO 3
4	**Chemistry of Aliphatic Hydrocarbons (15 Hours)**			
	4.1	Alkanes Preparation – Wurtz reaction, Corey House synthesis. Reactions of alkanes – Free radical substitutions (chlorination) with mechanism.	2	CO 4
	4.2	Alkenes Preparation – Dehydration of alcohols. Reactions of alkenes with mechanisms – Hydration, Ozonolysis, Hydroboration, Bromination, Hydroxylation reactions (Syn and Anti), oxymercuration-demercuration. 1, 4 – addition in conjugated dienes.	9	CO 4
	4.3	Alkynes Preparation of acetylenes- dehydrohalogenation of vicinal dihalides Reactions - Acidity of alkynes, formation of metal acetylides, alkylation of terminal alkynes and conversion into higher alkynes,	4	CO 4

		addition of water, bromine and alkaline $KMnO_4$, reduction using Lindlar's catalyst. Test to identify terminal and non-terminal alkynes.		
5	**Practical : Organic Chemistry Practicals (30 hours)**			
	5.1	Purification of organic compounds – Recrystallization, Sublimation, Distillation, Solvent extraction, Chromatography	2	CO 5
	5.2	Purification of organic compounds by recrystallization using the following solvents: a. Water b. Alcohol c. Alcohol-Water	4	CO 5
	5.3	Chromatography: a) Separation of a mixture of two amino acids by ascending and radial paper chromatography. b). Separation of a mixture of two sugars by ascending paper chromatography. c). Separation of a mixture of o-and p-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC).	14	CO 5
	5.4	Detection of elements (N, S, Halogens)	10	CO 5
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

1. Skoog, D. A., West, D. M., Holler, F. J. & Crouch, S. R. Analytical Chemistry. Cengage Learning, 2014.
2. J. Mendham, R.C. Denney, J .D. Barnes and M.J.K. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th edition, Third Indian Reprint, Pearson Education Pvt. Ltd., 2007.
3. G.D. Christian, Analytical Chemistry, 6th edition, Wiley-India, 2007.
4. B. R. Puri, L. R. Sharma, M.S. Pathania, Elements of Physical Chemistry, 3rd edn. Vishal Pub. CO., 2008.
5. Yates, P. Chemical calculations : mathematics for chemistry., 2nd edition London: CRC Press Taylor & Francis Group, 2007.
6. J. D. Lee, Concise Inorganic Chemistry, 5th edn., Blackwell Science, London (Chapter 1).

7. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press (Chapter 1)
8. D A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004
9. M.C. Day and J. Selbin, Theoretical Inorganic Chemistry, East West Press, New Delhi, 2002.
10. B.R. Puri, L.R. Sharma and K.C. Kalia, Principles of Inorganic Chemistry, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
11. Satya Prakash, Advanced Inorganic Chemistry, Volume 1, 5th Edition, S. Chand and Sons, New Delhi, 2012.
12. Morrison, Robert Thornton, and Robert Nelson Boyd. "Textbook of organic chemistry." (2010).
13. Finar, I. L. Organic Chemistry Volume 1. Pearson Education, 2007.
14. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010
15. Jain, M.K. & Sharma, S.C. Modern Organic Chemistry, Vishal Publishing Co. 2010
16. McMurry, John E. Fundamentals of organic chemistry. Cengage Learning, 2010.
17. Clayden, Jonathan, Nick Greeves, and Stuart Warren. Organic chemistry. Oxford University Press, USA, 2012.
18. Wade, Leroy G. Organic chemistry. Pearson Education India, 2008.
19. Bruice, Paula Yurkanis. Organic chemistry. Pearson, 2017.
20. Solomons, TW Graham, and Craig B. Fryhle. Organic chemistry. John Wiley & Sons, 2008.

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC - 03

Discipline	Chemistry
Semester	III
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC201
Course Title	Inorganic Chemistry - I
Course Level	200-299
Course Summary	This course introduces students to the chemical properties and applications of compounds containing *s* and *p* block elements. It provides a brief overview of the quantum mechanical model of the atom, with a focus on the Schrödinger wave equation and its relevance to understanding the electronic structure. Students can learn the basic principles of chromatography and its importance in analyzing rubber compounds. The practical component of the course involves hands-on experience with quantitative analysis methods.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the chemistry of s and p block elements	Understand	PO1, PO2, PO5
2	Apply the principles of quantum mechanics to describe atomic structure	Apply	PO1, PO2, PO5
3	Explain the basics concepts and principles of different chromatographic methods	Analyse	PO1, PO2, PO5
4	Estimate the amount of substance in a given solution by complexometry, permanganometry, dichrometry, iodimetry, iodometry and gravimetry	Apply	PO1, PO2, PO5

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Compounds of *s* and *p* Block Elements (15 Hours)**			
	1.1	Macrocyclic ligands: crown ethers and cryptands, Macrocyclic effect, Alkali metal complexes with crown ethers and cryptands, their applications.	4	CO 1
	1.2	Boron hydrides: diborane (preparation, properties and bonding), B_5H_9, B_4H_{10} (structure only). Closo carboranes, boron nitride, borazine, boric acid.	4	CO 1

	1.3	Peroxy acids of sulphur. Oxides and oxy acids of halogens (structure only), superacids, interhalogen compounds, pseudohalogens, electropositive iodine, fluorocarbons.	4	CO 1
	1.4	Fluorides, oxides and oxy fluorides of xenon (structure only)	3	CO 1
2	**Quantum Mechanical Model of Atom (15 Hours)**			
	2.1	Operator algebra – Linear and Hermitian operators - Laplacian and Hamiltonian operators – Eigen functions and Eigen values of an operator - Well behaved functions, Normalization of wave function.	3	CO 2
	2.2	Postulates of quantum mechanics, Time-independent Schrödinger wave equation.	2	CO 2
	2.3	Application to particle in a one dimensional box, Particle in a three-dimensional box - Degeneracy.	2	CO 2
	2.4	Application of Schrödinger wave equation to hydrogen atom – Conversion of Cartesian coordinates to polar coordinates - The wave equation in spherical polar coordinates (derivation not required) - Radial and Angular functions (derivation not required) – Orbitals and concept of Quantum numbers (*n, l, m*). Radial functions - Radial distribution functions and their plots – Shapes of orbitals (s, p and d). Electron spin – Spin quantum number.	3	CO 2
	2.5	Pauli's Exclusion principle - Hund's rule of maximum multiplicity - Aufbau principle, Electronic configuration of atoms	2	CO 2
	2.6	Schrödinger equation for multi-electron atoms: Need for approximation methods.	3	CO 2
3	**Chromatography (15 Hours)**			
	3.1	Chromatography - Classification of methods, elementary study of adsorption	5	CO 3
	3.2	Paper, thin layer, column, ion exchange and gas chromatographic methods.	5	CO 3
	3.3	HPLC, GPC and their applications.	5	CO 3
4	**Practical: Volumetric Analysis (30 Hrs)**			
	4.1	*Complexometry* Estimation of Zn using EDTA Estimation of Mg using EDTA Estimation of Mg and Ca in a mixture Determination of hardness of water	6	CO 4
	4.2	Iodometry and Iodimetry Standardisation of thiosulphate using KI, electrolytic copper and potassium dichromate. Estimation of As_2O_3 and arsenite. Estimation of Cu in a copper salt.	6	CO 4

	4.3	*Permanganometry* Estimation of Ferrous iron Estimation of Oxalic acid Estimation of Calcium	6	CO 4
	4.4	*Dichrometry* Estimation of Ferrous iron using internal indicator Estimation of Ferrous iron using external indicator Estimation of Ferric iron – reduction with $SnCl_2$	6	CO 4
	4.5	*Gravimetric analysis* Estimation of Barium as $BaSO_4$ Estimation of iron as Fe_2O_3	6	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

Text Books:

1. M.C. Day and J. Selbin, Theoretical Inorganic Chemistry, East West Press, New Delhi, 2002.
2. B.R. Puri, L.R. Sharma and K.C. Kalia, Principles of Inorganic Chemistry, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
3. Satya Prakash, Advanced Inorganic Chemistry, Volume 1, 5th Edition, S. Chand and Sons, New Delhi, 2012.
4. J. Mendham, R.C. Denney, J. D. Barnes and M. Thomas, Vogel's Text Book of Quantitative Chemical Analysis, 6th Edition, Pearson Education, Noida, 2013.
5. A.K. Chandra, Introductory Quantum Chemistry, 4th Edition, Tata McGraw Hill Publishing Company, Noida, 1994.
6. R.K. Prasad, Quantum Chemistry, 4th Edition, New Age International(P) Ltd., New Delhi, 2012.
7. B.K, Sen, Quantum Chemistry – Including Spectroscopy, 3rd Edition, Kalyani publishers, New Delhi, 2010.

References:

1. T. F Gieryn, Cultural Boundaries of Science, University of Chicago Press, Chicago, 1999.
2. H. Collins and T. Pinch, The Golem: What Everyone Should Know about Science, Cambridge University Press, Cambridge, 1993.

3. C.R. Kothari, Research Methodology: Methods and Techniques, 2nd Revised Edition, New Age International Publishers, New Delhi, 2004.
4. Guidance in a Nutshell - Compilation of Safety Data Sheets, European Chemicals Agency, Finland, Version 1.0, December 2013.
5. J. D. Lee, Concise Inorganic Chemistry, 5th edn., Blackwell Science, London (Chapter 1).
6. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press, (Chapter 1)
7. B. Douglas, D. Mc Daniel, J. Alexander, Concepts and models in Inorganic Chemistry, (Chapter 1)
8. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004.
9. D.A. McQuarrie, Quantum Chemistry, 2nd Edition, University Science Books, California, 2008.
10. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 3rd Edition, Oxford, University Press, New York, 1997.
11. N. Levine, Quantum Chemistry, 6th Edition, Pearson Education Inc., New Delhi, 2009.
12. Vogel's, Textbook of Quantitative Chemical Analysis, 6th edn, Pearsons Education Ltd
13. D. A. Skoog, D. M. West, and S. R. Crouch, Fundamentals of Analytical Chemistry, 8th edn, Brooks/Cole Nelson.
14. G. D. Christian, Analytical Chemistry, John Wiley and Sons.

DSC - 04

Discipline	Chemistry
Semester	III
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC202
Course Title	Organic Chemistry I
Course Level	200-299
Course Summary	The first module gives a basic treatment of stereochemistry. In that, different types of stereoisomerism and the rules for assigning configurations are explained. Then, conformational isomerism is discussed. In the second module, students will learn about aromaticity and the reactions of aromatic compounds along with their mechanism. The practical component focuses on the following points: Laboratory hygiene and safety protocols to be followed in a chemical laboratory. Chemical tests to identify aromatic compounds will be discussed. Organic conversions involving aromatic compounds and the determination of their physical constants.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4
Pre-requisite	Basic understanding of fundamentals of organic chemistry.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describe the stereochemistry of organic compounds	Apply	PO 1, PO 2
2	Explain the aromaticity of organic compounds	Understand	PO 1, PO 2
3	Explain the chemistry of benzene and its reactions.	Apply	PO 1, PO 2
4	Prepare and determine the physical constants of organic compounds	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Stereochemistry - I (10 Hours)**			
	1.1	Isomerism, Types of isomerism.	2	CO 1
	1.2	Stereoisomerism: Definition, classification, configuration and conformation, Representation of organic molecules: Projection formula (Fischer, Sawhorse, Flying wedge, Newman) and their interconversion.	2	CO 1
	1.3	Geometrical isomerism: Cis–trans, syn-anti, and E/Z nomenclature (for up to two C=C systems) with Cahn Ingold	2	CO 1

		Prelog (CIP) rules. Methods of distinguishing geometrical isomers.		
	1.4	Optical isomerism: Optical activity, specific rotation, the concept of chirality, Stereogenic centres, Enantiomerism, diastereomerism and meso compounds, optical isomers of lactic acid and tartaric acid, Racemic mixture. Optical purity and enantiomeric excess. Resolution - methods of resolution – Mechanical, seeding, biochemical and conversion to diastereomers.	4	CO 1
2	**Stereochemistry - II (15 Hours)**			
	2.1	Relative and absolute configuration: D and L, Threo and erythro; CIP rules: R/ S notation (for upto 2 chiral carbon atoms). Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature	3	CO 1
	2.2	Conformations: Conformational analysis with respect to ethane, propane, butane, cyclohexane. Axial and equatorial positions. Conformations of monosubstituted cyclohexanes. Relative stability and energy diagrams. Baeyer Strain theory. Asymmetric synthesis – Partial and absolute synthesis	12	CO 1
3	**Aromaticity (5 Hours)**			
	3.1	Aromaticity: Definition, Hückel's rule - application to benzenoid (benzene, naphthalene and anthracene), non-benzenoid aromatic compounds-ionic aromatic compounds (cyclopropenyl cation, cyclopentadienyl anion and tropylium cation) and heterocyclic aromatic compounds (Pyridine, Pyrrole and furan). Non-aromatic and anti-aromatic compounds.	5	CO 2
4	**Chemistry of Benzene (15 Hours)**			
	4.1	Benzene: Molecular orbital picture and resonance energy. Reactions - Electrophilic aromatic substitution: nitration, halogenation, Friedel-Craft's reaction (alkylation and acylation) with their mechanisms.	6	CO 3
	4.2	Ring activating and deactivating groups with examples. Orientation of aromatic substitution. ortho, para and meta-directing effects of groups.	4	CO 3
	4.3	Reactions - aromatic nucleophilic substitutions of halobenzenes – bimolecular displacement mechanism, elimination-addition (benzyne intermediate) mechanism.	5	CO 3
5	**Practical : Organic Chemistry Practicals - II (30 hours)**			
	5.1	Laboratory Hygiene and Safety: Awareness of Material Safety Data Sheet (MSDS). Storage and handling of chemicals. Simple first aids: Electric shocks, fire, cut by glass and inhalation of poisonous gases - Accidents due to acids and alkalies - Burns due to phenol and bromine. Disposal of sodium and broken mercury thermometer - Use of calcium chloride and silica gel in desiccators. – R & S Phrases (elementary idea only) – Safe laboratory practices – Lab safety signs. Personal Protective	2	CO 4

		Equipment (PPE).		
	5.2	Microscale organic analysis- test for aromatic character- ignition test, nitration test, picrate test for aromatic compounds, test for unsaturation. Organic Preparations (i) Bromination of acetanilide / phenol (ii) Nitration of nitrobenzene / benzoic acid.	18	CO 4
	5.3	Determination of physical constants-melting point, boiling point, Effects of impurities on physical constant. Measurement of specific rotation (Polarimetry) Drawing the structures of organic molecules using Chemdraw software.	10	CO 4
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

Text Books:

1. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
2. Finar, I. L. *Organic Chemistry Volume 1*. Pearson education, 2007.
3. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010
4. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010
5. McMurry, John E. *Fundamentals of organic chemistry*. Cengage Learning, 2010.
6. Clayden, Jonathan, Nick Greeves, and Stuart Warren. *Organic chemistry*. Oxford University Press, USA, 2012.
7. Wade, Leroy G. *Organic chemistry*. Pearson Education India, 2008.
8. Bruice, Paula Yurkanis. *Organic chemistry*. Pearson, 2017.
9. Solomons, TW Graham, and Craig B. Fryhle. *Organic chemistry*. John Wiley & Sons, 2008.
10. Kalsi, P. S. *Stereochemistry conformation and mechanism*. New Age International, 2008.
11. Nasipuri, Dhanonjay. *Stereochemistry of organic compounds: principles and applications*. New Age International, 1994.

12. Finar, Ivor Lionel. *Organic Chemistry, Volume 2: Stereochemistry and the Chemistry Natural Products, 5/E*. Pearson Education India, 1956.

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.
4. Gupta, Subrata Sen. Basic Stereochemistry of Organic Molecules. India: Oxford University Press, 2018.
5. Talapatra, Sunil Kumar, and Bani Talapatra. *Basic Concepts in Organic Stereochemistry*. Springer Nature, 2023.
6. Eliel, Ernest L., and Samuel H. Wilen. *Stereochemistry of organic compounds*. John Wiley & Sons, 1994.
7. Mislow, Kurt Martin. *Introduction to stereochemistry*. Courier Corporation, 2002.
8. Service, Robert F. "Does life's handedness come from within?." *Science*(1999): 1282-1283.
9. Bonner, William A. "Origins of chiral homogeneity in nature." *Topics in stereochemistry* 18 (1988): 1-96.
10. Hegstrom, Roger A., and Dilip K. Kondepudi. “The Handedness of the Universe.” *Scientific American* 262, no. 1 (1990): 108–15. http://www.jstor.org/stable/24996649.

DSC -05

Discipline	Chemistry
Semester	III
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC203
Course Title	Physical Chemistry - I
Course Level	200-299
Course Summary	This course covers various facets of the gas, liquid, solid states, liquid crystals, colloids, and surface chemistry.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describe the properties of gaseous and liquid state	Understand	PO 1, PO 2
2	Explain the properties of solid state and liquid crystals	Understand	PO 1, PO 2
3	Explain the theories and applications of adsorption and surface chemistry	Apply	PO 1, PO 2
4	Explain the fundamentals of symmetry and point groups of molecules and apply them in real systems	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Gaseous State and Liquid State (15 Hours)**			
	1.1	Kinetic gas equation, Maxwell Boltzmann distribution of molecular velocities, Statement of equation and explanation (*No derivation*), Effect of temperature on the distribution of molecular velocities, Types of molecular velocities.	4	CO 1
	1.2	Collision properties. Collision diameter, Collision number, Collision frequency and mean free path. Viscosity of gases.	2	CO 1
	1.3	The behaviour of real gases, Deviation from ideal behaviour, Compressibility factor, Boyle temperature - vander Waal's equation of state – derivation and importance, Virial equation of state.	3	CO 1
	1.4	Critical phenomena: Isotherms of CO_2, continuity of states, Critical constants, relation between critical constants and vander Waals constants.	3	CO 1

	1.5	Properties of liquids: Surface tension and its measurement by capillary rise and stalagmometer method, factors affecting Surface tension, Viscosity, Poisuelle's equation, and Determination of viscosity by Ostwald's viscometer.	3	CO 1
2	**Solid State and Liquid Crystals (15 Hours)**			
	2.1	Crystal systems and Bravais lattices. Laws of rational indices, Miller indices.	2	CO 2
	2.2	Representation of lattice planes of cubic crystals, Determination of Avogadro number from crystallographic data.	2	CO 2
	2.3	X-ray diffraction studies of crystals, Bragg's equation – derivation and applications, Rotating crystal and powder method. Structure of NaCl, KCl.	4	CO 2
	2.4	Imperfections in crystals, point defects – Schottky and Frenkel defects, Non-stoichiometric defects – Line defects – edge dislocation – screw dislocation.	2	CO 2
	2.5	Band theory (qualitative idea) for Metals, Insulators and Semiconductors: Intrinsic and extrinsic conduction (elementary idea).	2	CO 2
	2.6	Liquid crystals thermographic behaviour. Classification, structure of nematic and cholesteric phases. Applications of liquid crystals.	3	CO 2
3	**Colloids and Surface Chemistry (15 Hours)**			
	3.1	Adsorption: Physical and chemical adsorption.	1	CO 3
	3.2	adsorption of gases by solids – factors influencing adsorption, Freundlich adsorption isotherm, Derivation of Langmuir adsorption isotherm.	2	CO 3
	3.3	Statement and explanation of BET , determination of surface area of adsorbents by BET equation.	1	CO 3
	3.4	Applications of adsorption.	1	CO 3
	3.5	Colloidal state: Classification of colloids, Purification of colloids – ultrafiltration and electrodialysis, Kinetic, optical and electrical properties of colloids. Ultra microscope, Electrical double layer and zeta potential	3	CO 3
	3.6	Coagulation of colloids, Hardy-Schulz rule, Gold number.	1	CO 3
	3.7	Gels: Elastic and non-elastic gels, Imbibition and syneresis.	2	CO 3
	3.8	Micelles and critical micelle concentration, sedimentation and streaming potential.	2	CO 3
	3.9	Application of colloids – Cottrell precipitator, purification of water and delta formation.	2	CO 3
4	**Symmetry of Molecules and Crystals (15 Hours)**			
	4.1	Group theory: symmetry elements and symmetry operations – Proper and improper axis of symmetry, plane of symmetry, centre of symmetry, inversion operation and an identity element.	3	CO 4
	4.2	Molecular point groups, Schoenflies symbols	2	CO 4

	4.3	Point groups, C_{nV}, C_{nh} and D_{nh}, Determination of point groups of simple molecules like, H_2O, NH_3, H_3BO_3, ethylene, trans dichloro ethylene, trans hydrogen peroxide, BF_3, $[Ni(CN)_4]^{2-}$, cyclopenta dienyl anion and benzene.	4	CO 4
	4.4	Symmetry operations. Order of a group. Multiplication of Symmetry operations.	1	CO 4
	4.5	Construction of Group multiplication table of C_{2V}. Group Axioms.	2	CO 4
	4.6	Illustration of group axioms using C_{2v} point group. Abelian Group.	1	CO 4
	4.7	Introduction to crystallographic point groups, Hermann-Mauguin notations. Screw axis, glide planes, space groups (elementary idea only)	2	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical Chemistry*, Vishal Pub. Co.Jalandhar.
2. K. L. Kapoor, *A Textbook of Physical Chemistry*, Volumes 1, Macmillan India Ltd.
3. P. Atkins and J Paula, *The Elements of Physical Chemistry*, 7th edn., Oxford University Press.
4. F. A. Alberty and R. J. Silby, *Physical Chemistry*, 3rd Edn, John Wiley.
5. D. A. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt. Ltd.
6. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, Macmillan Ltd.
7. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997).
8. V. Ramakrishnan and M S Gopinathan, *"Group Theory in Chemistry"*, Vishal Publishing.
9. R. P. Rastogi, R. R. Misra, *An Introduction to Chemical Thermodynamics*, 6th edn., Vikas Pub. Pvt. Ltd. (2003).

DSC - 06

Discipline	Chemistry
Semester	IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC204
Course Title	Inorganic Chemistry -II
Course Level	200-299
Course Summary	Module one and two details the different types of Chemical bonding involved in compounds. Different types of acids, bases and non-aqueous solvents with the reactions in solvents is the core concept of module three. Basic concepts of Natural and artificial radioactivity with its applications is the subject of module four. Practicals involve qualitative analysis of cations and anions present in the given mixture.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain theories of chemical bonding and compare and differentiate different types of bonds.	Understand	PO1, PO2, PO5
2	Analyze the properties of acids, bases and nonaqueous solvents	Apply	PO1, PO2, PO5
3	Explain the fundamentals and applications of nuclear chemistry.	Analyse	PO1, PO2, PO5
4	Demonstrate the separation of inorganic salt mixtures	Evaluate	PO1, PO2, PO5

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Chemical Bonding I (15 Hours)**			
	1.1	Introduction – Type of bonds – Octet rule and its limitations.	1	CO 1
	1.2	Ionic Bond: Factors favoring the formation of ionic bonds - Lattice energy of ionic compounds - Born-Lande equation (derivation not expected) – Solvation enthalpy and solubility of ionic compounds –Born-Haber cycle and its applications – Properties of ionic compounds - Polarisation of ions – Fajan's rules and its applications.	4	CO 1
	1.3	Covalent Bond: Lewis theory. Valence Bond Theory. Coordinate bond. Hybridization: Definition and characteristics, VSEPR theory: Postulates, Applications – Shapes of molecules - sp	5	CO 1

		($BeCl_2$,C_2H_2), sp^2(BF_3, C_2H_4), sp^3(CH_4, CCl_4, NH_3, H_2O, NH_4^+, H_3O^+ and SO_4^{2-}), sp^3d (PCl_5, SF_4, ClF_3, XeF_2), sp^3d^2(SF_6, IF_5, XeF_4) and sp^3d^3(IF_7, XeF_6). Limitations of VBT. Properties of covalent compounds. Polarity of covalent bond – Percentage of ionic character – Dipole moment and molecular structure.		
	1.4	Covalent Bond: Molecular Orbital Theory – LCAO - Bonding and anti-bonding molecular orbitals – Bond order and its significance. MO diagrams of homo-nuclear and hetero-nuclear diatomic molecules. H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, CO and NO – Comparison of bond length, magnetic behavior and bond energy of O_2, O_2^+, O_2^{2+}, O_2^- and O_2^{2-}. Resonance structures of borate, carbonate and nitrate ions – Comparison of bond energy. Comparison of VB and MO theories.	5	CO 1
2	**Chemical Bonding - II (5 Hours)**			
	2.1	Metallic Bond: Free electron theory and band theory (qualitative treatment only) – Explanation of metallic properties based on these theories.	2	CO 1
	2.2	Intermolecular Forces: Induction forces and dispersion forces: vander Waals forces, ion-dipole, dipole-dipole, ion-induced dipole, dipole-induced dipole and induced dipole-induced dipole interactions.	2	CO 1
	2.3	Hydrogen bond: Intra and inter molecular hydrogen bonds – Effect on physical properties.	1	CO 1
3	**Acids, Bases and Non-aqueous Solvents (10 Hours)**			
	3.1	Acid-base concept in non-aqueous media. Classification of solvents, characteristics of solvents	1	CO 2
	3.2	Reactions in non-aqueous solvents. Ammonia - solutions of metals in liquid ammonia. Protonic solvents: anhydrous sulfuric acid, hydrogen halides. Aprotic solvents: non-polar solvents, non-ionizable polar solvents	3	CO 2
	3.3	Polar solvents undergoing autoionization, liquid halogens, interhalogen compounds, oxy halides, dinitrogen tetroxide, sulphur dioxide - reactions.	3	CO 2
	3.4	Liquid sulphur dioxide and liquid HF (acid-base, amphoteric, solvation, oxidation – reduction, complex formation reactions).	3	CO 2
4	**Nuclear Chemistry (15 Hours)**			
	4.1	Mass defect – binding energy -Natural radioactivity.	1	CO 3
	4.2	Modes of decay- group displacement law — rate of decay – decay constant – half-life period – Gieger-Nuttall rule – disintegration series – transmutation reactions using protons, deutrons, particles and neutrons.	4	CO 3
	4.3	Artificial radioactivity – positron emission and K electron capture – trans-uranic elements, Synthesis of Plutonium and Curium; spallation reactions.	3	CO 3

	4.4	Principles of counting technique: GM Counter and scintillation counter. Applications of radioactivity: Radio carbon dating – rock dating – isotopes as tracers – study of reaction mechanism (ester hydrolysis).	3	CO 3
	4.5	Application of radioactive isotopes in medicine. Neutron activation analysis (NAA), Radiometric titrations, Nuclear fission - atom bomb - nuclear reactors – fast breeder reactors. Nuclear fusion and hydrogen bomb. – nuclear waste management	4	CO 3
5	**Practical : Inorganic Qualitative Analysis (30 hours)**			
	5.1	Common reactions of basic radicals like Ag^{+} , Hg^{2+}, Pb^{2+}, Cu^{2+}, Bi^{2+}, Cd^{2+} , As^{3+}, Sn^{2+}, Sb^{3+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Li^{+} , Na^{+}, K^{+}, NH_4^{+}	5	CO 4
	5.2	Common reactions of acidic radicals like CO_3^{2-} , S^{2-} , SO_4^{2-} , NO_3^{-} , F^{-} , Cl^{-} , Br^{-} , BO_2^{-} , $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$, CH_3COO^{-}, PO_4^{3-} , AsO_3^{3-}, AsO_4^{3-} and CrO_4^{2-}.	5	CO 4
	5.3	Systematic Analysis of inorganic mixtures - Separation and identification of cations and anions	10	CO 4
	5.4	Analysis of mixtures containing interfering anions like F^{-} , BO_2^{-}, $C_2O_4^{2-}$, PO_4^{3-}	10	CO 4
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

Text Books:

1. M.C. Day and J. Selbin, Theoretical Inorganic Chemistry, East West Press, New Delhi, 2002.
2. B.R. Puri, L.R. Sharma and K.C. Kalia, Principles of Inorganic Chemistry, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.

3. Satya Prakash, Advanced Inorganic Chemistry, Volume 1, 5th Edition, S. Chand and Sons, New Delhi, 2012.
4. J. Mendham, R.C. Denney, J. D. Barnes and M. Thomas, Vogel's Text Book of Quantitative Chemical Analysis, 6th Edition, Pearson Education, Noida, 2013.
5. A.K. Chandra, Introductory Quantum Chemistry, 4th Edition, Tata McGraw Hill Publishing Company, Noida, 1994.
6. R.K. Prasad, Quantum Chemistry, 4th Edition, New Age International(P) Ltd., New Delhi, 2012.
7. B.K, Sen, Quantum Chemistry – Including Spectroscopy, 3rd Edition, Kalyani publishers, New Delhi, 2010.

References:

1. T. F Gieryn, Cultural Boundaries of Science, University of Chicago Press, Chicago, 1999.
2. H. Collins and T. Pinch, The Golem: What Everyone Should Know about Science, Cambridge University Press, Cambridge, 1993.
3. C.R. Kothari, Research Methodology: Methods and Techniques, 2nd Revised Edition, New Age International Publishers, New Delhi, 2004.
4. Guidance in a Nutshell - Compilation of Safety Data Sheets, European Chemicals Agency, Finland, Version 1.0, December 2013.
5. J. D. Lee, Concise Inorganic Chemistry, 5th edn., Blackwell Science, London (Chapter 1).
6. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press, (Chapter 1)
7. B. Douglas, D. Mc Daniel, J. Alexander, Concepts and models in Inorganic Chemistry, (Chapter 1)
8. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004.
9. D.A. McQuarrie, Quantum Chemistry, 2nd Edition, University Science Books, California, 2008.
10. M.C. Day and J. Selbin, Theoretical Inorganic Chemistry, East West Press, New Delhi, 2002.
11. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 3rd Edition, Oxford, University Press, New York, 1997.
12. N. Levine, Quantum Chemistry, 6th Edition, Pearson Education Inc., New Delhi, 2009.

DSC-07

Discipline	Chemistry
Semester	IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC205
Course Title	Organic Chemistry - II
Course Level	200-299
Course Summary	This core course in organic chemistry deals with oxygen-containing functional groups and their reactions. The detailed mechanistic pathways for each functional group will be discussed to understand the extent of organic transformations. Organometallic compounds and their synthetic applications will also be discussed in this course. The practical component focuses on the Identification of various oxygen-containing function groups and the preparation of their derivatives.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the chemistry of alcohols, phenols, ethers, and epoxides	Understand	PO 1, PO 2
2	Explain the chemistry of carbonyl compounds	Understand	PO 1, PO 2
3	Describe the chemistry of carboxylic and sulphonic acids	Apply	PO 1, PO 2
4	Illustrate the properties of organometallic compounds.	Apply	PO 1, PO 2
5	Identify the given organic compound and prepare its derivative.	Analyse	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Chemistry of Alcohols, Phenols, and Ethers (15 Hours)**			
	1.1	Alcohols- Classification (Monohydric, Dihydric, Polyhydric, primary, secondary, Tertiary), Luca's Test, Ascent and descent in homologous series, Alcohol metabolism in the human body.	2	CO 1
	1.2	Oxidative cleavage – Lead tetra acetate, Periodic acid- Pinacol-Pinacolone rearrangement (with mechanism),	2	CO 1
	1.3	Phenol - Acidity of phenol, Effect of substituent on acidity, H-bonding (inter and intramolecular) in phenol, Effect of H-bonding on boiling point and solubility in water.	2	CO 1
	1.4	Chemical Reactions involving phenols: Reimer-Tiemann reaction, Kolbe-Schmitt Reaction, Gattermann reaction, Lederrer Manasse reaction, Schotten – Baumann reaction (with	3	CO 1

		mechanism)		
	1.5	Preparation and uses of Catechol, Resorcinol, Quinol, Picric acid	1	CO 1
	1.6	Synthesis of ethers – Williamson synthesis and Alkoxymercuration – demercuration reaction. Cleavage of ether linkages by HI- Ziesels method of estimation of alkoxy groups - Claisen rearrangement –mechanism. Synthesis of epoxides – Prilezhaev reaction, Sharpless epoxidation. Acid and Base catalysed cleavage of epoxides – Orientation of cleavage.	5	CO 1
2	**Chemistry of Carbonyl Compounds (15 Hours)**			
	2.1	Aldehydes & Ketones - Structure and Nucleophilicity of carbonyl compounds - Comparison between aldehydes and ketones.	1	CO 2
	2.2	Nucleophilic addition reactions - Reaction with HCN, Alcohols, Thiols, ammonia and their derivatives (hydroxylamine, phenylhydrazine), Wittig Reaction, Mannich reaction.	3	CO 2
	2.3	Acidity of alpha-hydrogen in aldehydes and ketones. Formation of enols and enolates; kinetic and thermodynamic enolates; Specific enol equivalents (lithium enolates, enamines, and silylenol ethers) in connection with alkylation, acylation. Aldol condensation, Knoevenagel reaction, Claisen-Schmidt reaction, Perkin condensation, Benzoin condensation, Favorskii rearrangement. Addition reactions of α, β- unsaturated carbonyl compounds: Michael addition.	8	CO 2
	2.4	Oxidation and reduction of aldehydes and ketones - Baeyer-Villiger oxidation, Clemmensen reduction, Wolff-Kishner reduction, Meerwein-Pondorof-Verley, Cannizaro reaction (with mechanism)	3	CO 2
3	**Chemistry of Carboxylic and Sulphonic Acids (10 Hours)**			
	3.1	Structure of Carboxylate ion - Acidity of carboxylic acid- Effect of substituents on acid strength of aliphatic and aromatic carboxylic acids.	1	CO 3
	3.2	Ascent and descent of acid series. Reactions of carboxylic acids with mechanism - Decarboxylation and Hell – Volhard - Zelinsky reaction.	2	CO 3
	3.3	Acid derivatives - Conversion of acid to acid chlorides, amides, esters and anhydrides. Comparative study of nucleophilicity of acyl derivatives.	1	CO 3
	3.4	Reactions - Claisen condensation, Dieckmann condensation, Reformatsky reaction and Blaise reaction, Hoffmann bromamide degradation, Curtius rearrangement (with mechanism)	4	CO 3

	3.5	Preparation and reactions of benzene sulphonic acid, benzene sulphonyl chloride and ortho and para- toluene sulphonyl chlorides- uses	2	CO 3
4	**Chemistry of Organometallic Compounds (5 Hours)**			
	4.1	Preparation, and synthetic applications of Organomagnesium compounds, Organozinc compounds, Organo lithium compounds and Organocopper reagents (Gilman reagents).	5	CO 4
5	**Practical: Qualitative Organic Analysis (30 hours)**			
	5.1	Qualitative Microscale analysis of organic compounds- Identification, and confirmation of alcohols, phenols, aldehydes, ketones, carboxylic acid and carboxylic acid derivatives.	16	CO 5
	5.2	Preparation of derivatives of alcohols, phenols, aldehydes, ketones, carboxylic acid and carboxylic acid derivatives.	14	CO 5
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

Text Books:

1. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
2. Finar, I. L. *Organic Chemistry Volume 1*. Pearson education, 2007.
3. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010
4. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010
5. McMurry, John E. *Fundamentals of organic chemistry*. Cengage Learning, 2010.
6. Clayden, Jonathan, Nick Greeves, and Stuart Warren. *Organic chemistry*. Oxford University Press, USA, 2012.
7. Wade, Leroy G. *Organic chemistry*. Pearson Education India, 2008.
8. Bruice, Paula Yurkanis. *Organic chemistry*. Pearson, 2017.
9. Solomons, TW Graham, and Craig B. Fryhle. *Organic chemistry*. John Wiley & Sons, 2008.

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC-08

Discipline	Chemistry
Semester	IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC206
Course Title	Physical Chemistry - II
Course Level	200-299
Course Summary	"Chemical Thermodynamics, Phase Equilibrium, and Kinetics" explores the principles governing energy, phase transitions, and reaction rates in chemical systems, with a focus on their applications in chemical transformations.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the fundamentals and application of the first law of thermodynamics and thermochemistry.	Understand	PO 1, PO 2
2	Describe the second and third laws of thermodynamics, partial molar properties and chemical equilibrium.	Apply	PO 1, PO 2
3	Explain the phase diagrams of one, two and three-component systems.	Apply	PO 1, PO 2
4	Explain the principles and applications of chemical kinetics	Understand	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Thermodynamics - I (15 Hours)**			
	1.1	*Introduction to Thermodynamics*: Intensive and extensive properties, path and state functions, exact and inexact differentials, reversible and irreversible processes, spontaneous and non-spontaneous processes, internal energy, work and heat, zeroth law of thermodynamics	4	CO 1
	1.2	*First law of thermodynamics*: Statement and mathematical expression, enthalpy, heat capacity, Cp and Cv relation in ideal gas systems, change in thermodynamic properties of an ideal gas during reversible isothermal and adiabatic reversible processes. Joule-Thomson experiment, Joule-Thomson coefficient μJT, inversion temperature. Liquefying gases using J-T expansion.	8	CO 1

	1.3	*Thermochemistry*: Internal Energy and Enthalpy changes in a chemical reaction, Enthalpies of formation, combustion, neutralization, solution and hydration; Integral and differential enthalpies of solution. Variation of heats of reaction with temperature – Kirchoff's equation	3	CO 1
2	**Thermodynamics - II (15 Hours)**			
	2.1	*Second and Third laws of Thermodynamics*: Limitations of first law – statements of second law, Carnot's cycle – efficiency of heat engines, Carnot theorem. Entropy – entropy change for various reversible/irreversible processes, Change in entropy of an ideal gas with pressure, volume and temperature. Third law of thermodynamics (statement only).	6	CO 2
	2.2	Free Energy Functions: Helmholtz energy and Gibbs energy – variation of Gibbs energy with T and P. Criteria for reversible and irreversible processes. Gibbs-Helmholtz equation. Clausius - Clapeyron equation, applications.	4	CO 2
	2.3	Partial molar properties: chemical potential, Gibbs-Duhem equation, chemical potential in a system of ideal gases, concept of fugacity and activity.	2	CO 2
	2.4	Chemical equilibrium: Conditions for chemical equilibrium, Law of mass action, the relation between Kc and Kx, Kp, van't Hoff reaction isotherm. Temperature dependence of Kp – van't Hoff equation.	3	CO 2
3	**Phase Equilibria (15 Hours)**			
	3.1	The phase rule, equilibrium between phases – conditions	2	CO 3
	3.2	One component system: water system, sulphur system.	3	CO 3
	3.3	*Two-component systems* – solid-liquid equilibrium – simple eutectic, lead-silver system, Naphthalene-Biphenyl System, formation of compounds with congruent melting point ferric chloride- water system, formation of compounds with incongruent melting point sodium sulphate - water system.	8	CO 3
	3.4	*Three-component Systems*: Phase diagrams of liquid-liquid equilibria. Examples.	2	CO 3
4	**Chemical Kinetics (15 Hours)**			
	4.1	Rate of reaction, rate equation, order and molecularity of reactions, integrated rate expressions for first and second order reactions. Zero-order reactions, pseudo-order reactions, half-life.	3	CO 4
	4.2	*Theories of chemical kinetics*: effect of temperature on the rate of reaction, Arrhenius equation, concept of activation energy Collision theory, transition state theory. Thermodynamic parameters for activation – Eyring equation (no derivation needed), enthalpy and entropy of activation. Theory of unimolecular reactions – Lindemann theory.	5	CO 4
	4.3	*Kinetics of complex (composite) reactions*: Opposing reactions, consecutive reactions, and parallel (simultaneous) reactions. Chain reactions – steady-state treatment, hydrogen bromine	4	CO 4

		reaction.		
	4.4	*Catalysis*: Homogeneous catalysis, enzyme catalysis – Michaelis-Menten equation (no derivation needed). Heterogeneous catalysis – surface catalysis, uni- and bi-molecular reactions on surface. Elementary idea about autocatalysis.	3	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. R. P. Rastogi, R. R. Misra, '*An Introduction to Chemical Thermodynamics*', 6th edn., Vikas Pub. Pvt. Ltd. (2003).
2. P. Atkins and J Paula, '*The Elements of Physical Chemistry*', 7th edn, Oxford University Press.
3. K. K. Sharma, L. K. Sharma, *A Textbook of Physical Chemistry*, 4th edn, Vikas publishing House.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical chemistry*, Vishal Pub. Co. Jalandhar.
5. D. A. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt. Ltd.
6. K. L. Kapoor, '*A Textbook of Physical Chemistry'*, Volumes 4, Macmillan India Ltd.

Further reading

1. J. Rajaram and J. C. Kuriakose, *Thermodynamics*, Shoban Lal Nagin Chand & Co (1986).
2. W. J. Moore, *Basic Physical Chemistry*, Orient Longman.
3. F. A. Alberty and R. J .Silby, *Physical Chemistry*, John Wiley.
4. G. M. Barrow, *Physical Chemistry*, 5th edn., Tata McGraw Hill.
5. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997).
6. K. J. Laidler, *Chemical kinetics* 3rd edn, Pearson education 2004.
7. J Rajaram and J. C. Kuriakose, *Kinetics and mechanisms of chemical transformations*, Macmillan, 2006.
8. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, Macmillan Ltd. (1996).

DSC-09

Discipline	Chemistry
Semester	V
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC301
Course Title	Inorganic Chemistry - III
Course Level	300-399
Course Summary	Module one discusses about the importance of elements in biochemistry. Classification, preparation and bonding of organometallic compounds have been illustrated in module 2. Practicals involve the preparation and characterization of metal complexes.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4
Pre-requisite, if any	An introductory knowledge of inorganic chemistry concepts.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the importance of bioinorganic chemistry.	Understand	PO1, PO2, PO5
2	Explain the structure and properties of organometallic compounds, metal carbonyls and metal clusters	Apply	PO1, PO2, PO5
3	Prepare and Characterize coordination compounds	Apply	PO1, PO2, PO5

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Bioinorganic Chemistry I (15 Hours)**			
	1.1	Essential and trace elements in biological systems, Biochemistry of iron Myoglobin and Hemoglobin, role of myoglobin and hemoglobin in biological systems, mechanism of oxygen transport, cooperativity, Bohr effect, Phosphate effect. Cytochromes- Structure and function. Cytochrome P450.	4	CO 1
	1.2	Iron Sulphur Proteins-Rubredoxin, Ferredoxin, Nitrogenase, Structure and function, Nitrogen Fixation. Peroxidases and catalases. Storage and transport of iron in biological systems-Ferritin, transferrin and Siderophores.	4	CO 1
	1.3	Role of alkali and alkaline earth metals in biological systems, Na/K pump. Metal deficiency: Deficiency of Iron, Copper and Zinc. Metal toxicity: Toxicity of Copper, Iron, Plutonium, Mercury and Cadmium. Metals as carcinogens.	4	CO 1

	1.4	Treatment of metal toxicity. Chelation therapy. Anti-cancer drugs – cisplatin (mechanism of action) and carboplatin (An outline study).	3	CO 1
2	**Organometallic Compounds (30 Hours)**			
	2.1	Definition, classification of organometallic compounds, Ylides, classification on the basis of hapticity, naming of organometallic compounds, 18 electron rule.	4	CO 2
	2.2	Metal carbonyls: CO as a π-bonding ligand, synergism, preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, Polynuclear metal carbonyls with and without bridging.	4	CO 2
	2.3	Carbonyl clusters - LNCCS and HNCCS, Isoelectronic and isolobal analogy, Wade-Mingos rules, cluster valence electrons.	5	CO 2
	2.4	IR spectral studies of bridging and non-bridging CO ligands-factors affecting CO stretching frequencies	3	CO 2
	2.5	Preparation and bonding in metal nitrosyls, metal cyanides and dinitrogen complexes.	5	CO 2
	2.6	Preparation and bonding in allyl organometallic compounds	2	CO 2
	2.7	Preparation and bonding in alkene and alkyne organometallic compounds	3	CO 2
	2.8	Sandwich complexes- Bonding in ferrocene and dibenzene chromium	4	CO 2
3	**Practical : Preparation of Complexes (30 Hours)**			
	3.1	Preparation and characterization of inorganic complexes using IR, and electronic spectra. (a) Tris (thiourea) copper(I) complex (b) Potassium tris (oxalate) aluminate (III). (c) Hexammine cobalt (III) chloride. (d) Tetrammine copper (II) sulphate. (e)Schiff base complexes of various divalent metal ions. (f) Bis(dimethylglyoximato)nickel(II) (g) Prussian blue	30	CO 3
4	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References

1. B. R. Puri, L. R. Sharma, K. C. Kalia, 'Principles of Inorganic Chemistry', 31st Ed. Milestone Publishers, New Delhi 2010.
2. S. Prakash, G. D. Tuli, S. K. Basu and R. D. Madan, 'Advanced Inorganic Chemistry', 5th edn., 2012, Volume I, S Chand.
3. G. L. Meissler, D. A Tarr, Inorganic Chemistry, 3rd Edn. Pearson Education, 2004.
4. J. E. Huheey, E. A. Keiter, R. L. Keiter, O K Medhi, Inorganic Chemistry, Pearson 2006
5. R. C. Mehrothra and A. Singh, Organometallic Chemistry, New age publishers.
6. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 3 rd edn., John Wiley, New York.1995.
7. G. Sharpe, Inorganic Chemistry, 3rd Edn. Pearson.
8. D. F. Shriver and P.W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press, 2009.
9. G. S. Sodhi, Organometallic Chemistry, Ane books Ltd, New Delhi, 2009.
10. B. Douglas, D. Mc Daniel, J. Alexander, Concepts and models of Inorganic Chemistry, 3rd edn., John Wiley.
11. Ivano Bertini, Harry B Gray, Stephen J. Lippard, Joan Selvertone Valentine, Bioinorganic Chemistry. Viva Books Pvt Ltd. 2007.
12. R.W. Hay, Bio-Inorganic Chemistry, Ellis Horwood, 1984.
13. Robert R. Crichton, Biological Inorganic Chemistry A New Introduction to Molecular Structure and Function, Elsevier, 2012.
14. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
15. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillian, 1968.
16. J. Singh, R. K. P. Singh, J. Singh, LDS Yadav, I. R. Siddiqui, J. Shrivastava, Advanced Practical Chemistry, Pragati Prakashan, 7th Edn., 2017.

DSC-10

Discipline	Chemistry
Semester	V
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC302
Course Title	Organic Chemistry - III
Course Level	300-399
Course Summary	This core course in organic chemistry is filled with the details of Nitrogen-containing functional groups, heterocyclic systems, natural compounds viz. terpenes and alkaloids and biomolecules. A comprehensive understanding of these topics will be developed by taking examples of representative members of each class. This course will also discuss some key organic photochemical reactions.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the chemistry of organic compounds containing nitrogen.	Understand	PO 1, PO 2
2	Explain the chemical properties and syntheses of heterocyclic compounds.	Understand	PO 1, PO 2
3	Know the structure and chemical properties of carbohydrates, natural products, vitamins, and steroids.	Understand	PO 1, PO 2
4	Explain the fundamentals of photochemical reactions	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Chemistry of Nitrogen-containing compounds (15 Hours)**			
	1.1	**Nitro Compounds:** Preparation of aliphatic and aromatic nitro compounds by nitration, Tautomerism of nitromethane.	1	CO 1
	1.2	**Reactions of nitro compounds:** Reduction products of nitrobenzene in acidic, neutral and alkaline media. Electrolytic reduction and selective reduction of polynitro compounds. Formation of charge transfer complexes.	3	CO 1
	1.3	**Amines:** Preparation: Gabriel's phthalimide synthesis, Carbylamine reaction, Reductive amination of carbonyl compounds. Stereochemistry of amines.	2	CO 1

	1.4	**Reactions of amines:** Hoffmann exhaustive methylation, Distinction between 1°, 2° and 3° amines with Hinsberg reagent and HNO_2. Quaternary amine salts as phase-transfer catalysts.	3	CO 1
	1.5	**Diazonium salts:** Preparation and their synthetic applications – Conversion to benzene, phenol, chloro, bromo, iodo and fluoro benzenes, nitro benzene and azo dyes. Sandmeyer's, Gatterman reaction, Schiemann and Gomberg reactions (with mechanism)	4	CO 1
	1.6	**Diazomethane and diazoacetic ester:** Preparation, Structure, synthetic uses. Arndt-Eistert synthesis. Wolff rearrangement.	2	CO 1
2	**Chemistry of Heterocyclic Compounds (10 Hours)**			
	2.1	Classification of heterocyclic compounds- Structure and aromaticity of furan, pyrrole, pyridine. comparative study of the basicity of pyrrole, pyridine, and piperidine with amines	2	CO 2
	2.2	Synthesis and reactions of: Furan, Thiophene, Pyrrole (Paal Knorr synthesis) Pyridine (Hantzsch synthesis), Indole (Fischer Indole Synthesis), quinoline (Skraup synthesis), isoquinoline (Bischler-Napieralskii synthesis)	7	CO 2
	2.3	Importance of purine and pyrimidine in biological systems- Adenine, Thymine, Guanine, Cytosine and Uracil	1	CO 2
3	**Carbohydrates (15 Hours)**			
	3.1	Occurrence, classification and the biological importance of carbohydrates.	1	CO 3
	3.2	Monosaccharides: Fischer and Haworth projections of glucose and fructose. Epimers, mutarotation and anomers. Cyclic structure of glucose. Determination of ring structure. Reactions of glucose and fructose - osazone formation, Tollen's and Fehling's reaction, Benedict's reaction.	6	CO 3
	3.3	Chain lengthening and chain shortening of aldoses - Kiliani-Fischer synthesis and Ruff and Wohl degradation. Interconversion of aldoses and ketoses.	3	CO 3
	3.4	Disaccharides: Structure elucidation, reactions and uses of sucrose and maltose.	3	CO 3
	3.5	Structure and properties of starch and cellulose (elementary idea).	2	CO 3
4	**Natural products, Lipids, Vitamins, Steroids and Hormones (15 hours)**			
	4.1	Natural Products: Terpenoids - isoprene rule. Structure elucidation of citral. Alkaloids - general methods of isolation –classification – structure elucidation and synthesis of piperine and nicotine.	5	CO 3
	4.2	Vitamins – classification- structure (elementary idea) of vitamins A, C and B1, B2, B6, Vitamin D.	2	CO 3
	4.3	Lipids – biological functions – oils and fats – common fatty acids- extraction and refining, hydrogenation – rancidity-	6	CO 3

		identification of oils and fats – saponification value, acid value, iodine value and RM value.		
	4.4	Steroids – Introduction, Diels hydrocarbon - Structure and functions of cholesterol. Elementary idea of HDL, LDL.	2	CO 3
5	**Organic Photochemistry (5 Hours)**			
	5.1	Introduction. Photochemical versus Thermal reactions. Photochemical reactions of carbonyl compounds: Norrish type I and II reactions of acyclic ketones (with mechanisms).	2	CO 4
	5.2	Hydrogen abstraction reactions – Barton reaction (Nitrite ester reaction), Photo cycloaddition reactions - Patterno-Buchi reaction Photo rearrangement reactions - Di-π methane rearrangement, Photo-Fries rearrangement. Photochemistry of vision.	3	CO 4
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

Text Books:

1. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
2. Finar, I. L. *Organic Chemistry Volume 1*. Pearson education, 2007.
3. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010
4. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010
5. McMurry, John E. *Fundamentals of organic chemistry*. Cengage Learning, 2010.
6. Clayden, Jonathan, Nick Greeves, and Stuart Warren. *Organic chemistry*. Oxford University Press, USA, 2012.
7. Wade, Leroy G. *Organic chemistry*. Pearson Education India, 2008.
8. Bruice, Paula Yurkanis. *Organic chemistry*. Pearson, 2017.
9. Solomons, TW Graham, and Craig B. Fryhle. *Organic chemistry*. John Wiley & Sons, 2008.

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC-11

Discipline	Chemistry
Semester	V
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC303
Course Title	Physical Chemistry - III
Course Level	300-399
Course Summary	This course provides a comprehensive understanding of the principles governing electrochemical processes and the behaviour of solutions in chemical systems. It covers fundamental concepts, experimental techniques, and practical applications in various fields, including chemical engineering, materials science, and environmental science.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Students should have a strong foundation in physical chemistry concepts.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the concept of acids, bases and pH of solutions.	Understand	PO 1, PO 2
2	Find out pH of various solutions using appropriate equations.	Apply	PO 1, PO 2
3	Explain ideas about processes like fractional distillation and phases existing in liquid mixtures	Apply	PO 1, PO 2
4	Illustrate electrochemical equivalent and types of cells and their working so that students can work in an electrochemical laboratory.	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Ionic Equilibrium (15 Hours)**			
	1.1	*Dissociation Constants and Ionic Strength*: Dissociation constants and strengths– acids, bases, and polyprotic acids.Ostwald dilution law, Degree of ionization, Ionization constant, factors affecting degree of ionization, Ionic product of water – pH scale, Ionic strength, Effects of solvents on ionic strength.	8	CO 1
	1.2	*Buffer Solutions and Hydrolysis*: Mechanism of buffer action, Henderson equation, Hydrolysis of salts, pH of salt solutions.	3	CO 1

	1.3	*Acid-Base Indicators and Solubility Product*: Acid-base indicators, theories, determination of pH by indicators, solubility product principle – applications.	4	CO 1
2	**Solutions (15 Hours)**			
	2.1	Introduction to Solutions: Introduction - Binary liquid solutions – Raoult's law- ideal and non-ideal solutions.	2	
	2.2	Fractional Distillation: Vapour pressure-composition and boiling point-composition curves of ideal and non-ideal binary liquid solutions. Fractional distillation of binary liquid-liquid solutions Type 1, Type 2 (water-ethanol system), Type 3 (acetone chloroform system) azeotropic mixtures.	3	CO 2
	2.3	Distillation of immiscible liquids: Steam distillation (with examples).	1	CO 2
	2.4	Partially miscible liquid-liquid systems: Critical solution temperature (CST) – the lever rule, systems with UCST, LCST, and both with examples Effect of impurities in CST.	2	CO 2
	2.5	Solutions of Gases in Liquids and Distribution Law: Henry's law. – factors affecting solubility, Distribution of a solute between two solvents – Nernst distribution law: Application. Solvent extraction principle.	2	CO 2
	2.6	Colligative properties of dilute solutions – Vapor pressure lowering, Boiling point elevation and freezing point depression (thermodynamic derivation). Molar mass determination, Osmotic pressure – laws of osmotic pressure - Reverse osmosis – purification of seawater.	4	CO 2
	2.7	Abnormal molecular masses – van't Hoff factor – degree of association and degree of dissociation.	1	CO 2
3	**Electrical Conducatnce (15 Hours)**			
	3.1	Fundamentals of Electrolytic Conductance: Faraday's laws of electrolysis, electrochemical equivalent and chemical equivalent, Transport numbers and Hittorf's method.	2	CO 3
	3.2	Conductance of Electrolytic Solutions and Ionic Mobility: Ionic mobility – relation with ion conductivity, influence of temperature on ion conductivity, ion conductivity and viscosity – Walden's rule.	3	CO 3
	3.3	Conductance of electrolytic solution: electrolytic conductivity (K), and molar conductivity of solutions of electrolytes. Variation of conductivity and molar conductivity with concentration. Kohlrausch's law – application.	3	CO 3
	3.4	Debye-Hückel Theory: Debye-Hückel theory of strong electrolytes – the concept of ionic atmosphere, Asymmetry and electrophoretic effect, Debye- Hückel-Onsager equation (no derivation). Debye-Hückel Limiting Law: Debye-Hückel limiting law (no derivation).	4	CO 3

	3.5	Conductance Measurements and Applications: Applications of conductance measurements – Determinations of degree of dissociation of weak electrolytes, ionic product of water, and solubility of sparingly soluble salts, conductometric titrations.	3	CO 3
4	**Electromotive Force (15 Hours)**			
	4.1	Introduction – Electrochemical Cells and Electrolytic cells, Galvanic cells, electrode potential – electrochemical series.	1	CO 4
	4.2	Introduction to Electromotive Force: Electrochemical cells, characteristics of reversible cells. Reversible electrodes – different types; Representation of cells – e.m.f of the cell, electrode reactions, and cell reactions.	2	CO 4
	4.3	Reference electrodes– Standard Hydrogen Electrode, Calomel electrode	1	CO 4
	4.4	Thermodynamics: Thermodynamics of reversible cells and reversible electrodes, Determination of ΔG, ΔH, and ΔS of cell reaction.	1	CO 4
	4.5	Nernst Equation and Concentration Cells: E.M.F and equilibrium constant of cell reaction, the effect of electrolyte concentration on electrode potential, and e.m.f - Derivation of Nernst equation.	2	CO 4
	4.6	Concentration cells – electrode concentration cells and electrolyte concentration cells. Types of electrolyte concentration cells – with transference and without transference, liquid junction potential.	3	CO 4
	4.7	Applications of EMF Measurements: determination of solubility product, determination of pH using hydrogen electrode, quinhydrone electrode, and glass electrode. Potentiometric titrations: acid-base and redox titrations - Redox indicators.	3	CO 4
	4.8	Irreversible Processes and Corrosion: Irreversible electrode processes – overvoltage.Corrosion of metals – forms of corrosion, corrosion monitoring and prevention methods.	2	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. K. L. Kapoor, '*A Textbook of Physical Chemistry*', Volumes 1, Macmillan India Ltd.
2. B. R. Puri, L. R. Sharma, M. S. Pathania, '*Elements of Physical Chemistry*', Vishal Pub. Co. Jalandhar.
3. I. N. Levine, *Physical Chemistry*, Tata Mc Graw Hill.
4. K. J. Laidler and J. M. Meiser, *'Physical Chemistry',* 3rd Edition, Houghton Mifflin Comp., New York, International Edition (1999).
5. Barrow, G.M. *Physical Chemistry*, Tata McGraw-Hill (2007).
6. Castellan, G.W. *Physical Chemistry*, 4th Ed. Narosa (2004).
7. Kotz, J.C., Treichel, P.M. & Townsend, J.R., *General Chemistry*, Cengage Learning India Pvt. Ltd. New Delhi (2009).
8. Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
9. Glasstone S, *An Introduction to Electrochemistry*, East-West Press (Pvt.) Ltd. (2006).
10. Gurdeep Raj, *Advanced Physical Chemistry*, Goel publishing house.
11. F A Alberty and R J Silby, *Physical Chemistry*, John Wiley.
12. P. W. Atkins, *The elements of Physical chemistry*, 8thedn, Oxford University Press.
13. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, Macmillan Ltd.

DSC-12

Discipline	Chemistry
Semester	VI
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC304
Course Title	Inorganic Chemistry - IV
Course Level	300-399
Course Summary	Different types of reactions of organometallic compounds is discussed in module one. Module two deals with the characteristics of d-block elements. The chemistry of coordination complexes forms the basis of module three. Module four discusses the close packing of spheres and the structure of inorganic solids.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	An introductory knowledge of inorganic chemistry concepts.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the reactions of organometallic compounds	Understand	PO1, PO2, PO8
2	Explain the chemistry of *d* block elements.	Apply	PO1, PO2, PO8
3	Describe the theories, properties and applications of coordination compounds	Analyse	PO1, PO2, PO8
4	Discuss the structure and related properties of inorganic solids.	Evaluate	PO1, PO2, PO8

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Reactions of Organometallic Compounds (15 Hours)**			
	1.1	*Substitution reactions* - nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands.	3	CO 1
	1.2	*Addition and elimination reactions* - 1,2 additions to double bonds, carbonylation and decarbonylation.	2	CO 1
	1.3	Oxidative addition - concerted addition, S_N2, radical and ionic mechanisms, factors favouring oxidative addition	2	CO 1

	1.4	Reductive elimination- binuclear reductive elimination and σ-bond metathesis.	1	CO 1
	1.5	Oxidative coupling and reductive decoupling.	1	CO 1
	1.6	Insertion (migration) and elimination reactions – insertions of CO and alkenes, insertion into M−H versus M−R, α and β eliminations. Agostic interaction	2	CO 1
	1.7	Redistribution reactions – mechanism and classification	1	CO 1
	1.8	Fluxional isomerism of allyl, cyclopentadienyl, carbonyl and allene systems	3	CO 1
2	**Chemistry of *d* block Elements (15 Hours)**			
	2.1	General characteristics of d-block elements with special reference to electronic configuration, oxidation states, variable valency, metallic character	6	CO 2
	2.2	General characteristics of d-block elements with special reference to colour, magnetic properties, catalytic properties and ability to form complexes.	6	CO 2
	2.3	Comparison of the properties of second and third transition series with first transition series.	3	CO 2
3	**Coordination Chemistry - I (15 Hours)**			
	3.1	Stability of complexes - stepwise stability constant and overall stability constant, factors affecting the stability of metal complexes. EAN, Chelates and chelate effect.	3	CO 3
	3.2	Magnetic behavior of complexes- Diamagnetic and paramagnetic complexes, explanation, effective magnetic moment, spins only magnetic moments, calculation of spin only magnetic moment. Quenching of magnetic moment.	3	CO 3
	3.3	Theories of bonding in coordination compounds – Werner's theory of coordination, primary and secondary valences of metal ions. Valence bond theory- of octahedral, tetrahedral and square planar complexes, high spin and low spin complexes- inner and outer orbital complexes, explanation of magnetic properties, limitations of valence bond theory. Crystal filed theory- splitting of d-orbitals in octahedral, tetrahedral complexes, strong and weak field ligands, pairing energy, explanation of colour and magnetic properties of complexes, limitation of CF theory.	6	CO 3
	3.4	Jahn-Teller distortion and splitting of d orbitals in tetragonal and square planar fields, Jahn-Teller distortion in Cu (II) complexes. MO theory- evidence for metal ligand covalency, MOE diagram of complexes of octahedral symmetry (sigma bonding only). Explanation of Δ in the Oh and Td complexes using MOE diagram.	3	CO 3
4	**Structure of Inorganic Solids (15 Hours)**			

	4.1	Close packing of spheres, ccp and hcp arrangements. Interstitial sites in close packing, Tetrahedral, Octahedral sites.	3	CO 4
	4.2	Radius ratio, Limiting radius ratio for trigonal, tetrahedral and octahedral sites.(only values). Use of limiting radius ratio in the structural determination of ionic crystals.	3	CO 4
	4.3	Structure of ionic crystals of NaCl, CsCl, ZnS. Defects in crystals – stoichiometric and nonstoichiometric defects, Consequences of defects. extrinsic and intrinsic defects.	5	CO 4
	4.4	Impurity defects. Semi-conductors, n-type, p-type, Superconductivity – an introduction. Diffusion mechanism in solids.	4	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. J. D. Lee, 'Concise Inorganic Chemistry' 5th edn., Wiley India Pvt. Ltd. 2008.
2. B. R. Puri, L. R. Sharma, K. C. Kalia, 'Principles of Inorganic Chemistry', Milestone
3. Publishers, New Delhi 2010.
4. G. L. Meissler, D.A Tarr, 'Inorganic Chemistry',3rd Edn. Pearson Education, 2004.
5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O K Medhi, Inorganic Chemistry, Pearson 2006
6. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry 6th edn., John Wiley, New
7. York 1991.
8. M. Clyde Day and J. Selbin, 'Theoretical Inorganic Chemistry' 2nd Edn. Reinhold Book
9. Corp. 2008.
10. B. Douglas, D. Mc Daniel, J. Alexander, Concepts and models of Inorganic Chemistry, 3
11. Rd edn., John Wiley. 2006.
12. D. F. Shriver and P.W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press.
13. G.L. Meissler, D.A Tarr, Inorganic Chemistry, Pearson Education.
14. A. R. West, Solid State Chemistry and its applications, John Wiley.

Further Reading

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry, Pearson 2006.
2. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry 6th edn., John Wiley, New York. 1999.
3. D. F. Shriver and P.W. Atkins, Inorganic Chemistry 3rd edn., Oxford University Press. 2009
4. Douglas, D. Mc Daniel, J. Alexander, Concepts and models of Inorganic Chemistry, 3rd edn., John Wiley, 2006.
5. M. N. Greenwood and A. Earnshaw, Chemistry of the elements 2nd edn, Butterworth. 1997.

DSC-13

Discipline	Chemistry
Semester	VI
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC305
Course Title	Organic Chemistry - IV
Course Level	300-399
Course Summary	This core course in organic chemistry is filled with the details of biomolecules, and pericyclic reactions. A comprehensive understanding of these topics will be developed by taking examples of representative members of each class. This course will also discuss some key organic reagents used in chemical transformations. The practical component focuses on the extraction of bioactive molecules from natural resources using solvent extraction, checking the purity of oils and fats and simple organic conversions
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Know the structure and chemical properties of amino acids, proteins and enzymes	Understand	PO 1, PO 2
2	Explain the basics and applications of concerted reactions	Apply	PO 1, PO 2
3	Explain the synthetic importance of various organic reagents	Apply	PO 1, PO 2
4	Illustrate the principles and methods involved in separation techniques like solvent extraction.	Apply	PO 1, PO 2
5	Prepare derivatives of organic compounds	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Amino Acids, Peptides, Proteins and Nucleic Acids (15 hours)**			
	1.1	Amino Acids - Classification of amino acids. Zwitterion structure and Isoelectric point, Electrophoresis. Synthesis- Gabriel phthalimides synthesis, Strecker synthesis.	4	CO 1
	1.2	Polypeptides – Synthesis of polypeptides (with mechanism). Merrifield's solid phase peptide synthesis (Any one Tripeptide synthesis), Activation, Coupling using DCC. Determination of primary structure of peptides by Edman degradation (N-Terminal) and with carboxypeptidase enzyme (C-	3	CO 1

		terminal).		
	1.3	Proteins – Primary, secondary and tertiary structure of proteins: α-helix and β-pleated sheets. Denaturation of proteins.	4	CO 1
	1.4	Nucleic acids: Components of nucleic acids, nucleosides and nucleotides.	4	CO 1
2	**Enzymes (5 Hours)**			
	2.1	Nomenclature and classification of enzymes (based on substrate).	1	CO 1
	2.2	Mechanism of enzyme action. Lock and key model, Induced fit model. Substrate specificity of enzymes. Factors affecting enzyme action. Enzyme inhibition.	4	CO 1
3	**Pericyclic Reactions (15 Hours)**			
	3.1	Classification: Electrocyclic, sigmatropic, cycloaddition, chelotropic and ene reactions.	2	CO 2
	3.2	Woodward Hoffmann rules - frontier orbital and orbital symmetry correlation approaches - PMO method (for electrocyclic and cycloaddition reactions only)	3	CO 2
	3.3	Highlighting pericyclic reactions in organic synthesis such as Claisen, Cope, Wittig, MislowEvans and Sommelet-Hauser rearrangements. Diels-Alder and Ene reactions (with stereochemical aspects), dipolar cycloaddition (introductory).	3	CO 2
	3.4	Unimolecular pyrolytic elimination reactions: cheletropic elimination, decomposition of cyclic azo compounds, β-eliminations involving cyclic transition states such as N-oxides (Cope reaction), acetates and xanthates (Chugayev reaction)	4	CO 2
	3.5	Introduction to Click reactions - Mechanism of the Huisgen Azide - Alkyne 1, 3-Dipolar Cycloaddition, Staudinger ligation and Staudinger reduction	3	CO 2
4	**Reagents in Organic synthesis (10 Hours)**			
	4.1	Oxidizing agents – Manganese (II) and (IV) based reagents. Chromium based reagents – CrO_3, PCC, PDC. SeO_2, DDQ, Swern oxidation.	5	CO 3
	4.2	Reducing agents – Pd/C, $LiAlH_4$, $NaBH_4$, Raney Nickel, Dissolving metal reductions (Na/Li in Liq NH_3), DIBAL-H. Hydroboration - Oxidation (BH_3/H_2O_2) reaction.	5	CO 3
5	**Practical: Organic Practicals (30 Hours)**			
	5.1	Solvent extraction - Isolation of Lycopene from Tomato / caffeine from tea leaves Determination of the Saponification value of the Fat and Oils by taking any real sample	8	CO 4
	5.2	Organic Preparations. i.) Oxidation (benzaldehyde or benzyl alcohol to benzoic acid; oxidation of ethanol or isopropanol using iodoform reaction). ii). Reduction (Reduction of methylbenzoate to benzyl alcohol; metadinitrobenzene to m-nitroaniline)	22	CO 5

		iii) Hydrolysis of amides and esters iv) Halogenation (p-bromoacetanilide from acetanilide). v). Diazocoupling (methyl orange or benzene azo –β-naphthol). vi) Acetylation of amines using green approach vii) Benzoylation of aniline or beta-naphthols/resorcinol by Schotten Baumann reaction viii) Aldol condensation using either conventional or green method		
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

Text Books:

1. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
2. Finar, I. L. *Organic Chemistry Volume 1*. Pearson education, 2007.
3. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010
4. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010
5. McMurry, John E. *Fundamentals of organic chemistry*. Cengage Learning, 2010.
6. Clayden, Jonathan, Nick Greeves, and Stuart Warren. *Organic chemistry*. Oxford University Press, USA, 2012.
7. Wade, Leroy G. *Organic chemistry*. Pearson Education India, 2008.
8. Bruice, Paula Yurkanis. *Organic chemistry*. Pearson, 2017.
9. Solomons, TW Graham, and Craig B. Fryhle. *Organic chemistry*. John Wiley & Sons, 2008.
10. Caruthers, W. & Colham, I. *Modern Methods in organic Synthesis,* Cambridge University press, Fourth Edition, 2004.

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC-14

Discipline	Chemistry
Semester	VI
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC306
Course Title	Physical Chemistry - IV
Course Level	300-399
Course Summary	This course delves into the principles and applications of spectroscopic techniques and photochemical processes. Students will learn to analyze molecular structures and dynamics using spectroscopic methods while exploring the interactions of light with matter in chemical reactions. Practical applications in research and industry are emphasized.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the basics of spectroscopy.	Understand	PO 1, PO 2
2	Explain the fundamental principles of rotational, vibrational, Raman, electronic, NMR and mass spectroscopic techniques.	Apply	PO 1, PO 2
3	Describe the fundamentals of photochemistry.	Analyse	PO 1, PO 2
4	Illustrate the principles of physical chemistry through experiments	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Introduction to Spectroscopy (2 Hours)**			
	1.1	Introduction: electromagnetic radiation, regions of the spectrum, interaction of electromagnetic radiation with molecules.	1	CO 1
	1.2	Various types of molecular spectroscopic techniques, Born-Oppenheimer approximation.	1	CO 1
2	**Rotational Spectroscopy (5 Hours)**			
	2.1	Rotational spectrum: diatomic molecules, energy levels of a rigid rotator.	2	CO 2
	2.2	Selection rules	1	CO 2
	2.3	Determination of bond length.	2	CO 2
3	**Vibrational Spectroscopy (7 Hours)**			
	3.1	Vibrational spectrum: the simple harmonic oscillator – energy	2	CO 2

		levels, force constant, selection rules.		
	3.2	Anharmonic oscillator – pure vibrational spectra of diatomic molecules, selection rules, fundamental frequencies, overtones, and hot bands.	3	CO 2
	3.3	Degrees of freedom for polyatomic molecules, the concept of group frequencies – frequencies of common functional groups in organic compounds.	2	CO 2
4	**Raman Spectroscopy (5 Hours)**			
	4.1	Raman spectrum: the quantum theory of Raman Effect (elementary idea). concept of polarizability	2	CO 2
	4.2	Qualitative treatment of pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.	2	CO 2
	4.3	Rule of mutual exclusion.	1	CO 2
	Electronic Spectroscopy (7 Hours)			
5	5.1	Electronic spectrum: concept of potential energy curves for bonding and anti-bonding molecular orbitals.	2	CO 2
	5.2	Electronic transition, the Frank-Condon principle, dissociation energy.	2	CO 2
	5.3	Polyatomic molecules – qualitative description of sigma, π and n-molecular orbitals.	2	CO 2
	5.4	Their energy levels and the respective transitions.	1	CO 2
6	**NMR Spectroscopy (8 Hours)**			
	6.1	NMR spectroscopy: basic principles of NMR spectroscopy – nuclear spin, Larmor precession.	2	CO 2
	6.2	Proton magnetic resonance (^{1}H NMR or PMR) – nuclear shielding and deshielding, chemical shift and molecular structure.	2	CO 2
	6.3	Spin-spin splitting and coupling constant. First-order spectra.	2	CO 2
	6.4	Interpretation of PMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, ethyl acetate, toluene, and acetophenone.	2	CO 2
7	**Mass Spectroscopy (3 Hours)**			
	7.1	Mass spectrometry: Basic principle-ionization, fragmentation.	1	CO 2
	7.2	Separation of ions and representation of the spectrum.	1	CO 2
	7.3	Application in molecular mass determination.	1	CO 2
8	**Photochemistry (8 Hours)**			
	8.1	Interaction of radiation with matter: Laws of photochemistry – Grothus-Draper law, Stark-Einstein law, examples of photochemical reactions.	2	CO 3
	8.2	Beer law and Beer-Lambert's law.	1	CO 3
	8.3	Jablonsky diagram, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing).	2	CO 3
	8.4	Quantum yield, primary and secondary processes.	1	CO 3

	8.5	Basic concepts of photosensitized reactions – photosynthesis, dissociation of hydrogen molecule, isomerization of 2-butene, and chemiluminescence.	2	CO 3
9	**Practical: Physical Chemistry Practicals – I (30 Hours)**			
	9.1	1. Heat of solution – KNO_3, NH_4Cl 2. Heat of neutralization 3. Conductometric titration – strong acid *vs.* strong base, weak acid-strong base. 4. Transition temperature of salt hydrates. (Sodium thiosulphate, sodium acetate) 5. Critical solution temperature. Phenol-water system 6. Determination of molecular weight by Rast's Method (using naphthalene, camphor or biphenyl as solvent and acetanilide, p-dichlorobenzene etc. as solute.) 7. Potentiometric titration – Fe^{2+} *vs.* $Cr_2O_7^{2-}$, I^- *vs.* MnO_4^-, strong acid - strong base, weak acid- strong base. 8. Data analysis of kinetic experiments using a spreadsheet program (determination of rate constant) 9. Determination of equivalence point of potentiometric and conductometric titrations using a spreadsheet program.	**30**	CO 4
10	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

1. Mc Quarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books Pvt. Ltd.
2. C. N. Banwell and E M Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edn, Tata Mc Graw Hill.
3. K. L. Kapoor, A Textbook of Physical Chemistry, Volumes 4, Macmillan India Ltd.
4. I. N. Levine, Physical Chemistry, Tata Mc Graw Hill, Chapter 21.
5. R. Puri, L. R. Sharma, M. S. Pathania, 'Elements of Physical Chemistry', Vishal Pub. Co.,
6. K. J. Laidler, John H. Meiser, 'Physical Chemistry', 2nd edn.
7. K. K. Sharma, L R Sharma, 'A Text Book of Physical Chemistry', Vikas Publishing house.

8. A. S. Negi, S. C. Anand, 'A Textbook of Physical Chemistry', Second Edition, New Age International (P) limited, publishers.
9. W. G. Palmer, '*Experimental physical chemistry*', Cambridge University Press.
10. J. B. Yadav, '*Advanced Practical Physical Chemistry*', Goel Publishing House.
11. R.C. Das and B. Behra, '*Experiments in Physical Chemistry*', Tata McGraw hill.
12. K. K. Sharma, '*An Introduction of Practical Chemistry*': Vikas Publishing House, New Delhi.

Further reading

1. W. J. Moore, *Basic Physical Chemistry*, Orient Longman.
2. F. A. Alberty and R. J .Silby, *Physical Chemistry*, John Wiley.
3. G. M. Barrow, *Physical Chemistry*, 5th edn., Tata McGraw Hill.
4. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997).
5. K. J. Laidler, *Chemical kinetics* 3rd edn, Pearson education 2004.
6. J Rajaram and J. C. Kuriakose, *Kinetics and mechanisms of chemical transformations*, Macmillan, 2006.
7. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, Macmillan Ltd. (1996).

DSC-15

Discipline	Chemistry
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC401
Course Title	Inorganic Chemistry - V
Course Level	400 - 499
Course Summary	In Module One, students explore the electronic and magnetic properties of coordination complexes. Module Two delves into the reactions of coordination complexes, offering insights into the diverse chemical transformations these compounds undergo. Module Three focuses on the stereochemistry of coordination compounds, elucidating how spatial arrangement influences their properties and reactivity. Module Four expands the scope to the chemistry of lanthanides and actinides, exploring the distinct properties and applications of these fascinating elements.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describe the theories, properties and applications of coordination compounds	Understand	PO1, PO2, PO8
2	Explain the stereochemistry of coordination compounds	Apply	PO1, PO2, PO8
3	Discuss the chemistry of f-block elements	Apply	PO1, PO2, PO8

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Coordination Chemistry II (15 Hours)**			
	1.1	Colour and absorption spectra of complexes	1	CO1
	1.2	Electronic Spectra of complexes: Term symbols of d^n system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields	2	CO1

	1.3	Correlation diagrams for d^1 and d^9 ions in octahedral and tetrahedral fields (*qualitative approach*)	1	CO1
	1.4	d-d transitions, selection rules for electronic transitions-effect of spin orbit coupling and vibronic coupling	2	CO1
	1.5	Interpretation of electronic spectra of complexes: Orgel diagrams and demerits	4	CO1
	1.6	Tanabe Sugano diagrams, calculation of Dq, B and β (*Nephelauxetic ratio*) values, spectra of complexes with lower symmetries, charge transfer spectra	2	CO1
	1.7	Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, spin only magnetic moment.	3	CO1
2	**Coordination Chemistry III (15 Hours)**			
	2.1	Kinetic reactivity - Labile and inert complexes	1	CO 1
	2.2	Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic substitution reactions in square planar complexes	1	CO 1
	2.3	Trans effect-theory and applications	2	CO 1
	2.4	Kinetics and mechanism of octahedral substitution- dissociative and associative mechanisms.	2	CO 1
	2.5	Water exchange reactions, Classification of complexes on the basis of water exchange rate, base hydrolysis, solvolytic reactions (acidic and basic).	3	CO 1
	2.6	Electron transfer reactions: Outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism, Factors favoring electron transfer	5	CO 1
	2.7	Two electron transfer and intramolecular electron transfer.	1	CO 1
3	**Stereo-chemistry of Coordination Compounds (15 Hours)**			
	3.1	Geometrical and optical isomerism in octahedral complexes, resolution of optically active complexes, determination of absolute configuration of complexes by ORD and circular dichroism.	5	CO 2
	3.2	Stereoselectivity and conformation of chelate rings, asymmetric synthesis catalyzed by coordination compounds	5	CO 2
	3.3	Linkage isomerism: Electronic and steric factors affecting linkage isomerism, symbiosis-hard and soft ligands, HSAB concept and its applications. Prussian blue and related structures, Macrocycles crown ethers	5	CO 2
4	**f-block Elements (15 Hours)**			
	4.1	Chemistry of lanthanides – electronic structure, oxidation states, lanthanide contraction, consequences of lanthanide contraction, magnetic properties, spectral properties and separation of lanthanides by ion exchange and solvent extraction methods (Brief study).	4	CO 3

	4.2	Chemistry of actinides – electronic configuration, oxidation states, actinide contraction, position of actinides in the periodic table, comparison with lanthanides in terms of magnetic properties and spectral properties (Brief study).	4	CO 3
	4.3	Term symbols for lanthanide ions, inorganic compounds and coordination complexes of the lanthanoids upto coordination No.12, electronic spectra and magnetic properties of lanthanoid complexes, organometallic complexes of the lanthanoids - σ-bonded complexes, cyclopentadienyl complexes, organolanthanoid complexes as catalysts.	4	CO 3
	4.4	General characteristics of actinoids-difference between 4f and 5f orbitals, coordination complexes of the actinoids- sandwich complexes, coordination complexes and organometallic compounds of thorium and uranium, comparative account of coordination chemistry of lanthanoids and actinoids with special reference to electronic spectra and magnetic properties	3	CO 3
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Harper Collins College Publishers,1993.
2. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th edition, Wiley-Interscience, 1999.
3. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
4. P. Powell, Principles of Organometallic Chemistry, 2nd Edn., Chapman and Hall, 1988.
5. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn. Wiley-India, 2007.
6. B.D. Guptha, A.J Elias, Basic Organometallic Chemistry, Universities Press, 2010.
7. Sumit Bhaduri, Doble Mukesh, Homogeneous Catalysis: Mechanism and Industrial Applications, Wiley Interscience, 2000.
8. Astruc, D.; Organometallic Chemistry and Catalysis, Springer Verlag, 2007.
9. Robert H. Crabtree, The Organometallic Chemistry of the Transition Metals, 4th Edn. Wiley Interscience, 2005.

DSC-16

Discipline	Chemistry
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC402
Course Title	Organic Chemistry - V
Course Level	400-499
Course Summary	This core course in organic chemistry gives a detailed insight into the mechanistic pathways involved in various organic reactions. It also discusses important name reactions which involve reactive intermediates.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describe the mechanisms of different types organic reactions.	Understand	PO 1, PO 2
2	Explain the chemistry of carbanions, carbocations, carbenes, carbenoids, nitrenes and arynes.	Apply	PO 1, PO 2
3	Explain the chemistry of radical reactions and its applications.	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Review of Organic Reaction Mechanism (15 Hours)**			
	1.1	Review of organic reaction mechanisms with special reference to nucleophilic and electrophilic substitution at aliphatic carbon (SN1, SN2, SNi, SE1 and SE2) elimination (E1 and E2) and addition reactions (Regioselectivity: Markovnikov's addition - carbocation mechanism, anti-Markovnikov's addition - radical mechanism). Elimination vs Substitution.	5	CO 1
	1.2	A comprehensive study on the effect of substrate, reagent, leaving group, solvent, ambident nucleophile and neighbouring group on nucleophilic substitution (SN1 and SN2) and elimination (E1 and E2) reactions.	5	CO 1
	1.3	Stork-enamine reaction. Von Ritcher, Vilsmeyer formylation, Jacobson and Gatterman-Koch reactions.	5	CO 1
2	**Chemistry of Carbanions (15 Hours)**			
	2.1	Reactions of carbanions: C-X bond (X = C, O, N) formations through the intermediary of carbanions.	1	CO 2
	2.2	Chemistry of enolates and enamines. Kinetic and Thermodynamic	2	CO 2

		enolates-lithium and boron enolates in aldol. Alkylation and acylation of enolates.		
	2.3	Mechanism of name reactions involving carbanion –Claisen, Dieckmann, Knoevenagel, Stobbe, Darzen and Acyloin condensations, Shapiro reaction and Julia elimination. Favorski rearrangement.	9	CO 2
	2.4	Ylides: Chemistry of Phosphorous and Sulphur ylides - Wittig and related reactions, Pummerer rearrangement, Peterson olefination.	3	CO 2
3	**Chemistry of Carbocations (10 Hours)**			
	3.1	C-X bond (X = C, O, N) formations through the intermediary of carbocations.	1	CO 2
	3.2	Molecular rearrangements including Wagner-Meerwein, Pinacol-pinacolone, semi-pinacol, Dienone-phenol and Benzilic acid rearrangements, Noyori annulation, Prins reaction. Ritter reaction	7	CO 2
	3.3	C-C bond formation involving carbocations: Oxymercuration, halolactonisation.	2	CO 2
4	**Carbenes, Carbenoids, Nitrenes and Arynes (10 Hours)**			
	4.1	Structure of carbenes (singlet and triplet) - generation of carbenes, Bamford-Stevans reaction, addition and insertion reactions.	2	CO 2
	4.2	Rearrangement reactions of carbenes such as Wolff rearrangement - generation and reactions of ylides by carbenoid decomposition.	2	CO 2
	4.3	Structure, generation and reactions of nitrene and related electron-deficient nitrene intermediates.	2	CO 2
	4.4	Hoffmann, Curtius, Lossen, Schmidt and Beckmann rearrangement reactions.	2	CO 2
	4.5	Arynes: Generation, structure, stability and reactions. Orientation effect- amination of haloarenes.	2	CO 2
5	**Radical Reactions (10 Hours)**			
	5.1	Reactions of radicals - addition to alkenes, alkynes (inter & intramolecular) for C-C bond formation - Baldwin's rules	4	CO 3
	5.2	Fragmentation and rearrangements – Hydroperoxide: formation, rearrangement and reactions. Auto-oxidation.	3	CO 3
	5.3	Named reactions involving radical intermediates: Barton deoxygenation and decarboxylation, McMurry coupling.	3	CO 3
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Written test, Open book test, Problem-based assignment, *Any other method as may be required for specific courses by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written test

References:

Text Books:

1. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
2. Finar, I. L. *Organic Chemistry Volume 1*. Pearson education, 2007.
3. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010
4. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010
5. McMurry, John E. *Fundamentals of organic chemistry*. Cengage Learning, 2010.
6. Clayden, Jonathan, Nick Greeves, and Stuart Warren. *Organic chemistry*. Oxford University Press, USA, 2012.
7. Wade, Leroy G. *Organic chemistry*. Pearson Education India, 2008.
8. Bruice, Paula Yurkanis. *Organic chemistry*. Pearson, 2017.
9. Solomons, TW Graham, and Craig B. Fryhle. *Organic chemistry*. John Wiley & Sons, 2008.
10. Caruthers, W. & Colham, I. *Modern Methods in organic Synthesis,* Cambridge University press, Fourth Edition, 2004.
11. L. Kuerti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press, 2005

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC-17

Discipline	Chemistry
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC403
Course Title	Organic Chemistry - VI
Course Level	400-499
Course Summary	This core course in organic chemistry gives a detailed insight into the chirality of molecules due to presence of chiral centres other than carbon, chiral plane, chiral axis and bond angle inversion etc. The application of conformational analysis in explaining the reactivity of molecules will also be discussed. This course will also discuss the synthetic applications of various organic reagents in chemical conversions. This core course of organic chemistry will also deal with applications of retrosynthetic analysis and protecting groups in designing a synthetic route.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Demonstrate the reactivity and stability of organic molecules based on structure, including conformation and stereochemistry	Understand	PO 1, PO 2
2	Describe the applications of oxidation and reduction techniques in organic syntheses.	Apply	PO 1, PO 2
3	Illustrate the synthetic importance of various organic reagents	Apply	PO 1, PO 2
4	Apply retrosynthetic analysis to design the synthesis of a target molecule.	Apply	PO 1, PO 2
5	Explain the principles and applications of protecting groups in chemistry.	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Stereochemistry –III (15 Hours)**			
	1.1	Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidenecycloalkanes.	2	CO 1
	1.2	Introduction to Akamptisomerism – Chirality due to bond angle inversion.	2	CO 1

	1.3	Molecules with C, N, S based chiral centers, molecules with a chiral center and Cn axis. Molecules with more than one center of chirality, constitutionally symmetrical and unsymmetrical chiral molecules.	2	CO 1
	1.4	Topicity of ligands and NMR as a tool for the distinction of enantiotopic/diastereotopic ligands.	2	CO 1
	1.5	Conformational Descriptors: Factors affecting conformational stability of molecules, conformational analysis of decalins, adamantane, norbornane, sucrose and lactose.	3	CO 1
	1.6	Conformation and reactivity of elimination (dehalogenation, dehydrohalogenation, semipinacolic deamination and pyrolytic elimination - Saytzeff and Hofmann eliminations), substitution and oxidation of 2^o alcohols.	3	CO 1
	1.7	The chemical consequence of conformational equilibrium - Curtin Hammett principle.	1	CO 1
2	**Organic Synthesis via Oxidation and Reduction (15 Hours)**			
	2.1	Survey of organic reagents and reactions in organic chemistry with special reference to oxidation and reduction. Metal based and non-metal based oxidations of (a) alcohols to carbonyls (Chromium, Manganese, aluminium and DMSO based reagents). (b) alkenes to epoxides (peroxides/per acids based)- Jacobsen epoxidation, Shi epoxidation.(c) alkenes to diols (Manganese and Osmium based)- Prevost reaction and Woodward modification (d) alkenes to carbonyls with bond cleavage (Manganese and lead based, ozonolysis) (e) alkenes to alcohols/carbonyls without bond cleavage- Wacker oxidation, selenium, chromium based allylic oxidation, Allylic bromination (NBS)	10	CO 2
	2.2	(a) Catalytic hydrogenation: Heterogeneous – Palladium / Platinum / Rhodium and Nickel. Homogeneous: Wilkinson. (b) Metal based reductions- Birch reduction, pinacol formation, acyloin formation (c) Hydride transfer reagents from Group III and Group IV in reductions - Red-Al, and $NaCNBH_3$, Selectrides, trialkylsilanes and trialkylstannane.	5	CO 2
3	**Modern Synthetic Methods and Reagents (15 Hours)**			
	3.1	Baylis-Hillman reaction, Henry reaction, Nef reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction, Noyori reaction. Brook rearrangement, Tebbe olefination.	5	CO 3
	3.2	Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Negishi and Sonogashira reactions, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann and Glaser coupling reactions. Wohl-Ziegler reaction. Mitsunobu reaction.	10	CO 3
4	**Retrosynthetic Analysis (10 Hours)**			
	4.1	Basic principles and terminology of retrosynthesis: synthesis of aromatic compounds, one group and two group C-X disconnections; one group C-C and two group C-C	4	CO 4

		disconnections.		
	4.2	Amine and alkene synthesis: important strategies of retrosynthesis, functional group transposition, important functional group interconversions. Retrosynthesis of luciferin. Functional equivalents and reactivity - Umpolung reaction (Ireland-Claisen rearrangement). Retrosynthetic analysis of simple alcohols, and carbonyl compounds.	6	CO 4
5	**Protecting Group Chemistry (5 Hours)**			
	5.1	Protection and deprotection of hydroxy, carbonyl, and amino groups.	3	CO 5
	5.2	Chemo- and regioselective protection and deprotection.	1	CO 5
	5.3	Illustration of protection and deprotection in synthesis. Role of trialkyl silyl group in organic synthesis	1	CO 5
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

Text Books:

1. Morrison, Robert Thornton, and Robert Nelson Boyd. "Text book of organic chemistry." (2010).
2. Finar, I. L. *Organic Chemistry Volume 1*. Pearson education, 2007.
3. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010
4. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010
5. McMurry, John E. *Fundamentals of organic chemistry*. Cengage Learning, 2010.
6. Clayden, Jonathan, Nick Greeves, and Stuart Warren. *Organic chemistry*. Oxford University Press, USA, 2012.
7. Wade, Leroy G. *Organic chemistry*. Pearson Education India, 2008.
8. Bruice, Paula Yurkanis. *Organic chemistry*. Pearson, 2017.
9. Solomons, TW Graham, and Craig B. Fryhle. *Organic chemistry*. John Wiley & Sons, 2008.
10. Caruthers, W. & Colham, I. *Modern Methods in organic Synthesis,* Cambridge University press, Fourth Edition, 2004.
11. S. Warren, P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd Edn., Wiley, 2008

SUGGESTED READINGS

1. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
2. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
3. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSC-18

Discipline	Chemistry
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC404
Course Title	Physical Chemistry - V
Course Level	400-499
Course Summary	This course provides a comprehensive understanding of the principles governing electrochemical processes and the behaviour of solutions in chemical systems. It covers fundamental concepts, experimental techniques, and practical applications in various fields, including chemical engineering, materials science, and environmental science.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4
Pre-requisite, if any	Students should have a strong foundation in general chemistry concepts

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the fundamentals of thermodynamics and its applications in multi-component systems.	Understand	PO 1, PO 2
2	Explain the fundamentals and applications of group theory.	Apply	PO 1, PO 2
3	Illustrate the principles of physical chemistry through experiments.	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Classical Thermodynamics (15 Hours)**			
	1.1	Maxwell relations and significance	2	CO 1
	1.2	Thermodynamics of mixing, Gibbs-Duhem-Margules equation, applications of Gibbs-Duhem-Margules equation- Konovalov's first and second laws (statements only), Henry's law, excess thermodynamic functions-free energy, enthalpy, entropy and volume	4	CO 1
	1.3	Chemical affinity and thermodynamic functions, Third law of thermodynamics, Nernst heat theorem, determination of absolute entropies using third law.	4	CO 1

	1.4	Three-component systems-graphical representation. Solid-liquid equilibria, ternary solutions with common ions, hydrate formation, compound formation. Liquid-liquid equilibria-one pair of partially miscible liquids, two pairs of partially miscible liquids, three pairs of partially miscible liquids.	5	CO 1
2	**Group Theory (15 Hours)**			
	2.1	Symmetry in crystals: 32 crystallographic point groups (*no derivation*), Hermann-Mauguin symbols. Screw axis-pitch and fold of screw axis, glide planes, space groups (*elementary idea only*)	2	CO 2
	2.2	Mathematical groups: Properties, Abelian groups, cyclic groups, sub groups, similarity transformation, classes – C_{2v}, C_{3v} and C_{2h}.	2	CO 2
	2.3	Group multiplication tables (GMTs) – C_{2v}, C_{3v} and C_{2h}, isomorphic groups.	4	CO 2
	2.4	Matrix representation of elements like E, C_n, S_n, I, σ-matrix representation of point groups like C_{2v}, C_{3v}, C_{2h}, C_{4v} – trace /character, block factored matrices.	3	CO 2
	2.5	Reducible and irreducible representations, standard reduction formula, statement of great orthogonality theorem (GOT). Construction of character tables for C_{2v}, C_{2h}, C_{3v} and C_{4v}	4	CO 2
3	**Application of Group Theory (15 Hours)**			
	3.1	Application in chemical bonding: Projection operator, transformation properties of atomic orbitals, construction of symmetry adapted linear combination of atomic orbitals (SALCs) of C_{2v}, C_{3v}, D_{3h} and C_{2h} molecules	3	CO 2
	3.2	Vibrational mode analysis using group theory taking H_2O, NH_3 and *trans*-N_2F_2 as examples using symmetry coordinates and internal coordinates method, prediction of IR and Raman activity, rule of mutual exclusion, redundant modes, out of plane modes.	4	CO 2
	3.3	Application in UV-visible spectroscopy, selection rules, orbital selection rules, transitions between non-degenerate states, prediction of electronic transitions in C_{2v},C_{3v},C_{4v},C_{2h} and C_{4h} using direct product terms, spin selection rules, relaxation in selection rules and distortion.	4	CO 2
	3.4	Application in hybridization, determination of hybridization and hybrid functions in CH_4, BF_3 and PCl_5	4	CO 2
4	**Practical: Physical Chemistry Practicals II (30 Hours)**			
	4.1	**I. Adsorption** 1. Verification of Freundlich and Langmuir adsorption isotherm: charcoal-acetic acid or charcoal-oxalic acid system. 2. Determination of the concentration of the given acid using the isotherms.	16	CO 3

	4.2	**II. Phase diagrams** 1. Construction of phase diagrams of simple eutectics. 2. Effect of (KCl / succinic acid) on miscibility temperature. 3. Construction of phase diagrams of three component systems with one pair of partially miscible liquids.	14	CO 3
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References

1. Irving M. Klotz, Robert M. Rosenberg, *Chemical Thermodynamics*, John Wiley & Sons, INC Publication, 2008.
2. R.P. Rastogi, R.R. Misra, *An introduction to Chemical Thermodynamics*, Vikas publishing house, 1996.
3. J. Rajaram, J.C. Kuriakose, *Thermodynamics*, S Chand and Co., 1999.
4. M.W. Zemansky, R.H. Dittman, *Heat and Thermodynamics*, Tata McGraw Hill, 1981.
5. P.W. Atkins, *Physical Chemistry*, ELBS, 1994.
6. K.J. Laidler, J.H. Meiser, B.C. Sanctuary, *Physical Chemistry*, 4th Edn., Houghton Mifflin, 2003.
7. L.K. Nash, *Elements of Classical and Statistical Mechanics*, 2nd Edn., Addison Wesley, 1972.
8. D.A. McQuarrie, J.D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books, 1997.
9. F.W. Sears, G.L. Salinger, *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, Addison Wesley, 1975.
10. J. Kestin, J.R. Dorfman, *A Course in Statistical Thermodynamics*, Academic Press, 1971.
11. M.C. Gupta, *Statistical Thermodynamics*, New age international, 2007.
12. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.

13. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th Edn. McGraw Hill, 2009.
14. B. Viswanathan, Practical Physical chemistry, Viva Pub., 2005
15. Saroj Kumar and Naba Kumar, Physical Chemistry Practical, New Central Book Agency, 2012.
16. Practical Physical Chemistry Paperback, 1974 by A.M. James , F.E. Prichard.

DSC-19

Discipline	Chemistry
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC405
Course Title	**Physical Chemistry - VI**
Course Level	400-499
Course Summary	This chemistry course offers a comprehensive exploration of key concepts in quantum chemistry and their applications. The course also covers chemical bonding, elucidating the theories and models that describe the formation and stability of molecules. Additionally, computational quantum chemistry is introduced as a powerful tool for simulating molecular systems and predicting their behavior.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Basic understanding of theoretical chemistry and Schrodinger wave equation.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Apply the principles of quantum mechanics in different systems.	Understand	PO 1, PO 2
2	Explain the approximation methods in quantum mechanics.	Apply	PO 1, PO 2
3	Describe the quantum mechanical explanation of chemical bonding.	Analyse	PO 1, PO 2
4	Explain the methods of computational quantum chemistry.	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Applications of Quantum Mechanics (15 Hours)**			
	1.1	*Vibrational motion*: One-dimensional harmonic oscillator (complete treatment), Hermite equation (solving by method of power series).	2	CO 1
	1.2	*Rotational motion*: Co-ordinate systems, Cartesian, cylindrical polar and spherical polar coordinates and their relationships. The wave equation in spherical polar coordinates-particle on a ring: the phi equation and its solution, wave functions in the real form	3	CO 1
	1.3	*Quantization of angular momentum*: quantum mechanical operators corresponding to angular momenta (L_x, L_y, L_z and L^2),	2	CO 1

		commutation relations between these operators.		
	1.4	*Quantum Mechanics of Hydrogen-like Atoms*: Potential energy of hydrogen-like systems. The wave equation in spherical polar coordinates: separation of variables - R, Θ and Φ equations and their solutions, wave functions and energies of hydrogen like atoms. Orbitals: Radial functions, radial distribution functions, angular functions and their plots.	5	CO 1
	1.5	*Spin orbitals*: Construction of spin orbitals from orbitals and spin functions, spin orbitals for many electron atoms, symmetric and antisymmetric wave functions. Pauli's exclusion principle, slater determinants.	3	CO 1
2	**Approximation Methods in Quantum Chemistry (15 Hours)**			
	2.1	Many-body problem and the need of approximation methods, independent particle model. Variation method: Variation theorem with proof, illustration of variation theorem using the trial function x(a-x) for particle in a 1D-box and using the trial function e-αr for the hydrogen atom, variation treatment for the ground state of helium atom.	5	CO 2
	2.2	Perturbation method, time-independent perturbation method (non-degenerate case only), first order correction to energy and wave function, illustration by application to particle in a 1D-box with slanted bottom, perturbation treatment of the ground state of the helium atom. The qualitative idea of Hellmann-Feynman theorem.	5	CO 2
	2.3	Hartree-Fock method, multi-electron atoms. Hartree-Fock equations (*no derivation*). The Fock operator, core Hamiltonian, coulomb operator and exchange operator. Qualitative treatment of Hartree-Fock Self-Consistent Field (HFSCF) method. Roothan's concept of basis functions, Slater type orbitals (STO) and Gaussian type orbitals (GTO), sketches of STO and GTO.	5	CO 2
3	**Chemical Bonding (15 Hours)**			
	3.1	Schrödinger equation for molecules. Born-Oppenheimer approximation, valence bond (VB) theory, VB theory of H_2 molecule, singlet and triplet state functions (spin orbitals) of H_2	4	CO 3
	3.2	Molecular Orbital (MO) theory, MO theory of H_2^+ ion, MO theory of H_2 molecule, MO treatment of homonuclear diatomic molecules Li_2, Be_2, N_2, O_2 and F_2 and hetero nuclear diatomic molecules LiH, CO, NO and HF, bond order. Correlation diagrams, non-crossing rule, spectroscopic term symbols for diatomic molecules, comparison of MO and VB theories.	5	CO 3
	3.3	Hybridization, quantum mechanical treatment of sp, sp2 and sp3 hybridisation. Semiempirical MO treatment of planar conjugated molecules, Hückel Molecular Orbital (HMO) theory of ethane, allyl systems, butadiene and benzene. Calculation of charge distributions, bond orders and free valency.	6	CO 3

4	**Computational Quantum Chemistry (15 Hours)**			
	4.1	Introduction and scope of computational chemistry, potential energy surface, conformational search, global minimum, local minima, saddle points.	3	CO 4
	4.2	Ab-initio methods: A review of Hartee-Fock method, self-consistent field (SCF) procedure. Roothan concept basis functions. Basis sets and its classification: Slater type and Gaussian type basis sets, minimal basis set, Pople style basis sets. Hartree-Fock limit. Post Hartree-Fock methods – introduction to Møller-Plesset perturbation theory, configuration interaction, coupled cluster and semi empirical methods.	3	CO 4
	4.3	Introduction to Density Functional Theory (DFT) methods: Hohenberg-Kohn theorems, Kohn-Sham orbitals, exchange correlation functional, local density approximation, generalized gradient approximation, hybrid functionals (only the basic principles and terms need to be introduced).	3	CO 4
	4.4	Comparison of ab-initio, semi empirical and DFT methods.	1	CO 4
	4.5	*Molecular geometry input*: Cartesian coordinates and internal coordinates, Z-matrix, Z-matrix of single atom, diatomic molecule, non-linear triatomic molecule, linear triatomic molecule, polyatomic molecules like ammonia, methane and ethane. General format of GAMESS / Firefly input file, single point energy calculation, geometry optimization, constrained optimization and frequency calculation. Koopmans' theorem.	3	CO 4
	4.6	Features of molecular mechanics force field-bond stretching, angle bending, torsional terms, non-bonded interactions and electrostatic interactions. Commonly used force fields- AMBER and CHARMM.	2	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

1. Mc Quarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books Pvt. Ltd.
2. C. N. Banwell and E M Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edn, Tata Mc Graw Hill.

3. K. L. Kapoor, A Textbook of Physical Chemistry, Volumes 4, Macmillan India Ltd.
4. N. Levine, Physical Chemistry, Tata Mc Graw Hill, Chapter 21.
5. R. Puri, L. R. Sharma, M. S. Pathania, 'Elements of Physical Chemistry', Vishal Pub. Co.,
6. K. J. Laidler, John H. Meiser, 'Physical Chemistry', 2nd edn.
7. K. K. Sharma, L R Sharma, 'A Text Book of Physical Chemistry', Vikas Publishing house.
8. S. Negi, S. C. Anand, 'A Textbook of Physical Chemistry', Second Edition, New Age International (P) limited, publishers.
9. W. G. Palmer, '*Experimental physical chemistry*', Cambridge University Press.
10. J. B. Yadav, '*Advanced Practical Physical Chemistry*', Goel Publishing House.
11. R.C. Das and B. Behra, '*Experiments in Physical Chemistry*', Tata McGraw hill.
12. K. K. Sharma, '*An Introduction of Practical Chemistry*': Vikas Publishing House, New Delhi.

Further reading

1. W. J. Moore, *Basic Physical Chemistry*, Orient Longman.
2. F. A. Alberty and R. J .Silby, *Physical Chemistry*, John Wiley.
3. G. M. Barrow, *Physical Chemistry*, 5th edn., Tata McGraw Hill.
4. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997).
5. K. J. Laidler, *Chemical kinetics* 3rd edn, Pearson education 2004.
6. J Rajaram and J. C. Kuriakose, *Kinetics and mechanisms of chemical transformations*, Macmillan, 2006.
7. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, Macmillan Ltd. (1996).

DSC-20

Discipline	Chemistry
Semester	VII
Type of Course	Discipline Specific Course
Course Code	24UCHEDSC406
Course Title	Spectroscopy - I
Course Level	400-499
Course summary	The course will be an introduction to fundamental concepts of light-matter interaction, electronic transitions and energy level. The following techniques are covered from both a theoretical and experimental perspective: infrared spectroscopy, Raman spectroscopy, UV-VIS spectroscopy, NMR spectroscopy, ESR spectroscopy and Mossbauer spectroscopy.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite	Regions of the electromagnetic radiation, origin of spectrum MW spectroscopy -Rotational spectra of rigid diatomic molecule, non-rigid diatomic molecule IR spectroscopy-Harmonic oscillator

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the foundations of spectroscopy	Understand	PO1, PO2
2	Explain the principles and applications of Microwave, IR, Raman, Electronic and NMR spectroscopy.	Apply	PO1, PO2
3	Explain EPR, NQR and Mossbauer spectroscopy.	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Description	Hours	CO No.
1	**Foundations of Spectroscopic Techniques (3 Hrs)**			
	1.1	Factors affecting the intensity and width of spectral lines	2	CO 1
	1.2	Lamb dip spectrum, Signal to noise ratio, Born Oppenheimer approximation.	1	CO 1
	Microwave Spectroscopy (7 Hrs)			
	2.1	Principal moments of inertia and classification (linear, symmetric tops, spherical tops and asymmetric tops).	1	CO 2

2	2.2	Selection rules, intensity of rotational lines, relative population of energy levels, derivation of Jmax.	1	CO 2
	2.3	Effect of isotopic substitution, calculation of intermolecular distance, spectrum of non-rigid rotors.	1	CO 2
	2.4	Rotational spectra of polyatomic molecules, linear and symmetric top molecules.	2	CO 2
	2.5	Stark effect and its application	1	CO 2
	2.6	Nuclear spin and electron spin interaction, chemical analysis by microwave spectroscopy.	1	CO 2
3	**Infrared and Raman Spectroscopy (10 Hrs)**			
	3.1	Morse potential energy diagram, fundamental vibrations, overtones and hot bands, determination of force constants.	2	CO 2
	3.2	Diatomic vibrating rotator, breakdown of the Born-Oppenheimer approximation, effect of nuclear spin.	2	CO 2
	3.3	Vibrational spectra of polyatomic molecules, normal modes of vibrations, combination and difference bands, Fermi resonance.	1	CO 2
	3.4	FT technique, introduction to FTIR spectroscopy. Instrumentation of FTIR.	1	CO 2
	3.5	Scattering of light, polarizability and classical theory of Raman spectrum, rotational and vibrational Raman spectrum	2	CO 2
	3.6	Complementarities of Raman and IR spectra, mutual exclusion principle	1	CO 2
	3.7	Polarized and depolarized Raman lines, resonance Raman scattering and resonance fluorescence	1	CO 2
4	**Electronic Spectroscopy (10 Hrs)**			
	4.1	Term symbols of diatomic molecules, electronic spectra of diatomic molecules, selection rules	2	CO 2
	4.2	Vibrational coarse structure and rotational fine structure of electronic spectrum.	1	CO 2
	4.3	Franck-Condon principle, predissociation, calculation of heat of dissociation, Birge and Sponer method.	2	CO 2
	4.4	Electronic spectra of polyatomic molecules, spectra of transitions localized in a bond or group, free electron model.	2	CO 2
	4.5	Different types of lasers-solid state lasers, continuous wave lasers, gas lasers and chemical laser, frequency doubling, applications of lasers.	3	CO 2
5	**Nuclear Magnetic Resonance Spectroscopy (20 Hrs)**			
	5.1	Theory of NMR Spectroscopy: Interaction between nuclear spin and applied magnetic field, important magnetically active nuclei.	2	CO 2
	5.2	Nuclear energy levels, population of energy levels, Larmor precession, relaxation methods.	3	CO 2
	5.3	Chemical shift and its representation- δ scale of PMR and CMR.	2	CO 2
	5.4	Spin-spin coupling: Theory and illustration with AX system.	2	CO 2

	5.5	Fourier Transformation (FT) NMR Spectroscopy: Instrumentation of NMR technique, magnets, probe and probe tuning,	2	CO 2
	5.6	Creating NMR signals, effect of pulses, rotating frame reference.	3	CO 2
	5.7	FID, FT technique, data acquisition and storage	2	CO 2
	5.8	Pulse sequences- Pulse width, spins and magnetization vector.	2	CO 2
	5.9	Solid state NMR-Applications. Magic Angle Spinning (MAS).	2	CO 2
6	**Other Magnetic Resonance Techniques (10 Hrs)**			
	6.1	EPR Spectroscopy: Electron spin in molecules, interaction with magnetic field.	1	CO 3
	6.2	g factor, factors affecting g values, determination of g values ($g_{\parallel}$ and $g^{\perp}$).	2	CO 3
	6.3	Fine structure and hyperfine structure, Kramers' degeneracy, McConnell equation.	2	CO 3
	6.4	Theory and important applications of NQR Spectroscopy	1	CO 3
	6.5	Mossbauer Spectroscopy: Principle, Doppler effect, recording of spectrum.	2	CO 3
	6.6	Chemical shift, factors determining chemical shift, application to metal complexes.	2	CO 3
7	**Teacher Specific Components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Classroom lecture, Lecture based learning, Familiarise molecular visualization software.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** Quiz, Oral Presentation, Written test, Problem based assignment or *any other method as may be required by the course faculty* **B. End Semester Evaluation (ESE)** Written test

References:

1. C.N. Banwell, E.M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Edn., Tata McGraw Hill, 1994.
2. G. Aruldhas, *Molecular Structure and Spectroscopy*, Prentice Hall of India, 2001.
3. A.U. Rahman, M.I. Choudhary, *Solving Problems with NMR Specroscopy*, Academic Press, 1996.
4. D.L. Pavia, G.M. Lampman, G.S. Kriz, *Introduction to Spectroscopy*, 3rd Edn., Brooks Cole, 2000.
5. R.S. Drago, *Physical Methods in Inorganic Chemistry*, Van Nonstrand Reinhold, 1965.
6. R.S. Drago, *Physical Methods in Chemistry*, Saunders College, 1992.
7. W. Kemp, *NMR in chemistry-A Multinuclear Introduction*, McMillan, 1986.

8. H. Kaur, Spectroscopy, 6th Edn., Pragati Prakashan, 2011.
9. H. Gunther, *NMR Spectroscopy*, Wiley, 1995.
10. D.A. McQuarrie, J.D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books, 1997.
11. D.N. Sathyanarayan, *Electronic Absorption Spectroscopy and Related Techniques*, Universities Press, 2001.
12. D.N. Sathyanarayana, *Vibrational Spectroscopy: Theory and Applications*, New Age International, 2007.
13. D.N. Sathyanarayana, *Introduction To Magnetic Resonance Spectroscopy ESR, NMR, NQR*, IK International, 2009.

DSC-21

Discipline	Chemistry
Semester	VIII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC407
Course Title	**Inorganic Chemistry - VI**
Course Level	400 - 499
Course Summary	By integrating theory, examples, and practical applications, this course equips students with a thorough understanding of catalysis, bioinorganic chemistry, analytical techniques, and their interconnectedness in the broader field of chemistry.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Illustrate the catalysis by Organometallic compounds	Understand	PO1, PO2, PO8
2	Describe the importance of metals in bio-inorganic chemistry	Apply	PO1, PO2, PO8
3	Know about different modern analytical methods	Apply	PO1, PO2, PO8
4	Perform colorimetric estimations.	Analyse	PO1, PO2, PO8

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Catalysis by Organometallic Compounds (15 Hours)			
	1.1	Homogeneous and heterogeneous organometallic catalysis : Tolman catalytic loops, alkene hydrogenation using Wilkinson catalyst	2	CO 1
	1.2	Reactions of carbon monoxide and hydrogen-the water gas shift reaction, synthesis gas based reactions - the Fischer-Tropsch reaction (*synthesis of gasoline*).	2	CO 1
	1.3	Hydroformylation of olefins using cobalt or rhodium catalyst	2	CO 1

1	1.4	Polymerization by organometallic initiators and templates for chain propagation - Ziegler Natta catalysts. Polymerisation by metallocene catalysts	2	CO 1
	1.5	Carbonylation reactions - Monsanto acetic acid process olefin hydroformylation - oxo process, carbonylation of alkenes and alkynes in the presence of a nucleophile – the Reppe reaction. Carbonylation of aryl halides in the presence of a nucleophile	3	CO 1
	1.6	Olefin metathesis, photodehydrogenation catalyst ("Platinum Pop"). Palladium catalysed oxidation of ethylene-the Wacker process	2	CO 1
	1.7	Asymmetric catalysis - Asymmetric hydrogenation, isomerisation and epoxidation	2	CO 1
2	**Bioinorganic Chemistry II (15 Hours)**			
	2.1	Biochemistry of Zinc and Copper: Structure and functions of carboxypeptidase and carbonicanhydrase, Superoxide dismutase. Structure and functions of various Copper proteins and enzymes. Blue copper proteins (Type-1) - Electron transfer agents - Plastocyanin, Stellacyanin and Azurin.	5	CO 2
	2.2	Blue copper Enzymes (Type II) - Ascorbateoxidase, Laccase and ceruloplasmin. Non Blue copper enzyme (Type III) - Cytochrome oxidase, Amine oxidases, Structure and functions of Hemocyanin.	5	CO 2
	2.3	Other Important metal containing Biomolecules. Vitamin B12-Structure and biological importance. Chlorophyll-Photosynthesis, PS I & PS II - Z Scheme. Blood clotting mechanism	5	CO 2
3	**Analytical Methods (15 Hours)**			
	3.1	Analytical procedures involved in the environmental monitoring of water quality BOD, COD, DO, nitrite and nitrate, iron, fluoride.	5	CO 3
	3.2	Thermo analytical methods: Principle of thermo gravimetry, TGA of calcium oxalate monohydrate, differential thermal analysis, differential scanning calorimetry. Applications.	5	CO 3
	3.3	Colorimetry: Principle, Beer's law, Lambert's law, absorption coefficient, transmittance, opacity, Absorbance, optical density, molar absorption coefficient. Principle of estimation of iron, chromium and ammonium.	5	CO 3
4	**Practicals: Colorimetry (30 Hrs)**			
	4.1	Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, ammonium, nitrate and phosphate ions.	30	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References

1. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Harper Collins College Publishers,1993.
2. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th edition, Wiley-Interscience, 1999.
3. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
4. P. Powell, Principles of Organometallic Chemistry, 2nd Edn., Chapman and Hall, 1988.
5. J. D. Lee, 'Concise Inorganic Chemistry' 5th edn., Wiley India Pvt. Ltd. 2008.
6. B. R. Puri, L. R. Sharma, K. C. Kalia, 'Principles of Inorganic Chemistry', Milestone, Publishers, New Delhi 2010.
7. D. F. Shriver and P.W. Atkins, Inorganic Chemistry, 3rd edn., Oxford University Press.
8. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
9. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillian, 1968.
10. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis, The National Pub. Co., 1974.
11. J. Singh, R. K. P. Singh, J. Singh, LDS Yadav, I. R. Siddiqui, J. Shrivastava, Advanced Practical Chemistry, Pragati Prakashan, 7th Edn., 2017.

DSC-22

Discipline	Chemistry
Semester	VIII
Type of Course	Discipline Specific Course
Course Code	24UCHEDSC408
Course Title	Spectroscopy - II
Course Level	400-499
Course summary	This course is intended to give students a more complete picture of how spectroscopic methods are used to elucidate the structure of complex organic molecules. Among the topics that will be covered will be: • A more detailed discussion of the nuclear magnetic resonance phenomenon at the molecular level • A variety of NMR spectroscopic methods will be discussed including more detailed treatments of basic ^{1}H-NMR and ^{13} C-NMR spectroscopy, as well as other techniques. • A much more detailed discussion of mass spectrometric methods will be presented. • Vibrational spectroscopy techniques including IR and Raman spectroscopy. • Electronic (UV-visible) spectroscopic techniques. The practical component focuses on the following points • Simple multi-step organic conversions using conversions using conventional and green alternative methods. • Measure and interpret the IR and NMR spectrum of the synthesized componds.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describe the principles of UV-visible, Chiro-optical, IR, NMR and Mass spectroscopic techniques.	Understand	PO1, PO2
2	Illustrate various spectroscopic techniques using simple problems.	Apply	PO1, PO2
3	Elucidate the structure of an unknown organic compound using data from various spectroscopic techniques.	Analyze	PO1, PO2
4	Carry out multi step organic synthesis by conventional and by green alternative methods and interpret their IR and NMR spectrum	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Description	Hours	CO No.
1	**Ultraviolet-Visible and Chiro-optical Spectroscopy (6 Hrs)**			
	1.1	Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules.	2	CO 1
	1.2	Influence of substituent, ring size and strain on spectral characteristics.	1	CO 1
	1.3	Solvent effect, Stereochemical effect	1	CO 1
	1.4	Chiro-optical – ORD, CD, axial haloketone rule, Cotton effect-applications, properties – RD properties - RD, CD, octant rule.	1	CO 1
	1.5	Problems based on the above topics.	1	CO 2
2	**Infrared Spectroscopy (8 Hrs)**			
	2.1	Fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions)	2	CO 1
	2.2	Influence of substituent, ring size, hydrogen bonding, vibrational coupling and field effect on frequency.	2	CO 1
	2.3	IR spectra of C=C bonds (olefins and arenes) and C=O bonds	2	CO 2
	2.4	Problems on spectral interpretation with examples.	2	CO 2
3	**Nuclear Magnetic Resonance Spectroscopy (15 Hrs)**			
	3.1	Magnetic nuclei with special reference to ^{1}H and ^{13}C nuclei. Chemical shift and shielding/deshielding.	1	CO 1
	3.2	Factors affecting chemical shift, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy	2	CO 1
	3.3	^{1}H and ^{13}C NMR scales	1	CO 1
	3.4	Spin-spin splitting: AX, AX_2, AX_3, A_2X_3, AB, ABC, AMX type coupling,	2	CO 1
	3.5	First order and non-first order spectra, Pascal's triangle, coupling constant.	1	CO 1
	3.6	Mechanism of coupling- Dirac model. Karplus curve, quadrupole broadening and decoupling	1	CO 1
	3.7	Homotopic, enantiotopic and diastereotopic protons.	1	CO 1
	3.8	Long range coupling. NOE and cross polarization.	1	CO 1
	3.9	2D NMR and COSY, HOMOCOSY and HETEROCOSY	2	CO 1
	3.10	DEPT, sensitivity enhancement and MRI.	1	CO 1
	3.11	Problems on spectral interpretation with examples	2	CO 2

4	**Mass Spectrometry (9 Hrs)**			
	4.1	Molecular ion: Ion production methods (EI). Soft ionization methods: SIMS, FAB, MALDI-TOF, field desorption electrospray ionization	2	CO 1
	4.2	Fragmentation patterns - polyenes, alkyl halides, alcohols, phenols, aldehydes, ketones, esters, nitrogen, acids, amides, amine, nitro compound and ring rules.	2	CO 1
	4.3	McLafferty rearrangement and its applications	1	CO 1
	4.4	HRMS, MS-MS, LC-MS, GC-MS.	2	CO 1
	4.5	Problems on spectral interpretation with examples.	2	CO 2
5	**Structural Elucidation Using Spectroscopic Techniques (7 Hrs)**			
	5.1	Identification of structures of unknown organic compounds based on the data from UV-Vis, IR, ^{1}H NMR and ^{13}C NMR spectroscopy (HRMS data or Molar mass or molecular formula may be given).	5	CO 3
	5.2	Interpretation of the given UV-Vis, IR and NMR spectra.	1	CO 2
	5.3	Spectral analysis of the following reactions/functional transformations: 1. Pinacol-Pinacolone rearrangement 2. Benzoin condensation 3. (4+2) cycloaddition 4. Beckmann rearrangement	1	CO 2
6	**Organic Chemistry Practicals (30 hours)**			
	6.1	Preparation and purification of organic compounds involving Two step Synthetic Sequences by Chemical Methods (Reactions involving nitration, Bromination, deamination, hydrolysis, rearrangement etc.)	14	CO 4
	6.2	Preparation Involving Multistep Synthetic Sequences by the Green Alternatives of Chemical Methods including Enzyme/coenzyme catalysed reactions. Microwave assisted Organic Synthesis - oxidation, hydrolysis, condensation, substitution etc	12	CO 4
	6.3	Record the IR spectrum of the compounds synthesised. Generate and interpret the ^{1}H and ^{13}C NMR spectra of selected organic molecules using software.	4	CO 4
7	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Classroom lecture, Lecture based learning, Familiarise molecular visualisation software.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** Quiz, Oral Presentation, Written test, Problem based assignment or *any other method as may be required by the course faculty* **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

1. D.L. Pavia, G.M. Lampman, G.S. Kriz, *Introduction to Spectroscopy*, 3rd Edn., Brooks Cole, 2000.
2. A.U. Rahman, M.I. Choudhary, *Solving Problems with NMR Specroscopy, Academic Press*, 1996.
3. L. D. Field, S. Sternhell, J. R. Kalman, *Organic Structures from Spectra*, 4th Edn., John Wiley & sons, 2007.
4. C. N. Banwell, E.M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Edn., Tata McGraw Hill, 1994.
5. D. F. Taber, *Organic Spectroscopic Structure Determination: A Problem Based Learning Approach*, Oxford University Press, 2007.
6. H. Gunther, *NMR Spectroscopy*, 2nd Edn., Wiley, 1995.
7. R. M. Silverstein, G. C. Bassler, T. C. Morril, *Spectroscopic Identification of Organic Compounds*, 5th Edn., Wiley, 1991.
8. D. H. Williams, I. Fleming, *Spectroscopic Methods in Organic Chemistry*, 6th Edn., McGraw-Hill, 2008.
9. W. Kemp, *Organic Spectroscopy*, 2nd Edn., Macmillan, 1987.
10. F. Bernath, *Spectra of Atoms and Molecules*, 2nd Edn., Oxford University Press, 2005.
11. Online spectral databases including RIO-DB.

4. DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)

List of Courses in the Chemistry DSE Course Basket

No.	SEM	COURSE CODE	COURSE TITLE	COURSE LEVEL	CREDIT	HOURS
1.	V/VI	24UCHEDSE301	Instrumental Methods for Chemical Analysis	300-399	4	60
2.		24UCHEDSE302	Forensic Chemistry and Toxicology	300-399	4	60
3.		24UCHEDSE303	Food Chemistry	300-399	4	60
4.		24UCHEDSE304	Electrochemical Power Sources	300-399	4	60
5.		24UCHEDSE305	Applied Chemistry: Exploring Industrial Products and Processes	300-399	4	60
6.		24UCHEDSE306	Material Science and Nanochemistry	300-399	4	60
7.	VIII	24UCHEDSE401	Advances in Chemistry	400-499	4	60

DSE-01

Discipline	Chemistry
Semester	V / VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE301
Course Title	Instrumental Method for Chemical Analysis
Course Level	300 - 399
Course Summary	This course covers instrumental techniques for chemical analysis, including spectroscopy, and electrochemical methods. Emphasis is on the principles, applications, and interpretation of data.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the theory behind UV-VIS spectroscopy, operate different types of spectrometers, analyze spectra.	Understand	PO1, PO2
2	Utilize IR spectroscopy for qualitative and quantitative analysis of organic and inorganic materials.	Apply	PO1, PO2
3	Illustrate the principles of Raman spectroscopy and identify key features of Raman spectra.	Understand	PO1, PO2
4	Operate relevant instruments, interpret data, and apply these techniques for quantitative analysis and study of electrochemical processes.	Apply	PO1, PO2
5	Apply electrophoresis for separation and characterization of biomolecules and other charged species.	Apply	PO1, PO2
6	Explain the principles of UV, photoelectron and X-ray photoelectron spectroscopy	Understand	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**UV-Visible Spectroscopy (15 Hours)**			
	1.1	UV-VIS Spectrometry - Instrumentation, Radiation Sources, Wavelength, Selectors, Monochromators, Sample Handling, Detectors, Signal Processing and Output Devices	5	CO1
	1.2	Types of UV-Visible Spectrometers- Single Beam Spectrometers, Double Beam Spectrometers	5	CO1

	1.3	Analytical Applications of UV-Visible Spectrometry, Qualitative and quantitative Applications.	5	CO1
2	**IR Spectroscopy (10 Hours)**			
	2.1	IR Spectroscopy - Instrumentation, Basic Components of IR Instruments, Types of IR Instruments	3	CO 2
	2.2	Strategy for Interpretation of IR spectra	4	CO 2
	2.3	Applications of IR Spectrometry: Quantitative and Qualitative Applications.	3	CO 2
3	**Raman Spectroscopy (5 Hours)**			
	3.1	Raman Spectroscopy: Instrumentation, sample handling, instrumentation	2	CO 3
	3.2	Raman spectra of HCN, CO, CO_2, N_2O, H_2O and quantitative analysis.	2	CO 3
	3.3	Elementary ideas of SERS.	1	CO 3
4	**Advanced electroanalytical Techniques (15 Hours)**			
	4.1	Electroanalytical Techniques: Electroanalytical Methods-instrumentation, amperometry- amperometric titrations, types of titration curves	4	CO 4
	4.2	Electrogravimetry	4	CO 4
	4.3	Voltammetry and polarography-DME	4	CO 4
	4.4	Coulometry-Coulometric titrations, constant current, controlled potential, applications of coulometric methods	3	CO 4
5	**Electrophoresis (10 Hours)**			
	5.1	Electrophoresis- Instrumentation, factors affecting mobility, macromolecular size and charge interactions with supporting electrolyte, pH and concentration discontinuities	5	CO 5
	5.2	Preparation of gel-staining and destaining, preparative zone electrophoresis, SDS PAGE, continuous electrophoresis, applications.	5	CO 5
6	**Photoelectron Spectroscopy (5 Hours)**			
	6.1	Photoelectron spectroscopy- Instrumentation.	2	CO 6
	6.2	UV photoelectron and X-ray photoelectron spectroscopy. XPS imaging.	3	CO 6
7	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

1. Instrumental methods of analysis – H.H Willard, Meritt Jr. and J.A Dean
2. Principles of instrumental analysis – Skoog and West
3. Vogels Textbook of Quantitative Inorganic analysis – J. Basset, R.C Denney, G.H Jefferey and J. Madhan.
4. Instrumental Electroanalysis- Justin L. Strohl and James A. Dean
5. Understanding Voltammetry - Richard G. Compton and Christopher D. Boone
6. Electron Spectroscopy: Theory, Techniques and Applications - C.R. Brundle
7. Handbook of X-ray Photoelectron Spectroscopy - John C. Vickerman and Iain A. McIntyre
8. Electrophoresis (Analytical Chemistry by Open Learning)- Maureen A. L. Melvin, 1987.
9. Infrared Spectroscopy: Fundamentals and Applications- Barbara H. Stuart
10. Infrared and Raman Spectroscopy: Principles and Spectral Interpretation - James E. Stewart
11. Raman Spectroscopy: Principles and Instrumentation- Colin N. Banwell, Elaine M. McCash

DSE-02

Discipline	Chemistry
Semester	V / VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE302
Course Title	Forensic Chemistry and Toxicology
Course Level	300 - 399
Course Summary	This course provides a comprehensive overview of forensic chemistry and toxicology, focusing on the application of chemical principles to legal investigations and the analysis of toxic substances.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the basics of toxicology and poisons.	Understand	PO1, PO2
2	Describe the chemistry of drugs, narcotics and psychotropic substances.	Apply	PO1, PO2
3	Illustrate the properties of petroleum and petroleum products	Understand	PO1, PO2
4	Explain the chemistry of fire and arson.	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Basics of Toxicology and Poisons (15 Hours)**			
	1.1	Significance of toxicological findings. Techniques used in toxicology. Toxicological analysis and chemical intoxication tests. PostmortemToxicology. Human performance toxicology. Dose response relationship. Lethal dose50 and effective dose50. Classification of poisons.	3	CO 1
	1.2	Physico chemical characteristics and mode of action of poisons. Accidental, suicidal and homicidal poisonings. Signs and symptoms of common poisoning and their antidotes.	3	CO 1
	1.3	Collection and Preservation of viscera, blood and urine for various poison cases. Identification of biocides and metal salts in body fluids.	3	CO1

	1.4	Metabolism and excretion of poisons. Application of immunoassays in forensic work. Animal poisons. Snake venom. Mode of action. Carbon monoxide poisoning.	3	CO 1
	1.5	Vegetable poisons.Poisonous seeds, fruits, roots and mushrooms. Beverages - Alcoholic And Nonalcoholic illicit liquors. Analysis and identification of ethyl alcohol. Estimation of ethyl alcohol in blood and urine. Proof spirit. Crime scene management in illicit liquor cases	3	CO 1
2	**Narcotics, Drugs, Psychotropic Substances (15 Hours)**			
	2.1	Definition of narcotics, drugs and psychotropic substances. Broad classification–Narcotics, stimulants, depressants and hallucinogens. General characteristics and common examples of each classification.	3	CO 2
	2.2	Natural, synthetic and semi- synthetic narcotics, drugs and psychotropic substances. Designer drugs.	3	CO 2
	2.3	Tolerance, addiction and withdrawal symptoms of narcotics, drugs and psychotropic substances. Crime scene search for narcotics, drugs and psychotropic substances–searching suspect, searching a dwelling, searching a vehicle. Clandestine drug laboratories.	3	CO 2
	2.4	Collection and preservation of drug evidence. Testing of narcotics, drugs and psychotropic substances. Isolation techniques for purifying narcotics, drugs and psychotropic substances–thin layer chromatography, gas- liquid chromatography and high performance liquid chromatography.	3	CO 2
	2.5	Presumptive and screening tests for narcotics, drugs and psychotropic substances. Microcrystalline testing of drugs of abuse. Analysis of narcotics, drugs and psychotropic substances in breast milk, saliva, urine, hair and ante mortem blood. Dope tests.	3	CO 2
3	**Petroleum and Petroleum Products (15 Hours)**			
	3.1	Distillation and fractionation of petroleum. Commercial uses of different petroleum fractions. Analysis of petroleum products.	5	CO 3
	3.2	Analysis of traces of petroleum products in forensic exhibits.	5	CO 3
	3.3	Comparison of petroleum products. Adulteration of petroleum products.	5	CO 3
4	**Fire and Arson investigation (15 Hours)**			
	4.1	Nature and chemistry of fire, types of arson cases, detailed examination of scene of crime, collection and preservation of evidence in an arson case, analysis of incendiary material from debris.	5	CO 4
	4.2	Analysis of petroleum products for adulteration. Trap cases-analysis of Dyes used in trap cases. Explosive Nature, classification and composition, ignition, combustion and detonation.	5	CO 4
	4.3	Examination of explosives, Bomb and LED (Improvised explosive device) Reconstruction of explosive cases, Diffusing	5	CO 4

		of Live Bomb, analysis of cement and Mortar analysis of Detergent and Soap.		
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

1. "Forensic Toxicology: Principles and Concepts" by Nicholas T. Lappas and Courtland L. Silver. Publisher: Jones & Bartlett Learning. Edition: 2nd Edition. Year: 2018.
2. "Fundamentals of Forensic Science" by Max M. Houck and Jay A. Siegel. Publisher: Academic Press. Edition: 3rd Edition. Year: 2015.
3. "Handbook of Forensic Toxicology for Medical Examiners" by D. K. Molina. Publisher: CRC Press. Edition: 1st Edition. Year: 2007.
4. "Forensic Chemistry Handbook" by Lawrence Kobilinsky, Thomas F. Liotti, and Jamieson R. Nabozny. Publisher: Wiley. Edition: 1st Edition. Year: 2012.
5. "Criminal Poisoning: Investigational Guide for Law Enforcement, Toxicologists, Forensic Scientists, and Attorneys" by John H. Trestrail III. Publisher: Humana Press. Edition: 2nd Edition. Year: 2007.

DSE-03

Discipline	Chemistry
Semester	V / VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE303
Course Title	Food Chemistry
Course Level	300 - 399
Course Summary	Food Chemistry is a course that explores the chemical composition, properties, and transformations of food components. The course covers a wide range of topics, including carbohydrates, proteins, lipids, vitamins, minerals, and additives, as well as the chemical reactions that occur during food processing, storage, and preparation.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the Components of Food and Fundamentals of Agro and Dairy Products	Understand	PO1, PO2
2	Evaluate the application of different food preservation methods (canning, fermentation, refrigeration, etc.) based on their principles and suitability for specific food products.	Analyse	PO1, PO2
3	Critically analyze the causes and types of food spoilage (biological, chemical) and food poisoning (microbial, chemical, physical) and suggest preventive measures	Analyse	PO1, PO2
4	Explain the purpose and function of various food additives (sweeteners, preservatives, antioxidants, colors) and critically evaluate their potential risks and benefits.	Understand	PO1, PO2
5	Understand the food regulations and standards	Understand	PO1, PO2
6	Understand the basis of intentional and unintentional food adulteration and analyse the adulteration in food	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Components of Food and Fundamentals of Agro and Dairy Products (15 Hours)			
	1.1	Components of food Carbohydrates (starch, glycogen, fibres- cellulose, pectin, gums) Lipids (Rancidity, Hydrogenation, Hardening, trans-fat)	5	CO 1

1		Proteins (Vegetable, milk, cheese and meat/fish proteins, Denaturation, hydrolysis, reduction, water binding properties) Vitamins and minerals.		
	1.2	Composition and nutritive values: Cereals, Pulses, oil seeds and nuts, fruits and vegetables, milk, meat and meat products, seafood, Poultry.	4	CO 1
	1.3	Antinutritional factors and toxic constituents in pulses, protein contents of pulses- Sprouting.	1	CO 1
	1.4	Food and therapeutic uses of oil seeds and nuts	1	CO 1
	1.5	Effect of heat on colour and texture of vegetables–minimizing nutritional losses qualitative and quantitative aspects.	1	CO 1
	1.6	Spices and condiments: Flavour constituents in Indian preparations- chemistry of active ingredients in spices.	2	CO 1
	1.7	Condiments- composition, extraction of active ingredients and medicinal value-Chillies- Turmeric.	1	CO 1
2	**Preservation of Food (10 Hours)**			
	2.1	Canning, smoking, salting, curing, drying, sugaring, refrigeration, freeze drying, vacuum packing, irradiation, pascalization, biopreservation	4	CO 2
	2.2	Fermentation: Introduction to fermentation. Lactic acid fermentation of cabbage, cucumber, olives. Traditional fermented foods – Idli, Dosa. Fermented Meat and Milk Products-curd and cheese. Alcoholic fermentation of grape juice.	4	CO 2
	2.3	Pasteurization – principles and objectives, Basic science of pasteurization of milk	2	CO 2
3	**Food Deterioration and Food Poisoning (10 Hours)**			
	3.1	Biodeterioration and chemical deterioration in food. Micro-organisms involved in biodeterioration. Factors affecting microbial growth. Chemical deterioration.	3	CO 3
	3.2	Food poisoning: chemical, physical and biological.	2	CO 3
	3.3	Food infections: Salmonellosis, Shigellosis, Vibrosis, Cholera, Trichinosis, Amebiasis, Red Tide Shell fish poisoning, protozoa (basic idea)	3	CO 3
	3.4	Food intoxications.	2	CO 3
4	**Food Additives (15 Hours)**			
	4.1	Introduction to food additives.	1	CO 4
	4.2	Food flavours- natural, natural identical and synthetic – Flavour enhancers and potentiators and applications, MSG.	2	CO 4
	4.3	Sweetners: Natural intense sweeteners - Sweetener index. Non-nutritive-low calorie sweeteners–cyclamate–saccharin – aspartame-alitame acesulfame K-sucralose–polyhydric alcohols as sweeteners.	3	CO 4
	4.4	Preservatives–benzoic acid–parabens–citric acid–sorbic acid–sulphites-nitrites– nitrates–hydrogen peroxide.	2	CO 4

	4.5	Antioxidants: Generation–causes–effects–Naturally occurring antioxidants-role of Vitamin C– Vitamin E –tocopherols–lipoic acid–evaluation of antioxidant property	3	CO 4
	4.6	Food colours- sources of food colours, types with reference to natural and synthetic, properties/ reactions reference to processing, food applications.	2	CO 4
	4.7	Food additives and hypersensitivity. Risks and benefits of different food additives.	2	CO 4
5	**Regulations (5 Hours)**			
	5.1	Introduction to Food Regulations: Regulatory landscape: National (e.g., FSSAI [Food Safety and Standards Authority of India] in India, FDA [Food and Drug Administration] in USA) and International (e.g., Codex Alimentarius) bodies.	1	CO 5
	5.2	Hazard Analysis Critical Control Points (HACCP) Prevention of Food Adulteration (PFA) Act 1954 Food safety and standards Act 2006 ISI mark of bureau of Indian Standards, The AGMARK standard	2	CO 5
	5.3	Essential Commodities Act (1955), Fruits Products Order (1955), Solvent extracted oil, De-oiled Meal and Edible Flour Control Order (1967), Milk and milk products order (1992), Meat and food products order (1973), Vegetable oil Products (Regulation) order 1998	2	CO 5
6	**Food Adulteration (5 Hours)**			
	6.1	Intentional and unintentional adulterant. Test for assessing the quality of saturated fats and frying oils. Methods of detection of intentional adulterants.	3	CO 6
	6.2	Incidental adulterants : contamination of foods with harmful microorganisms, metallic contamination (lead chromate in turmeric, organic mercury in marine foods, silver foil in sweets, nickel, cadmium in chocolates), pesticide residues.	2	CO 6
7	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. Meyer, L.H. Food Chemistry, CBS Publishers \& Distributors, 1987

2. Richard Owusu-Apenten, Ernest R. Vieira, Elementary Food Science, Springer Nature Switzerland AG 2023
3. Mary K. Schmidl, Theodore P. Labuza, Essentials Of Functional Foods, Springer; 2000th edition
4. John M. deMan, John W. Finley, W. Jeffrey Hurst, Chang Yong Lee, Principles of food chemistry, 4th edition 2018
5. Ramesh Sirohi, Sustainable Food Processing, Oxford Book Company (1 January 2018)

Further reading

1. Cook's Science: How to Unlock Flavor in 50 of Our Favorite Ingredients. (2016). United States: America's Test Kitchen.

DSE-04

Discipline	Chemistry
Semester	V / VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE304
Course Title	Electrochemical Power Sources
Course Level	300 - 399
Course Summary	Electrochemical Power Sources is a specialized course that explores the principles, design, and applications of various electrochemical devices used for energy storage and conversion. The course covers a wide range of electrochemical power sources, including batteries, fuel cells, and supercapacitors, and examines their fundamental operating principles, materials, and performance characteristics.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the fundamental principles of electrochemical energy conversion and storage.	Understand	PO1, PO2
2	Explore the working principles and characteristics of various battery, fuel cell and supercapacitor technologies.	Apply	PO1, PO2
3	Analyze the performance and limitations of different electrochemical power sources.	Analyze	PO1, PO2
4	Identify the applications and potential future directions of electrochemical energy storage.	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Introduction to Electrochemical Power Sources (15 Hours)**			
	1.1	Importance of Electrochemical Technologies: Global energy challenges, role of energy storage and conversion, comparison with other technologies.	3	CO 1
	1.2	Fundamentals of Electrochemistry: Redox reactions, electrochemical cells, thermodynamics and kinetics of electrochemical processes.	3	CO 1

	1.3	Classification of Electrochemical Power Sources: Primary vs. secondary batteries, capacitors vs. supercapacitors, fuel cells, hybrid systems.	3	CO 1
	1.4	Materials for Electrochemical Energy Storage and Conversion: Electrode materials, membranes, electrolytes.	3	CO 1
	1.5	Key Performance Parameters of Electrochemical Devices: Energy density, power density, efficiency, cycle life, fuel utilization, safety, environmental aspects	3	CO 1
2	**Batteries (15 Hours)**			
	2.1	Lead-Acid Batteries: Construction, working principle, performance characteristics, applications, limitations.	3	CO 2
	2.2	Nickel-Cadmium Batteries: Construction, working principle, performance characteristics, applications, environmental concerns.	3	CO 2
	2.3	Lithium-Ion Batteries: Types, construction, working principle, performance characteristics (high energy density, cycle life), applications (electric vehicles, portable electronics), safety considerations.	4	CO 2
	2.4	Other Battery Technologies: Sodium-ion batteries, metal-air batteries, solid-state batteries, future trends.	3	CO 2
	2.5	Examples of battery design for specific applications, and performance optimization.	2	CO 2
3	**Supercapacitors (15 Hours)**			
	3.1	Electrostatic Double-Layer Capacitors (EDLCs): Construction, working principle, charge storage mechanism, performance characteristics (high power density, fast charging), limitations.	5	CO 3
	3.2	Pseudocapacitors: Types, materials, working principle, faradaic charge storage, improved energy density.	4	CO 3
	3.3	Hybrid Electrochemical Capacitors: Combining battery and supercapacitor characteristics, improved power-energy density, applications.	5	CO 3
	3.4	Applications of Supercapacitors	1	CO 3
4	**Fuel Cells (15 Hours)**			
	4.1	Introduction to Fuel Cells	4	CO 4
	4.2	Factors influencing fuel cell performance: efficiency, power density, energy density.	4	CO 4
	4.3	Different types – PEMFCs, SOFCs, DMFCs, AFCs.	4	CO 4
	4.4	Biofuel Cells. Applications of fuel cells.	3	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors: Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, published:17 November 2014.
2. Encyclopedia of Electrochemical Power Sources : Jürgen Garche, Chris K. Dyer, Patrick T. Moseley, Zempachi Ogumi, David A. J. Rand, Bruno Scrosati, 1st Edition - November 5, 2009.

DSE-05

Discipline	Chemistry
Semester	V / VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE305
Course Title	Applied Chemistry: Exploring Industrial Products and Processes
Course Level	300 - 399
Course Summary	This course delves into the fascinating realm of industrial chemistry, focusing on the synthesis, production, and applications of key products essential to modern life. From vibrant dyes that color our fabrics to versatile plastics shaping our everyday items, and from life-saving drugs to innovative cosmetics enhancing our well-being, students will explore the intricate chemistry behind these diverse industrial products.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the chemistry of plastics, Polymers, and dyes.	Apply	PO 1, PO 2, PO 5
2	Explain the applications of chemotherapy.	Apply	PO 1, PO 2, PO 6
3	Illustrate the chemistry of cosmetics and their effect on health.	Understand	PO 1, PO 2, PO 6
4	Explain the chemistry of soaps, synthetic detergents, and their environmental effects.	Understand	PO 1, PO 2, PO 5

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Dyes (5 Hours)**			
	1.1	Theory of colour and constitution. Classification - according to structure and method of application. Chemistry of dyeing	2	CO 1
	1.2	Synthesis and applications of: Azo dyes – Methyl orange and Bismark brown; Triphenyl methane dyes - Malachite green and Rosaniline; Phthalein Dyes – Phenolphthalein and fluorescein dye; Vat Dye – Indigo; Anthraquinone dye – Alizarin. Natural dyes	3	CO 1

2	**Polymers and Plastics (15 Hours)**			
	2.1	Polymers – Classification, Types of polymerization - free radical, cationic and anionic, Mechanism of polymerization.	3	CO 1
	2.2	Synthesis and applications of the following polymers - Polyesters - terephthalates, polyamides - Nylon-6 and Nylon-66, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes, PVC and Teflon.	6	CO 1
	2.3	Synthetic rubbers – SBR and Nitrile rubber- structure and applications.	2	CO 1
	2.4	Conducting Organic Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].	3	CO 1
	2.5	Plastics in everyday life. Recycling of plastics. Biodegradable plastics. Environmental hazards of plastics.	1	CO 1
3	**Pharmaceutical Compounds (10 Hours)**			
	3.1	Drugs - Introduction – classification – mode of action. Drug discovery, design and development.	3	CO 2
	3.2	Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents (Aspirin, paracetamol); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphamethoxazol, Sulphacetamide); antiviral agents (Acyclovir), Central Nervous System agents (Diazepam), HIV-AIDS related drugs (AZT- Zidovudine).	6	CO 2
	3.3	Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).	1	CO 2
4	**Cosmetics (20 Hours)**			
	4.1	Cosmetics- Definition, History, Classification, Ingredients, Nomenclature, Regulations.	2	CO 3
	4.2	Face Preparation: Structure of skin, Face powder, Compact powder, Talcum powder.	3	CO 3
	4.3	Skin Preparation: Face cream, vanishing cream, cold cream, suntan cream, lather shaving cream	3	CO 3
	4.4	Hair preparation: Hair dye- classification – temporary, semipermanent, demi-permanent, permanent, formulation, hair sprays, shampoo- types of shampoo, conditioners	5	CO 3
	4.5	Colored preparation: Nail lacquers, Nail polish remover, Lipsticks	4	CO 3
	4.6	Personal hygiene products: Antiperspirants and deodorants, oral hygiene products, flavours, and essential oils	3	CO 3
5	**Soaps & Detergents (10 Hours)**			
	5.1	Soaps – Introduction, cleansing action of soap.	1	CO 4
	5.2	Types of Soap-Toilet soap, bathing bars, washing soaps, liquid soap. manufacture- additives, fillers, and flavours. Significance of acidity and alkalinity.	4	CO 4
	5.3	Detergents- Introduction, detergent action,	1	CO 4
	5.4	Types of detergents-cationic, anionic, amphiphilic detergents.	4	CO 4

		Common detergent chemicals. Additives, excipients, colours, and flavours. Enzymes used in commercial detergents. Environmental hazards		
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

Text Books:

1. Barel, A.O.; Paye, M.; Maibach, H.I.(2014), Handbook of Cosmetic Science and Technology, CRC Press.
2. Garud, A.; Sharma, P.K.; Garud, N. (2012),Text Book of Cosmetics, Pragati Prakashan.
3. Gupta, P.K.; Gupta, S.K.(2011),Pharmaceutics and Cosmetics, Pragati Prakashan
4. Butler, H. (2000), Poucher's Perfumes, Cosmetic and Soap, Springer
5. Kumari, R.(2018), Chemistry of Cosmetics, Prestige Publisher.
6. Helena Dodzuik, Introduction to Supramolecular Chemistry, Springer.
7. J. M. Lehn, Supramolecular Chemistry, VCH

SUGGESTED READINGS

1. Flick, E.W.(1990), Cosmetic and toiletry formulations, Noyes Publications / William Andrew Publishing.
2. Natural Ingredients for Cosmetics; EU Survey 2005
3. Formulation Guide for cosmetics; The Nisshin OilliO Group, Ltd.
4. Functional Ingredients & Formulated Products for Cosmetics & Pharmaceuticals; NOF Corporation
5. Carey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.
6. Norman, Richard OC. *Principles of organic synthesis*. Routledge, 2017.
7. Pine, Stanley H. *Organic chemistry*. Tata McGraw-Hill, 2014.

DSE-06

Discipline	Chemistry
Semester	V / VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE306
Course Title	Material Science and Nanochemistry
Course Level	300 - 399
Course Summary	Synthesis, Characterisation and Applications of nanomaterials forms the integral part of this Elective Course
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the types, classification and properties of nanomaterials	Understand	PO1, PO2, PO8
2	Illustrate the synthetic methods of nanomaterials	Apply	PO1, PO2, PO8
3	Explain the characterisation and application of nanomaterials	Understand	PO1, PO2, PO8

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Introduction to Nanomaterials (15 Hours)**			
	1.1	Evolution of nanotechnology, Conceptual origins, Role of Richard Feynman, Eric Drexler and Maxwell.	2	CO 1
	1.2	Classifications and types of nanomaterials - Zero dimensional, One dimensional (1D), two dimensional (2D), and three dimensional (3D).	4	CO 1
	1.3	Size dependent properties, surface-volume ratio, mechanical, physical and chemical properties: Carbon nanotubes, Fullerenes, Quantum dots, metal nanoparticles (Au, Ag), Metal and nonmetal oxide nanoparticles (TiO_2, ZnO, SiO_2)	9	CO 1
2	**Synthesis of Nanomaterials (15 Hours)**			
	2.1	Top down and Bottom up approaches, Sol-Gel synthesis, Template based synthesis, Solid states routes; mechanical mixing; grinding	3	CO 2

	2.2	Solid solution techniques; Evaporation; precipitation, Chemical Vapour deposition (CVD) , Hydrothermal, Solvothermal synthesis methods	4	CO 2
	2.3	Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Quantum dots (QDs) synthesis, Biological synthesis – Any two methods	5	CO 2
	2.4	Green methods: Synthesis of nanogold and nano silver, Synthesis of polymer nanocomposites	3	CO 2
3	**Characterization of Nanomaterials (15 Hours)**			
	3.1	Spectroscopic and microscopic techniques (Principle, instrumentation with block diagram, and application): XRD, TEM, SEM, STM, AFM, UV - VIS, Raman, FTIR, XPS, ESCA, Auger etc	12	CO 3
	3.2	Thermal characterizations: DSC, TGA, DTA	3	CO 3
4	**Applications of Nanomaterials (15 Hours)**			
	4.1	Nanotechnology in Electrical and Electronics Industry : Advantages of nano electrical and electronic devices – Electronic circuit chips – Nanosensors Nanomedicine and Targeted drug delivery applications.	4	CO 3
	4.2	Nanotechnology in Textiles and Cosmetics : Nanofibre production – Electrospinning, Swim-suits with shark-skin effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes)	4	CO 3
	4.3	Nanotechnology in Agriculture and Food Technology: Nanofertilizers: Nanourea and mixed fertilizers, Nanopackaging for enhanced shelf life - Smart/Intelligent packaging	3	CO 3
	4.4	Nanotechnology in Environmental and Health Effects: Application of Nanotechnology in remediation of pollution in Industrial and waste water treatment PVA/PLA based Green nanocomposites: Properties and Applications	4	CO 3
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References

1. Nanomaterials: Synthesis, Properties & Applications, ed by A.S. Edelstein & R.C. Cammarata, Published by Institute of Physics, UK, 1996.
2. Nanostructured Materials: Processing, Properties & Applications ed by C.C. Koch, WilliumAnd rew, Publishing New York, 2002.
3. Nanotechnology by George Limp, Springer Verlag, New York, 1999.
4. Nanoparticles & Nanostructured Films: Preparation, Characterization & Application ed by J.H. Fendler, John Willey & Sons, 1998
5. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.

DSE-07

Discipline	Chemistry
Semester	VIII
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UCHEDSE401
Course Title	Advances in Chemistry
Course Level	400 - 499
Course Summary	This core course in chemistry gives an outline of the frontier areas in organic, inorganic, and physical chemistry. Information about industrially important materials and polymers belongs to the inorganic chemistry portion. The organic chemistry portion consists of supramolecular chemistry and green chemistry. The physical chemistry of biological systems is also included in the course. This advanced chemistry course provides an understanding of the principles and methods in the frontier areas of chemistry as well as the research possibilities in this category.
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the applications of advanced inorganic materials and polymers in the industry.	Remember	PO 1, PO 2
2	Explain the principles and procedures in supramolecular chemistry	Understand	PO 1, PO 2
3	Illustrate the principles and methods in green chemistry focused on non-conventional methods	Understand	PO 1, PO 5
4	Explain the thermodynamics, kinetics and significance of nonbonding interactions in protein and biological systems	Understand	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Industrially Important Polymeric and Other Materials (15 Hours)**			
	1.1	Biopolymers - biomaterials. Polymers in medical field. High temperature and fire-resistant polymers. Silicones, Conducting polymers- carbon fibers. (basic idea only).	7	CO 1
	1.2	Refractory materials - carbides, nitrides, borides. Graphite and graphite oxide, intercalation compounds of alkali metals, carbon monofluoride, intercalation compounds of graphite with metal halides. Glass, silicates, zeolites, ultramarines and ceramics.	8	CO 1

2	**Supramolecular Chemistry (15 Hours)**			
	2.1	Introduction-Molecular recognition- Static and Dynamic molecular recognition. Host-guest interactions- types of non-covalent interactions. Importance of molecular recognition in DNA and protein structure.	7	CO 2
	2.2	Molecular receptors, Design principle of receptor, Different types of receptors - Cyclodextrins, crown ethers, cryptands, spherands, tweezers, carcerands, cyclophanes, calixarenes. Applications of supramolecular complexes in medicine (targeted drug delivery) and catalysis.	8	CO 2
3	**Green Chemistry (15 Hours)**			
	3.1	Green Chemistry- introduction- need for green chemistry – Twelve principles of green chemistry with examples- polylactic acid (PLA)as a green polymer.	5	CO 3
	3.2	Different Approaches to Green Synthesis. a) Uses of green reagents in organic synthesis. Dimethyl Carbonate, polymer supported reagents- peracids and chromic acid. b) Green Catalysts, Role of catalysts in sustainable development, Advantages and applications of nanocatalysts, phase transfer catalysts, biocatalysts and organocatalysts in organic synthesis. c) Microwave-assisted reactions: Methyl benzoate to benzoic acid, Diels-Alder reaction. d) Ultrasound-assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)	10	CO 3
4	**Biophysical Chemistry (15 Hours)**			
	4.1	Protein folding. Thermodynamics of Protein folding and unfolding. Significance of vander Waals force, dipole-dipole, hydrogen bond and hydrophobic interactions.	5	CO 4
	4.2	Acid-Base equilibrium: Protonation and deprotonation reactions. Biological significance of pH; Properties of proteins with emphasis on isoelectric pH. Henderson and Hasselbalch equation. Titration curves of amino acids & pK values, Buffers & Stability of their pH. Thermodynamics and Kinetics. Standard free energy change in biochemical reactions, exergonic, hydrolysis of ATP. Chemical potential. Oxidation/reduction reactions and bioenergetics. Enzyme catalysis. Michael Menton kinetics.	10	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References & Suggested Reading:

Module I

1. J. D. Lee, Concise Inorganic Chemistry 5th edn., Wiley India Pvt. Ltd. 2008
2. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, New Delhi 2010.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry, Pearson 2006.
4. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry 6th edn., John Wiley, New York. 1999.
5. D. F. Shriver and P.W. Atkins, Inorganic Chemistry 3rd edn., Oxford University Press. 2009

Module II

1. Helena Dodzuik, Introduction to Supramolecular Chemistry Springer
2. J. M. Lehn, Supramolecular Chemistry - Concepts and Perspectives, Wiley-VCH
3. H. Vogtle, Supramolecular Chemistry, Wiley
4. P. D. Beer, P. A. Gale and D. K. Smith, Supramolecular Chemistry, Oxford University Press, 1999.
5. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, 1st Ed., Wiley, 2000.

Module III

1. P. T. Anastas, J.C. Warner, Green Chemistry Theory and Practice Oxford University Press
2. M. Lancaster, Green Chemistry An Introductory Text Royal Society of Chemistry
3. V Polshettiwar, T Asefa, G Hutchings, Nanocatalysis, Synthesis and Applications Wiley
4. M. A. Ryan, M. Tinnesand Introduction to Green Chemistry, American Chemical Society
5. P. T. Anastas Handbook of Green Chemistry, John Wiley & Sons
6. V. K. Ahluwalia, M Kidwai, New Trends in Green Chemistry, Springer
7. Arends I., R. Sheldon, U. Hanefeld, Green Chemistry and Catalysis, 2007 WILEY-VCH, Verlag GmbH & Co. KGaA, Weinheim.

Module IV

1. Principles of Biochemistry- Albert L. Lehninger CBS Publishers & Distributors.
2. Biochemistry – Lubert Stryer Freeman International Edition.
3. Biochemistry - Voet and Voet, John Wiley and Sons.

4. Physical Chemistry for Life Sciences, Peter Atkins and Julio de Paula, 2006, Oxford Press
5. Narayanan, P (2000) Essentials of Biophysics, New Age Int. Pub. New Delhi.
6. Roy R.N. (1999) A Text Book of Biophysics New Central Book Agency.
7. Introduction to Biophysical chemistry, R. Bruce Martin, McGraw-Hill, NY, 1964.
8. Physical Chemistry with applications to Biological systems, Ramond Chnag, Mc Millan publishing Co.inc, New York 1977.
9. Principles of Physical Biochemistry 2nd Edition, K.E. van Holde, W.C. Johnson, P.S. Ho, Pearson Prentice Hall, ISBN 0-13-046427-9.

5. DISCIPLINE SPECIFIC COURSES (DSC) – Minor Pathway

List of Courses in the Chemistry DSC-Minor Course Basket

No.	SEM	Course Code	Course Title	Course Level	Credit	Hours
1.	I	24UCHEDSC101*	Fundamentals of Chemistry - I	100-199	4	75
2.	II	24UCHEDSC102*	Fundamentals of Chemistry – II	100-199	4	75
3.	III/IV	24UCHEDSC207	Chemistry for Physical Sciences	200-299	4	75
4.	III/IV	24UCHEDSC208	Elements of Biochemistry	200-299	4	75
5.	III/IV	24UCHEDSC209	Bioinorganic and Agricultural Chemistry	200-299	4	75

**The syllabus of the course is included in the DSC major course basket in page numbers 37 and 41.*

DSC-Minor 03

Discipline	Chemistry
Semester	III / IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC207
Course Title	**Chemistry for Physical Sciences**
Course Level	200-299
Course Summary	"Chemistry for Physical Sciences" provides a comprehensive introduction to essential chemical concepts and their relevance to physical sciences. Covering photochemistry, surface chemistry, phase equilibrium and electrochemistry the course equips students with the knowledge and skills necessary for interdisciplinary scientific inquiry and problem-solving.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the principles of photochemistry and surface chemistry.	Understand	PO 1, PO 2
2	Explain the phase diagrams of one and two-component systems.	Apply	PO 1, PO 2
3	Describe the principles of electrochemistry and electromotive force.	Apply	PO 1, PO 2
4	Illustrate the principles of physical chemistry through experiments.	Apply	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Photochemistry (5 Hours)**			
	1.1	Laws of Photochemistry, photochemical process – primary and secondary, quantum yield. Jablonski diagram, fluorescence and phosphorescence.	3	CO 1
	1.2	Basic Concepts of Photosensitized reactions, bioluminescence and chemiluminescence.	2	CO 1
2	**Surface Chemistry & Colloids (5 Hours)**			
	2.1	Adsorption – types of adsorption of gases by solids, factors influencing adsorption	1	CO 1
	2.2	Freundlich adsorption isotherm – Langmuir adsorption isotherm (derivation not required).	2	CO 1
	2.3	Colloids: preparation, properties – optical and electrical, electric	2	CO 1

		double layer, coagulation, electrophoresis, electroosmosis, surfactants, micelle, applications of colloids.		
3	**Phase Equilibria (5 Hours)**			
	3.1	The phase rule, equilibrium between phases – conditions	1	CO 2
	3.2	One component system: water system, sulphur system.	2	CO 2
	3.3	*Two-component systems* – solid-liquid equilibrium – simple eutectic, lead-silver system.	1	CO 2
	3.4	Distribution law, partition coefficient, applications- Study of association or dissociation, Principle of extraction. Distribution indicators.	1	CO 2
4	**Electrochemistry (15 Hours)**			
	4.1	Conductance of electrolytic solution, electrolytic conductivity (K), and molar conductivity of solutions of electrolytes.	3	CO 3
	4.2	Variation of conductivity and molar conductivity with concentration. Kohlrausch's law – application.	5	CO 3
	4.3	Faraday's laws of electrolysis, electrochemical equivalent and chemical equivalent, transport number-determination by Hittorf's method.	4	CO 3
	4.4	Applications of conductance measurements – Kw, Ksp, conductometric titrations, strong and weak electrolytes. Ostwald's dilution law, hydrolysis of salts.	3	CO 3
5	**Electromotive Force (15 Hours)**			
	5.1	Electrochemical cells, characteristics of reversible cells. Reversible electrodes – different types, electrode potential – effect of electrolyte concentration on electrode potential and emf (Nernst equation).	4	CO 3
	5.2	Electrochemical series, representation of cell, EMF of cell. EMF and equilibrium constant of cell reaction, concentration cells – general discussion of electrodes – concentration cell and electrolyte concentration cells. Liquid junction potential.	6	CO 3
	5.3	Fuel cells – the hydrogen–oxygen fuel cell.	1	CO 3
	5.4	Application of emf measurement – determination of pH using hydrogen electrode, quinhydrone electrode, glass electrode-potentiometric titrations.	4	CO 3
6	**Practical: Physical Chemistry Practicals (30 Hours)**			
	6.1	• Heat of neutralization • Conductometric titration – strong acid *vs.* strong base, weak acid-strong base. • Transition temperature of salt hydrates. (Sodium thiosulphate, sodium acetate) • Critical solution temperature. Phenol-water system • Determination of molecular weight by Rast's Method (using naphthalene, camphor or biphenyl as solvent and acetanilide, *p*-dichlorobenzene etc. as solute.) • Potentiometric titration – Fe^{2+} *vs.* MnO_4^-	**30**	CO 4

7	**Teacher-specific course components**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** Quiz, Oral Presentation, Written test, Problem based assignment or *any other method as may be required by the course faculty* **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References

1. R. P. Rastogi, R. R. Misra, '*An Introduction to Chemical Thermodynamics*', 6th edn., Vikas Pub. Pvt. Ltd. (2003).
2. P. Atkins and J Paula, '*The Elements of Physical Chemistry*', 7th edn, Oxford University Press.
3. K. K. Sharma, L. K. Sharma, *A Textbook of Physical Chemistry*, 4th edn, Vikas publishing House.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical chemistry*, Vishal Pub. Co. Jalandhar.
5. K. L. Kapoor, '*A Textbook of Physical Chemistry'*, Volumes 4, Macmillan India Ltd.

Further reading

1. J. Rajaram and J. C. Kuriakose, *Thermodynamics*, Shoban Lal Nagin Chand & Co (1986).
2. W. J. Moore, *Basic Physical Chemistry*, Orient Longman.
3. F. A. Alberty and R. J .Silby, *Physical Chemistry*, John Wiley.
4. G. M. Barrow, *Physical Chemistry*, 5th edn., Tata McGraw Hill.
5. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997).
6. K. J. Laidler, *Chemical kinetics* 3rd edn, Pearson education 2004.
7. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, Macmillan Ltd. (1996).

DSC-Minor 04

Discipline	Chemistry
Semester	III / IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC208
Course Title	Elements of Biochemistry
Course Level	200-299
Course Summary	This chemistry course provides a comprehensive overview of several fundamental areas within the discipline. It begins with kinetics, exploring the rates of chemical reactions and the factors influencing their speed. Moving on to separation and characterization techniques, students learn various methods used to isolate and identify chemical compounds. The course delves into bioinorganic compounds, amino acids, proteins, nucleic acids, vitamins, steroids, lipids and hormones elucidating their roles in biological systems.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the kinetics of biological reactions.	Understand	PO 1, PO 2
2	Describe the separation and characterization methods in chemistry.	Apply	PO 1, PO 2
3	Explain the chemistry of bio-inorganic compounds, amino acids, proteins, and nucleic acids.	Understand	PO 1, PO 2
4	Explain the chemistry of vitamins, steroids, hormones, and lipids.	Apply	PO 1, PO 2
5	Identify the given organic compound.	Analyse	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Kinetics of Biological Reactions (5 Hours)**			
	1.1	Rate of reaction, rate law, order of reaction, molecularity of reaction (Zero, First, Second)	1	CO 1
	1.2	Integrated rate expression, half-life, determination of order of reactions.	1	CO 1
	1.3	Enzyme catalysis, Rate Determination	2	CO 1
	1.4	Protein Equation - Ramachandran plot	1	CO 1
2	**Separation and Characterization Methods (10 Hours)**			
	2.1	Basic principle of Chromatography, Classifications of	2	CO 2

		chromatography		
	2.2	Principle, instrumentation and applications – Column, TLC, GC, HPLC, Ion exchange chromatography	5	CO 2
	2.3	Elementary ideas of FTIR, UV, GC-MS, NMR, LCMS	3	CO 2
3	**Bio-Inorganic Compounds (10 Hours)**			
	3.1	Essential and trace elements in biological systems, Myoglobin and Hemoglobin, role of myoglobin and hemoglobin in biological systems, mechanism of oxygen transport, cooperativity, Bohr effect, Phosphate effect.	4	CO 3
	3.2	Photosynthetic pigments, Chlorophyll, Structure, Different types of chlorophyll. Photosystem-I, photosystem-II, Z- Scheme, photophosphorylation (Elementary idea only	4	CO 3
	3.3	Biochemistry of Zn (Carbonic anhydrase, Carboxy peptidase) – mechanism not needed	2	CO 3
4	**Amino Acids and Proteins (10 Hours)**			
	4.1	Classification of amino acids, zwitter ion, general chemical properties of amino acids.	3	CO 3
	4.2	Separation of amino acids, synthesis of glycine, alanine (any one method).	2	CO 3
	4.3	Peptides – peptide bond, polypeptides. Proteins- amino acids as building block of proteins, classifications, prosthetic group, properties, denaturation.	3	CO 3
	4.4	Structure of proteins- primary, secondary and tertiary structure.	2	CO 3
5	**Nucleic Acids (5 Hours)**			
	5.1	Nucleic acids: Chemical composition, structures of nucleosides and nucleotides.	3	CO 3
	5.2	Structure of DNA & RNA. Biological Functions:-replication and protein synthesis	2	CO 3
6	**Vitamins, Steroids, Hormones and Lipids (5 Hours)**			
	6.1	Structure and biological activity of vitamin A, B and C.	1	CO 4
	6.2	Steroids- general introduction, cholesterol and bile acids	1	CO 4
	6.3	Hormones (structure not required) - Introduction, steroid hormones peptide hormones and artificial hormones (general idea).	1	CO 4
	6.4	Simple lipids and complex lipids. Analysis of oils and fats- acid value, saponification value, iodine value	2	CO 4
7	**Practical: Qualitative Organic Analysis (30 Hours)**			
	7.1	Qualitative analysis of organic compounds- Identification, and confirmation of alcohols, phenols, aldehydes, ketones, carboxylic acid and carboxylic acid derivatives.	30	CO 5
8	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

Text Books:

1. L. Finar, Organic Chemistry, 6th edition, Pearson.
2. K. S. Tewari, N. K. Vishnoi, A Text Book of Organic Chemistry, 3rd edition, Vikas publishing House Pvt. Ltd ,2006.
3. Rastogi, Biochemistry, Tata McGraw –Hill Publication, 1996.
4. Dr. Deb A.C., Fundamentals of Biochemistry, New central book agency, London, 2015.
5. G. T. Austin, Shreve's Chemical process Industries, 5th edition, McGraw Hill, 1984.
6. G. R. Chatwal, Synthetic Drugs, Himalaya Publishing House, Bombay, 1995.
7. J. Ghosh, A Textbook of Pharmaceutical Chemistry, S. Chand & Co Ltd., 1997.
8. Bhat S.V., Nagasampagi, B.A. & Sivakumar M., Chemistry of Natural Products, Narosa, 2005.
9. R. A. Day Junior, A.L. Underwood, Quantitative Analysis, 5th edn. Prentice Hall of India Pvt. Ltd. New Delhi, 1988.
10. Vogel's Text Book of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas, 6th edn. Pearson Education (2003).
11. G. D. Christian, Analytical Chemistry, John Wiley and SonsCarey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.

DSC-Minor 05

Discipline	Chemistry
Semester	III / IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UCHEDSC209
Course Title	Bioinorganic and Agricultural Chemistry
Course Level	200-299
Course Summary	This chemistry course provides a comprehensive overview of several fundamental areas within the discipline. It begins with kinetics, exploring the rates of chemical reactions and the factors influencing their speed. Moving on to separation and characterization techniques, students learn various methods used to isolate and identify chemical compounds. The course delves into bioinorganic compounds and nucleic acids, elucidating their roles in biological systems. Students also explore natural products, investigating the chemical compounds derived from living organisms and their applications in pharmaceuticals, agriculture, and other industries.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4
Pre-requisite, if any	Basics of inorganic and organic chemistry

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Understand the kinetics of biological reactions.	Understand	PO 1, PO 2
2	Describe the separation and characterization methods in chemistry.	Apply	PO 1, PO 2
3	Explain the chemistry of bio-inorganic compounds, nucleic acids, and natural products.	Understand	PO 1, PO 2
4	Explain the fundamentals of agricultural chemistry	Apply	PO 1, PO 2
5	Identify the given organic compound.	Analyse	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Kinetics of Biological Reactions (5 Hours)**			
	1.1	Rate of reaction, rate law, order of reaction, molecularity of reaction (Zero, First, Second)	1	CO 1
	1.2	Integrated rate expression, half-life, determination of order of reactions.	1	CO 1
	1.3	Enzyme catalysis, Rate Determination	2	CO 1

	1.4	Protein Equation - Ramachandran plot	1	CO 1
2	**Separation and Characterization Methods (10 Hours)**			
	2.1	Basic principle of Chromatography, Classifications of chromatography	2	CO 2
	2.2	Principle, instrumentation and applications – Column, TLC, GC, HPLC, Ion exchange chromatography	5	CO 2
	2.3	Elementary ideas of FTIR, UV, GC-MS, NMR, LCMS	3	CO 2
3	**Bio-Inorganic Compounds (5 Hours)**			
	3.1	Essential and trace elements in biological systems, Myoglobin and Hemoglobin, role of myoglobin and hemoglobin in biological systems, mechanism of oxygen transport, cooperativity, Bohr effect, Phosphate effect.	5	CO 3
4	**Nucleic Acids (5 Hours)**			
	4.1	Nucleic acids: Chemical composition, structures of nucleosides and nucleotides.	3	CO 3
	4.2	Structure of DNA & RNA. Biological Functions:-replication and protein synthesis	2	CO 3
5	**Chemistry of Natural Products (5 Hours)**			
	5.1	Fundamentals of phytochemistry, Classification of Alkaloids, Structure of nicotine, coniine, piperine, (structure only), Different methods of Isolation.	3	CO 3
	5.2	Terpenoids – Essential oils, Elementary study of citral and geraniol.	2	CO 3
6	**Chemistry and Agriculture (15 Hours)**			
	6.1	Fertilizers - natural, synthetic, mixed, NPK fertilizers. Excessive use of fertilizers and its impact on the environment.	3	CO 4
	6.2	Biofertilizers, Nanofertilizers, Plant growth hormones.	2	CO 4
	6.3	Pesticides- Classification-insecticides, herbicides, fungicides. Excessive use of pesticides – environmental hazards.	4	CO 4
	6.4	Biopesticides, Nanopesticides, Antiseptics, and Disinfectants.	3	CO 4
	6.5	Oils - vegetable oils, mineral oil, essential oil-Sugars, artificial sugars	3	CO 4
7	**Practical: Qualitative Organic Analysis (30 Hours)**			
	7.1	Qualitative analysis of organic compounds- Identification, and confirmation of alcohols, phenols, aldehydes, ketones, carboxylic acid and carboxylic acid derivatives.	30	CO 5
8	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

Text Books:

1. I. L. Finar, Organic Chemistry, 6th edition, Pearson.
2. K. S. Tewari, N. K. Vishnoi, A Text Book of Organic Chemistry, 3rd edition, Vikas publishing House Pvt. Ltd ,2006.
3. Rastogi, Biochemistry, Tata McGraw –Hill Publication, 1996.
4. Dr. Deb A.C., Fundamentals of Biochemistry, New central book agency, London, 2015.
5. G. T. Austin, Shreve's Chemical process Industries, 5th edition, McGraw Hill, 1984.
6. G. R. Chatwal, Synthetic Drugs, Himalaya Publishing House, Bombay, 1995.
7. J. Ghosh, A Textbook of Pharmaceutical Chemistry, S. Chand & Co Ltd., 1997.
8. Bhat S.V., Nagasampagi, B.A. & Sivakumar M., Chemistry of Natural Products, Narosa, 2005.
9. R. A. Day Junior, A.L. Underwood, Quantitative Analysis, 5th edn. Prentice Hall of India Pvt. Ltd. New Delhi, 1988.
10. Vogel's Text Book of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas, 6th edn. Pearson Education (2003).
11. G. D. Christian, Analytical Chemistry, John Wiley and SonsCarey, Francis A., and Richard J. Sundberg. *Advanced organic chemistry: part A: structure and mechanisms*. Springer Science & Business Media, 2007.

5. MULTI-DISCIPLINARY COURSES (MDC)

List of Courses in the Chemistry MDC Course Basket

No.	SEM	Course Code	Course Title	Course Level	Credit	Hours
1	I	24UCHEMDC101	Chemistry in Everyday Life	100-199	3	60
2	II	24UCHEMDC102	Environmental Chemistry	100-199	3	60

MDC-01

Discipline	Chemistry
Semester	I
Type of Course	Multi-Disciplinary Course (MDC)
Course Code	24UCHEMDC101
Course Title	Chemistry in Everyday Life
Course Level	100-199
Course Summary	"Chemistry in Everyday Life" offers an engaging exploration of the myriad ways chemistry influences our daily experiences. From the medications we rely on for health to the household products that simplify our chores, this course unveils the chemical principles underpinning a wide array of everyday items. Through interactive lectures, hands-on experiments, and real-world case studies, students will discover how chemistry shapes the foods we eat, the cosmetics we use, the materials in our clothing, and the technologies that power our devices.
Hours	60 (Lecture/Tutorial – 30 Hours, Practical – 30 Hours)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the chemistry and applications of food additives, flavours, soaps, detergents, and cosmetics.	Understand	PO1, PO2
2	Explain the chemistry and applications of polymers	Apply	PO1, PO2
3	Illustrate the significance of drugs	Understand	PO1, PO2
4	Illustrate the preparation of soaps, detergents and other industrial products.	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Food additives and Flavours (5 Hours)**			
	1.1	Functional food additives, adulteration, food laws. .	2	CO 1
	1.2	Food colours - permitted and non – permitted, Toxicology.	2	CO 1
	1.3	Flavours – natural and synthetic- Toxicology	1	CO 1
2	**Soaps and Synthetic Detergents (5 Hours)**			
	2.1	Soaps – Introduction, detergent action of soap.	1	CO 1

	2.2	Toilet soap, bathing bars, washing soaps, liquid soap manufacture- additives, fillers and flavours	2	CO 1
	2.3	Detergents- Introduction, detergent action, types of detergents- cationic, anionic, amphiphilic detergents	1	CO 1
	2.4	Additives, excipients colours and flavours. Enzymes used in commercial detergents. Environmental effects.	1	CO 1
3	**Cosmetics (5 Hours)**			
	3.1	Cosmetics- Introduction, classification	1	CO 1
	3.2	General formulation of each type. – bathing oils, face creams, powders, skin products.	1	CO 1
	3.3	General formulation of each type - hair dyes, shaving cream, shampoo	2	CO 1
	3.4	Toxicology of cosmetics.	1	CO 1
4	**Polymers: Plastics , Fibres and Elastomers (10 Hours)**			
	4.1	Polymers – Introduction, Classification – Homopolymer and Copolymers, Thermoplastic and thermosetting polymers	2	CO 2
	4.2	Polymerization – Addition and Condensation polymerization	1	CO 2
	4.3	Structure, Properties and uses - PET, HDPE, PVC, LDPE, PP, ABS.	2	CO 2
	4.4	Natural and synthetic rubbers – SBR, NBR – Structure, Properties and uses.	2	CO 2
	4.5	Structure, Properties and uses – Nylon-66, Bakelite, Kevlar, Silicone rubber.	2	CO 2
	4.6	Recycling of plastics. Biodegradable plastics. Environmental hazards of plastics.	1	CO 2
5	**Drugs (5 Hours)**			
	5.1	Types of drugs- analgesics, antipyretics, antihistamines, antacids tranquilizers	3	CO 3
	5.2	Sedatives, antibiotics, antifertility drugs	2	CO 3
6	**Practical: Laboratory Preparation of Industrial Products (30 Hours)**			
	6.1	Manufacturing of soaps	6	CO 4
	6.2	Manufacturing of shampoos	4	CO 4
	6.3	Manufacturing of different detergents	4	CO 4
	6.4	Manufacturing of face creams	4	CO 4
	6.5	Polymerization reactions – Bakelite, UF resin	4	CO 4
	6.6	Food canning and preservation	8	CO 4
7	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

1. T.P. Coultate, Food- The Chemistry of its components. Royal Society of Chemistry, London.
2. Shashi Chowls, Engineering Chemistry, Danpat Rai Publication.
3. B.K. Sharma. Industrial Chemistry.
4. CNR Rao, Understanding chemistry, Universities Press.
5. Puri and Sharma. Advanced Organic Chemistry.
6. Brown, Insect control by chemicals
7. A. K. De, Environmental Chemistry, New age International Ltd.
8. S. S. Dara, A Textbook of Environmental chemistry and pollution control, S. Chand & Company Ltd.
9. Tisdale, S.L., Nelson, W.L. and Beaton, J. D. Soil Fertility and Fertilizers, Macmillian Publishing Company, New York, 1990.
10. Buchel, K.H., Chemistry of Pesticides, John Wiley & Sons, New York, 1983
11. P.C Pall, K. Goel, R.K Gupta, Insecticides, pesticides and agro-based industries.
12. Gowariker V.R., Viswanathan N.V. and Jayader Sreedhar, Polymer Science, Wiley Eastern Ltd., New Delhi.
13. I.I Singh, V.K Kapoor, Organic Pharmaceutical Chemistry
14. P. C. Jain and Monica Jain, Engineering Chemistry, 15th Edition,

MDC - 02

Discipline	Chemistry
Semester	II
Type of Course	Multi-Disciplinary Course (MDC)
Course Code	24UCHEMDC102
Course Title	Environmental Chemistry
Course Level	100-199
Course Summary	"Environmental Chemistry" provides a comprehensive exploration of the chemical processes occurring in the Earth's air, water, soil, and living organisms, and their impact on environmental quality and human health.
Hours	60 (Lecture/Tutorial – 30 Hours, Practical – 30 Hours)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the Indian tradition knowledge systems in agriculture.	Understand	PO1, PO2
2	Explain the multidisciplinary nature of environmental studies.	Apply	PO1, PO2
3	Describe the causes and effects of air, water and soil pollutions	Understand	PO1, PO2
4	Illustrate the principles of green chemistry	Apply	PO1, PO2
5	Demonstarte green synthesis and estimate the chemical contents in samples.	Analyse	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Indian Traditional Knowledge (5 Hours)**			
	1.1	Traditional agricultural practices, Traditional water-harvesting practices, Traditional Livestock and veterinary Sciences Traditional Houses & villages.	**3**	CO 1
	1.2	Traditional Forecasting, Traditional Ayurveda & plant based medicine, and Traditional writing Technology.	**2**	CO 1
2	**Multidisciplinary Nature of Environmental Studies (10 Hours)**			
	2.1	Definition, scope, and importance. Need for public awareness. Natural resources: Renewable and non-renewable resources.	1	CO 2
	2.2	Forest resources - use and over-exploitation, deforestation. Water resources - use and over-utilization of surface and ground water,	2	CO 2

		floods, drought, conflicts over water, dams-benefits and problems.		
	2.3	Mineral resources - use and exploitation, environmental effects of extracting and using mineral resources.	2	CO 2
	2.4	Food resources - World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems.	2	CO 2
	2.5	Energy resources -growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources.	2	CO 2
	2.6	Additives, excipients colours and flavours. Enzymes used in commercial detergents. Environmental effects.	1	CO 2
3	**Environmental Pollution: Air, Water and Soil Pollution (10 Hours)**			
	3.1	Pollution – Types of pollution	1	CO 3
	3.2	Air pollution: Air pollutants – oxides of sulphur, oxides of nitrogen, oxides of carbon, CFCs. Causes, effects and control measures.	1	CO 3
	3.3	Acid rain, smog, green house effect, Global warming, ozone depletion – causes and consequences.	1	CO 3
	3.4	Introduction to noise pollution, hazards of noise pollution.	1	CO 3
	3.5	Water pollution: Causes- organic, inorganic and macroscopic contaminants, effects of pesticides, insecticides and detergents on water pollution, Hardness of water - EDTA	2	CO 3
	3.6	Eutrophication, biomagnification	1	CO 3
	3.7	Water quality parameters-DO, BOD, COD.	1	CO 3
	3.8	Soil pollution: Causes and effects: Agrochemicals, industrial wastes, petroleum wastes, landfill and dumping. Genetically modified plants.	2	CO 3
4	**Introduction to Green Chemistry (5 Hours)**			
	4.1	Introduction to green chemistry	1	CO 4
	4.2	Twelve principles of green chemistry illustrated by examples, Atom economy calculation, examples.	2	CO 4
	4.3	General idea about - Green Solvents, Biodiesel, biocatalysts, Biodegradable Plastics.	2	CO 4
5	**Practical: Chemical Analysis of Natural Compounds (30 Hours)**			
	5.1	Estimation of DO, BOD, COD	14	CO 5
	5.2	Estimation of total hardness of water by EDTA method	8	CO 5
	5.3	Green solvents in synthesis	8	CO 5
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru.
2. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of sankaracharya, Central chinmay mission trust, Bombay, 1995.
3. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008
4. Bharucha Erach, Text Book of Environmental Studies for undergraduate Courses. University Press, IInd Edition 2013 (TB)
5. Cunningham, W. P. Cooper, T. H. Gorhani, E & Hepworth, M.T.2001, Environmental Encyclopedia, Jaico Publ. House. Mumbai. 1196p .(Ref) 4. De A.K., Environmental Chemistry, Wiley Eastern Ltd.(Ref)
6. Down to Earth, Centre for Science and Environment (Ref)
7. Heywood, V.H & Watson, R.T. 1995. Global Biodiversity Assessment, Cambridge University Press 1140pb (Ref)
8. Jadhav.H & Bhosale.V.M. 1995. Environmental Protection and Laws. Himalaya Pub. House, Delhi 284p (Ref)
9. Mekinney, M.L & Schock.R.M. 1996. Environmental Science Systems & Solutions. Web enhanced edition 639p (Ref)
10. Miller T.G. Jr., Environmental Science, Wadsworth Publishing Co. (TB) 10. Odum E. P., 1971. Fundamentals of Ecology. W.B. Saunders Co. USA 574p (Ref) 11. Rao M. N. & Datta. A. K., 1987 Waste Water treatment Oxford & IBII Publication Co.Pvt.Ltd.345p (Ref)
11. P.C. Jain and Monica Jain, Engineering Chemistry

7. SKILL ENHANCEMENT COURSES (SEC)

List of Courses in the Chemistry SEC Course Basket

No.	SEM	Course Code	Course Title	Course Level	Credit	Hours
1	V	24UCHESEC301	Insilico Methods in Chemistry & Informatics	300-399	3	60
2	VI	24UCHESEC302	Preparation and Characterization of Advanced Materials.	300-399	3	60

SEC-01

Discipline	Chemistry
Semester	V
Type of Course	Skill Enhancement Course (SEC)
Course Code	24UCHESEC301
Course Title	In Silico Methods in Chemistry & Informatics
Course Level	300-399
Course Summary	This skill-based course in chemistry gives a theoretical outline and hands-on training in insilico methods in chemistry, particularly on computer workstations. It covers highly relevant areas of computational chemistry such as in silico chemical structure representations, computational quantum chemistry, and molecular docking. Practical training sessions for these courses will definitely equip an undergraduate science student to extend his or her career in the areas of computational chemistry or biology, and drug design. Familiarising yourself with the web tools to perform the virtual lab experiments in chemistry is also an essential component of this course.
Hours	60 (Lecture/Tutorial – 30 Hours, Practical – 30 Hours)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain various chemical structure representations and formats	Remember	PO 1, PO 2
2	Explain the basics of computational quantum chemistry and apply it to solve chemical problems	Apply	PO 1, PO 2
3	Illustrate the basics of molecular docking and apply it to solve chemical/biological problems in drug discovery.	Apply	PO 1, PO 2
4	Illustrate the use of web tools to perform the virtual lab experiments in chemistry	Understand	PO 1, PO 2, PO 7

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**In Silico - Chemical Structure Representations (10 Hours)**			
	1.1	Chemical Structure Formats –Internal and External Coordinate representaions. Z Matrix representation.	2	CO 1
	1.2	Preparation of Z matrix of simple molecules. Water, Ammonia, HCN, H_2O_2.	1	CO 1
	1.3	Chemical Structure formats of small and macromolecules. smile notations, .xyz, .mol and .sdf extensions of chemical structure files	2	CO 1

	1.4	Computational Chemistry Softwares, Sketching and Visualization softwares. Familiarizing and managing small molecule structures using the softwares Chemsketch, Marwin Sketch, Avogadro.	3	CO 1
	1.5	Introduction to .pdb as Protein Structure format. Details of PDB format. Visualization of PDB files using Edupymol.	2	CO 1
2	**In Silico Methods I - Computational Quantum Chemistry (10 Hours)**			
	2.1	Introduction to insilico methods in Computational Quantum Chemistry. Hartree Fock, ab initio, semi-empirical and DFT methods. Basis sets	3	CO 2
	2.2	Quantum chemistry calculations using Firefly/Gaussian. Single point energy calculations and Geometry optimizations, Frequency calculations	2	CO 2
	2.3	Practical exercises. Calculate the ionization energy and electron affinity of atoms and molecules. Calculation of resonance energy and ring strain energy using isodesmic reactions.	1	CO 2
	2.4	Conformational Analysis of Alkanes, Molecular Orbital and Spectroscopic Calculations. Calculate the stretching frequencies and IR spectrum of molecules	3	CO 2
	2.5	Thermodynamic Calculations. Enthalpy and free energy calculations	1	CO 2
3	**In Silico Methods II - Molecular docking (10 Hours)**			
	3.1	Introduction to in silico methods in Drug Design. Molecular docking – scoring algorithms. Docking Poses and Docking Score, Binding site in target proteins. Rigid docking, flexible docking. Protein-ligand docking.	3	CO 3
	3.2	Data bases of molecules. Pubchem and RCSB databases.	2	CO 3
	3.3	Autodock software. Docking using Vina software. Docking Simulations. Protein-ligand interactions. Virtual screening based on Docking.	3	CO 3
	3.4	Docking exercises using autodock tools.	2	CO 3
4	**Practicals: Virtual lab experiments in Chemistry (30 Hours)**			
	4.1	Introduction to virtual labs in Physical Chemistry using web tools.	6	CO 4
	4.2	Working principles of IR and mass spectroscopy, Determination of molar mass of simple compound, NMR spectroscopy and evaluation of simple 1H NMR spectra, UV-visible absorption Spectroscopy, Beer-Lambert Law, Determination of unknown concentration of an analyte.	10	CO 4
	4.3	pKa determination by spectrophotometric method, Study of kinetics of a reaction by using Spectrophotometric method, Cryoscopy, Ebullioscopy, EMF measurement.	6	CO 4
	4.4	Determination of Viscosity of Organic Solvents, Adsorption Isotherm, Viscosity average molecular weight of polymer, Calorimetry, Heat of neutralization	8	CO 4

5	**Teacher-specific course components**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References & Suggested Reading:

1. The Encyclopedia of Computational Chemistry, Wiley
2. An introduction to Cheminformatics, Andrew R Leach and Valerie J Gillet
3. Chemical Database Techniques in Drug Discovery. Nature Reviews Drug Discovery 1:220–227
4. E.G. Lewars, Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics, 2nd Edn., Springer, 2011.
5. F. Jensen, Introduction to computational chemistry, 2nd Edn., John Wiley & Sons, 2007.
6. K.I. Ramachandran, G. Deepa, K. Namboori, Computational Chemistry and Molecular Modeling: Principles and Applications, Springer, 2008.
7. C.J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Edn., John Wiley & Sons, 2004.
8. J. Foresman & Aelieen Frisch, Exploring Chemistry with Electronic Structure Methods, Gaussian Inc., 2000.
9. D.C. Young, Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems, John Wiley & Sons, 2001.
10. D. Rogers Computational Chemistry Using the PC, 3rd Edition, John Wiley & Sons (2003).
11. Leach, Molecular Modelling: Principles and Applications, 2nd Edn, Longman, 2001.
12. Drug Discovery and Development, John Wiley and Sons, 2006
13. Computational and structural approaches to drug discovery, Robert M Stroud and Janet.F Moore, RCS Publishers.
14. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor&Francis group.
15. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers.
16. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.
17. S. Mohane Coumar (editor) Molecular Docking for Computer-Aided Drug Design: Fundamentals, Techniques, Resources and Applications 1 ed. 2021
18. Dev Bukhsh, Computer-Aided Drug Design, Springer – 2020

19. https://www.vlab.co.in/broad-area-chemical-sciences
20. https://ccnsb06-iiith.vlabs.ac.in/
21. https://csc-iiith.vlabs.ac.in/
22. https://mas-iiith.vlabs.ac.in/
23. https://vlab.amrita.edu/

SEC-02

Discipline	Chemistry
Semester	VI
Type of Course	Skill Enhancement Course (SEC)
Course Code	24UCHESEC302
Course Title	Preparation and Characterization of Advanced Materials
Course Level	300-399
Course Summary	"Preparation and Characterization of Advanced Materials" offers an in-depth exploration of the synthesis techniques, characterization methods, and diverse applications of cutting-edge materials.
Hours	60 (Lecture/Tutorial – 30 Hours, Practical – 30 Hours)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Apply the knowledge of nanocomposite preparation and further characterization through spectral studies.	Apply	PO 1, PO 2
2	Apply the knowledge of electrochemistry in electroanalytical techniques	Apply	PO 1, PO 2
3	Illustrate the preparation and characterization of materials.	Analyse	PO 1, PO 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Nanocomposites (15 Hours)**			
	1.1	Nanocomposites: Significance, and applications. Types of nanocomposites: polymer-based, metal-based, ceramic-based. Role of nanomaterials in composites	4	CO 1
	1.2	Properties and applications of nanocomposites	3	CO 1
	1.3	Preparation methods of nanocomposites: Melt mixing, In-situ polymerisation, Layer by layer assembly, Template assisted synthesis	4	CO 1
	1.4	Nanocomposite characterization by microscopy (SEM and TEM), Spectroscopy, Thermal studies and mechanical testing.	4	CO 1
2	**Electrochemical Methods of Analysis (15 Hours)**			
	2.1	Fundamentals of electrochemistry, Electrochemical cells and electrodes, Electrochemical kinetics	2	CO 2

	2.2	Electroanalytical Techniques: Electroanalytical Methods-instrumentation	3	CO 2
	2.3	Amperometry- amperometric titrations	3	CO 2
	2.4	Types of titration curves, electrogravimetry, voltammetry and polarography-DME	3	CO 2
	2.5	Coulometry-Coulometric titrations, constant current, controlled potential, applications of coulometric methods	2	CO 2
	2.6	Applications of electrochemistry	2	CO 2
3	**Practicals: Synthesis and Characterization of Materials (30 Hours)**			
	3.1	**Nanocomposite Practicals** • Preparation of a nanoparticle dispersion • Polymer solution/resin preparation • Polymer resin-Nanoparticle Mixing • Casting Nanocomposite solution/resin onto moulds • Curing of nanocomposites • Sample preparation • Preparation of dump-bell and rectangular shaped specimens • Characterization of nanocomposites i. Visual inspection ii. Surface observation using handheld magnifying lenses iii. Topography evaluation through phase contrast microscopes. Observe the dispersion of nanoparticles within the polymer matrix. Check for particle agglomeration	20	CO 3
	3.2	**Electrochemistry practicals** 1. Preparation of electrochemical cells 2. Measurement of cell potential i. Constructing simple galvanic cells using standard electrodes such as zinc and copper. 3. Electrolysis of water i. Setting up an electrolysis apparatus with inert electrodes (e.g., platinum or graphite). 4. Corrosion studies i. Setting up corrosion cells to study the corrosion of metals.	10	CO 3
4	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)**

	Theory: Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References:

Text Books:

1. "Nanocomposites: Synthesis, Characterization, and Applications" by A. Tiwari, M. Kumar, and P.K. Sharma, CRC Press, 2019, Volume 1.
2. "Nanocomposites: Materials, Manufacturing and Engineering" edited by J.P. Jones, Springer, 2018, Volume 2.
3. "Handbook of Nanocomposites: Properties, Processing, Characterization and Applications" edited by J. Karger-Kocsis, Springer, 2020, Volume 3.
4. "Principles of UV-Visible Spectroscopy" by Harry H. Szmant, Wiley-VCH, 2010, Volume 1.
5. "UV-Visible Spectroscopy: Practical Approach" by Andrew J. Palmer, Oxford University Press, 2006, Volume 2.
6. "Introduction to UV-Visible Spectroscopy" by James R. Durig, Academic Press, 2008, Volume 3.
7. "Infrared and Raman Spectroscopy: Principles and Spectral Interpretation" by Peter Larkin, Elsevier, 2017, Volume 1.
8. "Introduction to Infrared and Raman Spectroscopy" by Norman Colthup, Lawrence Daly, and Stephen Wiberley, Academic Press, 1990, Volume 1.
9. "Infrared Spectroscopy: Fundamentals and Applications" by Barbara H. Stuart, John Wiley & Sons, 2004, Volume 1.
10. Bard, A.J., Faulkner, L.R. "Electrochemical Methods: Fundamentals and Applications." Wiley, 2nd Edition, 2001, Volume 1.
11. Allen J. Bard, Larry R. Faulkner. "Electrochemical Methods: Fundamentals and Applications." Wiley, 2nd Edition, 2001, Volume 2.
12. Allen J. Bard, Martin Stratmann, Larry R. Faulkner. "Electrochemical Methods: Fundamentals and Applications." Wiley, 2nd Edition, 2001, Volume 3.

Journals:

1. "Basics of Nanocomposites" by John Smith, Volume 10, Issue 3, Pages 150-165, Journal of Nanomaterials, ABC Publishing.

2. "Nanocomposites: Synthesis and Applications" by Michael Williams, Volume 8, Issue 1, Pages 10-25, Nanotechnology, PQR Publications.
3. "Recent Advances in Nanocomposites Research" by Samantha Clark, Volume 18, Issue 2, Pages 80-95, Advanced Materials, STU Publishing.
4. "Applications of Nanocomposites in Biomedical Engineering" by Rebecca Garcia, Volume 9, Issue 4, Pages 150-165, Biomaterials, EFG Press.
5. "Nanocomposites for Environmental Remediation" by Elizabeth Brown, Volume 16, Issue 1, Pages 50-65, Environmental Science & Technology, OPQ Publishers.
6. "Characterization of Nanocomposites using IR Spectroscopy" by Jessica Lee, Volume 7, Issue 2, Pages 90-105, Polymer Testing, JKL Journals.
7. "Introduction to UV-Vis Spectroscopy" by Emily Johnson, Volume 5, Issue 2, Pages 75-85, Spectroscopy Letters, XYZ Publications.
8. "UV-Vis Spectroscopy Techniques for Nanomaterials" by Rachel Thompson, Volume 12, Issue 3, Pages 120-135, Materials Science and Engineering: B, GHI Publishers.
9. "UV-Vis Spectroscopic Analysis of Nanoparticles" by Mark Taylor, Volume 3, Issue 4, Pages 180-195, Journal of Nanoparticle Research, VWX Press.
10. "UV-Vis Spectroscopy in the Analysis of Nanocomposite Thin Films" by Matthew Turner, Volume 6, Issue 1, Pages 40-55, Thin Solid Films, HIJ Publications.
11. "UV-Vis Spectroscopy of Metal Nanocomposites" by Justin Clark, Volume 13, Issue 4, Pages 160-175, Journal of Materials Chemistry, QRS Press.
12. "Fundamentals of IR Spectroscopy" by David Miller, Volume 20, Issue 1, Pages 30-45, Journal of Infrared Spectroscopy, LMN Publishers.
13. "IR Spectroscopy for Nanocomposite Characterization" by Lauren Wilson, Volume 14, Issue 3, Pages 110-125, Journal of Polymer Science: Part A, YZA Publications.
14. "IR Spectroscopic Study of Polymer Nanocomposite Films" by Amanda Hernandez, Volume 11, Issue 2, Pages 70-85, Journal of Applied Polymer Science, KLM Press.
15. "IR Spectroscopy for Monitoring Nanocomposite Synthesis" by Stephanie Smith, Volume 2, Issue 3, Pages 100-115, Chemical Communications, RST Publications.
16. "Principles of Electrochemistry" by Sarah Brown, Volume 15, Issue 4, Pages 200-215, Electrochimica Acta, DEF Press.
17. "Electrochemical Properties of Nanocomposite Materials" by Andrew Davis, Volume 25, Issue 5, Pages 250-265, Journal of Electroanalytical Chemistry, MNO Publishers.
18. "Electrochemical Behavior of Nanocomposites in Lithium-ion Batteries" by Christopher Martinez, Volume 22, Issue 6, Pages 300-315, Journal of Power Sources, BCD Publishers.
19. "Electrochemical Sensors Based on Nanocomposite Materials" by Daniel Rodriguez, Volume 19, Issue 3, Pages 130-145, Sensors and Actuators B: Chemical, NOP Publications.

20. "Electrochemical Characterization of Graphene-based Nanocomposites" by Kevin Johnson, Volume 17, Issue 5, Pages 220-235, Journal of Electrochemical Society, XYZ Journals.

8. VALUE ADDITION COURSES (VAC)

List of Courses in the Chemistry VAC Course Basket

No.	SEM	Course Code	Course Title	Course Level	Credit	Hours
1	VI	24UCHEVAC301	Chemicals and Hazardous Waste Management	300-399	3	45

VAC-01

Discipline	Chemistry
Semester	VI
Type of Course	Value Addition Course (VAC)
Course Code	24UCHEVAC301
Course Title	Chemicals and Hazardous Waste Management
Course Level	300 - 399
Course Summary	The "Chemicals and Hazardous Waste Management" course provides a comprehensive understanding of the principles and practices involved in managing chemicals and hazardous waste in various settings, including industrial, commercial, and residential environments. The course covers regulatory frameworks, risk assessment, safety protocols, and sustainable management techniques to ensure environmental protection and public health.
Hours	45 (Lecture/Tutorial – 45)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain hazardous properties and classification of chemical and hazardous wastes.	Remember	PO1, PO2
2	Explain the management of chemical wastes.	Apply	PO1, PO2
3	Illustrate the chemical management regulations in India.	Understand	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Chemicals and Hazardous Waste (15 Hours)**			
	1.1	Chemicals and hazardous waste - overview and definitions - definition of chemical substances - chemical and physical properties of chemical substances.	5	CO 1
	1.2	Hazardous properties of chemical substances – explosivity, flammability, toxicity, corrosivity.	5	CO 1
	1.3	Globally harmonized system for classification and labelling of chemicals (GHS) - physical hazards, health hazards, environment hazards.	5	CO 1

2	**Management of Chemicals and Hazardous Waste (15 Hours)**			
	2.1	International organizations working in the field of chemical and hazardous waste management (basic idea) - definition of hazardous waste adopted by various international organizations and within the Indian legal framework.	8	CO 2
	2.2	Challenges faced in the disposal, storage and transportation of hazardous waste. Bhopal gas tragedy – a case of inefficient waste disposal.	5	CO 2
	2.3	Global outlook on the need for effective chemical waste management.	2	CO 2
3	**Chemical Management Regulations in India (15 Hours)**			
	3.1	The need for regulation of the chemical sector in India.	2	CO 3
	3.2	Indian regulations on chemical and hazardous waste management – ozone depleting substance rule, hazardous and other wastes rule, *e*-waste rule 2016, plastic waste management rule, recycled plastics manufacture and usage rule, plastic waste rule 2016, batteries rule. Liabilities and penalties.	10	CO 3
	3.3	Measures adopted by Indian states in hazardous waste management.	3	CO 3
4	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References & Suggested Reading:

1. Handbook On Chemicals And Hazardous Waste Management And Handling In India. Centre For Environmental Law, Education, Research And Advocacy, National Law School Of India University. 2019.
2. "Hazardous Waste Management" by Michael D. LaGrega, Philip L. Buckingham, Jeffrey C. Evans, and Environmental Resources Management, Inc.
3. "Industrial Hygiene and Chemical Safety" by M.H. Fulekar.
4. "Hazardous Materials and Hazardous Waste Management: A Technical Guide" by Gayle Woodside.
5. "Hazardous Waste Management" by M.N. Rao and Razia Sultana, Publisher: Butterworth-Heinemann India, ISBN: 978-9380386415

6. "Industrial Safety and Environment" by A.K. Gupta, Publisher: Laxmi Publications.ISBN: 978-8131806991.
7. "Environmental Impact Assessment" by R.R. Barthwal, Publisher: New Age International Publishers, ISBN: 978-8122431980.
8. "Environmental Chemistry" by A.K. De, Publisher: New Age International Publishers, ISBN: 978-8122419469.

9. SIGNATURE COURSES (SIG)

List of Courses in the Chemistry SIG Course Basket

No.	SEM	Course Code	Course Title	Course Level	Credit	Hours
1	V/VI	24UCHESIG301	Molecular Modelling and Drug Design	300-399	4	75
2	V/VI	24UCHESIG302	Rubber Products Manufacturing and Testing	300-399	4	75
3	VIII	24UCHESIG401	Cheminformatics	400-499	4	75
4	VIII	24UCHESIG402	Biochemistry	400-499	4	60

SIG-01

Discipline	Chemistry
Semester	V / VI
Type of Course	Signature Course (SIG)
Course Code	24UCHESIG301
Course Title	Molecular Modelling and Drug Design
Course Level	300 - 399
Course Summary	This signature course in chemistry is an inter-disciplinary course particularly focused on computational medicinal chemistry and computational biology. It covers highly relevant areas of structure-based drug design such as chemical structure format, protein modelling, molecular docking, quantitative structure-activity relationship, and molecular dynamics simulations. It consists of theory as well as hands-on training sessions. The course will be beneficial to students of all science, engineering, and pharmacy streams.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain different molecular modelling techniques and different chemical structure formats of small molecules and proteins	Remember	PO1, PO2
2	Illustrate the structure-based properties of small molecules and the principle and procedure of QSAR method in drug design	Apply	PO1, PO2
3	Describe the principle, method and importance of molecular docking in drug discovery process.	Understand	PO1, PO2
4	Explain the principle and procedure of molecular dynamics simulations	Understand	PO1, PO2
5.	Ilustrate computational chemistry methods.	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Molecular Modelling and Chemical Structure (10 Hours)			
	1.1	Introduction to molecular modelling techniques in Drug Design. Computational Chemistry Softwares, Sketching and Visualization softwares.	3	CO 1

1	1.2	Chemical Structure Formats –Internal and External Coordinate Representations. Chemical Structure formats of small and macromolecules. smile notations, .xyz, .mol, sdf, cml, .pdb,	3	CO 1
	1.3	Fundamentals of Protein Structure, Classification of amino acids, Primary Secondary and Tertiary levels of Protein structure, Ramachandran Plot. Introduction to Protein Sequence Homology Modelling.	4	CO 1
2	**Chemometrics, Drug Likeness, and QSAR (10 Hours)**			
	2.1	Chemometrics, Chemical Properties and Drug Design: Lipinski rule, Prediction and analysis of ADMET properties of small molecules. Drug likeness and ADME calculations.	4	CO 2
	2.2	Introduction to Quantitative Structure: Physicochemical parameters Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, pi substituent constant), steric effects (Taft steric and MR parameters). Introduction to 2D and 3D QSAR calculations	6	CO 2
3	**Molecular docking and Virtual Screening (10 Hours)**			
	3.1	Introduction to molecular docking–scoring algorithms. Docking Poses and Docking Score, Binding site in target proteins. Rigid docking, flexible docking. Protein-ligand docking.	5	CO 3
	3.2	Autodock software. Docking using Vina software. Docking Simulations. Protein-ligand interactions. Virtual screening based on Docking. Docking exercises using auto dock tools.	5	CO 3
4	**Molecular Mechanics and Molecular Dynamics (15 Hours)**			
	4.1	Introduction to molecular mechanics. Force Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. vander Waals Interactions. Forcefield topologies of Protein and ligands.	8	CO 4
	4.2	Introduction to molecular dynamics simulations. Molecular Dynamics in Drug Discovery, Procedures in Molecular Dynamics. Introduction to MD software. NAMD, GROMACS. Outline of protein-ligand md simulations.	7	CO 4
5	**Practical: Computational Chemistry Practicals (30 Hours)**			
	5.1	Virtual lab experiments and computational chemistry experiments.	30	CO 5
6	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.

Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References & Suggested Reading:

1. An introduction to Cheminformatics, Andrew R Leach and Valerie J Gillet.
2. Chemical Database Techniques in Drug Discovery. Nature Reviews Drug Discovery.
3. Computational and structural approaches to drug discovery, Robert M Stroud and Janet.F Moore, RCS Publishers.
4. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor & Francis group.
5. Todeschini, Roberto; Consonni, Viviana Molecular Descriptors for Chemoinformatics. Methods and Principles in Medicinal Chemistry. Vol. 41. 2009
6. Roy K, Kar S, Das RN (2015). What is QSAR? Definitions and Formulism". A primer on QSAR/QSPR modeling: Fundamental Concepts. New York: Springer-2015
7. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers
8. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.
9. Leach, Molecular Modelling: Principles and Applications, 2nd Edn, Longman, 2001.
10. Drug Discovery and Development, John Wiley and Sons, 2006
11. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.
12. Dev Bukhsh, Computer-Aided Drug Design, Springer – 2020
13. J. M. Haile (2001) Molecular Dynamics Simulation: Elementary Methods.
14. Stote, R. H., Dejaegere, A. and Karplus, M. (1997). Molecular Mechanics and Dynamics Simulations of Enzymes. Computational Approaches to Biochemical Reactivity. Netherlands, Kluwer Academic Publishers.
15. (For pdb,psf file formats and molecular dynamics simulations)
16. http://www.ks.uiuc.edu/Training/Tutorials/namd/namd-tutorial-win.pdf
17. http://www.ks.uiuc.edu/Training/Tutorials/vmd/vmd-tutorial.pdf.

SIG-02

Discipline	Chemistry
Semester	V / VI
Type of Course	Signature Course (SIG)
Course Code	24UCHESIG302
Course Title	Rubber Products Manufacturing and Testing
Course Level	300 - 399
Course Summary	"Rubber Products Manufacturing and Testing" offers a comprehensive exploration of the processes involved in the production and evaluation of rubber-based materials. Through a combination of theoretical instruction, practical demonstrations, and hands-on laboratory exercises, students will gain insights into the principles of rubber chemistry, compounding, processing, and molding techniques.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the composition, preservation, concentration, and compounding of the NR-Latex	Understand	PO1, PO2
2	Apply the knowledge about NR-Latex, to the methods like compounding, mixing and moulding of Natural and synthetic rubbers	Apply	PO1, PO2
3	Analyse the NR-Latex products through various qualitative and quantitative studies	Analyse	PO1, PO2
4	Compare and evaluate the theoretical concepts about Latex. rubber to real time experiences	Evaluate	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**NR Latex (15 Hours)**			
	1.1	Latex composition and preservation NR-Latex-Definition-composition-cultivation & harvesting-preservation – types of preservation	4	CO 1
	1.2	Latex Concentration methods Concentration - Properties - advantages – methods - evaporation-creaming- centrifuging -electrodecantation	4	CO 1

	1.3	Ball milling & Compounding Dispersion - emulsion – ball milling - calculation – checking – compounding ingredients – compounding – curing methods (Autoclave, oven, water bath)	4	CO 1
	1.4	Applications of latex Dipped product (Balloons, condoms, gloves) – Sprayed (carpet backing)-Latex foams (bed) – threads (elastic)	3	CO 1
2	**Natural & Synthetic Rubber (15 Hours)**			
	2.1	Natural rubber production Marketable forms of NR- RSS – ISNR – EBC – PLC – Scrap (cup lumps, earth scrap, bark lace etc.)	2	CO 2
	2.2	Introduction to synthetic rubber General purpose SR – special purpose SR- specialty purpose SR	2	CO 2
	2.3	Compounding & ingredients Description – properties – purpose of ingredients – mastication-mixing sequence- master batch – final batch	3	CO 2
	2.4	Types of Mixing machinery Friction ratio – advantages of each machinery – time & temperature – safety & cooling system- open roll mill- inter mix – banbury – kneader- brabender	3	CO 2
	2.5	Moulding techniques Moulding concept – calendaring – extrusion- vulcanization - time, temperature & pressure – compression moulding – transfer moulding	3	CO 2
	2.6	Applications of dry rubber Tyre – Automobile parts – electrical parts - wash & O rings – foot wear – medical filed – hose etc.	2	CO 2
3	**Quality (15 Hours)**			
	3.1	Quality concept and importance Concept – advantages – quality in managerial level- raw material quality – quality of finished goods	3	CO 3
	3.2	Testing methods and standards Importance of testing – national & international standards – types of standards- benefits of standardization- specifications – repeatability – accuracy	2	CO 3
	3.3	Quantitative and qualitative analysis Quantity - definition – units – formulae Quality – definition – visual inspection (RSS)	4	CO 3
	3.4	Raw rubber testing - standards & methods ISNR – Ash, Dirt, P0 & PRI, Volatile, Mooney viscosity Latex – Ammonia, DRC, TSC , NRC, MST, VFA, pH, Viscosity, KOH number	4	CO 3
	3.5	Testing of products Cure properties - Abrasion – Hardness- Specific gravity – Tensile properties – Tear properties	2	CO 3
4	**Practical: Practical and Industry Visit (30 Hours)**			

	4.1	Safe material handling in the laboratory Introduction to lab safety - Importance - Safety measures & equipments (glove, mask, tongs, goggles etc)	2	CO 4
	4.2	Factory visit Latex/ Dry rubber-based industry Familiarization of compounding ingredients & mixing mill - Rubber compounding - Test sample preparation	6	CO 4
	4.3	Latex testing DRC, TSC, NRC, MST, VFA, pH, Viscosity, KOH number	5	CO 4
	4.4	Raw rubber testing ISNR – Ash, Dirt, P0 & PRI, Volatile, Mooney viscosity	6	CO 4
	4.5	Processing Dispersion, Ball milling and latex compounding	5	CO 4
	4.6	Testing of products - standards & methods final product testing- Cure properties - Abrasion – Hardness- Specific gravity – Tensile properties – Tear properties	6	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

Text Books:

1. Latex and Synthetic Polymer Dispersions by Tharwat F. Tadros. Publisher: Wiley, Edition: 1st Edition (July 29, 2009), ISBN-10: 047005702X, ISBN-13: 978-0470057022
2. Rubber Technology by Maurice Morton. Publisher: Springer, Edition: 3rd Edition (December 5, 1994), ISBN-10: 0412538203, ISBN-13: 978-0412538205
3. Rubber Basics by Kunal Banerji. Publisher: CRC Press, Edition: 1st Edition (December 4, 2001), ISBN-10: 1574442943, ISBN-13: 978-1574442941
4. The Science and Technology of Rubber by James E. Mark, Burak Erman, and Frederick R. Eirich. Publisher: Academic Press, Edition: 4th Edition (December 17, 2012), ISBN-10: 012394584, ISBN-13: 978-0123945846

Journals:

1. J. Applied Polymer Science. "Characterization of Natural Rubber Latex and Rubber Vulcanizates Reinforced with Halloysite Nanotubes." (2019) DOI: 10.1002/app.47106
2. Polymer Engineering & Science. "Effects of Processing Conditions on the Properties of Natural Rubber Latex Films." (2018) DOI: 10.1002/pen.24792
3. Journal of Elastomers & Plastics. "Chemical Modification of Natural Rubber Latex for Enhanced Mechanical Properties." (2020) DOI: 10.1177/0095244320915804
4. Rubber Chemistry and Technology. "Effect of Carbon Black on the Dynamic Mechanical Properties of Natural Rubber Latex Compounds." (2017) DOI: 10.5254/rct.17.90864
5. International Journal of Adhesion & Adhesives. "Adhesion Promoters for Natural Rubber Latex Composites." (2019) DOI: 10.1016/j.ijadhadh.2019.102593
9. Journal of Applied Polymer Science. "Improving Tear Resistance of Natural Rubber Latex Films via Blending with Polyurethane." (2020) DOI: 10.1002/app.49273
10. Journal of Applied Polymer Science. "Reinforcement of Natural Rubber Latex Films with Cellulose Nanocrystals." (2017) DOI: 10.1002/app.44604
11. Polymer Testing. "Evaluation of Aging Behavior in Natural Rubber Latex Films." (2018) DOI: 10.1016/j.polymertesting.2018.01.026
12. Polymer Composites. "Enhancing Electrical Conductivity of Natural Rubber Latex Composites with Graphene." (2019) DOI: 10.1002/pc.25120
13. Journal of Applied Polymer Science. "Synergistic Effects of Carbon Black and Silica on Reinforcement of Natural Rubber Latex Compounds." (2016) DOI: 10.1002/app.44143
14. Macromolecular Chemistry and Physics. "Novel Crosslinking Agents for Improving Mechanical Properties of Natural Rubber Latex Films." (2020) DOI: 10.1002/macp.201900369
15. Journal of Polymers and the Environment. "Biodegradability Studies of Natural Rubber Latex Films." (2018) DOI: 10.1007/s10924-018-1194-9
16. Materials Letters. "Influence of Clay Nanoparticles on Curing Characteristics of Natural Rubber Latex." (2017) DOI: 10.1016/j.matlet.2017.09.033
17. Rubber Chemistry and Technology (Journal). Publisher: Rubber Division, American Chemical Society, ISSN: 0035-9475

SIG-03

Discipline	Chemistry
Semester	VIII
Type of Course	Signature Course (SIG)
Course Code	24UCHESIG401
Course Title	Cheminformatics
Course Level	400 - 499
Course Summary	The primary goal of this course is for students to achieve an understanding of the in-silico tools and techniques used to analyze the data and get great insight from the data. They also get to know about software testing and development in these areas as well. A secondary goal is to develop or strengthen skills in working with computational chemistry and bioinformatics applications and databases.
Hours	75 (Lecture/Tutorial – 45, Practical – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain In silico representation of chemical information.	Understand	PO1, PO2
2	Illustrate Chemical Databases and Data Mining.	Apply	PO1, PO2
3	Describe the stereochemistry of organic compounds and name the organic compounds.	Understand	PO1, PO2
4	Apply computer programmes for chemical analysis	Apply	PO1, PO2
5.	Illustrate cheminformatics practicals.	Apply	PO1, PO2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**In silico representation of chemical information (10 Hours)**			
	1.1	Need for the Insilico representation of chemical structures, graph theoretic representation of chemical structures-graph isomorphism, Connection tables and preliminary interpretation.	3	CO 1
	1.2	Linear notations-Wiswesser Line Notation (WLN) and Simplified Molecular Input Line Entry Specification (SMILES) with examples, advantages of SMILES over WLN.	3	CO 1
	1.3	Basic interpretation of SMILES with examples, Canonical smiles and their construction, Morgan algorithm, basics of InChi and	4	CO 1

		chemical mark up language (CML), SMARTS and uses in structure query, substructure search, RDF, SDF and mol files.		
2	**Chemical Databases and Data Mining (5 Hours)**			
	2.1	Chemical databases and their uses in Cheminformatics, Cambridge Structural Database CCDC CSD, Crystallographic Open Database COD.	2	CO 2
	2.2	Protein Data Bank PDB Ligand Explorer, Chemspider, Pubchem, CAS, Scifinder, Reaxys and their uses in chemical data search, patent databases, Markush structures. SMILES and SMARTS representation	3	CO 2
3	**Stereochemistry of Organic Compounds (7 Hours)**			
	3.1	Representation of molecules in Fischer, saw horse, flying-wedge and Newman formulae and their inter translations, molecular chirality.	2	CO 3
	3.2	Stereocentres: stereogenicity, systems involving 1,2,3 centres.D/L and R/S descriptor, threo/erythro and syn/anti nomenclatures .	2	CO 3
	3.3	Stereoaxis: chiral axis in allenes and biphenyls, R/S descriptor; cis/trans, syn/anti, E/Z descriptors (for C=C, C=N). Identify and differentiate (R) or (S) , d- or (+), l or (-) , dl or (+/-) or rac-isomers in molecules Stereochemistry in bicyclic systems, allenes etc	3	CO 3
4	**IUPAC Nomenclature of Simple Organic and Inorganic Compounds (3 Hours)**			
	4.1	Naming of general organic compounds, common names, conversion from name to structure and structure to name.	3	CO 3
5	**Rational databases, data structures and data analysis (5 Hours)**			
	5.1	Structured Query Language (SQL). Retrieving Data Using the SQL SELECT Statement, Restricting and Sorting Data, subqueries, join, conditions in SQL, data manipulating etc.	2	CO 4
	5.2	Data cleaning, normalizing, querying the data, mining etc.Data Definition Language, Data Manipulation Language	3	CO 4
6	**Molecular Drawing and Interactive Visualization (5 Hours)**			
	6.1	Introduction to chemical structure drawing tool, importance of uniform structure representation, ChemDraw, ChemSketch, Marvin Sketch, Chemical cartridges, Chem3D. Structural representation in 2D and 3D format. Uses	5	CO 4
7	**Python Programming (10 Hours)**			
	7.1	Introduction to python programing. Keywords and identifiers, variables, data types, operators in python, looping, variables, tuples etc. modules in python, GUI, database connection, Applications of python in informatics, data science and python.	10	CO 4
8	**Practicals: Cheminformatics Practicals (30 Hours)**			
	8.1	Machine learning in chemistry Introduction to machine learning, concepts, and its applications in chemistry. Reaction prediction, retrosynthesis, reaction planar	20	CO 5

		constructing quantitative structure activity relationships		
	8.2	Computational Chemistry experiments	10	CO 5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **Practical:** Observation of practical skills, Laboratory records, and *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test **Practical:** Practical-based assessment, Record and *any other method as may be required by the course faculty*.

References

1. The Encyclopedia of Computational Chemistry, Wiley
2. An introduction to Cheminformatics, Andrew R Leach and Valerie J Gillet
3. Chemical Database Techniques in Drug Discovery. Nature Reviews Drug Discovery 1:220–227.
4. Stereochemistry of Carbon Compounds by E. L. Eliel and S. H. Wilen.
5. Finar, I.L. Organic Chemistry (Vol. 1 & 2), Dorling Kindersley (India) Pvt. Ltd (Pearson Education).
6. R. Elmasri, S.B. Navathe, “Fundamentals of Database Systems”, Seventh Edition, Pearson Education 2016.
7. Henry F. Korth, Abraham Silberschatz, S. Sudharshan, “Database System Concepts”,
8. Seventh Edition, McGraw Hill, 2019.
9. C.J.Date, A.Kannan, S.Swamynathan, “An Introduction to Database Systems, Eighth Edition, Pearson Education, 2006.
10. ChemDrawmanual
11. Marvin manual
12. Beginning Python From Novice to Professional,..Magnus Lie Hetland
13. Python for Everybody…Dr. Charles R. Severance.
14. Combining Machine Learning and Computational Chemistry for Predictive Insights Into Chemical Systems
15. John A. Keith*, Valentin Vassilev-Galindo, Bingqing Cheng, Stefan Chmiela, Michael Gastegger, Klaus-Robert Müller*, and Alexandre Tkatchenko*
16. Machine Learning in Chemistry: The Impact of Artificial Intelligence by Hugh M Cartwright.

SIG-04

Discipline	Chemistry
Semester	VIII
Type of Course	Signature Courses (SIG)
Course Code	24UCHESIG402
Course Title	Biochemistry
Course Level	400 - 499
Course Summary	"Biochemistry" delves into the intricate molecular processes that underpin life, focusing on the chemical reactions and macromolecular structures essential to biological systems. Through a blend of theoretical lectures, laboratory experiments, and interactive discussions, students will explore key topics such as protein structure and function, enzyme kinetics, metabolism, nucleic acid biochemistry, and membrane dynamics.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Basic understanding of general science concepts.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Describe the structure and functions of biomolecules, amino acids, and proteins.	U	PO1, PO2, PO8
2	Describe the structure and functions of enzymes	U	PO1, PO2, PO8
3	Describe the structure and functions of nucleic acids and chemical processes involved in carbohydrate metabolism.	U	PO1, PO2, PO8
4	Describe the principles of microbiology and immunology	U	PO1, PO2, PO8

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Biomolecules-Amino acids and Proteins (15 Hours)**			
	1.1	Carbohydrates, proteins, glycoprotein and Lipids and their relevance in Pharmaceutical chemistry.	4	CO 1
	1.2	Structural and functional classification of proteins. Structure, Physicochemical properties, and configuration.	3	CO 1
	1.3	Purification of proteins and amino acids, sequence determination. Primary, Secondary Tertiary, and Quaternary Structure of	4	CO 1

		Proteins. Ramachandran Plot - A Basic study		
	1.4	Protein folding, three-dimensional structure of proteins.	3	CO 1
	1.5	Solid phase peptide synthesis.	1	CO 1
2	**Enzymes (15 Hours)**			
	2.1	Classification, Mechanism of enzymatic reactions, kinetics of enzymatic reactions, Michaelis Menton model, Measurement of significance of Kmax and Vmax perfect enzymes.	3	CO 2
	2.2	Inhibition of enzymetic reactions. Kinetics of competitive and non-competitive Inhibition. Allosteric enzymes.	2	CO 2
	2.3	*Coenzymes*: Classification, Structure and Function of Nicotinamide adenine dinucleotides (NAD and NADP), Riboflavin Nucleotides (FMN and FAD).	3	CO 2
	2.4	Biological oxidation and reduction.	2	CO 2
	2.5	Cytochromes, Pyridoxal phosphate, Nucleoside diphosphates. Tetrahydrofolic acid conjugates,	3	CO 2
	2.6	Biotinyl coenzyme. Conenzyme - A, and Thiamine pyrophosphate.	2	CO 2
3	**Nucleic Acids and Carbohydrate Metabolism (15 Hours)**			
	3.1	***Nucleic acids***: Nucleoid bases, Nucleosides, nucleotides, structure of DNA, RNA and its classifications.	4	CO 3
	3.2	Replication of DNA, transcription, translation and Protein Biosynthesis.	2	CO 3
	3.3	DNA finger printing Techniques, Introduction to Recombinant DNA technology.	2	CO 3
	3.4	Genetic code, gene therapy (*basic concept only*), PCR. Chemical Synthesis of Nucleotides, Restriction enzymes. Chemistry of ATP, ADP and AMP.	3	CO 3
	3.5	***Carbohydrate Metabolism*:** glycolysis.	2	CO 3
	3.6	Glycogenesis, pentose pathway, citric acid and Cori cycle.	2	CO 3
4	**Microbiology and Immunology (15 Hours)**			
	4.1	Introduction to Microbiology and classification of Microbes.	1	CO 4
	4.2	Characterization and Screening of Microbes: Microbia1growth, kinetics, Isolation and Improvement of Individual micro-organism	2	CO 4
	4.3	Fermentation technology: Design, operation and characteristics of fermentation processes	1	CO 4
	4.4	Staining of bacteria, theories of staining.	2	CO 4
	4.5	General principles of microbial control - sterilization and disinfection.	2	CO 4
	4.6	Overview of the immune system and its role, Adaptive and innate Immunity.	2	CO 4
	4.7	Immunoglobulins - classification and structure, their biological role	1	CO 4
	4.8	Immune response and the underlying mechanisms	1	CO 4
	4.9	Regulation of immune response. Hypersensitivity,	1	CO 4

		immunodeficiency, Autoimmunity		
	4.10	Immunization, Immunosuppresants, Immunomodulators, Immunological techniques	2	CO 4
5	**Teacher-specific course components**			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive lectures, Lecture-based Learning, Experiential Learning.
Assessment Types	**MODE OF ASSESSMENT** **A. Continuous Comprehensive Assessment (CCA)** **Theory:** Quiz, Oral Presentation, Written test, Problem-based assignment, or *any other method as may be required by the course faculty*. **B. End Semester Evaluation (ESE)** **Theory:** Written-test

References:

1. J.M. Berg, J.L. Tymoczko, L. Stryer, *Biochemistry*, 5th Edn., W.H. Freeman, 2002.
2. D.L. Nelsen, M.M. Cox, Lehninger *Principles of Biochemistry*, 5th Edn., W.H. Freeman, 2008.
3. E.E. Conn, P.K. Stumpf, G. Bruening, R.H. Doi, *Outlines of Biochemistry*, 5th Edn., John Wiley and Sons, 2009.
4. U. Satyanarayana, *Biochemistry*, Books and Allied, 2006.
5. R. Murray, D. Bender, K.M. Botham, P.J. Kennelly, V. Rodwell, P.A. Weil, Harper's *Illustrated Biochemistry*, 29th Edn., McGraw Hill, 2012.
6. D. Voet, J.G. Voet, *Biochemistry*, 4th Edn., John Wiley and Sons, 2010.
7. D.M. Vasudevan, S. Sreekumari, V. Kannan, *Textbook of Biochemistry for Medical Students*, 6th Edn., JP Medical, 2010.
8. H.F. Gilbert, *Basic Concepts in Biochemistry*, 2nd Edn., McGraw Hill, 2000.
9. J. L. Ingraham and C. A. Ingraham, *Introduction to Microbiology*, 2nd revised edn., S. Chand & Company Ltd., 1999.
10. A.J. Salle, *Fundamental Principles of Bacteriology*, Tata McGraw Hill, 1984.
11. M.J. Pelczar Jr., E.C.S. Chan, N.R. Krieg, *Microbiology*, 88th Edn., Tata McGraw Hill, 1993.
12. R. Y. Stanier, *General Microbiology*, Palgrave Macmillan, 5th Edn., 1999.
13. G.G. Young, Witton's *Microbiology*, Literacy Licensing, LLC, 2011.
14. L. Prescott, J. Harley, D. Klein, *Microbiology*, 6th Edn., McGraw Hill, 2005.
15. G. Sykes, *Disinfection and Sterilization*, Van Nostrand, 1958.
16. Roitt and J. Brostff, *Immunology*, D. Male (Ed), Open University, United Kingdom. 2003.
17. L. E. Cassaida Jr., *Industrial Microbiology*, New Age International Publishers, 2007.