COURSE CURRICULUM (Draft)

BACHELOR OF SCIENCE

IN

CHEMISTRY AND NANOSCIENCE

DEPARTMENT OF CHEMISTRY

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

CHAPTER-1

GENERAL INFORMATION

1.1 Introduction to MIST

The establishment of the Military Institute of Science and Technology (MIST) on 19 April 1998 was a strategic response to the growing demand for advanced engineering and technological education within the Bangladesh Armed Forces. Prior to its founding, officers of the armed forces pursued technical degrees from institutions such as the Bangladesh University of Engineering and Technology (BUET), Bangladesh Institutes of Technology (BIT), and various foreign universities. Guided by the forward-looking motto "Technology for Advancement," MIST commenced its academic journey on 31 January 1999 by launching a Bachelor of Science in Civil Engineering. In subsequent years, the institution systematically expanded its academic portfolio, introducing programs in Computer Science and Engineering in 2001, Electrical, Electronic and Communication Engineering and Mechanical Engineering in 2003, and specialized disciplines such as Aeronautical Engineering and Naval Architecture and Marine Engineering in 2008 and 2012, respectively. Further solidifying its commitment to innovation, MIST introduced four new departments in 2014; Nuclear Engineering, Biomedical Engineering, Environmental, Water Resources and Coastal Engineering, and Architecture; followed by Industrial and Production Engineering and Petroleum and Mining Engineering in 2016. In a progressive move to align with contemporary scientific and technological frontiers, MIST inaugurated two pioneering departments in 2026: Chemistry and Nanoscience, and Mathematics and Data Science, both designed to cultivate expertise in cutting-edge fields and empower graduates to address complex global challenges. Throughout its evolution, MIST has remained dedicated to providing exceptional technical education to both military and civilian learners, thereby reinforcing its role as a premier institution in the advancement of engineering knowledge and national development.

1.2 Title of the Academic Program: Bachelor (Hons) in Chemistry and Nanoscience

1.3 Name of the Institute: Military Institute of Science and Technology

1.4 Vision of the Institute:

To be a center of excellence for providing quality education in the field of science, engineering and technology and conduct research to meet the national and global challenges.

1.5 Mission of the Institute:

M1. To provide comprehensive education and conduct research in diverse disciplines of science, engineering, technology and engineering management.

M2. To produce technologically advanced intellectual leaders and professionals with high moral and ethical values to meet socio- economic development of Bangladesh and global needs.

M3. To conduct collaborative research activities with national and international communities for continuous interaction with academician and industry.

M4. To provide consultancy, advisory, testing and other related services to government, non-government and autonomous organization including personnel for widening practical knowledge and to contribute in sustainable development of the society.

1.6 Name of the Program Offering Entity (Department/Faculty/Institute):

Department of Chemistry

1.7 Vision of the Program Offering Entity:

Department of Chemistry aims to provide quality education to develop innovative, ethical, and competent graduates capable of advancing scientific knowledge, contributing to fundamental research, and addressing complex challenges in chemistry, nanoscience, and related interdisciplinary fields.

1.8 Mission of the Program Offering Entity:

a. Provide a strong foundation in chemical sciences and nanoscience as well as interdisciplinary science through rigorous coursework, laboratory training, and research-oriented learning, developing graduates' analytical, experimental, and computational skills.
b. Develop analytical, experimental, and computational skills to solve real-world scientific and technological problems in the field of chemistry and nanoscience
c. Foster ethical, safe, and environmentally sustainable practices, while encouraging creativity and innovation for scientific discovery and technological advancement.

1.9 Objectives of the Program Offering Entity:

a. **Advance Knowledge and Education:** Provide high-quality teaching in chemistry and nanoscience, fostering strong theoretical understanding and practical laboratory skills.
b. **Promote Research and Innovation:** Encourage research, scientific inquiry, and development of nanoscale and analytical techniques.
c. **Foster Leadership and Societal Contribution:** Prepare graduates to take leadership roles and apply their knowledge for societal, industrial, and scientific impact.

1.10 Name of the Degree: BSc (Honours) in Chemistry and Nanoscience

1.11 Description of the Program:

The **BSc (Hons) in Chemistry and Nanoscience** is a four-year undergraduate program designed to provide students with a comprehensive understanding of chemical sciences alongside advanced knowledge of nanoscale materials and technologies. The program integrates core disciplines of chemistry, including inorganic, organic, physical, analytical, and biological chemistry with interdisciplinary subjects such as physics, mathematics, and nanoscience. Students gain hands-on experience through laboratory training, modern instrumentation, and research projects, developing skills in experimental design, data analysis, computational chemistry, and nanoscale characterization. The curriculum emphasizes problem-solving, critical thinking, and innovation, preparing graduates to address real-world scientific and technological challenges.

Graduates are prepared for careers in chemical, pharmaceutical, materials, and nanotechnology industries, research organizations, and academic pursuits, or to continue advanced studies in chemistry, nanoscience, and related fields.

1.12 Graduate Attributes (GA):

	Graduate Attribute (GA)	BNQF Domain(s)
1.	**Knowledge of Chemistry & Nanoscience**: Ability to understand, analyze, and apply core chemical and nanoscale principles to scientific and technological challenges.	Fundamental Skill
2.	**Experimental & Laboratory Skill**: High competence in chemical and nanomaterials synthesis, advanced instrumentation, nanoscale characterization, and safe laboratory practice.	Fundamental Skills
3.	**Analytical, Numerical & Computational Skills**: Ability to interpret data, use computational and digital tools, and solve quantitative chemical and nanoscience problems.	Fundamental Skills
4.	**Innovative & Critical Thinker**: Capacity for creativity, logical reasoning, and problem-solving in emerging fields such as nanotechnology, green chemistry, and materials science.	Thinking Skills
5.	**Effective Scientific Communicator**: Proficiency in presenting chemical and nanoscience-related findings through written, oral, and digital formats.	Social Skills
6.	**Teamwork, Collaboration & Leadership**: Ability to work effectively in multidisciplinary teams and demonstrate leadership and professional responsibility.	Social Skills
7.	**Ethical, Safe & Environmentally Responsible**: Commitment to ethical conduct, chemical and nanomaterial safety, data integrity, and sustainable scientific practice.	Social Skills
8.	**Lifelong Learner & Adaptable Professional**: Motivation for continuous learning, technological adaptability, and professional development in rapidly evolving fields.	Personal Skill

1.13 Program Educational Objectives (PEOs):

PEO1. **Strong Foundation in Chemical & Nanoscience Principles:** Graduates will acquire comprehensive and coherent knowledge across core chemical disciplines and foundational nanoscience, preparing them for advanced study and professional practice.

PEO2. **Research, Analytical & Experimentation Skills:** Graduates will develop high-level laboratory, analytical, and nanoscale research skills to address real-world scientific and technological challenges.

PEO3. **Critical, Creative & Interdisciplinary Thinking:** Graduates will integrate chemical and nanoscience knowledge to solve complex problems through analytical reasoning and innovation.

PEO4. **Professional Responsibility, Ethics & Safety:** Graduates will practise chemistry and nanoscience with ethical integrity, strong safety awareness, and adherence to environmental sustainability.

PEO5. **Career, Innovation & Higher Studies Preparedness:** Graduates will be prepared for employment in chemical, pharmaceutical, materials, nanotechnology industries, research organizations, or higher academic pursuits.

PEO6. **Leadership, Collaboration & Communication:** Graduates will demonstrate effective teamwork, leadership, and scientific communication in multidisciplinary environments

1.14 Program Learning Outcomes (POs):

PO1: Core and Interdisciplinary Knowledge

Graduates will demonstrate comprehensive and coherent knowledge of inorganic, organic, physical, analytical, biological chemistry, nanoscience as well as interdisciplinary subjects like mathematics and physics, integrating theoretical principles with modern developments.

PO2: Laboratory Skills, Instrumentation Competence & Chemical Safety

Graduates will perform experiments safely and effectively using standard and advanced laboratory techniques, modern analytical instruments, and nanoscience-related tools. They will apply chemical safety principles, conduct risk assessments, manage chemical waste responsibly, and follow emergency procedures to ensure safe laboratory practice and environmental protection.

PO3: Problem-Solving & Critical Thinking

Graduates will identify, analyze, and solve chemical problems by integrating interdisciplinary concepts, logical reasoning, and evidence-based approaches.

PO4: Experimental Design & Research Skills
Graduates will design experiments, formulate hypotheses, plan investigations, select appropriate methodologies, and maintain high-quality laboratory records following scientific standards.

PO5: Data Analysis, Computational Chemistry & Numerical Skills
Graduates will analyze experimental data using statistical tools, interpret spectroscopic/analytical results, and use computational or digital tools to solve chemical problems.

PO6: Scientific Communication Skills
Graduates will communicate effectively through scientific reports, presentations, posters, lab notebooks, and technical documentation for diverse scientific and non-scientific audiences.

PO7: Teamwork, Leadership & Collaboration
Graduates will work collaboratively and effectively in laboratory teams and multidisciplinary groups, demonstrating leadership, responsibility, and respect for diverse viewpoints.

PO8: Ethics, Integrity & Professional Conduct
Graduates will demonstrate integrity, ethical behavior, responsible conduct of research, respect for intellectual property, honest data handling, and professional responsibility as chemists.

PO9: Environmental Sustainability & Green Chemistry
Graduates will apply the principles of green chemistry and sustainable resource use to minimize ecological impact and support sustainable chemical practice.

PO10: Lifelong Learning & Career Development
Graduates will engage in continuous professional development, adapt to new technologies, and pursue self-directed learning to remain current in chemistry, nanoscience, and related fields.

1.15 Mapping mission of the Institute with PEOs

PEO → Mission	M1	M2	M3	M4
PEO-1: Strong foundation in chemical & nanoscience principles	✓			
PEO-2: Research, analytical & experimentation skills	✓		✓	
PEO-3: Critical, creative & interdisciplinary thinking	✓			✓
PEO-4: Professional responsibility, ethics & safety		✓		✓
PEO-5: Career, innovation & higher studies preparedness		✓		✓
PEO-6: Leadership, collaboration & communication		✓	✓	

1.16 Mapping POs with the PEOs:

Program Outcome (PO)	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	BNQF Domain(s)
PO1: Core and Interdisciplinary Knowledge	✓		✓		✓		Fundamental Skill
PO2: Laboratory Skills, Instrumentation Competence & Chemical Safety		✓		✓	✓		Fundamental Skill
PO3: Problem-Solving & Critical Thinking		✓	✓		✓		Thinking Skill
PO4: Experimental Design & Research Skills		✓	✓		✓		Fundamental Skill
PO5: Data Analysis, Computational Chemistry & Numerical Skills		✓	✓		✓		Thinking Skill
PO6: Scientific Communication Skills					✓	✓	Social Skill
PO7: Teamwork, Leadership & Collaboration		✓			✓	✓	Social Skill
PO8: Ethics, Integrity & Professional Conduct				✓		✓	Social Skill
PO9: Environmental Sustainability & Green Chemistry			✓	✓	✓		Social Skill
PO10: Lifelong Learning & Career Development			✓		✓	✓	Personal Skill

1.17 Mapping courses with the POs :

BNQF Field	Course Code	Course title	PO									
			1	2	3	4	5	6	7	8	9	10
Level 1 Term I												
0531	CHN 101	Introduction to Physical Chemistry	√		√							
0531	CHN 121	Organic Chemistry I	√		√							

0531	CHN 161	Fundamentals of Analytical Chemistry	√	√	√		√					
0541	MATH 101	Differential and Integral Calculus	√		√		√					
0223	GEESP 101	Ethics and Social Philosophy	√	√					√	√		
0541	CHN 122	Organic Chemistry Sessional I	√	√	√	√	√					
0231	LANG 102	Communicative English Sessional	√					√				
Level 1 Term II												
0531	CHN 141	Principles of Inorganic Chemistry	√		√							
0531	CHE 143	Chemistry of Representative Elements	√		√							
0541	MATH 103	Vector Analysis and Linear Algebra	√		√	√	√					
0613	CSE 101	Structured Programming Language	√	√		√	√					
0531	CHN 142	Inorganic Chemistry Sessional I	√	√	√		√					
0613	CSE 102	Structured Programming Sessional	√	√	√	√	√					
0531	CHN 191	Presentation on Modern Trends in Chemistry and Nanoscience-I						√				√
Level 2 Term I												
0531	CHN 201	Electrochemistry	√	√	√		√				√	
0531	CHN 203	Surface Chemistry, Colloid Science and Phase Equilibria	√		√		√					
0531	CHN 243	Transition Metal and Coordination Chemistry	√		√		√					
0541	MATH 201	Differential Equations and Fourier Transform	√		√							
0533	PHY 201	Mechanics, Waves and Optics	√									
0531	CHN 242	Inorganic Chemistry Sessional II	√	√	√		√	√				
Level 2 Term II												
0531	CHN 205	Chemical Thermodynamics	√		√							
0531	CHN 221	Organic Chemistry II	√		√		√					
0531	CHN 223	Stereochemistry of Organic Compounds	√		√		√					
0531	CHN 281	Fundamentals of Nanoscience	√		√		√			√	√	
0533	PHY 201	Electricity and Magnetism	√		√		√					

0531	CHN 202	Physical Chemistry Sessional I	√	√	√	√						
0533	PHY 202	Physics Sessional	√	√	√		√	√				
0531	CHN 292	Presentation on Modern Trends in Chemistry and Nanoscience-II						√				√
Level 3 Term I												
0531	CHN 301	Chemical Kinetics and Photochemistry	√	√	√							
0531	CHN 361	Inorganic Chemical Process Industries	√	√	√	√	√		√	√	√	
0531	CHN 371	Chemical Spectroscopy I	√		√		√					
0531	CHN 323	Organic Reaction Mechanism	√		√		√				√	
0531	CHN 363	Instrumental Methods of Analysis in Chemistry and Nanoscience	√	√	√							
0531	CHN 302	Physical Chemistry Sessional II	√	√	√	√		√		√		√
Level 3 Term II												
0531	CHN 305	Polymer and Supramolecular Chemistry	√	√	√							
0531	CHN 373	Quantum Chemistry and Statistical Mechanics	√		√	√	√					
0531	CHN 317	Organic Chemical Process Industries	√	√	√					√	√	
0531	CHN 325	Bioorganic Chemistry	√		√		√				√	
0531	CHN 341	Crystallography and Solid State Chemistry	√	√	√							
0531	CHN 383	Nanoscale Synthesis, Fabrication and Characterization	√	√	√							
0531	CHN 342	Organic Chemistry Sessional II	√	√	√							
0531	CHN 391	Presentation on Modern Trends in Chemistry and Nanoscience-III										
0531	CHN 393	Industrial Training/Factory Visit	√	√	√							
Level 4 Term I												
0531	CHN 421	Chemistry of Natural Products	√		√	√						
0531	CHN 437	Nuclear Chemistry	√	√		√						
0531	CHN 471	Chemical Spectroscopy II	√		√	√						
0531	CHN 485	Applications of Nanoscale Materials	√	√		√						
0531	GESHC 401	Chemical Security, Hazard Mitigation, and Chemical	√									

		Weapon Regulations										
0531	GERM 401	Research Methodology	√			√						
0531	CHN 482	Nanomaterials Synthesis Sessional		√		√						
0531	NSE 438	Nuclear Chemistry Sessional	√									
Level 4 Term II												
0531	CHN 451	Green Chemistry for Sustainable Environment	√	√	√							
0531	CHN 435	Advanced Topics in Inorganic Chemistry	√									
0531	CHN 453	Applied Physical Chemistry	√		√							
0531	CHN 455	Medicinal Chemistry	√									
0531	CHN 457	Bioinorganic Chemistry	√									
0531	CHN 459	Nanotechnology for Energy Conversion and Storage	√		√							
0531	CHN 485	Nanophotonics and Magnetic Nanostructures	√		√							
0512	BME 487	Chemistry of Nano-biomolecules	√			√						
0413	GELM 375	Leadership and Management							√	√		√
0531	CHN 440	Advanced Inorganic and Analytical Chemistry Laboratory	√	√		√	√	√				
0531	CHN 448	Computational Methods in Chemistry and Nanoscience				√	√	√				
0531	CHN 491	Presentation on Modern Trends in Chemistry and Nanoscience-IV						√				√
0531	CHN 493	Project/Thesis										√

1.18 Structure of the Curriculum

a. Duration of the program: Years 4 Semesters: 8
b. Admission Requirements:
   (i) SSC and HSC or Equivalent: In both the examinations (or equivalent public exams), applicants must have obtained a minimum GPA of 3.50 in each exam. Applicants who passed HSC (or equivalent) both in 2025 and 2024 can apply.
   (ii) GCE ('O' and 'A' Levels) or Equivalent:
   (1) The applicants who passed in 2023 or 2022 with minimum 'B' grade or equivalent in any five subjects including Mathematics, Physics and Chemistry in GCE 'O' Level.
   (2) The applicants who passed in 2025 or 2024 with minimum 'B' grade or equivalent in Mathematics, Physics and Chemistry in GCE 'A' Level.

c. Total minimum credit requirement to complete the program: According to BNQF for Higher Education 130 credit.
d. Total class weeks in a Year/semester: 14
e. Minimum CGPA requirements for graduation: 2.20
f. Maximum academic years of completion: 6 years

g. Category of Courses:

i. General Education Courses:

(Interdisciplinary courses, beyond the discipline/program, that provides a well-rounded learning experience to the students of an academic program)

For example: Arts and Humanities, Social Sciences, ICT, Basic Science/STEM etc. (as applicable for the discipline/academic program)

ii. Core courses (Courses that characterize the discipline)
iii. Elective Courses (Courses for specialization within the discipline)
iv. Capstone course/Internship/Thesis/Projects/Portfolio (as applicable for the discipline/ academic program)

CHAPTER-2

RULES AND REGULATIONS FOR UNDERGRADUATE PROGRAMME AT MIST

2.1 Introduction

MIST has introduced course system for undergraduate studies from the academic session 2025-26. Therefore, the rules and regulations mentioned in this paper will be applicable to students for administering undergraduate curriculum through the Course System. This will be introduced with an aim of creating a continuous, even and consistent workload throughout the term for the students.

2.2 The Course System

2.2.1 The salient features of the Course System are as follows:

1. Number of theory courses will be generally 06 or as per syllabus in each term. However, with the recommendation of course coordinator and Head of the Department, Commandant MIST may allow up to 07 courses in exceptional cases.
2. Students will not face any level repeat for failing.
3. Students will get scope to improve their grading.
4. Introduction of more optional courses to enable the students to select courses according to their individual needs and preferences.
5. Continuous evaluation of students' performance.
6. Promotion of student-teacher interaction and contact.

2.2.2 Beside the professional courses pertaining to each discipline, the undergraduate curriculum gives a strong emphasis on acquiring thorough knowledge in the basic sciences of mathematics, physics, and chemistry. Due importance is also given on the study of several subjects in humanities and social sciences.

2.2.3 The first two years of bachelor's degree programs generally consist of courses in basic chemistry, general science and humanities subjects; while the third and subsequent years focus in specific disciplines.

2.3 Number of Terms in a Year

There will be two terms Spring Term (Jan-Jun) and Fall Term (Jul-Dec) in an academic year.

2.4 Duration of Terms

The duration of each of Spring Term and Fall Term (maximum 22 weeks) may be as under:

Ser	Events	Durations
1.	Classes before Mid Term	7 weeks
2.	Mid Term Vacation	1 week
3.	Classes after Mid Term	7 weeks
4.	Makeup Classes and Preparatory leave	2/3 weeks
5.	Term Final Examination	2/3 weeks
6.	Term End Vacation	1/2 week

2.5 Course Pattern and Credit Structure

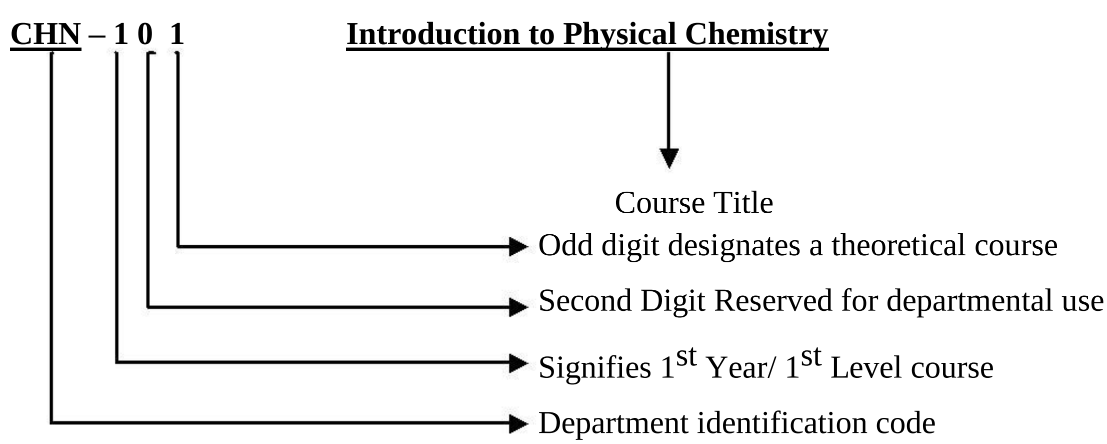
The undergraduate program is covered by a set of theoretical courses along with a set of laboratories (sessional) courses to support them.

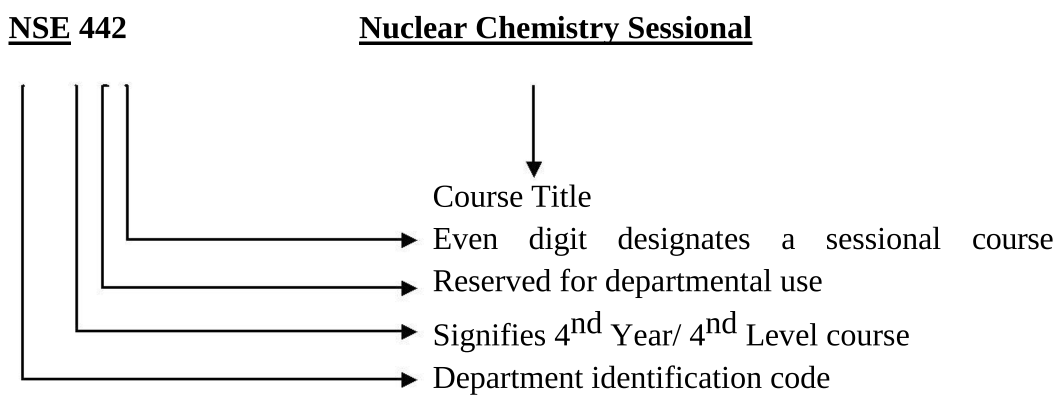
2.6 Course Designation System

Each course is designated by a maximum of three/four letter code identifying the department offering the course followed by a three-digit number having the following interpretation:

a. The first digit corresponds to the year/level in which the course is normally taken by the students.
b. The second digit is reserved for departmental use. It usually identifies a specific area/group of study within the department.
c. The last digit is an odd number for theoretical courses and an even number for sessional courses.

The course designation system is illustrated as follows:





2.7 Assignment of Credits

The assignment of credits to a theoretical course follows a different rule from that of a sessional course.

a. **Theoretical Courses:** One lecture per week per term is equivalent to one credit.
b. **Sessional Courses:** Credits for sessional courses is half of the class hours per week per term.
c. **Project and Thesis Courses**: Credits are also assigned to project and thesis work taken by the students. The amount of credits assigned to such work varies from one discipline to another.

2.8 Types of Courses

The types of courses included in the undergraduate curricula are divided into the following groups:

a. **Core Courses:** In each discipline, a number of courses are identified as core courses, which form the nucleus of the respective bachelor's degree program. A student has to complete the entire designated core courses of his/her discipline.

b. **Prerequisite Courses:** Some of the core courses are identified as prerequisite courses for a specific subject.

c. **Optional Courses:** Apart from the core courses, the students can choose from a set of optional courses. A required number of optional courses from a specified group have to be chosen.

2.9 Course Offering and Instruction

- The courses to be offered in a particular term are announced and published in the Course Catalog along with the tentative Term Schedule before the end of the previous term. The courses to be offered in any term will be decided by Board of Undergraduate Studies (BUGS) of the respective department.
- Each course is conducted by a course teacher who is responsible for maintaining the expected standard of the course and for the assessment of students' performance. Depending on the strength of registered students (i.e. on the number of students) enrolled for the course, the teacher concerned might have course associates and Teaching Assistants (TA) to aid in teaching and assessment.

2.10 Teacher Student Interaction

The new course system encourages students to come in close contact with the teachers. For promotion of a high level of teacher-student interaction, each student is assigned to an adviser and the student is free to discuss all academic matters with his/her adviser. Heads of the departments, Director of Administration, Director of Students Welfare (DSW), Dean and Commandant address the students at some intervals. Students are also encouraged to meet any time with other teachers for help and guidance in academic matters. However, students are not allowed to interact with teachers after the moderation of questions.

2.11 Students' Adviser

1. One adviser is normally appointed for a group of students by the BUGS of the concerned department. The adviser advises each student about the courses to be taken in each term by discussing the academic program of that particular term with the student.
2. However, it is also the student's responsibility to keep regular contact with his/her adviser who will review and eventually approve the student's specific plan of study and monitor subsequent progress of the student.
3. For a student of second and subsequent terms, the number and nature of courses for which he/she can register is decided on the basis of academic performance during the previous term. The adviser may permit the student to drop one or more courses based on previous academic performance.

2.12 Course Registration

Any student who uses classroom, laboratory facilities or faculty-time is required to register formally. Upon admission to the MIST, students are assigned to advisers. These advisers guide the students in choosing and registering courses.

2.13 Registration Procedure

At the commencement of each term, each student has to register for courses online in consultation with and under the guidance of his/her adviser. The date, time and venue of registration are announced in advance by the Registrar's Office. Counselling and advising are accomplished at this time. It is absolutely essential that all the students be present for registration at the specified time.

2.14 Pre-conditions for Registration

i. For first year students, department-wise enrollment/admission is mandatory prior to registration. At the beginning of the first term, an orientation program will be conducted for them where they are handed over with the registration package on submission of the enrolment slip.

ii. Any student, other than the new batch, with outstanding dues to the MIST or a hall of residence is not permitted to register. Each student must clear their dues and obtain a clearance certificate, upon production of which, he/she will be given necessary Course Registration Forms to perform course registration.

iii. A student is allowed to register in a particular course subject to the class capacity constraints and satisfaction of pre-requisite courses. However, even if a student fails in a pre-requisite course in any term, the concerned department (BUGS) may allow him/her to register for a course which depends upon the pre-requisite course provided that his/her attendance and performance in the continuous assessment of the mentioned pre-requisite course is found to be satisfactory.

2.15 Registration Deadline

Each student must register for the courses to be taken before the commencement of each term. Late registration is permitted only during the first week of classes. Late registration after this date will not be accepted unless the student submits a written application to the registrar through the concerned Head of the department explaining the reasons for delay. Acceptable reasons may be medical problems with supporting documents from the Medical Officer of MIST or some other academic commitments that prohibit enrollment prior to the last date of registration.

2.16 Penalty for Late Registration

Students who fail to register during the designated dates for registration are charged a late registration fee of Tk. 100.00 (One hundred only) per credit hours. Under no circumstances, the penalty for late registration will be waived.

2.17 Limits on the Credit Hours to be Taken

a. A student should be enrolled for at least 15 credit hours and is allowed to take a maximum of 24 credit hours. Relaxation on minimum credit hours may be allowed. A student must enroll for the sessional courses prescribed in a particular term within the allowable credit hour limits.

b. In special cases where it is not possible to allot the minimum required 15 credit hours to a student, the concerned department (BUGS) may permit with the approval of the Commandant, a lesser number of credit hours to suit individual requirements. Only graduating students may be allowed to register less than 15 credit hours without approval of Commandant. A list of all such cases to be forwarded to Register Office, ICT directorate and Controller of Exam Office by the respective Department.

2.18 Course Add/Drop

1. A student has some limited options to add or drop courses from the registration list. Addition of courses is allowed only within the first two weeks of a regular term. Dropping a course is permitted within the first four weeks of a regular term. Add or drop is not allowed after registration of courses for Supplementary-I and Supplementary-II examination.

2. Any student willing to add or drop courses has to fill up a Course Adjustment Form. This also has to be done in consultation with and under the guidance of the student's respective adviser. The original copy of the Course Adjustment Form has to be submitted to the Registrar's Office, where the required numbers of photocopies are made for distribution to the concerned adviser, Head, Dean, Controller of Examinations and the student.

3. All changes must be approved by the adviser and the Head of the concerned department. The Course Adjustment Form has to be submitted after being signed by the concerned persons.

2.19 Withdrawal from a Term

If a student is unable to complete the Term Final Examination due to serious illness or serious accident, he/she may apply to the Head of the degree awarding department for total withdrawal from the term before commencement of term final examination. However, application may be considered during term final examination in special case. The application must be supported by a medical certificate from the Medical Officer of MIST. The Academic Council will take the final decision about such applications. However, the total duration for graduation will not exceed 6 academic years.

2.20 The Grading System

The total performance of a student in a given course is based on a scheme of continuous assessment for theory courses. This continuous assessment is made through a set of quizzes, class tests, class evaluation, class participation, homework assignment and a term final examination. The assessments for sessional courses are made by evaluating performance of the student at work during the class, viva-voce during laboratory hours and quizzes. Besides that, at the end there will be a final lab test. Each course has a certain number of credits, which describes its corresponding weightages. A student's performance is measured by the number of credits completed satisfactorily and by the weighted average of the grade points earned. A minimum grade point average (GPA) is essential for satisfactory progress. A minimum number of earned credits also has to be acquired in order to qualify for the degree.

Letter grades and corresponding grade points will be given as follows:

Numerical Markings	Grade	Grade Points
80% and above	A+	4.00
75% to below 80%	A	3.75
70% to below 75%	A-	3.50
65% to below 70%	B+	3.25
60% to below 65%	B	3.00
55% to below 60%	B-	2.75
50% to below 55%	C+	2.50
45% to below 50%	C	2.25
40% to below 45%	D	2.00
below 40%	F*	0.00
Incomplete	I	-
Withdrawal	W	-
Capstone Project/Thesis continuation	X	-

* Subject in which the student gets F grade shall not be regarded as earned credit hours for the calculation of Grade Point Average (GPA)

2.21 Marks Distribution

2.21.1 Theory. Forty percent (40%) of marks of a theoretical course shall be allotted for continuous assessment, i.e. assignments, class tests, pop quizzes, observations, projects and mid-term assessment. These marks must be submitted to Office of the Controller of Exam before commencement of final exam. The rest of the marks will be allotted to the Term Final Examination. The duration of final examination will be three (03) hours. The scheme of continuous assessment that a particular teacher would follow for a course will be announced on the first day of the classes. Distribution of marks for a given course per credit is as follows:

Class Performance	5%
Class Attendance	5%
Class Test/ Assignment	20%
Mid Term Assessment (Exam / Project)	10%
Final Examination (Section A & B)	60%
Total	**100%**

Basis for awarding marks for class Attendance will be as follows:

Class Attendance	**Marks**
90% and above	100%
85% to less than 90%	90%
80% to less than 85%	80%
75% to less than 80%	70%
70% to less than 75%	60%
Below 70%	00%

<u>Note:</u>

1. In final exam, each section can be used for achieving not more than two course outcomes (COs). The remaining COs should be attained from mid-term assessment or class tests. The course teacher has to inform the student at the beginning of the terms.
2. Course teacher of a particular course has to inform the department whether he/she wants to assess mid-term through exam or project within first two weeks of beginning of a term. The duration of mid-term examination should not be more than 50 minutes which has to be conducted in between 6th to 9th week of a semester. If mid-term assessment is done through project, then there should be project report and presentation.
3. The weightage of class performance can be assessed through checking attentiveness during classes or arranging unnoticed pop quizzes.
4. The number of class tests shall be n for 3.0 and above credit courses and (n-1) shall be considered for grading where n is the number of credits of the course. However, for courses having credits below 3.0, the considered class tests shall be 2 out of 3.
5. All class test will carry 20 marks each. Exam software system will finally convert these achieved marks into total class test marks as per credit hour. i.e for n = 1(20), n = 2 (40), n = 3 (60), n = 4(80) etc.
6. Irrespective of the result of the continuous assessment (class performance, class test, mid-

term assessment), a student has to appear in the final examination (where applicable) for qualifying/passing the concern course/ subject.

2.21.2 Laboratory/Sessional/Practical Examinations.

Sessional courses are designed and conducted by the concerned departments. Examination on Laboratory/ sessional/practical subjects will be conducted by the respective department before the commencement of term final examination. The date of practical examination will be fixed by the respective department. Students will be evaluated in the sessional courses on the basis of the followings.

Conduct of Lab Tests/Class Performance	25%
Report Writing/ Programming	15%
Mid-Term Evaluation (exam/project/assignment)	20%
Final Evaluation (exam/project/assignment)	30%
Viva Voce/Presentation	10%
Total	**100%**

2.21.3 Laboratory/Sessional Course in Language. The distribution will be as under:

Class performance/observation	10%
Written Assignment	15%
Oral Performance	25%
Listening Skill	10%
Group Presentation	30%
Viva Voce	10%
Total	**100%**

2.21.4 Class Attendance.

Class Attendance may be considered as a part of continuous assessment. No mark will be allotted for attending class.

2.22 Collegiate, Non-collegiate and Dis-collegiate

Students having class attendance of 85% or above in individual subject will be treated as collegiate and less than 85% and up to 70% will be treated as non-collegiate in that subject. The non-collegiate student(s) may be allowed to appear in the examination subject to payment of non-collegiate fee/fine of an amount fixed by MIST/BUP. Students having class attendance below 70% will be treated as dis-collegiate and will not be allowed to appear in the examination and treated as fail. But in a special case such students may be allowed to appear in the examination with the permission of Commandant and it must be approved by the Academic Council.

2.23 Calculation of GPA

Grade Point Average (GPA) is the weighted average of the grade points obtained of all the courses passed/completed by a student. For example, if a student passes/completes n courses in a term having credits of C_1, C_2,…..C_n and his grade points in these courses are G_1, G_2,…..G_n respectively then

$$\mathrm{GPA} = \frac{\text{Grade points earned in the semester}}{\text{Credits completde in the semester}}$$

$$\mathrm{GPA} = \frac{\sum(\text{Credit hours in a course} \times \text{Grade points earned in that course})}{\text{Credits completed in the semester}}$$

$$\mathrm{GPA} = \frac{\sum_{i=1}^{n}(C_i \times G_i)}{\sum_{i=1}^{n} C_i}$$

The Cumulative Grade Point Average (CGPA) is the weighted average of the GPA obtained in all the terms passed/completed by a student. For example, if a student passes/ completes terms having total credits of TC_1, TC_2,….,TC_n and his GPA in these terms are GPA_1, GPA_2,…..GPA_n, respectively then

$$\mathrm{CGPA} = \frac{\sum_{i=1}^{n} TC_i \times GPA_i}{\sum_{i=1}^{n} TC_i}$$

Numerical Example

Suppose a student has completed eight courses in a term and obtained the following grades:

Course	Credit Ci	Grade Points	Gi	Ci*Gi
CHN 107	3.00	A+	4.00	12.00
CHEM 101	3.00	A+	4.00	12.00
PHY 101	3.00	A+	4.00	12.00
MATH 101	3.00	A+	4.00	12.00
GEBS 101	2.00	A	3.75	7.50
LANG 102	1.50	A+	4.00	6.00
ME 150	1.50	A	3.75	5.625
CHEM 122	1.50	A	3.75	5.625
SHOP 180	1.50	A+	4.00	6.00
Total	**20.00**			**78.75**

GPA = 78.75/20 = 3.9375 ≈ 3.94

Suppose a student has completed four terms and obtained the following GPA.

Level	Term	Earned Credit Hours TC_i	Earned GPA GPA_i	TCi*GPAi
1	I	20.00	3.94	78.80
1	II	21.00	3.84	80.64
2	I	20.25	3.92	79.38
2	II	20.25	3.98	80.60
Total		81.50		319.42

CGPA =319.42/81.50=3.92

2.24 Impacts of Grade Earned

a) The courses in which a student has earned a 'D' or a higher grade will be counted as credits earned by him/her. Any course in which a student has obtained an 'F' grade will not be counted towards his/her earned credits or GPA calculation. However, the 'F' grade will remain permanently on the Grade Sheet and the Transcript.

b) A student who obtains an 'F' grade in a core course will have to repeat that particular course. However, if a student gets an 'F' in an optional course, he/she may choose to repeat that course or take a substitute course if available. When a student will repeat a course in which he/she has previously obtained an 'F', he/she will not be eligible to get a grade better than 'B+' in that repeated course.

c) If a student obtains a grade lower than 'B+' in a particular course he/she will be allowed to repeat the course only once for the purpose of grade improvement. However, he/she will not be eligible to get a grade better than 'B+' for an improvement course.

d) A student will be permitted to repeat for grade improvement purposes a maximum of 6 courses in BSc in honours programs and a maximum of 7 courses in B. Arch. program.

e) If a student obtains a 'B+' or a better grade in any course he/she will not be allowed to repeat the course for the purpose of grade improvement.

2.25 Classification of Students

a. At MIST, regular students are classified according to the number of credit hours completed/earned towards a degree. The following classification applies to all the students:

Level	Credit Hours Earned	
	Honours/Engineering/URP	**Architecture**
Level 1	0.0 to 36.0	0.0 to 34.0
Level 2	More than 36.0 to 72.0	More than 34.0 to 72.0
Level 3	More than 72.0 to 108.0	More than 72.0 to 110.0

Level 4	More than 108.0	More than 110.0 to 147.0
Level 5		More than 147.0

b. However, before the commencement of each term all students other than new batch are classified into three categories:

<u>Category 1:</u> This category consists of students who have passed all the courses described for the term. A student belonging to this category will be eligible to register for all courses prescribed for the upcoming term.

<u>Category 2:</u> This category consists of students who have earned a minimum of 15 credits but do not belong to category 1. A student belonging to this category is advised to take at least one course less since he might have to register for one or more backlog courses as prescribed by his/her adviser.

<u>Category 3:</u> This category consists students who have failed to earn the minimum required 15 credits in the previous term. A student belonging to this category is advised to take at least two courses less than a category 1 student subject to the constraint of registering at least 15 credits. However, he will also be required to register for backlog courses as prescribed by the adviser.

C. <u>Definition of Graduating Student.</u> Graduating students are those students who will have ≤ 24 credit hour for completing the degree requirement.

2.26 Performance Evaluation

1. The performance of a student will be evaluated in terms of two indices, viz. Term Grade Point Average and Cumulative Grade Point Average which is the grade average for all the terms completed.
2. Students will be considered to be making normal progress toward a degree if their Cumulative Grade Point Average (CGPA) for all work attempted is 2.20 or higher. Students who regularly maintain a term GPA of 2.20 or better are making good progress toward the degrees and are in good standing with MIST. Students who fail to maintain this minimum rate of progress will not be in good standing. This can happen when any one of the following conditions exists.
   i. The term GPA falls below 2.20.
   ii. The Cumulative Grade Point Average (CGPA) falls below 2.20.
   iii. The earned number of credits falls below 15 times the number of terms attended.
3. All such students can make up their deficiencies in GPA and credit requirements by completing courses in the subsequent term(s) and backlog courses, if there are any, with better grades. When the minimum GPA and credit requirements are achieved, the student is again returned to good standing.

2.27 Minimum Earned Credit and GPA Requirement for Obtaining Degree

a. Minimum credit hour requirements for the award of Bachelor's degree in honours /engineering (BSc Engg) and architecture (B Arch) will be decided by the respective department (BUGS).

However, the syllabus of all BSc in chemistry program must be of minimum 130 credit hours or more and for architecture prog minimum 189 credit hours or more. A student must earn minimum credit hour set in the syllabus by the concerned department for qualifying Bachelor's Degree. The minimum CGPA requirement for obtaining a Bachelor's degree in engineering and architecture is 2.20.

b. A student may take additional courses with the consent of his/her Adviser in order to raise CGPA, but he/she may take a maximum of 15 such additional credits in engineering and 18 such additional credits in architecture beyond respective credit-hour requirements for Bachelor's degree during his/her entire period of study.

2.28 Application for Graduation and Award of Degree

A student who has fulfilled all the academic requirements for Bachelor's degree will have to apply to the Controller of Examinations through his/her Adviser for graduation. Provisional Degree will be awarded by BUP on completion of credit and GPA requirements.

2.29 Time Limits for Completion of Bachelor's Degree

A student must complete his studies within a maximum period of six years for honours degree / engineering and seven years for architecture.

2.30 Attendance, Conduct and Discipline

MIST has strict rules regarding the issues of attendance in class and discipline.

a) **Attendance**: All students are expected to attend classes regularly. The university believes that attendance is necessary for effective learning. The first responsibility of a student is to attend classes regularly and one is required to attend the classes as per MIST rules.

b) **Conduct and Discipline**: During their stay in MIST all students are required to abide by the existing rules, regulations and code of conduct. Students are strictly forbidden to form or be members of student organization or political party, club, society etc., other than those set up by MIST authority in order to enhance student's physical, intellectual, moral and ethical development. Zero tolerance in regards of sexual abuse and harassment in any forms and drug abuse and addiction are strictly observed in the campus.

2.31 Absence during a Term

A student should not be absent from quizzes, tests, etc. during the term. Such absence will naturally lead to reduction in points/marks, which count towards the final grade. Absence in the Term Final Examination will result in an F grade in the corresponding course. A student who has been absent for short periods, up to a maximum of three weeks due to illness, should approach the course teacher(s) or the course (s) for make-up quizzes or assignments immediately upon return to classes. Such request has to be supported by medical certificate from competent authority (e.g. CMH/MIST

Medical Officer).

2.32 Recognition of Performance

As recognition of performance and ensure continued studies MIST awards medals, scholarships and stipends will be given as per existing rules and practices.

2.33 Types of Different Examinations (Subject to change for different academic session)

Following different types of final Examinations will be conducted in MIST to evaluate the students of Undergraduate Programs:

a) **Term Final Examination:** At the end of each normal term (after 22wk or so), Term Final Examination will be held. Students will appear in the Term Final Examination for all the theory courses they have taken in the Term.

b) **Supplementary Examination:** It will take place twice in a year. Supplementary-I is defined as provision of giving exam in the first week of Spring Term (Jan-Jun) / Fall Term (Jul-Dec) end break and Supplementary-II in the first week of Fall Term (Jul-Dec) / Spring Term (Jan-Jun) end break, respectively. Students will be allowed to register for a maximum of two theory courses (Failed/Improvement) in Supplementary-I and maximum of one theory course (Failed/Improvement) in Supplementary-II. However, with the approval of Commandant, in special circumstances, departments may allow students to register for a maximum of one theory courses (Failed/Improvement) in Supplementary-I and maximum of two theory courses (Failed/Improvement) in Supplementary-II. Total courses to register by a student in supplementary examination in a year cannot be more than three.

c) **Improvement Examination:** It will be taken during Supplementary-I and Supplementary-II Examination. Questions will be same as the question of the regular examination of that Supplementary Examination (if any). Student can take maximum two subjects at a time (two subjects in supplementary-I and one subject in supplementary-II) and maximum 6 subjects in the whole academic duration. If a student obtains a grade lower than 'B+' in a course, he/she will be allowed to repeat the course only once for grade improvement. However, he/she will not be eligible to get a grade better then 'B+' for an improvement course. Among the previous result and improvement examination result, best one will be considered as final result for an individual student. However, performance of all examination i.e. previous to improvement examination, shall be reflected in the transcript.

2.34 Rules of Different Examinations (Subject to change for different academic session)

2.34.1 Term Final Examination

Following rules to be followed:

a. Registration to be completed before commencement of the Term. A student has to register his desired courses paying registration, examination fee and other related fees.

b. Late registration will be allowed without penalty within first two weeks of the term.

c. Within 1st two weeks of a term a student can Add/Drop course/courses. To add a course, in the 3rd week, one has to register the course by paying additional fees. To drop a course, one has to apply within three weeks and paid fees will be adjusted/refunded. If anyone wants to drop a course after three weeks and within 4 weeks, that will be permitted but paid fees will not be refunded in that case.

d. Registrar office will finalize registration of all courses within 7 (seven) weeks, issue registration slips and that will be followed by issuing Admit Card.

e. Term Final Examination to be conducted in the 18-20th week of the term as per approved Academic Calendar.

2.34.2 Supplementary Examination

Following rules are to be followed:

a. Supplementary-I is defined as provision of giving exam in the first week of Spring Term (Jan-Jun) / Fall Term (Jul-Dec) end break and Supplementary-II in the first week of Fall Term (Jul-Dec) / Spring Term (Jan-Jun) end break, respectively.

b. Students will be allowed to register for a maximum of two theory courses (Failed/Improvement) in Supplementary-I and maximum of one theory course (Failed/Improvement) in Supplementary-II. However, with the approval of Commandant, in special circumstances, departments may allow students to register for a maximum of one theory courses (Failed/Improvement) in Supplementary-I and maximum of two theory courses (Failed/Improvement) in Supplementary-II. Total courses to register by a student in supplementary examination in a year cannot be more than three,

c. No class will be conducted.

d. 40% marks will be considered from the previous exams.

e. Maximum grading in Supplementary Exam will be ‘B+’.

f. No Sessional Exam will be conducted.

g. Examination will be taken on 60% marks like Term Final Examination.

h. If a student fails in a course more than once in regular terms, then for calculating 40%marks best one of all continuous assessment marks will be counted.

i. If anyone fails in the laboratory/sessional course, that course cannot be taken in the supplementary examination.

j. If any student fails in a course, he can clear the course retaking it 2nd time or, he can clear the examination appearing at the supplementary examination as well. Any one fails twice in a course, can only retake it in the regular term for appearing third time. But anyone fails even after appearing third time. He/she has to take approval of Academic Council of MIST for appearing 4th (last) time in a course and need to pay extra financial penalty. If any student fails even 4th time in a course, will not be allowed to appear anymore in this same course.

k. Registration of Supplementary-I Exam to be done within 5th wk. after completion of Fall Term (July to Dec) and registration of Supplementary-II exam to be done during the Mid-Term break of Spring Term (Jan to Jun), paying all the required fees.

l. There will be no provision for add/drop courses after registration.

m. Question Setting, Moderation, and Result Publication to be done following the same rules of Spring (Jan to Jun) / Fall (July to Dec) Term Final Exam as per existing Examination Policy.

n. Moderation of the questions for Supplementary-I will be done in the 5th week after completion of Fall Term (July to Dec) Final Exam and Supplementary-II with the moderation of the questions of Spring Term (Jan to Jun).

o. Separate Tabulation sheet to be made.

p. **<u>Thesis:</u>** if a student cannot complete thesis in two consecutive terms, with the recommendation of the supervisor, he/she may continue for next one/two term within six academic years.

<u>2.34.3 Improvement Examination</u>

Following rules to be followed:

a. Improvement examination is to be taken during the Supplementary-I and Supplementary-II examinations.

b. For Improvement examination, registration is to be done during the registration of Supplementary-I and Supplementary-II examinations by paying all the fees.

c. Question Setting, Moderation and Result Publication to be done with courses of Supplementary-I and Supplementary-II examinations.

d. Any student gets a grading below ‘B+’ and desires to improve that course; he will be allowed to appear the improvement examination for that particular course.

e. Highest grade of Improvement examination will be ‘B+’.

f. One student is allowed to appear at Improvement exam in 6 (six) courses in his whole graduation period taking maximum two courses at a time (two courses at supplementary-I and one course at supplementary-II).

2.35 Irregular Graduation

If any graduating student clears his/her failed course in Spring Term/Fall Term/Supplementary examinations and his graduation requirements are fulfilled, his graduation will be effective from the result publication date of Spring Term/Fall Term/Supplementary examinations and that student will be allowed to apply for provisional certificate.

CHAPTER -3

COURSE CURRICULUM

3.1 Course Schedule

Keeping the above-mentioned program outcomes, the course schedule for the undergraduate students of the BSc in Chemistry & Nanoscience is given below.

3.1.1 Course Requirements

Mathematics

Ser	Course Code	Course Title	Credit Hour	Level & Term
Theoretical				
1.	MATH 101	Differential and Integral Calculus	3.0	L-1, T-I
2.	MATH 103	Vector Analysis and Linear Algebra	3.0	L-1, T-II
3.	MATH 201	Differential Equations and Fourier Transform	3.0	L-2, T-I

Physics

Ser	Course Code	Course Title	Credit Hour	Level & Term
Theoretical				
1.	PHY 201	Mechanics, Waves, and Optics	3.0	L-2, T-I
2.	PHY 203	Electricity and Magnetism	3.0	L-2, T-II
Sessional				
3.	PHY 202	Physics Sessional	1.5	L-2, T-II

Language

Ser	Course Code	Course Title	Credit Hour	Level & Term
Sessional				
1.	LANG 102	Communicative English Sessional	1.5	L-1, T-I

General Education Courses

Ser	Course Code	Course Title	Credit Hour	Level & Term
Theoretical				
1.	GEESP 101	Ethics and Social Philosophy	2.0	L-1, T-I
2.	GESHC 401	Chemical Security, Hazard Mitigation, and Chemical Weapon Regulations	2.0	L-4, T-I
3.	GERM 401	Research Methodology	1.0	L-4, T-I
4.	GELM 475	Leadership and Management	2.0	L-4, T-I

3.1.2 Program Core Courses

Ser	Course Code	Course Title	Credit Hour	Level & Term
Theoretical				
1.	CHN 101	Introduction to Physical Chemistry	3.0	L-1, T-I
2.	CHN 121	Organic Chemistry I	3.0	L-1, T-I
3.	CHN 161	Fundamentals of Analytical Chemistry	2.0	L-1, T-I
4.	CHN 141	Principles of Inorganic Chemistry	3.0	L-1, T-II
5.	CHN 143	Chemistry of Representative Elements	3.0	L-1, T-II
6.	CHN 201	Electrochemistry	3.0	L-2, T-I
7.	CHN 203	Surface Chemistry, Colloid Science and Phase Equilibria	2.0	L-2, T-I
8.	CHN 241	Transition Metal and Coordination Chemistry	3.0	L-2, T-I
9.	CHN 205	Chemical Thermodynamics	3.0	L-2, T-II
10.	CHN 221	Organic Chemistry II	3.0	L-2, T-II
11.	CHN 223	Stereochemistry of Organic Compounds	2.0	L-2, T-II
12.	CHN 281	Fundamentals of Nanoscience	3.0	L-2, T-II
13.	CHN 301	Chemical Kinetics and Photochemistry	3.0	L-3, T-I
14.	CHN 321	Organic Reaction Mechanism	3.0	L-3, T-I
15.	CHN 361	Instrumental Methods of Analysis in Chemistry and Nanoscience	3.0	L-3, T-I
16.	CHN 363	Inorganic Chemical Process Industries	2.0	L-3, T-I
17.	CHN 371	Chemical Spectroscopy I	3.0	L-3, T-I
18.	CHN 323	Bioorganic Chemistry	2.0	L-3, T-II
19.	CHN 341	Crystallography and Solid-State Chemistry	3.0	L-3, T-II
20.	CHN 365	Organic Chemical Process Industries	2.0	L-3, T-II
21.	CHN 373	Chemical Spectroscopy II	3.0	L-3, T-II
22.	CHN 375	Quantum Chemistry and Statistical Mechanics	2.0	L-3, T-II
23.	CHN 383	Nanoscale Synthesis, Fabrication and Characterization	3.0	L-3, T-II
24.	CHN 401	Polymer and Supramolecular Chemistry	3.0	L-4, T-I
25.	CHN 421	Chemistry of Natural Products	2.0	L-4, T-I
26.	CHN 441	Nuclear Chemistry	2.0	L-4, T-I
27.	CHN 485	Applications of Nanoscale Materials	3.0	L-4, T-I
28.	CHN 443	Advanced Topics in Inorganic Chemistry	2.0	L-4, T-II
29.	CHN 445	Green Chemistry for Sustainable Environment	2.0	L-4, T-II
Sessional				
30.	CHN 122	Organic Chemistry Sessional I	1.5	L-1, T-I
31.	CHN 142	Inorganic Chemistry Sessional I	3.0	L-1, T-II
32.	CHN 242	Inorganic Chemistry Sessional II	3.0	L-2, T-I
33.	CHN 202	Physical Chemistry Sessional I	1.5	L-2, T-II
34.	CHN 302	Physical Chemistry Sessional II	3.0	L-3, T-I

Ser	Course Code	Course Title	Credit Hour	Level & Term
35.	CHN 342	Organic Chemistry Sessional II	3.0	L-3, T-II
36.	CHN 482	Nanomaterials Synthesis Sessional	1.5	L-4, T-I
37.	NSE 442	Nuclear Chemistry Sessional	1.5	L-4, T-I
38.	CHN 444	Advanced Inorganic and Analytical Chemistry Sessional	1.5	L-4, T-II
39.	CHN 484	Computational Methods in Chemistry and Nanoscience	1.5	L-4, T-II

3.1.3 List of Elective/Optional Courses

i. One theoretical course will be registered for level 4 term II as offered from the following list (Optional 1):

Ser	Course Code	Course Title	Credit Hour	Level & Term
Sessional				
1.	CHN 451	Applied Physical Chemistry	2.0	L-4, T-II
2.	CHN 453	Medicinal Chemistry	2.0	L-4, T-II
3.	CHN 455	Bioinorganic Chemistry	2.0	L-4, T-II
4.	CHN 457	Nanotechnology for Energy Conversion and Storage	2.0	L-4, T-II
5.	CHN 459	Nanophotonics and Magnetic Nanostructures	2.0	L-4, T-II

Interdisciplinary Courses

Ser	Course Code	Course Title	Credit Hour	Level & Term
Theory				
1.	CSE 101	Structured Programming Language	3.0	L-1, T-II
2.	BME 487	Chemistry of Nano-Biomolecules	3.0	L-4, T-II
Sessional				
3.	CSE 102	Structured Programming Sessional	1.5	L-1, T-II
4.	NSE 442	Nuclear Chemistry Sessional	1.5	L-4, T-I

3.1.4 Summary of Course requirements

Level/ Term	Theory	Sessional	Total
Level-1, Term-I	13.0	3.0	16.0
Level-1, Term-II	12.0	5.5	17.5
Level-2, Term-I	14.0	3.0	17.0
Level-2, Term-II	14.0	4.0	18.0
Level-3, Term-I	14.0	3.0	17.0
Level-3, Term-II	15.0	5.5	20.5
Level-4, Term-I	12.0	4.0	16.0

Level-4, Term-II	11.0	7.0	18.0
Total	**105.0**	**35.0**	**140.0**

3.1.5 Courses Offered in Different Terms

Level 1 Term I				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 101	Introduction to Physical Chemistry	3.0	3.0
2.	CHN 121	Organic Chemistry I	3.0	3.0
3.	CHN 161	Fundamentals of Analytical Chemistry	2.0	2.0
4.	MATH 101	Differential and Integral Calculus	3.0	3.0
5.	GEESP 101	Ethics and Social Philosophy	2.0	2.0
	Subtotal Theory		**13.0**	**13.0**
6.	CHN 122	Organic Chemistry Sessional I	1.5	3.0
7.	LANG 102	Communicative English Sessional	1.5	3.0
	Subtotal Sessional		**3.0**	**6.0**
Total			**16.0**	**19.0**
Level 1 Term II				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 141	Principles of Inorganic Chemistry	3.0	3.0
2.	CHN 143	Chemistry of Representative Elements	3.0	3.0
3.	MATH 103	Vector Analysis and Linear Algebra	3.0	3.0
4.	CSE 101	Structured Programming Language	3.0	3.0
	Subtotal Theory		**12.0**	**12.0**
5.	CHN 142	Inorganic Chemistry Sessional I	3.0	6.0
6.	CSE 102	Structured Programming Sessional	1.5	3.0
7.	CHN 190	Presentation on Modern Trends in Chemistry and Nanoscience-I	1.0	2.0
	Subtotal Sessional		**5.5**	**11.0**
Total			**17.5**	**23.0**
Total Credit Hr Completion at Level 1			**33.5**	**42.0**

Level 2 Term I				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 201	Electrochemistry	3.0	3.0
2.	CHN 203	Surface Chemistry, Colloid Science, and Phase Equilibria	2.0	2.0
3.	CHN 241	Transition Metal and Coordination Chemistry	3.0	3.0
4.	MATH 201	Differential Equations and Fourier Transform	3.0	3.0
5.	PHY 201	Mechanics, Waves and Optics	3.0	3.0
	Subtotal Theory		**14.0**	**14.0**
6.	CHN 242	Inorganic Chemistry Sessional II	3.0	6.0
	Subtotal Sessional		**3.0**	**6.0**
Total			**17.0**	**20.0**

Level 2 Term II				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 205	Chemical Thermodynamics	3.0	3.0
2.	CHN 221	Organic Chemistry II	3.0	3.0
3.	CHN 223	Stereochemistry of Organic Compounds	2.0	2.0
4.	CHN 281	Fundamentals of Nanoscience	3.0	3.0
5.	PHY 203	Electricity and Magnetism	3.0	3.0
	Subtotal Theory		**14.0**	**14.0**
6.	CHN 202	Physical Chemistry Sessional I	1.5	3.0
7.	PHY 202	Physics Sessional	1.5	3.0
8.	CHN 290	Presentation on Modern Trends in Chemistry and Nanoscience-II	1.0	2.0
	Subtotal Sessional		**4.0**	**8.0**
Total			**18.0**	**22.0**
Total Credit Hr Completion at Level 2			**35.0**	**42.0**

Level 3 Term I				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 301	Chemical Kinetics and Photochemistry	3.0	3.0
2.	CHN 321	Organic Reaction Mechanism	3.0	3.0
3.	CHN 361	Instrumental Methods of Analysis in Chemistry and Nanoscience	3.0	3.0
4.	CHN 363	Inorganic Chemical Process Industries	2.0	2.0
5.	CHN 371	Chemical Spectroscopy I	3.0	3.0
	Subtotal Theory		**14.0**	**14.0**
6.	CHN 302	Physical Chemistry Sessional II	3.0	6.0
	Subtotal Sessional		**3.0**	**6.0**
Total			**17.0**	**20.0**

Level 3 Term II				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 323	Bioorganic Chemistry	2.0	2.0
2.	CHN 341	Crystallography and Solid State Chemistry	3.0	3.0
3.	CHN 365	Organic Chemical Process Industries	2.0	2.0
4.	CHN 373	Chemical Spectroscopy II	3.0	3.0
5.	CHN 375	Quantum Chemistry and Statistical Mechanics	2.0	2.0
6.	CHN 383	Nanoscale Synthesis, Fabrication, and Characterization	3.0	3.0
	Subtotal Theory		**15.0**	**15.0**
7.	CHN 342	Organic Chemistry Sessional II	3.0	6.0
8.	CHN 390	Presentation on Modern Trends in Chemistry and Nanoscience-III	1.0	2.0
9.	CHN 393	Industrial Training/Factory Visit	1.5	3.0
	Subtotal Sessional		**5.5**	**11.0**
Total			**20.5**	**26**
Total Credit Hr Completion at Level 3			**37.5**	**46.0**

Level 4 Term I				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 401	Polymer and Supramolecular Chemistry	3.0	3.0
2.	CHN 421	Chemistry of Natural Products	2.0	2.0
3.	CHN 441	Nuclear Chemistry	2.0	2.0
4.	CHN 485	Applications of Nanoscale Materials	3.0	3.0
5.	GESHC 401	Chemical Security, Hazard Mitigation, and Chemical Weapon Regulations	2.0	2.0
	Subtotal Theory		**12.0**	**12.0**
6.	GERM 401	Research Methodology	1.0	2.0
7.	CHN 482	Nanomaterials Synthesis Sessional	1.5	3.0
8.	NSE 442	Nuclear Chemistry Sessional	1.5	3.0
	Subtotal Sessional		4.0	8.0
Total			**16.0**	**20.0**

Level 4 Term II				
Ser	**Course Code**	**Course Title**	**Cr Hr**	**Contact Hr**
1.	CHN 443	Advanced Topics in Inorganic Chemistry	2.0	2.0
2.	CHN 445	Green Chemistry for Sustainable Environment	2.0	2.0
3.	CHN 451 CHN 453 CHN 455 CHN 457 CHN 459	Elective** (any one Course) • Applied Physical Chemistry • Medicinal Chemistry • Bioinorganic Chemistry • Nanotechnology for Energy Conversion and Storage • Nanophotonics and Magnetic Nanostructures	2.0	2.0
4.	BME 487	Chemistry of Nano-Biomolecules	3.0	3.0
5.	GELM 475	Leadership and Management	2.0	2.0
	Subtotal Theory		**11.0**	**11.0**
6.	CHN 444	Advanced Inorganic and Analytical Chemistry Sessional	1.5	3.0
7.	CHN 484	Computational Methods in Chemistry and Nanoscience	1.5	3.0
8.	CHN 490	Presentation on Modern Trends in Chemistry and Nanoscience-IV	1.0	2.0

9.	CHN 493	Project/Thesis	3.0	6.0
	Subtotal Sessional		**7.0**	**14.0**
Total			**18.0**	**25.0**
Total Credit Hr Completion at Level 4			**34.0**	**45.0**
Total Credit Earned (Theory:105, Sessional: 35)			**140.0**	**175.0**

3.1.6 Details of the course content

Course Code	0531 CHN 101	Course Type	Core (Theory)	Level 1 Term I	
Course Title	**Introduction to Physical Chemistry**			**Credit Hr**	**3**
Prerequisite	**None**			**Contact Hr**	**3**
Rational	This course will offer a fundamental understanding of physical chemistry and enhance students problem-solving skills related to thermochemistry, kinetics, and molecular behavior.				

Course Objective

- Impart detailed knowledge on different states of matter and their physical properties.
- Give knowledge on kinetic theory of gases and their application to ideal gases and also on deviation from ideal gas equation.
- Know the properties of solution, concepts of acid, base, pH and pH scale.
- Introduce concepts on Chemical equilibrium, energetics in chemistry and thermochemistry.
- Give preliminary concepts on electrochemistry and chemical kinetics.

Contents

State and Properties of Matter
Microscopic and macroscopic systems, physical properties and their classification, molar volume, refractive index and molar refraction, properties of molecules, optical activity and molecular structure, dipole moment and molecular structure, potential and kinetic energies of molecules, degrees of freedom of motion: translational, rotational and vibrational energy of systems, quantization of energy of particles, principle of equipartition of energy, intermolecular forces, states of aggregation of matter.

Gaseous State
Review of gas laws, ideal and real gases, equation of state: ideal gas equation, kinetic theory of gases: application to ideal gases, collision number, mean free path, Boltzmann distribution of molecules, deviation from ideal behavior: van der Waals equation, critical constants, principle of corresponding states.

Properties of Liquids and Solutions
Vapor pressure and its measurement, temperature variation, fractional distillation, steam distillation, surface tension of liquids, viscosity of liquids and molecular structure, solutions: Raoult’s law, ideal and non-ideal solution, temperature-composition diagram for pairs of miscible liquids, colligative properties of solutions, Nernst distribution law and its application.

Energetics in Chemistry

Observables in macroscopic systems, work and heat, internal energy, the first law of thermodynamics, state functions and exact differentials. Enthalpy, work of expansions: reversible and adiabatic expansions, Joule-Thomson effect, heat capacities at constant pressure and constant volume, enthalpy changes in various Chemical and physical processes, measurements of enthalpy changes, Hess's law and its applications, Born-Haber cycle.

Chemical Equilibrium

Equilibrium in Chemical reactions and the equilibrium law, K_p, K_x and K_c and their determination, degree of dissociation, response of equilibrium to temperature, concentration and pressure changes, principle of Le Chatelier and Brown, applications, dissociation in solution, Ostwald dilution law, ionic equilibria, dissolution of solids, solubility product, common ion effect, pH, pOH and buffer solution.

Electrochemical Cells

Electrolytic and Galvanic cells, electrodes, half-cell reaction, cell reaction, cell notation, reduction potentials, e.m.f. of cells, standard hydrogen electrode.

Rates of Chemical Reaction

Measurement of reaction rates, rate equation, order and rate constant, determination of order and rate constants, elementary and complex reactions, molecularity, effect of temperature on the rate of reaction, activation energy, collision theory of reaction rates, catalysis.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental concepts of physical chemistry, including states of matter, gas laws, thermodynamic systems, and basic intermolecular interactions.	L, D, QA	T, ASG, F
CO2	***Explain*** gas laws, kinetic molecular theory, and molecular collisions, and *describe* how these principles govern the behavior of gases and condensed phases.	L, D, QA	T, ASG, F
CO3	**Apply** kinetic theories and rate laws to analyze reaction mechanisms, energy profiles, and factors influencing reaction rates.	L, D, QA	T, ASG, F
CO4	**Analyze the intermolecular force of attraction, intermolecular space and other physical properties.**	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping										
Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3		2							
CO3	3									
CO4	3									
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1.Physical Chemistry, P. W. Atkins & Julio de Paula 2.Physical Chemistry: A Molecular Approach, Donald A. McQuarrie & John D. Simon 3.Principles of Physical Chemistry, Puri, Sharma & Pathania 4.Elements of Physical Chemistry, Peter Atkins & Julio de Paula 5.Chemical Kinetics and Dynamics, J. I. Steinfeld, J. S. Francisco & W. L. Hase
Others	-

Course Code	**0531 CHN 121**		**Course Type**	**Core (Theory)**		**Level 1 Term I**	
Course Title	**Organic Chemistry I**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	This course will offer a fundamental understanding of organic chemistry and help students develop clear concepts related to molecular structure, functional groups, reaction pathways, and the reactivity of organic compounds.						

Course Objective

- Impart preliminary knowledge on the atomic structure, electronic configuration, bond formation of molecules, and shapes of the molecules.
- Give knowledge on the energetics involved in bond formation, transition states, factors governing the rate of reactions and types of reaction.
- Understand different class of organic compounds, their synthesis, nomenclature, physical and chemical properties, and their applications.
- Impart knowledge on the mechanism of different types of addition, substitution, elimination reactions including their stereochemical changes.
- Give preliminary knowledge on detection of organic compounds by chemical test and

characterization by spectroscopic techniques.

Contents

- **Basic Principles of Organic Chemistry**

Atomic structure and Chemical bonding, atomic orbital, molecular orbital, shapes of molecules with reference to alkanes, alkanes, alkynes and arenes, bond angle, bond length and bond energy.

- **Alkanes**

Structure and reactivity of aliphatic hydrocarbons, chain reaction of methane and its mechanism, carbon-carbon single bond compounds, conformation of ethane and butane, optical activity of asymmetric carbon compounds, natural gas, petroleum, gasoline, petrochemicals and petroleum fraction, octane number, antiknocking agent-TEL etc.

- **Alkenes**

Structure and synthesis, electrophilic addition to alkenes, hydrogenation, bromination hydrohalogenation and ozonolysis, homolytic and heterolytic addition of hydrogen halides to unsymmetrical alkenes (Markovnikov and anti-Markovnikov rules) and their mechanism, reaction of alkenes with $KMnO_4$, OsO_4-, peracids etc., polymers of ethane, isoprene (rubber and gutta percha), styrene, tetrafluoro ethene, vinyl chloride etc., geometrical isomerism: cis-trans, E/Z-system, determination of configuration of geometrical isomers.

- **Dienes**

Synthesis, orbital picture of 1, 3-butadiene and cumene, isomerism of 1, 3-butadine-s-cis and s-trans, addition of halogen and hydrogen halides to, 1, 3-butadiene; 1,2 and 1, 4-addition.

- **Alkynes**

Structure and synthesis, acidic properties of alkynes, comparison among alkanes, alkenes and alkynes.

- **Alicyclic Compounds**

Small and normal-size rings, their formation, conformation on stability and reactions, Baeyer's strain theory, cistrans isomerism in alicyclic system.

- **Aromatic Hydrocarbons Arenes**

Structure and resonance of benzene, aromaticity of benzene, Huckel 4n+2 rule, source of benzene, electrophilic substitution in aromatic system-nitration, sulphonation halogenation, alkylation and acylation, aromaticity of some common heterocyclic compounds.

- **Polyaromatic Compounds**

Nomenclature, numbering in the rings and their resonance.

- **Halogeno Compounds**

Chemistry of alkyl-, aryl-, allyl- and vinyl halides, their synthesis and reactions, reactions of halogeno alkanes with alkali-substitution vs elimination, reactions with metals-Grignard and Wurtz reaction, halocarbons-DDT, gammexane, their uses and residual effect in the environment.

- **Hydroxyl Compounds**

Alcohols and phenols, their synthesis and reactions, hybridization of oxygen in alcohols and phenols, hydrogen bonding, resonance, acidity and reactivity of phenols, comparison between alcohols and phenols.

- **Ethers and Epoxides**

A brief description of synthesis and reaction of ethers and epoxides.

- **Carbonyl Compounds**

Synthesis and reactions of aldehydes and ketones, orbital picture, hybridization of carbonyl carbon and carbonyl oxygen, nucleophilic reactions, oxidation and reduction, relative reactivity of carbonyl compounds.

- **Carboxylic Acids**

Orbital picture, hydrogen bonging, synthesis and manufacture of methanoic, ethanoic, ethanedioic and butane-1,4-, dioic acids, preparation of acid halides, acid anhydrides and amides, relative reactivity of carboxylic acid derivatives.

- **Spectroscopic Methods**

A very brief treatment of spectroscopic methods- UV, IR NMR and Mass spectroscopy, their application in organic chemistry with reference to identification of organic compounds.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	**Define** the fundamental principles of bonding, hybridization, and molecular shapes in organic molecules.	L, D, QA	T, ASG, F
CO2	**Classify** major classes of organic compounds based on their structures, properties, and basic synthetic pathways.	L, D, QA	T, ASG, F
CO3	**Explain** the mechanisms of addition, substitution, and elimination reactions, including relevant stereochemical changes.	L, D, QA	T, ASG, F
CO4	**Analyze the** reaction rates, molecular interactions, and characterize different classes of organic compounds.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3									
CO3	3									
CO4	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)	
Learning Materials	
Recommended Readings	1.**A Textbook of Organic Chemistry** by A. Bahl & B.S. Bahl 2.**Organic Chemistry** by R. T. Morrison & R. N. Boyd 3.**Organic Chemistry: Volume 1** by I. L. Finar 4.**Organic Chemistry: Volume 2** by I. L. Finar 5.Vogel's Textbook of Practical Organic Chemistry by A. I. Vogel
Others	-

Course Code	**0531 CHN 161**		**Course Type**	**Core (Theory)**		**Level 1 Term I**	
Course Title	**Fundamentals of Analytical Chemistry**					**Credit Hr**	**2**
Prerequisite	**None**					**Contact Hr**	**2**
Rational	This course will offer a fundamental understanding of analytical chemistry and enhance students' skills in evaluating, interpreting, and applying quantitative and qualitative analytical techniques.						
Course Objective							
• Impart classical and modern concepts of analytical detection, separation and quantification mainly based on the sensitivity and selectivity of different Chemical reactions. • Impart knowledge on sampling and dealing with the sample for analysis, data presentation, significant figure convention and errors in the quantitative analysis. • Deal with the knowledge of Chemical separation and their application for quantitative determination by both gravimetric and solvent extraction methods. • Understand the knowledge of application of different types of reactions such as acid-base reaction, redox reaction, complexation reaction for the quantitative estimation of various species. • Give knowledge on a simple spectrophotometer and its use for quantitative determination.							
Contents							

- **Basic Concepts in Analytical Chemistry**

Classical and modern concepts of analytical detection and quantification, sensitivity, selectivity, specificity, concentration limit, dilution limit etc. of Chemical reactions, sample containers, sample preservation, sampling, sample dissolution, wet ashing and dry ashing, reagents and reactions, group separation, elemental analysis, and analysis of insoluble materials, precision and accuracy, mean and median, types of errors, significant figure convention.

- **Acid-Base Reactions**

Acid-base equilibria and buffers in analytical Chemistry, indicators, titrations of acid-base, titration in non-aqueous solvents - solvent choice and advantages.

- **Redox Reactions**

Oxidation-reduction equilibria in Chemical analysis, redox titration curve, indicators for oxidation-reduction titrations, $KMnO_4$ as a standard oxidant, titrations with $K_2Cr_2O_7$ and cerium (IV), redox titrations involving iodine, iodometric and iodimetric methods.

- **Complexation in Quantitative Analysis**

Complexation of metal ions, complexation equilibria, influence of $[H^+]$ on complexation, metal chelate stability, titration with chelating agent such as EDTA, NTA etc., metallochromic indicators, colour transition with metallochromic indicators, masking and demasking, uses of EDTA titrations.

- **Solvent Extraction in Analytical Chemistry**

Separation processes, liquid-liquid extraction, distribution of solute between solvent pair, effect of number of extractions, batch and continuous extractions, some examples of liquid-liquid extraction.

- **Gravimetric Methods of Analysis**

Principle of gravimetric method, properties of precipitates and precipitating agents, coagulation and peptization of precipitates, treatment of colloidal precipitates, co precipitation and post precipitation, drying and ignition of precipitates, Results and calculation.

- **Spectrophotometric Analysis**

Ultraviolet and visible radiation, absorbance, transmittance, absorptivity, the Beer-Lambert's law, limitations of Beer-Lambert's law, wavelength selection, basic components of a spectrophotometer, qualitative and quantitative analysis, stoichiometric determination of metal-ligand complexes, derivative spectrophotometry.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Define** the fundamental principles and concepts of analytical chemistry, including sampling, measurement, and data representation.	L, D, QA	T, ASG, F
CO2	**Understand** the importance of sample collection, preservation, and proper representation of analytical data according to standard conventions.	L, D, QA	T, ASG, F
CO3	**Apply** appropriate classical or instrumental methods for quantitative analysis, including techniques to eliminate interferences.	L, D, QA	T, ASG, F

CO4	**Analyze** chemical and environmental 2samples using classical titrimetric, separation, or spectrophotometric methods and interpret the results accurately.	L, D, CS, QA	T, ASG, F
(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2								
CO2	3		3							
CO3	3									
CO4	3	3			3					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1.Fundamentals of Analytical Chemistry – Douglas A. Skoog, Donald M. West, F. James Holler & Stanley R. Crouch 2.Quantitative Chemical Analysis – Daniel C. Harris 3.Vogel's Textbook of Quantitative Chemical Analysis – A. I. Vogel 4.Analytical Chemistry: A Modern Approach to Analytical Science – H. Michael Widmer, Robert Kellner, Jean-Michel Mermet, Matthias Otto & Miguel Valcarcel
Others	-

Course Code	**0541 MATH 101**	**Course Type**	**Theory**	**Level 1 Term I**
Course Title	**Differential and Integral Calculus**		**Credit Hr**	**3**
Prerequisite	**None**		**Contact Hr**	**3**
Rational	This course will offer a fundamental understanding of differential and integral calculus and enhance students' skills in analyzing, modeling, and solving mathematical problems involving rates of change and areas under curves			

Course Objective

- Be able to impart basic knowledge on differential and Integral Calculus to solve different problems and other applied problems.
- Developing understanding some of the important aspects of rate of change, area, tangent, normal and volume.
- Be expert in imparting in depth knowledge of functional analysis such as increasing, decreasing, maximum and minimum values of a function

Contents

Part A: Differential Calculus

- **Limit and Continuity:**
  Limit of a function; Basic limit theorems with proofs; Limit at infinity and infinite limit; Continuous and discontinuous functions; Properties of continuous functions on closed and bounded intervals; Horizontal and vertical asymptotes; Intermediate Value Theorem.
- **Differentiation:**
  Derivative of a function; One sided derivative; Techniques of differentiation; Chain rule theorem; Successive differentiation; Leibnitz theorem; Rates of change in Natural and Social Sciences; Related rates; Marginal analysis and approximations with increments; Linear approximations and differentials; Indeterminate forms; L' Hospital's rules.
- **Applications of Differentiation:**
  Concavity and extrema of functions; Curve sketching techniques; Rolle's theorem; Lagrange's and Cauchy's mean value theorems; Optimization problems; Newton's method; Applications to Business, Economics, Biology, Physics, Chemistry and Engineering sciences.
- **Expansion of Functions:**
  Taylor's theorem with general form of the remainder; Lagrange's and Cauchy's forms of the remainder; Taylor's series; Maclaurin's series; Convergence of series and validity regions; Differentiation and integration of series; Validity of Taylor expansions and computation of series.
- **Tangent Lines:**
  Tangents and Normals in Cartesian and Polar form, Equations of Tangent & Normal of functions in parametric form; Pedal Equation of a curve in Cartesian and Polar coordinates.
- **Curvature of Plane and Space Curves:**
  Curvature of intrinsic equations, Cartesian and parametric equations; Radius of curvature and Centre of curvature.
- **Partial Differentiation:**
  Functions of several variables; Graphs of functions of two variables; Limits and continuity; Partial derivatives; Differentiability; Euler's theorem for several variables and its applications; The Chain rule; Partial derivatives with constrained variables;

Part B: Integral Calculus

- **Various Techniques of Integration:**
  Antiderivatives and indefinite integrals; Techniques of integration; Definite integration using antiderivatives; Definite integration using Riemann sums.
- **Properties of Integration:**
  Basic properties; Fundamental theorems of calculus; Mean Value Theorem for integrals; Integration by reduction; Walli's formulae with geometrical interpretation.
- **Applications of Integration:**
  Areas; Volumes of solid by slicing, disks and washers; Volumes by cylindrical shells; Average value of a function; Arc length; Area of a surface of revolution; Applications to Business, Economics, Social Sciences, Biology and Engineering sciences.
- **Improper Integrals:**
  Different types of improper integrals; Test for convergence (comparison, ratio, absolute and conditional); Application to probability distribution; Gamma and beta functions.
- **Parametric and Polar Curves:**
  Arc length for parametric curves; Graphing in polar coordinates; Tangent lines, arc length and area for polar curves; Area and volume of surface by revolving in polar coordinates.
- **Multiple Integrals:**
  Area using double integral; Double integrals in polar form. Volume using triple integrals; Triple integrals in cylindrical and spherical coordinates.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Define** the fundamental concepts of limits, continuity, and differentiability of functions.	L, D, QA	T, ASG, F
CO2	**Understand** the techniques of differentiation and integration and their applications in solving mathematical problems.	L, D, QA	T, ASG, F
CO3	**Apply** methods of calculus to calculate lengths, areas, volumes, centers of gravity, and average values in chemical and physical contexts.	L, D, QA	T, ASG, F
CO4	**Analyze** functions and integrals to model and solve problems involving rates of change and cumulative quantities.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3		3							
CO3	3									
CO4	3		2		2					
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. *Differential and Integral Calculus, Volume 1* – Richard CourantJames Holler & Stanley R. Crouch 2.*Differential and Integral Calculus, Volume 2* – Richard Courant 3.Fundamentals of Mathematics: Differential Calculus – Sanjay Mishra Integral 4.Calculus & Differential Equations (Part 1-2*)* – Dr. Md. Abdul Matin & Bi dhubhushan Chakraborty 5.Integral Calculus Differential Equations – B. C. Das & B. N. Mukherjee
Others	-

Course Code	0223 GEESP101		Course Type	Theory		Level 1 Term I
Course Title	**Ethics and Social Philosophy**				**Credit Hr**	**2**
Prerequisite	**None**				**Contact Hr**	**2**
Rational	This course will offer a fundamental understanding of ethical theories and social philosophy, and enhance students critical thinking skills related to moral reasoning, human values, and societal issues.					

Course Objective
□ Demonstrate an understanding of major ethical theories and their historical foundations. □ Analyze moral problems through the frameworks of classical and contemporary moral philosophy. □ Evaluate philosophical arguments related to justice, rights, equality, freedom, and social obligations. □ Apply ethical principles to contemporary social, cultural, and technological issues.

Contents

Introduction to Ethics

- Definition, scope, and functions of ethics
- Normative vs. descriptive ethics
- Relativism vs. objectivism
- Epistemology, ontology, phenomenology

Classical Ethical Theories

- Classical school of thoughts (Socrates, Plato and Aristotle)
- Early social thinkers (Comte, Spencer, Durkheim, Weber, Marx)
- Comparison and critique of classical theories

Contemporary Ethical Perspectives

- Care ethics
- Moral pragmatism
- Existentialist ethics (Sartre)
- Environmental and sustainability ethics
- Sustainable science and green chemistry

Social Philosophy Foundations

- The nature of society, social order, and social norms
- Concepts of justice, liberty, equality, and rights
- The social contract tradition

Applied Ethics

- Bioethics: autonomy, consent, and human dignity
- Technology and AI ethics
- Human rights and global justice

Ethics in Contemporary Social Contexts

- Gender inequality and social justice
- Disability ethics and inclusion
- Cultural pluralism and multicultural ethics
- Ethics of migration, borders, and global inequality

Ethics, Social Responsibility, and Civic Life

- Moral responsibility in public life
- Digital citizenship and online behavioral ethics
- Community ethics and collective well-being
- Socialization and social institution

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamentals of social philosophy and ethical theories through understanding major ethical theories and their historical foundations.	L, D, QA	T, ASG, F

CO2	**Explain** the key phenomena such as moral problems through the frameworks of classical and contemporary moral philosophy.	L, D, QA	T, ASG, F
CO3	**Apply** ethical principles to contemporary social, cultural, and technological issues.	L, D, QA	T, ASG, F
CO4	**Evaluate** philosophical arguments related to justice, rights, equality, freedom, and social obligations.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3						2	3		
CO2	3	2						3		
CO3	3							3		
CO4	3						2	3		

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Aristotle, *Nicomachean Ethics* (Book I & II) 2. Anthony Giddens, Sociology 7th Edition 3. Simone de Beauvoir, *The Ethics of Ambiguity* (selected sections) 4. Rousseau, *The Social Contract* (Book I) 5. Luciano Floridi, "The Ethics of Information"
Others	-

Course Code	**0541 CHN 122**		**Course Type**	**Core (Sessional)**		**Level 1 Term I**
Course Title	**Organic Chemistry Sessional I**				**Credit Hr**	**1.5**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course will offer a fundamental understanding of practical organic chemistry and enhance students' skills in performing experiments, observing chemical reactions, and interpreting experimental results accurately.					

Course Objective
• Impart fundamental knowledge on dealing with the organic compounds such as purification by different techniques, drying, preservation etc. • Acquaint with the Sessional knowledge of recording melting point, mixed melting point, boiling point etc. • Understand the preparation of different organic compounds or conversion of one compound to the other by adopting different reactions. • Give knowledge on separation and purification by solvent extraction and fractional distillation.
Contents
Simple laboratory techniques and their uses in synthesis 1. Drying and storage of organic compounds. 2. Determination of melting temperature and mixed melting temperature melting temperature curve. 3. Purification of organic compounds by recrystallization. 4. Determination of boiling temperature. 5. Purification by distillation. Azeotropic distillation of mixtures of alcohol and water. 6. Separation of organic compounds by solvent extraction. 7. Preparation of alkene: Cyclohexene from cyclohexanol. 8. Preparation of alkyl halide: t-Butyl chloride from t-butyl alcohol. 9. Preparation of alcohol: t-Butyl alcohol from t-butyl chloride. 10. Oxidation of hydrocarbons: Benzoic acid from toluene. 11. Oxidation of alkene: Adipic acid from cyclohexene. 12. Oxidation of alcohol: Cyclohexanone from cyclohexanol. 13. Acetylation: Acetylation of aniline and salicylic acid. 14. Bromination of phenylamine/phenol, isolation and purification of bromo derivatives. 15. Addition reactions to carbon-carbon double bonds: halogenation of cinnamaldehyde/cinnamic acids.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Understand** the safe handling of fundamental glassware and laboratory instruments used in organic chemistry experiments.	L, D, QA	T, ASG, F
CO2	**Apply** purification techniques—such as recrystallization, solvent extraction, and fractional distillation—to separate and preserve organic compounds effectively.	L, D, QA	T, ASG, F
CO3	**Explain** the preparation of organic compounds or the conversion of one compound into another through appropriate reaction pathways.	L, D, QA	T, ASG, F
CO4	**Determine** the purity of organic compounds by accurately recording their melting or boiling points.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3								
CO2	3				2					
CO3	3									3
CO4	3		2	2						

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1.Vogel's Textbook of Practical Organic Chemistry, 5th Edition — A.I. Vogel 2.Practical Organic Chemistry (CBCS), Part A Dr. Amrit Krishna Mitra
Others	-

Course Code	**0231 LANG 102**		**Course Type**	**Sessional**		**Level 1 Term I**	
Course Title	**Communicative English Sessional**					**Credit Hr**	**1.5**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	This course will offer a fundamental understanding of English communication and enhance students' skills in listening, speaking, reading, and writing for effective academic and professional interactions.						

Course Objective

- To develop the four basics skills of English language, i.e. listening, speaking, reading and writing.
- To enhance students' interpersonal skills through participation in various group interactions and activities.
- To improve students' pronunciation to enhance comprehensibility in both speaking and listening.
- To gain proficiency in crafting well- organized paragraphs and learn to edit and revise both their own as well as peer's writing.

Contents

Speaking: Introduction to Language: Introducing basic skills of language. English for Science and Technology Self-introduction and introducing others: How a speaker should introduce himself to any stranger / unknown person / a crowd. Name, family background, education, experience, any special quality/interest, likings/disliking, etc. Asking and answering questions, Expressing likings and disliking; (food, fashion etc.) Asking and giving directions Discussing everyday routines and habits, Making requests/offers/invitations/excuses/apologies/complaints Describing personality, discussing and making plans(for a holiday or an outing to the cinema), Describing pictures / any incident / event Practicing storytelling, Narrating personal experiences/Anecdotes Telephone conversations (role play in group or pair) Situational talks / dialogues: Practicing different professional conversation (role play of doctor-patient conversation, teacher –student conversation)

Listening: Listening and understanding: Listening, note taking and answering questions; Students will listen to recorded text, note down important information and later on will answer to some questions Difference between different accents: British and American accents; Documentaries from BBC and CNN will be shown and students will try to understand; Listening to short conversations between two persons/more than two.

Reading: Reading techniques: scanning, skimming, predicting, inference; Reading Techniques: analysis, summarizing and interpretation of texts.

Writing: Introductory discussion on writing, prewriting, drafting; Topic sentence, paragraph development, paragraph structure, describing a person/scene/picture, narrating an event Paragraph writing, Compare-contrast and cause- effect paragraph.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Define** the fundamental principles of effective English communication, including grammar, vocabulary, and sentence structure.	L, D, QA	T, ASG, F
CO2	**Understand** the techniques of academic reading, writing, listening, and speaking for professional and academic purposes.	L, D, QA	T, ASG, F
CO3	**Apply** communication strategies to express ideas and opinions clearly and concisely in both oral and written formats.	L, D, QA	T, ASG, F
CO4	**Analyze** different communication situations and adapt language, tone, and style for effective interpersonal and group interactions.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO 1	3									
CO2	3					2				
CO3	3					2				
CO4	3									
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1.Communicative English by Lt Col Md G R Jahangir 2.A Textbook of Communicative & Practical English Grammar & Composition by Mohiuddin Mullick 3.Natural Communicative English (Bangladesh-edition, practical spoken English) by Lt Col Md G R Jahangir
Others	-

Course Code	**0531 CHN 141**		**Course Type**	**Core (Theory)**		**Level 1 Term II**
Course Title	**Principles of Inorganic Chemistry**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course will offer a fundamental understanding of inorganic chemistry and strengthen students' conceptual and problem-solving skills related to atomic structure, periodic properties, chemical bonding, and the behavior of inorganic compounds.					

Course Objective

- Provide fundamental knowledge on development of different theories of atomic structures over time period, electronic configurations and related principle and rules.
- Give knowledge on periodic classification and variation of different properties of elements along the periods and down the groups.
- Impart knowledge on different types and theories of bonding, Born- Haber cycle, Fajan's rule and different shapes of molecules.
- Acquaint with the basic rules of nomenclature of inorganic compounds, types of solids and different types of chemical reactions.
- Give fundamental concepts on different terms, theories and definitions for enabling learners to understand inorganic Chemistry on advanced level.

Contents

- **Atomic Structure**

Atomic nucleus, fundamental particles, nuclear forces, nuclear binding energy, nuclear stability, radioactivity, isotopes, mass spectrometry, cathode rays, mass and charge of an electron, a- particle scattering, Rutherford atom model, Planck's quantum theory, Bohr's theory for hydrogen atom, electromagnetic radiation, absorption and emission spectra, ionization energy from absorption spectrum, emission spectrometer, emission spectrum of atomic hydrogen, dual behaviour of electron, de Broglie equation, Heisenberg's uncertainty principle, quantum mechanics, Schrödinger wave equation for hydrogen atom, wave function and its significance, quantum numbers, atomic orbitals and their energies, shapes and orientation, Pauli exclusion principle, Aufbau principle, Hund's rule, electronic configurations.

- **Periodic Classification**

Periodic law, periodic table, prediction of elements, elements in groups, periods and blocks, naming of all elements, electronic configuration of groups and periods, metals, nonmetals and metalloids, diagonal relationship, periodicity of atomic and molecular properties e.g. ionization energy, electron affinity, electronegativity, atomic/ionic radii, metallic character, melting and boiling points, lattice energy etc., properties of main group elements, usefulness and limitation of periodic table.

- **Chemical Bonds**

Chemical bond, types of Chemical bonds, ionic bond: energetics of ionic bond formation, properties of ionic compounds, factors influencing the formation of ionic bond, radius ratio rule, Born-Haber cycle, Fajan's rule; covalent bond: sigma and pi bond, properties associated with covalent compounds, limitation of covalency, polar covalent bond, Lewis formulation, formal charge, valence shell electron pair repulsion (VSEPR) theory and molecular geometry, valence bond theory, energy change during formation of molecules, hybridization of bond orbitals, molecular orbital theory, bonding and antibonding orbitals and their significance, bond order, stability of molecules, MO diagram of simple diatomic H_2 to Ne_2 molecules, coordination bond, metallic bond, hydrogen bond, van der Waal's forces.

- **Inorganic Nomenclature**

Prefixes and affixes used in inorganic nomenclature, use of enclosing marks, numbers, letters, and italic letters, names for cations, anions, radicals and heteropolyanions, names of acids, salts, and salt like compounds.

- **Solids**

Types of solids, characteristics of crystalline and amorphous solids, unit cell, crystal lattice, seven crystal systems, crystal defects, description of NaCl, CsCl, graphite, diamond and ice structures.

- **Acids and Bases**

Various concepts on acids and bases, conjugate acids and bases, neutralization reactions, acid - base strength, hard and soft acids and bases, hard and soft acids and bases in qualitative analysis, acid - base properties of oxides, hydroxides and salts, effect of structures on acid - base properties.

- **Types of Reactions**

Oxidation - reduction reactions, oxidizing and reducing agents, assigning oxidation states to bounded atoms, redox half reactions, rules for balancing redox reactions, Ellingham diagram, Latimer diagram, and Frost diagram, standard reduction potential, the electrochemical series, disproportionate reactions, double decomposition reactions, Metathetic or precipitation reactions and solubility product principle, common ion effect, acid - base reactions, substitution reactions, condensation reactions, addition reaction, elimination reactions, isomerization reaction, polymerization reactions, nuclear reactions, nuclear disintegration.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Understand** the fundamental structure of atoms, periodic trends, and their influence on the chemical behavior of elements.	L, D, QA	T, ASG, F
CO2	**Describe** the nature of chemical bonding, molecular shapes, and the structural characteristics of crystalline and amorphous solids.	L, D, QA	T, ASG, F
CO3	**Classify** various types of inorganic chemical reactions such as acid–base, redox, and precipitation reactions based on their underlying principles.	L, D, QA	T, ASG, F
CO4	**Apply** core concepts and principles of inorganic chemistry to **solve** problems and interpret phenomena in other branches of chemistry.	L, D, CS, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3									
CO3	3									
CO4	3		2							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1.*Basic Inorganic Chemistry* by Giridhar Sharma 2.*Basic Inorganic Chemistry* by F. Albert Cotton 3.*Concise Inorganic Chemistry* by J. D. Lee 4.*Basic Concepts of Inorganic Chemistry* by D. N. Singh

Others	-

Course Code	0531 CHN 143		Course Type	Core (Theory)		Level 1 Term II
Course Title	**Chemistry of Representative Elements**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course will provide a fundamental understanding of the chemistry of representative elements and inert gases and enhance students' skills in analyzing their properties, bonding, reactivity, and applications in chemical systems.					

Course Objective

- Demonstrate an understanding on basics of s- and p-block elements.
- Discuss the characteristics features of alkali and alkaline earth metals, preparations and uses of alkali and alkaline earth metal compounds and the biological significance of sodium, potassium, magnesium and calcium.
- Explain large scale preparation and properties of some industrially important compounds viz. cement, plaster of Paris, sodium hydroxide, sodium carbonate and sodium bicarbonate, etc.
- Present the principles of p-block element chemistry with an emphasis on synthesis, structure, bonding and reaction mechanisms.
- Describe the properties and uses of inert gases and underlying principles of making their compounds.

Contents

- **Hydrogen**

Isotopes and heavy water, water gas: water gas shift reaction, reducing action, ortho and para hydrogen, binary hydrides and their classification, the hydrogen bond, structure of ice, hydrates and water clathrates, hydrogen: the prospective future fuel.

- **The Alkali Metals**

Occurrence and extraction, comparative properties, ionization energies, alkali metal solutions in liquid ammonia and other solvents, cation sizes and bond polarization, hydration radii and solubilities of salts, diagonal relation between Li and Mg, binary compounds: oxides, hydroxides, salts, complexation of alkali ions, organometallic compounds and crown ethers.

- **The Alkaline Earth Metals**

Occurrence and extraction, comparative properties of the elements, ionization energies, cation sizes and polarization, stability of ionic compounds, diagonal relation between Be and Al, compounds of beryllium and calcium, compounds of other metals, organometallic and complex compounds, minerals of nuclear materials.

- **The Boron Family**

Occurrence and extraction, borates and boric acid, Lewis acid character of BX3 compounds and their elimination reactions, stability of BX_4^- anions, chemistry of the boron hydrides, electron deficient bonds, polyhedral boranes and carboranes, aqua ions, oxo salts, aqueous chemistry of Al to Tl, stability of Tl(I) state.

- **Carbon and Its Congeners**

Allotropes of carbon, lamellar compounds of graphite, catenation, carbanion, carbonium ion, carbene intermediate, carbides. oxides of carbon and carbonic acid, reduction potentials of species having C-O linkage, C-N bond and related compounds, C-S bond, multiple bonding in carbon and silicon, silica, structure of silicates and aluminosilicates, inert pair effect and stability of 2+ oxidation state in the latter elements.

- **The Nitrogen Family**

The elements, electronic structure and oxidation states, compounds of nitrogen, strong triple bond, stability of N_2,nitrogen fixation, nitrides, nitrogen hydrides and their derivatives, NH_3 as a non-aqueous solvent, salts of ammonium ion, hydrazine as a rocket fuel, hydroxylamine, azides, oxides and oxoacids of nitrogen and phosphorus, reduction potentials of species having N-O and P-O linkages, occurrence and allotropes of phosphorus, comparing the valency of N and P, P-N polymers, major uses of phosphorus.

- **The Chalcogens**

General properties, electronic structure, and oxidation states, isotopes, and allotropes of oxygen, oxygen factories of nature, octet and oxygen compounds, SO_2 as non-aqueous solvent, ionic and covalent oxides, mono-,di-, and tri-coordinated oxygen species, ozone: its production and importance in atmosphere, CFCs and destruction of ozone layer, peroxidic and superoxidic compounds, dioxygen as ligand, hemoglobin and dioxygen, occurrence and allotropes of sulfur, oxides and oxoacids, sulfurdioxide as ligand, S-N polymers.

- **The Halogens**

Comparative properties, MO diagrams, colours and physical states of dihalogens, trends in bond dissociation energies, solid form and metallic luster of iodine, occurrence, electrolytic production of F_2 and Cl_2, their uses, recent chemistry of fluorine, pseudohalogens, polyhalogens, interhalogen compounds: classification, structures, physical and Chemical properties, polyhalides, oxides and oxoacids, reduction potentials of species having Cl-O linkage.

- **The Inert Gases**

Discovery of argon, occurrence, recovery and uses, chemistry of noble gases, xenon compound: fluorides, oxides, oxyfluorides, and oxo-acids and their structures, complexes of xenon, krypton compounds, chemistry of radon, clathrate compounds of noble gases.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Define the fundamental concepts, characteristics, and classification of s-block and p-block elements in the periodic table.	L, D, QA	T, ASG, F
CO2	Describe the physical and chemical properties of group I–VII elements and their significance in chemical reactions.	L, D, QA	T, ASG, F

CO3	Explain the applications of inert gases in various chemical systems.	L, D, QA	T, ASG, F
CO4	Analyze trends in reactivity across groups I–VII using atomic structure and electronic configuration to explain periodic variations.	L, D, CS, QA	T, ASG, F
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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3									
CO3	3									
CO4	3		2							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Fundamentals of Inorganic Chemistry by Ananya Ganguly 2.Concise Inorganic Chemistry by J. D. Lee 3.Advanced Inorganic Chemistry, Vol. I by G. D. Tuli 4.Inorganic Chemistry: Principles of Structure and Reactivity by Okhil K. Medhi
Others	-

Course Code	**0541 MATH 103**		**Course Type**	**Theory**		**Level 1 Term II**	
Course Title	**Vector Analysis & Linear Algebra**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**

Rational	This course will provide a fundamental understanding of vector analysis and linear algebra and enhance students' skills in solving problems related to vectors, matrices, and multidimensional geometric and engineering applications.

Course Objective

- Be able to impart basic knowledge on the Vector Analysis, Geometry and Linear Algebra.
- Achieving ability to familiarize the students with the working principle of calculating differentiation and integration of vector valued functions in Cartesian, cylindrical and spherical geometry.
- Be able to provide knowledge on using concept of vector, linear algebra and geometry in chemistry and solve other applied problems.
- Be expert in imparting the depth knowledge on the vector analysis, co-ordinate geometry and linear algebra

Contents

Part A: Linear Algebra & Vector Analysis

Linear Algebra

- **System of Linear Equations and Matrices:** System of linear equations; Elementary row operations; Gaussian elimination; Algebra on Matrices; Invertible matrices; Determinant and its properties; Applications: Balancing chemical equations.
- **Eigenvalues and Eigenvectors of Matrices:** Eigenvalues and eigenvectors; Diagonalization; Cayley-Hamilton theorem.

Vector Analysis

- **Vectors and scalars:** Vectors, scalars, vector algebra, laws of vector algebra, unit vectors, rectangular unit vectors, components of a vector, scalar fields, vector fields.
- **Combination of Vectors:** Linear Dependence and independence of vectors.
- **Product of Vectors**: Scalar or dot products, cross or vector products, geometrical interpretation, physical interpretation, scalar triple products, vector triple product, reciprocal sets of vectors.
- **Vector-Valued Functions of a Single Variable:** Limits, derivatives of vector-valued functions.
- **Differentiation of Vectors:** Gradient, Divergence, Curl and their physical meanings.
- **Integration of Vector:** Line and Surface integrals; Green's theorem; Gauss's theorem; Stokes' theorem.

Part B: Coordinate Geometry

- **Introduction to Coordinate Geometry:** Introduction to geometry, Rectangular co-ordinates, Distance between two points, Angle between two lines, Colinearity of points.
- **Transformation of Coordinates:** Translation and rotation of axes; Transformed coordinates;

Effect of translation and rotation on an equation; Identification of conics using rotation of axes.

- **Pair of Straight Lines**: Homogeneous equation of second degree; Existence and identification of pair of straight lines; Technique to compute pair of straight lines; General equation of second degree, Angle between two lines; Bisectors of angles between two lines; Equation of a pair of perpendicular straight lines to other pair.
- **Conic Sections:** Reduction of equation of conics; Standard equations and properties of parabola, ellipse, and hyperbola; Equations of conics in polar coordinates with applications; Parametric equations of conics; Tangent; Chord of contact; Pole and polar; Conjugate points and lines; Equation of chord in terms of its middle point; Pair of tangents.
- **System of Circles:** Chord of Contact, Pole and Polar of a circle, Radical axes of two circles, Coaxial system of circles, Limiting Points, Orthogonal Circles.
- **Coordinates in Three Dimensions:** Rectangular coordinates system in 3-space; Direction cosines and direction ratios; Projection of a line segment; Distance of a point from a line; Angle between two lines with given direction cosines and direction ratios.
- **The Straight Lines in Three Dimensions:** The plane (angle between two planes, parallel & perpendicular plane, distance of a point from a plane), Symmetrical form of equation of a line; Equation of a line of intersection of two planes; Equation and shortest distance between two skew lines; Coplanar lines; Distance and angle between a straight line and a plane.
- **Standard Forms of Conicoid:** Sphere, paraboloid, ellipsoid, hyperboloid (of one-sheet and two sheets) with sketches.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Define fundamental concepts of vector notation, matrices, and geometric entities in two- and three-dimensional spaces to build a clear mathematical foundation.	L, D, QA	T, ASG, F
CO2	Explain the physical and mathematical interpretations of vectors, vector fields, and matrix operations in relation to scientific and engineering applications.	L, D, QA	T, ASG, F
CO3	Apply appropriate vector and matrix techniques to calculate lengths, areas, volumes, inverse matrices, and to solve systems of linear equations.	L, D, QA	T, ASG, F
CO4	Analyze geometric problems involving straight lines, circles, systems of circles, parabolas, ellipses, and other conic sections using vector and linear algebraic methods.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

	Program Learning Outcome (PO)

Course Learning Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3		3							
CO3	3		3		2					
CO4	3		3	2	3					
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1.An Introduction to Vectors, Vector Operators and Vector Analysis — Pramod S. Joag 2.Vector Analysis, Tensor Analysis and Linear Vector Space — S. P. Kuila 3.Vector, Calculus and Linear Algebra — Ravish Singh 4.Linear Algebra — Surjeet Singh
Others	-

Course Code	**0613 CSE 101**		**Course Type**	**Theory**		**Level 1Term II**
Course Title	**Structured Programming Language**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**

Rational	This course will provide a foundational understanding of structured programming principles and enhance students' problem-solving skills through algorithm design, code implementation, and logical debugging.

Course Objective

- Enable students to apply theoretical concepts of C programming through practical exercises and laboratory tasks.
- Develop and implement simple C programs for solving chemistry-related computational and numerical problems.
- Enhance students' ability to analyze experimental or simulated chemical data using arrays, functions, and file handling in C.
- Foster good programming practices, including proper documentation, commenting, and logical structuring of code

Contents

computer programming
ncepts, Program Development Stages, Structured Programming Language

Number System
Binary, octal, decimal and hexadecimal systems, number representation

ing Structures
Data types and their memory allocation, Operators (includes bitwise operators), Expressions, Basic Input/output;

Control Structure
"if else", "switch", Flow Charts, Loop, Nested Loop

Arrays
One-dimensional array, multi-dimensional array, Character array/ string

Function
Function definition, Function declaration, Function call, Recursion pointers, Pass pointer as arguments, Call by value vs call by reference

User defined data types
Structures, Unions, Enumerations

File I/O and Error Handling
Read write append from files; Exception handling

Introduction to C++
Basic Ideas of OOP- encapsulation, inheritance and polymorphism, Classes and objects

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Define the fundamental concepts of structured programming, including variables, data types, operators, control structures, and functions.	L, D, QA	T, ASG, F

CO2	Explain how algorithms and flowcharts are used to represent problem-solving steps systematically before implementing code.	L, D, QA	T, ASG, F
CO3	Apply structured programming techniques to write efficient C programs using loops, conditionals, arrays, and functions.	L, D, QA	T, ASG, F
CO4	Analyze programming errors and logic flaws to debug, refine, and optimize code for improved performance.	L, D, CS, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3	3		4						
CO3	3									
CO4	3				3					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1.*Structured C/C Plus Plus Programming* by Dr. Mohammad Kaykobad, Dr. Md. Mostofa Akbar & Dr. M. A. Hakim. 2.*Programming in ANSI C* by E. Balagurusamy 3.*The C Programming Language* by Brian W. Kernighan & Dennis M. Ritchie 4.*Programming with C (Schaum's Outlines Series)*
Others	-

Course Code	**0531 CHN 142**		**Course Type**	**Core (Sessional)**		**Level 1 Term II**
Course Title	**Inorganic Chemistry Sessional I**				**Credit Hr**	**3**

Prerequisite	None	Contact Hr	6
Rational	This course will provide a fundamental understanding of qualitative inorganic analysis, inorganic compound preparation, and crystal chemistry, while enhancing students' practical skills in identifying ions, synthesizing inorganic compounds, and examining crystalline materials.		

Course Objective

- Discuss the difference between qualitative and quantitative chemical analysis.
- Become familiar with different volumetric and gravimetric measurements used for quantification in the inorganic laboratory.
- Gain an understanding of the underlying physical and chemical principles in both volumetric and gravimetric analysis of different chemicals.
- Make capable of recording and reporting findings from these experimental processes to a basic, scientific standard.

Contents

- **Data Collection and Processing**

Introduction to analytical balance, volumetric glassware, reagents and standard solutions, calibration of weights and glassware, uncertainty in measurements, accuracy and precision, standard deviation, systematic error, random error, probable error, propagation of error, rounding off, significant figures, primary and secondary standard substances.

- **Volumetric Analysis**

The principle of volumetric analysis, preparation of standard solutions, classifications of methods of volumetric analysis

(i) Neutralization Method: Standardization of sodium hydroxide solution using oxalic acid solution as a primary standard titrant, standardization of hydrochloric acid using standard sodium hydroxide solution, determination of acetic acid content in vinegar, determination of carbonate in washing soda, determination of bicarbonate in baking powder, determination of carbonate and bicarbonate in a mixture, determination of vitamin C in a vitamin C tablet, determination of acetylsalicylic acid in aspirin, determination of total acid and ascorbic acid in lemon juice.

(ii) Oxidation-Reduction Method: Standardization potassium permanganate using standard oxalic acid solution, determination of Fe(II) using standard permanganate solution, determination of Fe(II) using potassium dichromate solution as primary standard titrant, determination of Fe(III) using dichromate solution, determination of Fe(II) and Fe(III) in a Fe(II)-Fe(III) mixture.

(iii) Iodometric Method: Standardization of sodium thiosulphate solution using dichromate solution, iodometric determination of copper, iodometric determination of Fe(III) using Cu_2I_2 as catalyst, iodimetric determination of sulfite, determination of available chlorine in bleaching powder, determining the oxidizing capacity of a household cleanser.

(iv) Precipitation Method: Preparation of standard silver nitrate solution, standardization of ammonium or potassium thiocyanate solution, determination of chloride by Volhard's method.

(v) Complexometric Method: Preparation of standard EDTA solution, complexometric determination of copper using Fast sulphone Black as indicator, zinc and magnesium using Eriochrome Black T as indicator, nickel using murexide as indicator, determination of lead, zinc and copper in a mixture, determination of harness of water, determination of sulphate, determination of aluminium by back titration, determination of calcium by substitution titration, determination of Ca in egg shells.

- **Gravimetric Analysis**

Determination of calcium as oxalate, aluminium as 8-hydroxyquinolate, sulfate as barium sulfate, phosphate as ammonium magnesium phosphate hexahydrate, chromium as barium chromate, sodium as sulfate, nitrate as nitron nitrate, cobalt as $K_3Co(NO_2)_6$.

- **Analysis of Mixtures**

Separation and quantitative determination of copper and nickel, iron and manganese, copper and zinc, iron and calcium, chromium and nickel from the respective binary admixtures using suitable methods.

- **Colorimetric Method of Analysis**

Determination of iron with 1,10-phenanthroline.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Identify** inorganic ions through systematic preliminary and confirmatory tests and follow standard laboratory protocols for accurate analysis.	L, D, QA	T, ASG, F
CO2	**Describe** the structural features of crystalline materials and explain crystal classification, lattice types, and elemental arrangements.	L, D, QA	T, ASG, F
CO3	**Apply** appropriate laboratory techniques to prepare, purify, and preserve selected inorganic compounds using established inorganic synthesis methods.	L, D, QA	T, ASG, F
CO4	**Analyze** experimental observations related to inorganic analysis, compound formation, and crystal chemistry to draw logical and evidence-based conclusions.	L, D, CS, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3	3			2					
CO3	3	3								

CO4	3	3	2							
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1.Vogel's Qualitative Inorganic Analysis — G. Svehla 2.Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis 3.Textbook of Semimicro Inorganic Qualitative Analysis — Dr. K. Nagaraj, Dr. S. Kamalesu, etc 4.Practical Inorganic Chemistry Lab Manual — Dr. A. Padmanabha Rao & Dr. M. Akiful Haque
Others	-

Course Code	**0613 CHN 102**	**Course Type**	**Sessional**	**Level 1 Term II**
Course Title	**Structured Programming Sessional**		**Credit Hr**	**1.5**
Prerequisite	Structured Programming Language		**Contact Hr**	**3**
Rational	This course will provide a fundamental understanding of structured programming practices and enhance students' skills in writing, testing, and debugging programs to solve computational problems efficiently.			
Course Objective				
• Develop and implement simple C programs for solving chemistry-related computational and numerical problems. • Enhance students' ability to analyze experimental or simulated chemical data using arrays, functions, and file handling in C. • Foster good programming practices, including proper documentation, commenting, and logical structuring of code				
Contents				

1. Introduction to computer programming: Programming Concepts, Program Development Stages, Structured Programming Language;

2. Number System: binary, octal, decimal and hexadecimal systems, number representation;

3. Basic programming Structures: Data types and their memory allocation, Operators (includes bitwise operators), Expressions, Basic Input/output;

4. Control Structure: “if else”, “switch”, Flow Charts, Loop, Nested Loop;

5. Arrays: One-dimensional array, multi-dimensional array, Character array/ string;

6. Function: Function definition, Function declaration, Function call, Recursion;

7. Pointer: Different types of pointers, Pass pointer as arguments, Call by value vs call by reference;

8. User defined data types: Structures, Unions, Enumerations;

9. File I/O and Error Handling: Read write append from files; Exception handling;

10.Introduction to C++: Basic Ideas of OOP- encapsulation, inheritance and polymorphism, Classes and objects.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Understand** structured programming techniques to develop, compile, and execute programs that solve basic computational problems.	L, D, QA	T, ASG, F
CO2	**Describe** appropriate programming approaches for solving real-world tasks by documenting code, algorithms, and workflow in laboratory activities.	L, D, QA	T, ASG, F
CO3	Apply structured programming techniques to develop, compile, and execute programs that solve basic computational problems.	L, D, QA	T, ASG, F
CO4	Analyze program logic and identify errors to improve code efficiency, correctness, and performance during debugging.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO 1	3									
CO2	3	2	2	3						
CO3	3	2								
CO4	3				3					
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1.*Structured C/C Plus Plus Programming* by Dr. Mohammad Kaykobad, Dr. Md. Mostofa Akbar & Dr. M. A. Hakim. 2.*Programming in ANSI C* by E. Balagurusamy 3.*The C Programming Language* by Brian W. Kernighan & Dennis M. Ritchie 4.*Programming with C (Schaum's Outlines Series)*
Others	-

Course Code	**CHN 201**	**Course Type**	**Core (Theory)**	**Level 2 Term I**
Course Title	**Electrochemistry**		**Credit Hr**	**3**
Prerequisite	**None**		**Contact Hr**	**3**
Rational	This course provides a foundational understanding of electrolytes, ionic conductance, electrochemical equilibria, and galvanic/electrode processes. It strengthens the student's ability to apply electrochemical principles in analytical chemistry, energy systems, industrial processes, and environmental monitoring.			

Course Objective

The objectives of this course are to:

- Provide basic concepts of electrolytes, ionic conductance, and conductance behavior of weak and strong electrolytes.
- Impart understanding of acid–base equilibria, buffer mechanism, and theories of indicators.
- Acquaint students with galvanic cells, electrode potentials, Nernst equation, and electrical double layer.

- Provide ideas on analytical and industrial applications of electrochemistry including batteries, fuel cells, membrane electrodes, and electrochemical industries.

Contents

Conductance

Weak and strong electrolytes; specific and molar conductance (κ and λ), variation of κ and λ with concentration; measurement techniques; Kohlrausch's law of independent ion migration; transport number and its determination; effect of concentration on transport number; applications in kinetics, acid–base and precipitation titrations, solubility product of sparingly soluble salts, water quality assessment, electrochemical relevance in biology (ion channels, ion pumps).

Acid–Base Equilibria

pH of weak acid/base solutions; Henderson–Hasselbalch equation; theories of acid–base indicators; pKa of indicators; buffer mechanism and buffer capacity; salt hydrolysis.

Theories of Electrolytes

Theory of strong electrolytes; Debye–Hückel limiting law and its tests; activity and activity coefficients; Debye–Hückel–Onsagar equation: applications and limitations.

Galvanic Cells

Half-cells, electrodes, cell reactions, EMF of cells; Nernst equation; standard hydrogen electrode; reference electrodes; concentration cells; methods of EMF measurement (compensation method, high-impedance voltmeters); thermodynamic functions from EMF (ΔG°, equilibrium constant, activities); quinhydrone and ion-selective electrodes.

Applications of Galvanic Cells: Analytical Applications

Feasibility of reactions from EMF; potentiometric titrations; ion-selective electrodes; pH titration; electrogravimetry; rechargeable batteries, dry cells, fuel cells, solar cells; photoelectrochemical hydrogen production.

Electrode Processes

Polarization (concentration, activation, ohmic); polarography; voltammetry.

Industrial Applications of Electrochemistry

Chloro-alkali process, electrometallurgy, corrosion and corrosion protection, electrochemical treatment of industrial waste/effluents.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Describe the behavior of weak and strong electrolytes, conductance terms, Kohlrausch's law and its applications.	L, D, QA	T, ASG, F

CO2	Explain acid–base equilibria, pH, pKa, buffer mechanism, and theories of indicators.	L, D, QA	T, ASG, F
CO3	Demonstrate knowledge on galvanic cells, electrodes, Nernst equation, and thermodynamic functions from EMF.	L, D, QA	T, ASG, F
CO4	Analyze electrode processes, polarization, voltammetry, and industrial/analytical applications of electrochemistry.	L, D, QA, CS	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2		2					
CO2	3		2		2					
CO3	3		3		2				1	
CO4	3	2	3		2				2	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	6. A Textbook of Physical Chemistry – Atkins & De Paula 7. Electrochemistry – Bockris & Reddy 8. Principles of Electrochemistry – Glasstone 9. Electrochemical Methods: Fundamentals and Applications – Bard & Faulkner 10. Modern Electrochemistry – Bockris & Khan
Supplementary Readings	1. Physical Chemistry – P.W. Atkins 2. Electrochemical Systems – Newman & Thomas-Alyea 3. Fundamentals of Analytical Chemistry – Skoog, West, Holler
Others	Scientific articles on batteries, fuel cells, and industrial electrochemistry.

Course Code	CHN 203		Course Type	Core (Theory)		Level 2 Term I	
Course Title	Surface Chemistry, Colloid Science and Phase Equilibria					Credit Hr	2
Prerequisite	None					Contact Hr	2
Rational	This course develops foundational understanding of surface chemistry, adsorption phenomena, colloidal systems, and phase equilibria. It enhances the student’s ability to analyze interfacial properties, prepare and characterize colloids and emulsions, and interpret phase diagrams relevant to real chemical and industrial systems.						

Course Objective

The objectives of this course are to:

- Acquaint students with definitions, classification, and physicochemical properties of interfaces and adsorption.
- Provide understanding of adsorption measurements, adsorption isotherms, and their applications.
- Impart knowledge on preparation, properties, and behavior of colloids, emulsions, and microemulsions.
- Introduce the basic characteristics of nanoparticles, nanostructures, and nanofabrication techniques.
- Provide insight into the phases of substances and phase transition phenomena for single- and multi-component systems.

Contents

Surface Chemistry

Solid surfaces, surface characterization methods, adsorption on solids, measurement of adsorption from gas and solution phases; adsorption isotherms (Langmuir, Freundlich, BET); enthalpy of adsorption; role of adsorption in heterogeneous catalysis.

Adsorption on Liquid Surfaces

Gibbs adsorption equation, surface excess concentration, electrocapillary phenomena; surface films and surface pressure; determination of molecular cross-sectional area; Langmuir trough; Langmuir and Langmuir–Blodgett films: preparation, properties, and characterization; nanofabrication using self-assembled monolayers.

The Colloidal State of Matter

Classification, preparation, and physical properties of colloids; structure and stability; electrical double layer, zeta potential; flocculation and coagulation; electrokinetic phenomena; colloidal electrolytes; micelles and biological membranes; emulsions—preparation, properties, and stability; microemulsions.

Phase Equilibria

Phase rule; one-component systems (water, sulphur); Duhem–Margules equation; completely and partially miscible liquids; two-component solid–liquid systems; efflorescence and deliquescence; vapor pressure of saturated solutions; solid–solid binary systems (alloys), cooling curves; systems with/without compound formation; congruent/incongruent melting points; introduction to ternary systems and triangular diagrams

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Explain physicochemical characteristics of solid surfaces and their interfacial functions.	L, D, QA	T, ASG, F
CO2	Describe adsorption isotherms and determine molecular cross-sectional areas for surfactants.	L, D, QA	T, ASG, F
CO3	Demonstrate understanding of liquid surfaces, surface films, and surfactant behavior.	L, D, QA	T, ASG, F
CO4	Prepare and characterize colloids, emulsions, and microemulsions for practical (sessional) applications.	L, D, QA, CS	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		1		2					
CO2	3		1		3					
CO3	3		1		2					
CO4	3		2		3					
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. Surface Chemistry – Adamson & Gast 2. Colloid and Interface Science – Shaw 3. Introduction to Colloid and Surface Chemistry – Drew 4. Principles of Colloid and Surface Chemistry – Hiemenz & Rajagopalan 5. Physical Chemistry – P.W. Atkins (Surface and Phase Equilibria chapters)
Supplementary Readings	1. Colloidal Dispersions – Russel, Saville & Schowalter 2. Intermolecular & Surface Forces – Israelachvili 3. Nanostructures & Nanomaterials – Guo & Wang 4. Phase Equilibria in Chemical Engineering – Walas
Others	

Course Code	**CHN 241**	**Course Type**	**Core (Theory)**	**Level 2 Term I**
Course Title	**Transition Metal and Coordination Chemistry**		**Credit Hr**	**3**
Prerequisite	**None**		**Contact Hr**	**3**
Rational	This course provides an in-depth understanding of the chemistry of transition and inner transition elements, focusing on their electronic structures, magnetic properties, bonding theories, stereochemistry, stability, and reaction mechanisms of coordination compounds. Through this course, students will develop the conceptual and analytical skills required to interpret the behavior and properties of coordination complexes, and apply bonding theories to explain structure, reactivity, and stability.			
Course Objective				

This course aims to:

- Describe the typical properties of transition and inner transition elements.
- Impart knowledge on major bonding theories in coordination compounds and systematic nomenclature.
- Provide concepts for predicting the stability of metal complexes.
- Explain the stereochemistry and isomerism of coordination compounds.
- Convey mechanisms of inorganic reactions including substitution and redox processes in complexes.

Contents

Transition and Inner Transition Elements

General characteristics of transition metals and inner transition metals, shapes of d and f orbitals, energetics of d and f orbitals as functions of atomic numbers, magnetism in transition metal Chemistry, origin of paramagnetism and diamagnetism, magnetic susceptibility, Curie's law, techniques of magnetic measurements, Gouy balance, lanthanides and actinides oxidation states, atomic and ionic radii of M^{3+} ions, magnetic properties of M^{3+} ions, lanthanide contraction, Chemical reactivity of lanthanides, separation of lanthanide and actinide compounds, comparison between 3d and 4f block elements

Bonding in Coordination Compounds

Classical coordination compounds, double salts and coordination compounds, coordination number, ligand types, Werner's coordination theory, limitations of Werner's postulate, Sidgwick's electronic concept, application of EAN rule, limitations of Sidwick's concept, assumptions of valence bond theory (VBT), hybridization and geometry of complexes, inner orbital and outer orbital octahedral complexes, limitations of VBT, important features of crystal field theory (CFT), orbital splitting and electron spin, factors influencing the magnitude of 10dq, spectrochemical series, crystal field stabilizing energies of dn configuration (n = 0 to 10), magnetic moments, color of transition metal complexes, distortion of octahedral complexes and Jahn-Teller theorem, limitations of CFT, ligand field theory (LFT), molecular orbital theory (MOT), MOT as applied to octahedral complexes, comparison of different theories

Stability of Complex Compounds

Stability, stepwise formation constants and overall formation constants, kinetic vs. thermodynamic stability, labile and inert octahedral complexes, factors affecting the stability of a complex, experimental determination of stability constant and composition of a complex

Nomenclature and Isomers in Coordination Compounds

Names of coordination compounds, use of abbreviated names, four and six coordination preferences isomerism – structural and stereoisomerism in complex compounds, geometrical and optical isomerism in 4- and 6- coordinate complexes, chirality

Reactions and Mechanisms in Coordination Chemistry

Substitution reactions in octahedral complexes, types of substitution reactions, nucleophilic substitution reactions, association, dissociation and interchange mechanisms, factors affecting the rate of substitution reactions, acid and base hydrolysis reactions, the conjugate base mechanism, stereochemistry of octahedral substitution, substitution in square planar complexes, trans effect – theories of trans effect, uses of trans effect, substitution in tetrahedral complexes, fluxionality in coordination compounds

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Describe the chemistry and characteristic properties of transition and inner transition elements.	L, D, QA	T, ASG, F
CO2	Explain major bonding theories (VBT, CFT, LFT, MOT) for complex compounds.	L, D, QA	T, ASG, F
CO3	Apply CFT and MOT to explain magnetic, electronic, and thermodynamic properties of metal complexes.	L, D, QA	T, ASG, F
CO4	Construct molecular orbital diagrams and interpret bonding features of coordination compounds.	L, D, QA, CS	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2		3					
CO3	3		3		3					
CO4	3		2		3					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Inorganic Chemistry — Shriver & Atkins 2. Advanced Inorganic Chemistry — Cotton & Wilkinson 3. Basic Inorganic Chemistry — F. A. Cotton 4. Chemistry of the Elements — Greenwood & Earnshaw

Supplementary Readings	1. Ligand Field Theory — Carl Ballhausen 2. Theoretical Inorganic Chemistry — Day & Selbin 3. Coordination Chemistry — S. F. A. Kettle 4. Transition Metal Chemistry — R. L. Carlin
Others	

Course Code	**MATH 201**		**Course Type**	**Core (Theory)**		**Level 2 Term I**
Course Title	**Differential Equations and Fourier Transform**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course provides foundational understanding of ordinary and partial differential equations, mathematical modeling, and Fourier transform techniques. Students will develop analytical and problem-solving skills needed to model physical systems, solve differential equations, and apply Fourier transform methods in science and engineering.					

Course Objective

- Impart basic knowledge of ordinary and partial differential equations.
- Develop understanding of solution techniques and applications of ODEs and PDEs.
- Provide problem-solving skills through modeling and analytical approaches.
- Build expertise in Fourier series, Fourier integrals, and Fourier transforms for solving boundary-value problems.

Contents

Part A: ODEs

- **Introduction to Differential Equations:** Definition of Differential Equation, Order and Degree; Classification of Differential Equations; Formulation; Modeling Approach, Models and Initial Value Problems, Solution Curves without a solution.
- **First-Order Differential Equations**: Existence and Uniqueness theorem (without proof), Solution of First-order DE's, Linear models, Nonlinear models. Applications of first order DEs,
- **Higher-Order Differential Equations**: Homogeneous and Nonhomogeneous equations, Reduction of order, Homogeneous linear equations with constant coefficients, Cauchy Euler equations, Linear models: BVP, Nonlinear models.
- **Integration in Series**: Basic of power series, Some important facts about power series, ordinary and singular points, series solution about regular singular point $x = 0$ (Frobenius methods), Bessel's functions, Legendre's polynomial, Solution of DEs by methods based on factorization.
- **Systems of Linear Differential Equations**: Matrix form of a linear system, Homogeneous and Nonhomogeneous linear systems, Second order systems and Mechanical applications. Metapopulations, Natural killer cells and Immunity, Transport of Environmental pollutants.

Part B: PDEs & Fourier Transform

PDEs

- **Mathematical formulation** and modeling of physical systems in PDEs, classes of equations, boundary conditions.
- **First order partial differential equations**: Methods for finding general solutions using Lagrange's method, linear and quasi-linear equations, methods of characteristics. Charpit's method, Solution by ODEs method and separation variables.
- **Higher Order PDEs**: Linear PDEs with constant coefficients, Applications of PDEs (Heat equation, Wave equation, Laplace equation).

Fourier Transform

- Real and Complex form of Fourier Series
- Physical application of Fourier Series
- Fourier Integral
- Finite Fourier Transform
- Inverse Fourier Transform
- Applications of Fourier Transform for solving boundary value problems

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Describe the fundamental concepts, classifications, and modeling approaches related to ordinary and partial differential equations.	L, D, QA	T, Q, F
CO2	Explain solution techniques for first-order and higher-order ODEs, including systems of differential equations, power-series methods, special functions, and PDE classifications.	L, D, QA	T, Q, F
CO3	Apply analytical and modeling techniques to solve ODEs, PDEs, and related physical problems using appropriate mathematical methods.	L, D, QA, CS	T, Q, ASG, F
CO4	Compute and apply Fourier series, Fourier integrals, Fourier transforms, and inverse transforms to analyze and solve boundary-value and differential-equation problems.	L, D, QA,	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2							
CO3	3		3							

CO4	3		3								
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)											

Learning Materials	
Recommended Readings	1. Elementary Differential Equations and Boundary Value Problems – W. E. Boyce & R. C. DiPrima 2. Differential Equations with Applications and Historical Notes – G. F. Simmons 3. Partial Differential Equations for Scientists and Engineers – S. J. Farlow 4. Fourier Series and Integral Transforms – Allan Pinkus & Samy Zafrany 5. Advanced Engineering Mathematics – Erwin Kreyszig
Supplementary Readings	1. Ordinary Differential Equations – Morris Tenenbaum 2. Introduction to PDEs – John C. Polking 3. Fourier Transform and Its Applications – Ronald N. Bracewell 4. PDEs and Boundary-Value Problems – P. Duchateau & D. W. Zachmann
Others	

Course Code	**PHY 201**		**Course Type**	**Core (Theory)**		**Level 2 Term I**
Course Title	**Mechanics, Waves and Optics**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course provides foundational knowledge of mechanics, wave motion, and optics, enabling students to understand physical laws that describe the motion of particles, propagation of waves, and behavior of light. It strengthens analytical skills needed for solving real-world physics problems and prepares students for higher-level courses in classical mechanics, electromagnetism, and modern physics.					

Course Objective

- Impart concepts of particle dynamics in one, two, and three dimensions, including Newton's laws, conservation of momentum and energy, work–energy principles, and oscillatory motions such as simple harmonic, damped, and forced oscillations, resonance, and Lissajous figures.
- Acquaint students with wave phenomena in elastic media, principles of superposition, vibrations of strings, Doppler effect, and provide knowledge of rotational dynamics and related experimental methods.
- Impart concepts of coherence in optics, including first-order and higher-order coherence, spatial and temporal coherence, and optical aberrations such as spherical, chromatic, and astigmatism along with their applications.

- Provide knowledge of wave interference, superposition principle, phase and group velocities, Huygens' principle, and classical interference experiments including Young's double-slit, biprism, Newton's rings, and Michelson's interferometer, with analysis of fringe patterns.
- Acquaint students with diffraction phenomena, including Fresnel and Fraunhofer diffraction through single, double, and multiple slits, diffraction gratings, spectrometers, and calculation of resolving power.
- Provide an understanding of polarization phenomena including types of polarization, methods of producing polarized light, Brewster's law, Malus' law, birefringence, wave plates, and optical activity.

Contents

Particle Dynamics

Motion in One Dimension, Motion in Two and Three Dimension, Application of Newton's Law, Conservation of Linear Momentum, Work and Energy. Conservation Laws. Conservative Force. Simple Harmonic Motion. Combination of Two SHM's. Lissajou's Figures. Damped SHM. Forced Oscillation. Resonance. Power and Intensity of Wave Motion, Principle of Superposition.

Wave in Elastic Media

Wave Equation Derivation. Longitudinal vibration. Transverse Waves on Strings. Expressions for plane progressive wave, wave velocity, phase, and group velocity. Differential Equation of a progressive wave and general solution. Energy density of a plane progressive wave. Beats. Doppler Effect. Standing Waves and Normal Modes. Linear bounded medium and classifications. Formation of stationary waves, two cases: fixed and free boundary. Equation of Displacement of medium. Nodal and anti-nodal points of a stationary wave.

Rotational Motion

Toque, Newton's Law of Rotation. Moment of Inertia of Various Soid Bodies. Perpendicular Axis Theorem. Parallel Axis Theorem. Radius of Gyration. Angular Momentum. Rolling Motion without Slipping. Physical Pendulum and Compound Pendulum. Kater's Pendulum. Gyroscopic Motion.

Geometrical Optics

Spherical Aberration. Chromatic Aberration. Astigmatism. Coma and Distortion Aberrations. Lens Maker's Formula and Thin Lens Approximation. Ray Matrices. Applications.

Coherence

First Order Coherence. Coherence Length and Time. Partial Coherence. Mutual Coherence Function. Spatial and temporal coherence Higher Order Coherence.

Interference of Waves

Principle of Superposition. Phase Velocity and Group velocity: Huygens Principle. Young's Experiment. Biprism. Thin Film Interference. Fabry-Perot Interferometer. Anti-Reflection Coatings. Newton's Rings

Michelson's Interferometer. Shapes and Positions of Fringes.

Diffraction

Diffraction. Fresnel and Fraunhofer Diffraction. Single, Double and Multiple, Slits. Diffraction Grating. Spectrometer. Resolving power. Maximum Visible Order. Missing Orders.

Polarization of Light

Polarized and unpolarized light. Representation using electric field vectors. Types of Polarization. Production of Polarized Light. Brewster's law. Malus' law. Polarization by refraction. Polarization by Double Refraction (Birefringence): Ordinary and extraordinary rays, Uniaxial and biaxial crystals, Optic axis, Nicol prism. Wave Plates and Retardation Plates. Optical Activity: Specific rotation, Polarimeter.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Analyze particle motion in one, two-, and three-dimensions using Newton's laws, conservation principles, and work–energy relations, and solve problems involving simple harmonic motion, damped and forced oscillations, resonance, and Lissajous figures.	L, D, QA	T, ASG, F
CO2	Explain and apply the principles of wave propagation in elastic media, including superposition, longitudinal and transverse waves, phase and group velocities, beats, Doppler effect, standing waves, and normal modes.	L, D, QA	T, ASG, F
CO3	Apply principles of rotational dynamics to calculate torque, angular momentum, moment of inertia of rigid bodies, use parallel and perpendicular axis theorems, analyze motion of pendulums including Kater's pendulum, and interpret geometrical optics systems including aberrations and ray matrices.	L, D, QA	T, ASG, F
CO4	Explain and analyze optical interference, coherence (first- and higher-order, spatial and temporal), diffraction phenomena through apertures and gratings, polarization of light, and interpret results from classical optical experiments such as Young's double-slit, Newton's rings, and Michelson's interferometer.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							

CO2	3		2								
CO3	3		3								
CO4	3		3								

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	1. Fundamentals of Physics — R. Resnick, D. Halliday, J. Walker (10th Ed.) 2. Physics — Resnick, Halliday, Krane 3. Classical Mechanics — H. Goldstein 4. Vibrations and Waves — A. P. French 5. Fundamentals of Optics — Francis A. Jenkins & Harvey E. White 6. Introduction to Modern Optics — Grant R. Fowles 7. Optics — Eugene Hecht 8. Principles of Optics — Born & Wolf (7th Ed.) 9. Fundamentals of Physics — Halliday–Resnick–Walker (4th Ed.)
Supplementary Readings	
Others	

Course Code	**CHN 242**		**Course Type**	**Core (Sessional)**		**Level 2 Term I**
Course Title	**Inorganic Chemistry Sessional II**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course provides practical skills necessary for quantitative chemical analysis using volumetric, gravimetric, and colorimetric techniques. Students will learn to handle analytical instruments, perform accurate measurements, apply chemical principles in quantitative determinations, and develop scientific reporting skills required in laboratory-based chemical analysis.					

Course Objective

- Discuss differences between qualitative and quantitative chemical analysis.
- Familiarize students with volumetric and gravimetric techniques used in inorganic laboratories.
- Enable understanding of physical and chemical principles underlying analytical methods.
- Develop skills in recording, processing, and reporting experimental data according to scientific standards.

Contents

Data Collection and Processing

Introduction to analytical balance, volumetric glassware, reagents and standard solutions, calibration of weights and glassware, uncertainty in measurements, accuracy and precision, standard deviation, systematic error, random error, probable error, propagation of error, rounding off, significant figures, primary and secondary standard substances.

Volumetric Analysis

The principle of volumetric analysis, preparation of standard solutions, classifications of methods of volumetric analysis

(i) Neutralization Method: Standardization of sodium hydroxide solution using oxalic acid solution as a primary standard titrant, standardization of hydrochloric acid using standard sodium hydroxide solution, determination of acetic acid content in vinegar, determination of carbonate in washing soda, determination of bicarbonate in baking powder, determination of carbonate and bicarbonate in a mixture, determination of vitamin C in a vitamin C tablet, determination of acetylsalicylic acid in aspirin, determination of total acid and ascorbic acid in lemon juice.

(ii) *Oxidation-Reduction Method:* Standardization potassium permanganate using standard oxalic acid solution, determination of Fe(II) using standard permanganate solution, determination of Fe(II) using potassium dichromate solution as primary standard titrant, determination of Fe(III) using dichromate solution, determination of Fe(II) and Fe(III) in a Fe(II)-Fe(III) mixture.

(iii) *Iodometric Method:* Standardization of sodium thiosulphate solution using dichromate solution, iodometric determination of copper, iodometric determination of Fe(III) using Cu_2I_2 as catalyst, iodimetric determination of sulfite, determination of available chlorine in bleaching powder, determining the oxidizing capacity of a household cleanser.

(iv) *Precipitation Method:* Preparation of standard silver nitrate solution, standardization of ammonium or potassium thiocyanate solution, determination of chloride by Volhard's method.

(v) *Complexometric Method:* Preparation of standard EDTA solution, complexometric determination of copper using Fast sulphone Black as indicator, zinc and magnesium using Eriochrome Black T as indicator, nickel using murexide as indicator, determination of lead, zinc and copper in a mixture, determination of harness of water, determination of sulphate, determination of aluminium by back titration, determination of calcium by substitution titration, determination of Ca in egg shells.

Gravimetric Analysis

Determination of calcium as oxalate, aluminium as 8-hydroxyquinolate, sulfate as barium sulfate, phosphate as ammonium magnesium phosphate hexahydrate, chromium as barium chromate, sodium as sulfate, nitrate as nitron nitrate, cobalt as $K_3Co(NO_2)_6$.

Analysis of Mixtures

Separation and quantitative determination of copper and nickel, iron and manganese, copper and zinc, iron and calcium, chromium and nickel from the respective binary admixtures using suitable methods.

Colorimetric Method of Analysis

Determination of iron with 1,10-phenanthroline.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Describe laboratory equipment, measurement techniques, analytical errors, and the principles underlying volumetric, gravimetric, and colorimetric quantitative analyses.	L, D, QA	Q, ASG, F
CO2	Explain the chemical principles, indicators, redox systems, complexation reactions, and precipitation mechanisms involved in quantitative inorganic analytical methods.	L, D, QA	Q, ASG, F
CO3	Perform accurate quantitative analyses using volumetric, gravimetric, and colorimetric procedures, including standardization, titration, separation, and determination of inorganic species.	L, D, EXP, QA	PR, ASG, F
CO4	Analyze, interpret, and report experimental data with appropriate error analysis, significant figures, calibration, and scientific documentation standards.	L, D, QA, CS	ASG, Pr, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2		2	2				
CO2	3	2	2		2	2				

CO3	3	3	3		3	2				
CO4	3	3	3		3	3				

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	1. A.I. Vogel, Quantitative Inorganic Analysis 2. Harris, Quantitative Chemical Analysis 3. Skoog, West & Holler, Fundamentals of Analytical Chemistry
Supplementary Readings	1. Christian, Analytical Chemistry 2. Day & Underwood, Quantitative Analysis
Others	

Course Code	**CHN 205**		**Course Type**	**Core (Theory)**		**Level 2 Term II**
Course Title	**Chemical Thermodynamics**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course introduces the fundamental principles of thermodynamics and their applications to physical and chemical processes. Students will develop a strong conceptual understanding of thermodynamic quantities, energy transformations, phase behaviour, chemical equilibria, and the feasibility of reactions, enabling them to solve real-world chemical problems.					

Course Objective

- Impart knowledge on the laws of thermodynamics and the limits of conversion of heat into work and vice versa.
- Acquaint students with key thermodynamic functions such as enthalpy, entropy, Helmholtz and Gibbs free energies.
- Provide understanding of thermodynamic derivations, especially for colligative properties.
- Introduce foundational concepts related to phase rule, phase diagrams, and phase equilibria.

Contents

Thermodynamics

Review of the first law of thermodynamics, temperature dependence of enthalpy, the concept of the second law of thermodynamics, the direction of spontaneous change, dispersal of energy, heat engines, Carnot cycle, search for a state function, entropy, Clausius inequality, changes in U, H, and S with T and P, criterion for equilibrium in closed systems, Helmholtz and Gibbs functions, heat engines, refrigerator and heat pumps, properties of exact differentials, chain rule, Maxwell's relations: reversible, irreversible, adiabatic and isothermal process, general expression for C_p-C_v, Joule-Thomson expansion: inversion temperature, thermodynamic derivation, experimental determination of Joule-Thomson coefficient, internal pressure, temperature and pressure dependence of Gibb's function, chemical potential and fugacity, Euler's theorem, partial molar quantities and their determinations, Gibb's-Duhem equation, thermodynamics of mixing, chemical potential in mixtures

Third Law of Thermodynamics

Nernst heat theorem, statement of the third law, absolute entropy, applications and limitations of third law

Phase Equilibrium

Phase, component and degrees of freedom, phase rule, thermodynamic interpretation of phase diagram of water, thermodynamics of phase change, Clapeyron and Clausius-Clapeyron equations, thermodynamic derivation of colligative properties: depression of freezing point, elevation of boiling point and osmotic pressure.

Chemical Equilibrium

Extent of reaction, reactions and the Gibb's function, the equilibrium law, thermodynamic equilibrium constant, equilibrium constant from thermal data, exergonic and endergonic reactions, coupled reactions, feasibility of reactions, Ellingham's diagram, thermodynamics of ATP, biological energy conversion synthesis of proteins and the oxidation of glucose.

Applications of Thermodynamic Principles

Energy conversion, efficiencies of power plants: possibilities and limitations of the heat engine, energy balance in a closed system, energy balance in a reacting system, fuels and combustion, adiabatic flame temperature, ignition, flash point.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Describe the fundamental laws of thermodynamics, key thermodynamic quantities, and their roles in chemical and physical processes.	L, D, QA	T, Q, ASG, F
CO2	Explain the mathematical relationships, equations, and thermodynamic functions—including Gibbs, Helmholtz, chemical potential, fugacity, and partial molar quantities.	L, D, QA	T, Q, ASG, F
CO3	Apply thermodynamic principles to solve problems related to phase equilibria, colligative properties, energy conversion, and reaction feasibility.	L, D, QA, CS	T, ASG, F
CO4	Analyze chemical and physical systems using thermodynamic criteria, evaluating spontaneity, equilibrium, energy efficiency, and thermodynamic parameters.	L, D, QA, CS	T, ASG, Pr, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2							
CO3	3		3							
CO4	3		3							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Atkins' Physical Chemistry – P. Atkins & J. de Paula 2. ThTermodynamics for Chemists – S. Glasstone 3. Chemical Thermodynamics – T. L. Hill
Supplementary Readings	1. Introduction to Chemical Thermodynamics – R. C. Reid 2. Physical Chemistry – Ira Levine
Others	

Course Code	**CHN 221**		**Course Type**	**Core (Theory)**		**Level 2 Term II**	
Course Title	**Organic Chemistry II**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	This course provides a comprehensive understanding of organic compounds containing carbon–nitrogen, carbon–sulfur, carbon–phosphorus, and metal–carbon bonds. It builds the foundation for studying heterocyclic systems, organometallic reagents, and dye chemistry, enabling students to analyze structures, reactivity, and synthetic applications of various organic systems.						

Course Objective

- Provide fundamental concepts on nitrogen-containing organic compounds, including their preparation, structure, and properties.
- Introduce organo-sulfur and organo-phosphorus compounds and their chemical behaviours.
- Acquaint students with the synthesis, properties, and applications of organometallic and heterocyclic compounds.
- Impart knowledge on the classification, theory of colour, and synthesis of different classes of dyes.

Contents

Nitro and Nitroso Compounds

Synthesis, resonance, reactivity and reactions of aliphatic and aromatic nitro and nitroso compounds. Reduction of nitro compounds

Amino Compounds

Synthesis, physical and chemical properties of amino compounds, basicity of amines, reactions of amino compounds, diazonium, azo and hydrazo compounds, uses with special emphasis on synthetic utility of diazonium compounds, separations of primary, secondary and tertiary aliphatic amines, quaternary compounds and N oxides, oxidation of amines, optical activity of quaternary nitrogen containing compounds, azides, enamines

Other Compounds Containing Carbon-Nitrogen Bond

Structure, shape, synthesis, physical and chemical properties of nitriles, isonitriles, thiocyanates, carbamates and ureas, imines and oximes and related compounds

Organo-Sulphur and Organo-Phosphorus Compounds

Structure, shape, synthesis, physical and chemical properties of thiols, alkyl-, dialkyl-, alkylaryl phosphines and sulphides, phosphonium salts, alkyl and aryl thioacids, alkyl and aryl sulphonic acids, sulphonates and sulphamic acid, optical activity of phosphorus and sulphur compounds

Organometallic Compounds and Their Uses in Organic Synthesis

Synthesis of organometallic compounds containing lithium, magnesium, copper, cadmium, zinc and their synthetic utility

Heterocyclic Compounds

Synthesis, structure, physical and chemical properties of heterocyclic compounds: pyridine, pyrrole, furan, thiophane, quinoline and isoquinoline, heterocyclic systems containing both N and S and both N and O: a few examples and their chemistry.

Dyes

Theory of color and constitution, classification of dyes and synthesis of some typical dyes: methyl orange, Congo red, Malachite green, crystal violet, indigo, Rosaline, phenolphthalein, rhodamine B, alizarin and thymol Blue.			
Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Describe the preparation, structure, and chemical properties of nitrogen-containing organic compounds including nitro, nitroso, amino, and carbon–nitrogen functional groups.	L, D, QA	T, Q, ASG, F
CO2	Explain the structural features, reactivity patterns, and synthetic applications of organo-sulphur and organo-phosphorus compounds.	L, D, QA	T, Q, ASG, F
CO3	Analyze the synthesis, reactivity, and applications of organometallic and heterocyclic compounds in organic transformations.	L, D, QA, CS	T, ASG, F
CO4	Interpret the theory of colour and constitution of dyes and outline the synthesis and chemical behaviour of major dye classes.	L, D, QA, CS	T, ASG, F
(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2		2					
CO3	3		3		3					
CO4	3		3		2					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Morrison & Boyd — Organic Chemistry 2. Carey & Sundberg — Advanced Organic Chemistry 3. Clayden, Greeves & Warren — Organic Chemistry
Supplementary Readings	1. Smith — Organic Chemistry 2. Finar — Organic Chemistry, Vol. 2

Others	

Course Code	CHN 223		Course Type	Core (Theory)		Level 2 Term II	
Course Title	**Stereochemistry of Organic Compounds**					**Credit Hr**	**2**
Prerequisite	**None**					**Contact Hr**	**2**
Rational	This course introduces the foundational concepts of stereochemistry, including optical activity, stereoisomerism, chirality, conformational behaviour, geometrical isomerism, and the stereochemistry of cyclic and polycyclic systems. It enables students to analyze three-dimensional arrangements of atoms in organic molecules and relate stereochemistry to structure, reactivity, and physical properties.						

Course Objective

- Provide fundamental knowledge of stereoisomers, their three-dimensional representation, and projection formulas.
- Impart understanding of chirality, optical activity, and optical isomerism.
- Demonstrate geometric isomerism in various molecular frameworks and its effect on physical properties.
- Develop knowledge of conformation, conformational analysis, and configurational assignments.
- Introduce stereochemical features of fused-ring and bicyclic organic systems.

Contents

Fundamentals of Stereochemistry

Stereochemistry and stereoisomerism, stereochemical representation of structures (Fischer projection, Newman, Sawhorse, conversion among these forms).

Optical Activity and Optical Isomerism

Cause of optical activity, chirality (asymmetry and dissymmetry), symmetry elements, optical isomerism, diastereoisomers, enantiomers, epimers, anomers, meso and racemic compounds, racemic modifications and their resolution, atropisomerism: biphenyls, allenes and spirans.

Geometrical Isomerism

Conditions, configurations of geometrical isomers- cis-trans, syn-anti, E/Z system, physical properties and configurational assignments of geometrical isomers, interconversion of geometrical isomers, geometrical isomerism of polyenes, carbonnitrogen, nitrogen-nitrogen double bonds and cyclic compounds (cistrans isomerism in substituted cyclohexane).

Conformation and Conformational Analysis

Conformations and conformers, conformations of ethane, propane, n-butane and butane- 2,3-diol, cyclohexane, methyl- and dimethylcyclohexanes, conformations of cyclobutane, cyclopentane and cyclohexane and their stability, conformation of mono and disubstituted cyclohexanes (1,3-diaxial interaction, butane-gauche interaction).

Configuration

D and L, threo and erythro, R and S absolute configurations, determination of the configurations of simple organic compounds, absolute and relative configurations and their correlation.

Stereochemistry of the Fused-Ring System and Bicyclic System

Stereochemistry of decalines, fused- and bicyclic bridges-ring systems, Bredt's rule and its exception in flexible ring systems

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Describe the fundamental concepts of stereochemistry, including chirality, stereochemical representations, and different types of stereoisomers.	L, D, QA	T, ASG, F
CO2	Explain optical activity, symmetry, optical isomerism, racemization, resolution, and atropisomerism in various classes of organic compounds.	L, D, QA	T, ASG, F
CO3	Analyze geometrical and conformational isomerism, including preferred conformations, configurational assignments, and stereochemical behaviour of substituted alkanes and cycloalkanes.	L, D, QA, CS	T, ASG, F
CO4	Determine absolute and relative configurations (R/S, D/L, threo/erythro) and evaluate the stereochemistry of fused-ring and bicyclic systems, including Bredt's rule.	L, D, QA, CS	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2							
CO3	3		3		2					
CO4	3		3		3					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	4. Eliel & Wilen — Stereochemistry of Organic Compounds 5. Clayden, Greeves & Warren — Organic Chemistry 6. Morrison & Boyd — Organic Chemistry
Supplementary Readings	3. Finar — Organic Chemistry 4. Nasipuri — Stereochemistry of Organic Compounds
Others	

Course Code	**CHN 281**		**Course Type**	**Core (Theory)**		**Level 2 Term II**	
Course Title	**Fundamentals of Nanoscience**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	Nanoscience is an emerging interdisciplinary field that deals with materials and phenomena at dimensions typically between 1–100 nm. Understanding nanoscale principles is essential for advancements in materials science, electronics, medicine, and energy technologies. This course provides foundational knowledge of nanoscale behaviour, synthesis strategies, and applications, preparing students for advanced studies and research in nanotechnology while creating awareness of societal and ethical issues associated with nanomaterials.						

Course Objective

The objectives of this course are to:

- Provide fundamental knowledge on the definition, scope, and historical development of nanoscience, including major discoveries.
- Impart understanding of the unique phenomena and behaviour of materials at the nanoscale.
- Acquaint students with the types, properties, and classifications of nanomaterials.
- Provide an overview of fundamental synthesis approaches and characterization techniques.
- Explore applications of nanomaterials across different fields and discuss societal, safety, and ethical implications.

Contents

Introduction to Nanoscience

Definition of nanoscience and nanotechnology, scale and scope (1-100 nm), historical perspective and development, contribution of Richard Feynman, overview of key discoveries: fullerenes, carbon nanotubes, graphene, quantum dots. The significance of the nanoscale.

Nanoscale Phenomena and Properties

Unique behaviour at the nanoscale, surface area to volume ratio, quantum confinement effect, size-dependent properties. Properties of nanomaterials: optical (e.g., plasmon resonance), electronic, magnetic, mechanical, thermodynamic, and chemical reactivity.

Types of Nanomaterials

Classification based on dimensionality: zero-dimensional (0D) - nanoparticles, quantum dots; one-dimensional (1D) - nanorods, nanowires, nanotubes; two-dimensional (2D) - nanofilms, nanolayers; three-dimensional (3D) - nanocrystalline materials. Nanocluster, metal-nonmetal transitions and geometric shell model of nanocluster. Introduction to nano-biomaterials.

Synthesis and Characterization of Nanomaterials

Top-down vs. bottom-up fabrication approaches. Overview of nano synthesis and characterization.

Applications of Nanomaterials

Examples of applications in electronics, sensors, energy, environmental remediation, medicine, manufacturing, and catalysis.

Societal Impact and Safety

Impact of nanotechnology on society and economy. Introduction to nano toxicology: factors affecting toxicity, routes of exposure. Environmental, health, and safety concerns. Ethical, legal, and social implications of nanomaterials.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain the fundamental concepts, history, and significance of nanoscience and nanoscale materials.	L, D, QA	T, ASG, F
CO2	Classify various types of nanomaterials based on dimensionality and structural features.	L, D, QA	T, ASG, F
CO3	Describe nanoscale phenomena and size-dependent physical and chemical properties of nanomaterials.	L, D, QA	T, ASG, F
CO4	Distinguish between top-down and bottom-up synthesis approaches and identify major characterization techniques.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		2							
CO2	3		3							
CO3	3		2							
CO4	3		3		2			2	2	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. **Textbook of Nanoscience and Nanotechnology** — B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath, James Murday 2. **Introduction to Nano: Basics to Nanoscience and Nanotechnology** — Amretashis Sengupta & Chandan Kumar Sarkar 3. **Nanomaterials and Nanochemistry** — Catherine Bréchignac, Philippe Houdy, Marcel Lahmani
Supplementary Readings	
Others	

Course Code	**PHY 201**		**Course Type**	**Core (Theory)**		**Level 2 Term II**	
Course Title	**Electricity and Magnetism**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	This course provides foundational and advanced concepts of electrostatics, magnetostatics, electric circuits, electromagnetic induction, AC/DC circuit behavior, Maxwell’s equations, electromagnetic waves, and basic electronics. It strengthens the analytical and problem-solving skills required to understand electric and magnetic fields, their interactions, and applications in electrical devices and modern technologies.						

	Students develop the ability to interpret physical laws, perform calculations, and relate theoretical principles to practical systems.

Course Objective

The objectives of this course are to:

- Provide understanding of electrostatics and magnetostatics, including electric and magnetic fields, Gauss's law, dipoles, dielectrics, capacitance, energy storage, and magnetic materials with B–H curves.
- Impart principles of direct and alternating currents, circuit laws, resistance combinations, Wheatstone bridge, transients, LCR circuits, power factor, Q-factor, transformers, and thermoelectric effects.
- Acquaint students with electromagnetic induction, inductance, Faraday's law, Biot–Savart law, Ampere's law, Lorentz force, and applications in circuit components and devices such as galvanometers and CRT.
- Provide fundamental concepts of semiconductors, energy bands, p-n junctions, rectification, diode characteristics, and basic electronic devices to prepare learners for advanced studies in classical and modern electronics.

Contents

Electric Field and Coulomb's Law

Coulomb's law, quantization of charge, charge conservation. Electric field due to a point charge, electric dipole, line of charge, charged disk. A point charge in electric field. Dipole in an electric field.

Gauss' Law

Electric flux. Gauss' law. Application of Gauss' law: cylindrical symmetry, planar symmetry, spherical symmetry.

Electric Potential

Electric potential. Equipotential surface. Potential due to a charged particle, electric dipole, continuous charge distributions. Calculation of electric field from potential. Electric potential energy.

Capacitance

Capacitor and capacitance. Capacitors in parallel and series. Energy stored in an electric field. Capacitors with dielectrics. Dielectrics and Gauss' law.

Current, Resistance and Circuits

Electric current and density. Resistance and resistivity. Ohm's law. Kirrchoff's law. Power in electric circuits. Single loop circuits. Multi loop circuits. The ammeter and the voltmeter. RC circuits.

Magnetic Fields

Magnetic field. Biot Savart law. The hall effect. Circulating charged particle. Magnetic force on a current carrying wire. Torque on a current loop. Magnetic dipole moment. Magnetic field due to currents, force between two parallel currents, Ampere's law, current carrying coil as a magnetic dipole.

Induction and Inductance

Faraday's law and Lenz law. Induction and energy transfer. Types of inductances. RL circuits. Energy stored in magnetic field. Energy density.

Electromagnetic Oscillations and Alternating Current

LC oscillations. Damped oscillations in RLC circuit. Forced oscillations. Transformers.

Maxwell's Equations and Magnetism of Matter

Gauss' law for magnetic fields. Induced magnetic field. Displacement current. Magnets, diamagnetism, paramagnetism and ferromagnetism. Magnetization. B-H curve. Hysteresis loop.

Electromagnetic Waves

EM waves. Energy transport. Poynting vectors. Radiation pressure. Polarization.

Basic Electronics

Semiconductors, energy bands, p-n junctions, rectification: full wave and half wave, diode characteristics and basic electronic devices

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Apply Gauss's law in electrostatics and magnetostatics, compute electric and magnetic fields and potentials for various charge distributions, analyze capacitors, dielectrics, energy storage, and interpret B–H curves of magnetic materials.	L, D, QA	T, ASG, F
CO2	Solve DC and AC circuits using Ohm's law, Kirchhoff's laws, resistance combinations, Wheatstone bridge, RC and LCR circuits, power factor, Q-factor, and transformers.	L, D, QA	T, ASG, F
CO3	Apply electromagnetic principles including Biot–Savart law, Ampere's law, Faraday's law, inductance, and Lorentz force, and explain the working of devices such as galvanometers, thermoelectric systems, and CRT.	L, D, QA	T, ASG, F
CO4	Explain semiconductor physics including energy bands, intrinsic/extrinsic semiconductors, p-n junction behavior, diode characteristics, and design rectifier circuits.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

	Program Learning Outcome (PO)

Course Learning Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3		2					
CO2	3		3		2					
CO3	3		3		2					
CO4	3		3		2					
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. Fundamentals of Physics — R. Resnick, D. Halliday, J. Walker 2. Physics — Resnick, Halliday, Krane 3. Foundations of Electromagnetic Theory — J. Reitz, F. Milford, R. Christy 4. Electronic Devices and Circuits — David A. Bell 5. Basic Electronics for Scientists — Brophy 6. Introduction to Electrodynamics — D. J. Griffiths
Supplementary Readings	
Others	

Course Code	**CHN 202**	**Course Type**	**Core (Sessional)**	**Level 2 Term II**	
Course Title	**Physical Chemistry Sessional I**			**Credit Hr**	**3**
Prerequisite	**None**			**Contact Hr**	**3**
Rational	This course provides hands-on experience with fundamental physical chemistry experiments. It aims to strengthen students' understanding of theoretical concepts such as kinetics, thermochemistry, chemical equilibrium, colligative properties, and electrochemistry through practical implementation and report writing.				

Course Objective
▪ Impart basic knowledge on the development of different theories in physical chemistry based on experimental data. ▪ Train students to carry out simple experiments in kinetics, thermochemistry, chemical equilibrium, colligative properties, and electrochemistry. ▪ Develop skills in scientific writing and report presentation based on experimental observations. ▪ Promote analytical thinking and problem-solving through practical investigations.

Contents

Determination of Molecular Weights

Volatile liquids and nonvolatile solids.

Experiments Involving Equilibrium

(a) Determination of partition coefficient.
(b) Determination of equilibrium constant of a reaction.
(c) Determination of molecular association and dissociation.
(d) Determination of solubility of a solute at different temperatures.

Thermochemical Measurements

(a) Determination of heat of neutralization of a strong base by a strong acid.
(b) Experiments involving the application of Hess's law.

Electrochemical Measurements

(a) Measurement of cell constant of a conductance cell.
(b) Measurement of specific and molar conductance.
(c) Conductometric titration.
(d) Measurement of e.m.f. and standard electrode potential.
(e) e.m.f. titration.
(f) pH-titration.

Study of Molecular Structure by Measurements of Some Physical Properties viz.

(a) Viscosity and density.
(b) Surface tension.
(c) Vapor pressure.

Measurement of the Colligative Properties of Solutions

(a) Depression of freezing point of water.
(b) Elevation of the boiling point of a liquid.

Experiments Involving Kinetics (a) Kinetic study of a clock reaction. (b) Effect of temperature on reaction rates.			
Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Follow kinetics of reactions and evaluate the effect of temperature on reaction rates.	EXP, D	R, ASG, T
CO2	Explain partition coefficient, solute distribution in two immiscible solvents, and determination of equilibrium constant.	EXP, D, QA	R, ASG, T
CO3	Determine molecular properties like viscosity and molecular diameter through experimental measurements.	EXP, D	R, ASG, Pr
CO4	Explain the conducting behavior of strong and weak electrolytes and perform conductometric and pH-metric titrations.	EXP, D	R, ASG, T
(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2								
CO2	3		2							
CO3	3			3						
CO4	3			3						

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Physical Chemistry, P. Atkins and J. de Paula 2. Experiments in Physical Chemistry, R.C. Das and B. Behera 3. Advanced Practical Physical Chemistry, J.B. Yadav 4. Vogel's Textbook of Quantitative Chemical Analysis, G.H. Jeffery et al.
Supplementary Readings	1. Experimental Physical Chemistry, S. Glasstone 2. Practical Physical Chemistry, A. Findlay
Others	

<table>
<tr><td>Course Code</td><td>PHY 202</td><td></td><td>Course Type</td><td>Core (Sessional)</td><td></td><td colspan="2">Level 2 Term II</td></tr>
<tr><td>Course Title</td><td colspan="5">Physics Sessional</td><td>Credit Hr</td><td>3</td></tr>
<tr><td>Prerequisite</td><td colspan="5">None</td><td>Contact Hr</td><td>3</td></tr>
<tr><td>Rational</td><td colspan="7">This course offers hands-on laboratory experience in fundamental areas of physics including electrical measurements, optics, thermal physics, mechanics, and modern physics. Students develop precise measurement skills, learn to use standard laboratory instruments, verify physical laws, and apply statistical and analytical methods to experimental data.</td></tr>
</table>

Course Objective

- Provide hands-on training in precise electrical, optical, mechanical, and thermal measurements.
- Impart practical skills in performing experiments using galvanometers, bridges, potentiometers, spectrometers, polarimeters, and optical benches.
- Enable students to determine mechanical, thermal, electrical, and optical constants through systematic experimentation.
- Verify key physical laws such as conservation of momentum and photoelectric effect.
- Develop competency in error analysis, laboratory record keeping, and interpretation of experimental data.

Contents

1. Determination of the specific resistance of a wire using meter bridge
2. Determination of focal length of a concave lens by auxiliary lens method
3. Determination of high resistance by the method of deflection
4. Determination of resistance of a galvanometer by half deflection method
5. Determination of specific heat of a liquid by the method of cooling
6. Determination of ECE of copper by using copper voltameter
7. Determination of the Young's modulus of bar by bending method
8. Determination of the Young's modulus for the material of a wire by Searle's apparatus
9. Determination of the wavelength of sodium light by a spectrometer using a plane diffraction grating
10. Determination of the moment of inertia of a Fly-wheel about its axis of rotation
11. Determination of the radius of curvature of a plano-convex lens by Newton's ring method
12. Determination of the temperature co-efficient of resistance of the material of a wire using a meter-bridge
13. Determination of the specific rotation of sugar by polarimeter

14. Determination of the refractive index of a liquid by plane mirror and pin method using a convex lens

15. Determination of the thermal conductivity of a bad conductor by Lee's method

16. Verification of the law of conservation of linear momentum

17. Determination of the value of g acceleration due to gravity by means of a compound pendulum

18. Comparison of the E.M.F's of two cells by a potentiometer

19. Determination of the spring constant, effective mass and the rigidity modulus of the spring

20. Determination of the pressure co-efficient of a gas at constant volume by constant volume air thermometer

21. Determination of the Planck's constant using photoelectric effect

22. Determination of the frequency of a tuning fork by Melde's experiment

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Perform electrical measurements—including resistance, temperature coefficient, high resistance, galvanometer resistance, EMF comparison, and electrochemical equivalent—with proper instrumentation and techniques.	L, D, EXP, QA	PR, Q, ASG, F
CO2	Conduct optical experiments to measure focal lengths, refractive index, wavelength, specific rotation, and radius of curvature using standard optical instruments.	L, D, EXP, QA	PR, ASG, F
CO3	Determine thermal properties such as specific heat, thermal conductivity, and pressure coefficient through appropriate experimental methods.	L, D, EXP, QA	PR, ASG, F
CO4	Evaluate mechanical properties and constants including Young's modulus, moment of inertia, rigidity modulus, spring constant, and acceleration due to gravity.	L, D, EXP, QA	PR, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2		2	2				
CO2	3	3	2		2	2				
CO3	3	3	2		2	2				

CO4	3	3	3		3	2				

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Practical Physics – G.L. Squires 2. Advanced Practical Physics – Worsnop & Flint 3. B.Sc. Physics Laboratory Manuals (Standard University Manuals)
Supplementary Readings	1. Modern Introduction to Physics Experiments – A. Melissinos 2. Optics – Ajoy Ghatak (for optical experiments)
Others	

Course Code	**0531 CHN 301**		**Course Type**	**Core (Theory)**		**Level 3 Term I**
Course Title	**Chemical Kinetics and Photochemistry**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course introduces chemical kinetics, photochemistry, and radiation chemistry, linking theoretical concepts with experimental techniques and mechanistic analysis to understand reaction rates and energy-driven processes.					

Course Objective

- Review the basic principles of chemical reaction kinetics.
- Provide theoretical understanding of reaction-rate theories in gas-phase reactions.
- Study kinetics of reactions in solution and unimolecular reactions.
- Introduce catalytic mechanisms and enzyme kinetics.
- Acquaint students with the fundamentals of photochemistry and radiation chemistry.

Contents

- **Chemical Kinetics**

Review of elementary concepts: order, molecularity and rate constant, integration of rate equations for model reaction systems: zero, first and second order reactions, parallel, consecutive, successive and opposing reactions: methods for determination of order and rate constants, complex reactions, steady state approximation, kinetics of polymerization reactions, chain reactions, explosions.

- **Techniques and Methods for Measuring Rates of Reactions**

Conventional chemical methods: conductance methods, polarimetry, spectrophotometry, methods based on gas pressure and volume measurements, techniques for measuring rates of fast reactions: production and measurement of free radicals, flash photolysis, flow methods, relaxation techniques, relative methods.

- **Temperature Dependence of Reaction Rates and Theories**

The Arrhenius equation, bimolecular reactions: collision theory-its success and failures, transition state theory: elementary treatment, Eyring equation, thermodynamic formulation, reaction enthalpy and enthalpy diagrams.

- **Reactions in Solution**

Diffusion and activation-controlled reactions, theories of reaction rate in solutions, effect of dielectric constant and ionic strength on rates of reactions in solution.

- **Theories of Unimolecular Reactions**

Unimolecular reactions: Lindemann theory, Hinshelwood treatment.

- **Kinetics and Reaction Mechanism**

Principle of steady state approximation, iodination of acetone, decomposition of nitrogen pentoxide, decomposition of ethane and acetaldehyde, hydrogen chlorine, and hydrogen bromine reaction, hydrogenation of ethylene.

- **Catalysis**

Homogeneous and heterogeneous catalysis, acid-base catalysis, Hinshelwood and Rideal mechanism, enzyme catalysis: Michael-Menten equation, autocatalysis, oscillatory reactions.

- **Photochemistry and Photochemical Reaction**

Laws of photochemistry, quantum yield and its significance, light source, actinometer and its working principle, fates of photo excited species, photodissociation, photoionization, some typical photochemical reactions, photosensitization and photocatalysis, mechanism of photocatalytic reactions, formation and depletion of ozone in the stratosphere, ozone hole.

- **Radiation Chemistry**

Types of radiation, deference between photochemistry and radiation chemistry, G-value and its significance.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Demonstrate understanding of different theories of rates of chemical reactions.	L, D, QA	T, ASG, F
CO2	Correlate theoretical principles with experimental observations in physical chemistry.	L, D, QA	T, ASG, F
CO3	Apply various techniques to study kinetics of bimolecular and unimolecular reactions.	L, D, QA	T, ASG, F
CO4	Gain knowledge of catalytic and enzyme-controlled kinetic processes.	L, D, QA	T, ASG, F
CO5	Describe photophysical, photochemical, and radiation-controlled processes.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**CO1**	3	2							
CO2	**CO2**	3	2							
CO3	**CO3**	3								
CO4	**CO4**	2	3							
CO5	**CO5**	2								

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	1. Chemical Kinetics – Frost & Pearson 2. Kinetics and Mechanism – A. A. Frost & R. G. Pearson 3. Photochemistry – Atkins & de Paula 4. Chemical Kinetics and Dynamics – Steinfeld, Francisco & Hase 5. Physical Chemistry – Atkins 6. Radiation Chemistry – Farhataziz & Rodgers
Supplementary Readings	1. Principles of Chemical Kinetics – James E. House 2. Modern Molecular Photochemistry – Turro 3. Fundamentals of Photochemistry – K. K. Rohatgi-Mukherjee 4. Chemical Kinetics and Reaction Dynamics – Paul L. Houston
Others	

Course Code	**0531 CHN 321**		**Course Type**	**Core (Theory)**		**Level 3 Term I**
Course Title	**Organic Reaction Mechanism**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course provides fundamental and advanced understanding of organic reaction mechanisms, including substitution, addition, elimination, molecular orbital theory, and important named reactions.					

Course Objective
• Impart knowledge on mechanisms of substitution reactions at aliphatic and aromatic carbons and their kinetics, thermodynamics, and stereochemistry. • Provide understanding of factors affecting substitution reactions. • Develop knowledge on electrophilic and nucleophilic addition mechanisms. • Explain E1, E2 and E1cB mechanisms, stereoselectivity, orientation effects, and Saytzev vs Hofmann products. • Provide detailed knowledge on important organic reaction mechanisms. • Impart understanding of molecular orbital theory, orbital phases, bonding/antibonding interactions, shapes, and energy states.
Contents
▪ **Substitution Reactions** **(i) Nucleophilic Substitution at a Saturated Carbon Atom:** Mechanism for nucleophilic substitution, Determining the Applicable Mechanism: S_N1 vs. S_N2, Closer look at the S_N1 and S_N2 reaction, Contrast between S_N1 and S_N2 reaction, the leaving group in S_N1 and S_N2 reactions, the nucleophile in the S_N1 and S_N2 reactions. **(ii) Electrophilic Substitution in Aromatic System:** Conjugate substitution reactions, Nucleophilic epoxidation, Nucleophilic aromatic substitution, The addition-elimination mechanism, S_N1 mechanism: diazonium compounds, benzyne mechanism. **(iii) Nucleophilic Substitution in Aromatic System:** Introduction: Enols and Phenols, Benzene and its reactions with electrophiles, Electrophilic Substitution on phenols, Activation by Nitrogen-Containing Substituents, Orientation Effects of Alkyl Groups (Ortho/Para Directing), Meta-Directing Effects of Electron-Withdrawing Groups, Combined Effects of Multiple Substituents in Aromatic Rings, Challenges and Applications in Substituted Aromatic Chemistry, Inside Friedel-Craft chemistry. ▪ **Addition Reactions** **(i) Electrophilic addition to Carbon-Carbon Double Bonds:** Electrophilic addition to unsymmetrical alkenes is regioselective, Electrophilic addition to Dienes, unsymmetrical bromonium ions open regioselectively, dihydroxylation, Periodate cleavage and ozonolysis, adding one hydroxyl group (water). **(ii) Nucleophilic Addition to Carbonyl Compounds:** Molecular orbitals explain the reactivity of the carbonyl compound, attack of cyanide on aldehydes and ketones, the angle of nucleophilic attack on aldehydes and ketones, nucleophilic attack by hydride on aldehydes and ketones, addition of organometallic reagents to aldehydes and ketones, addition of water to aldehydes and ketones, hemiacetals from reaction of alcohols with aldehydes, ketones also form hemiacetals, acid and base catalysis of hemiacetals and hydrate formation. ▪ **Elimination Reaction** Elimination Reactions: Nucleophile Effects on Substitution vs. Elimination, E1 and E2 Mechanisms, substrate structure may allow E1, the role of the leaving group, E1 reactions can be stereoselective, E2

eliminations have anti-periplanar transition states, the regioselectivity of E2 eliminations, Anion-stabilizing groups allow another mechanism-E1cB.

- **Mechanism of Some Important Reactions**

Aldol condensation, Benzoin condensation, Cannizzaro reaction, Perkin reaction, Diels- Alder reaction, Michael and Mannich reactions, Reimer-Tiemann reaction, Meerwein-Ponndorf, Clemmensen, Wolf-Kishner reduction and Oppenauer oxidation reaction.

- **Molecular Orbital Theory**

Phase of an orbital and its role in bonding and antibonding, Hückel molecular orbital theory, LCAO`S theory and M.O's theory - their shapes and energy states, illustration with 1,3- butadiene, allyl system and 1,3,5-hexatriene.

Orbital Symmetry and Chemical Reactions: Woodward and Hofmann rules and their applications in thermal and photochemical reactions, electrocyclic reactions, cycloaddition reactions and sigmatropic rearrangements.

Conformational Analysis and Its Effect on Reactivity: Conformational effects on stability and reactivity, Curtius-Hammet principle, transannular effects, the concept of I-Strain.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain mechanisms of substitution reactions at aliphatic and aromatic carbons and the associated kinetics, thermodynamics, stereochemistry, and influencing factors.	L, D, QA	T, ASG, F
CO2	Demonstrate knowledge on electrophilic and nucleophilic additions to carbon–carbon double bonds and carbonyl compounds.	L, D, QA	T, ASG, F
CO3	Understand E1, E2, and E1cB mechanisms including stereoselectivity, orientation, and regioselectivity.	L, D, QA	T, ASG, F
CO4	Explain the formation and reactions of organic intermediates and derivatives of synthetic importance.	L, D, QA	T, ASG, F
CO5	Furnish detailed knowledge on mechanisms of important organic reactions and molecular orbital theory.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3		2					

CO2	3		3		2					
CO3	3		3		2					
CO4	3		2		2				1	
CO5	3		3		2				1	
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. Advanced Organic Chemistry (Carey & Sundberg) 2. Organic Chemistry (Clayden, Greeves & Warren) 3. Reaction Mechanism in Organic Chemistry (Mukherji & Singh) 4. March's Advanced Organic Chemistry (Smith & March)
Supplementary Readings	1. Organic Reaction Mechanisms (Ahluwalia) 2. Peter Sykes: A Guidebook to Mechanism in Organic Chemistry 3. Modern Molecular Orbital Theory textbooks
Others	

Course Code	**0531 CHN 361**	**Course Type**	**Core (Theory)**	**Level 3 Term I**
Course Title	**Instrumental Methods of Analysis in Chemistry and Nanoscience**		**Credit Hr**	**3**
Prerequisite	**None**		**Contact Hr**	**3**
Rational	This course introduces modern instrumental and analytical techniques used for qualitative and quantitative chemical analysis, emphasizing thermal methods, spectroscopy, electroanalytical techniques, chromatography, mass spectrometry, and statistical data interpretation.			

Course Objective

- Extend skills in procedures and instrumental methods applied in analytical tasks.
- Explain the principles, instrumentation, and applications of thermal analysis, atomic spectrometry, electroanalytical methods, chromatography, and mass spectrometry.
- Demonstrate the usefulness of statistical analysis in interpreting analytical results.

Contents

- **Thermal Analysis**

Thermogravimetry (TG), types of TG, instrumentation, application of TG, derivative thermogravimetry (DTG), simultaneous TG and DTG, differential thermal analysis (DTA): working principle, instrumentation, factors affecting DTA, applications, differential scanning calorimetry (DSC): principle, instrumentation and applications

- **Atomic Spectrometric Methods**

Atomic absorption and atomic emission, absorption line width, choice of absorption line, flame emission spectrometry: instrumentation, flame emission analysis, atomic absorption spectrophotometry: principles, instrumentation and interferences, electro-thermal atomizers, sample requirements and general preparation techniques, the effect of different solvents, sensitivity, qualitative and quantitative analysis, hydride vapour generation technique, cold vapor technique, advantages and disadvantages of AAS

- **Polarographic and Voltametric Analysis**

Current voltage relationship, mass transport processes, direct current polarography (DC), diffusion current, charging current, factors affecting the diffusion current, characteristics of dropping mercury electrode, three electrode potentiostat, polarographic maxima, oxygen interference, half wave potential, alternating current and pulse polarography, principle and advantages over dc polarography, voltammetry – ASV, CSV and CV, multicomponent analysis, quantitative applications

- **Chromatographic Techniques**

Overview, retention behavior, efficiency, selectivity, resolution, chromatographic theory, measured chromatographic parameters, evaluation methods, and classification of chromatography.

i. Liquid Chromatography: Types of liquid Chromatography;

(a) Planar Chromatography: Theories and mechanism of PC and TLC, nature of stationary phases, general properties required of a mobile phase, development of the chromatograms, location of spots, superiority of TLC, analytical applications.

ii. Column Chromatography: Column selectivity, efficiency, capacity factor etc.

(a) Ion-Exchange Chromatography: Ion-exchange resin, types of resins and their structure and properties, factors affecting the ion-exchange equilibria, eluting solvents, effect of pH, effect of complexing agents, and application of ion-exchange chromatography

(b) Gel Chromatography: Mechanism of gel chromatography, advantages of gel chromatography, technique of gel chromatography, applications of gel chromatography

(c) High-Performance Liquid Chromatography: The HPLC system, particle size and support material, filtration and degassing, HPLC columns, solvent requirements, solvent pumping systems, injection systems, HPLC detectors, applications

iii. Gas Chromatography: Principles, GC columns, selection of materials and column design, stationary phases, carrier gas, sample injection system, general properties of detectors, detectors types, scope of gas chromatography.

- **Analytical Mass Spectrometry**

The general principles and basic instrumental aspects of mass spectrometry, interpretation of mass spectra, analytical-chemical aspects of mass spectrometry.

- **Statistical Treatment of Data**

Population and sample mean, standard deviation, relative standard deviation, coefficient of variation, variance, confidence limit, Gaussian distribution, statistical tests, coefficient of correlation, regression lines, least square method

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Apply thermal and atomic spectroscopic methods for qualitative and quantitative analysis.	L, D, QA	T, ASG, F
CO2	Solve analytical problems involving polarographic and voltammetric techniques.	L, D, QA	T, ASG, F
CO3	Understand chromatographic separations, LC, GC, column technology, detectors, and chromatogram interpretation.	L, D, QA	T, ASG, F
CO4	Explain the fundamentals and analytical applications of mass spectrometry.	L, D, QA	T, ASG, F
CO5	Apply statistical tools to improve presentation and interpretation of analytical data.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2							
CO2	3	2	2							
CO3	3		2							
CO4	2	3	2							

CO5	2		2							
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. Principles of Instrumental Analysis – Skoog, Holler & Crouch 2. Instrumental Methods of Chemical Analysis – Chatwal & Anand 3. Fundamentals of Analytical Chemistry – Skoog, West, Holler 4. Introduction to Spectroscopy – Pavia 5. Chromatography: Concepts and Contrasts – James Miller 6. Mass Spectrometry: Principles and Applications – de Hoffmann & Stroobant
Supplementary Readings	1. Thermal Analysis – Wendlandt 2. Electrochemical Methods – Bard & Faulkner 3. Practical HPLC – McDowell 4. Gas Chromatography – Poole 5. Statistics for Analytical Chemistry – Miller & Miller
Others	-

Course Code	**0531 CHN 363**		**Course Type**	**Core (Theory)**		**Level 3 Term I**
Course Title	**Inorganic Chemical Process Industries**				**Credit Hr**	**2**
Prerequisite	**None**				**Contact Hr**	**2**
Rational	This course provides a foundational understanding of inorganic process industries, emphasizing raw materials, unit operations, unit processes, production technologies, and quality control. It links chemistry with engineering, industrial processing,					

	environmental considerations, and economic perspectives relevant to Bangladesh's industrial sector.

Course Objective
The learning objectives of this course are to • Impart a knowledge linkage in engineering, chemical processing, economics and industrial management. • Provide details about the fact that every industrial chemical process is based on unit operations (physical treatment) and unit process (chemical treatment) to produce economically a desired product from specific raw materials. • Give a general understanding of classification, properties, uses and industrial manufacturing process of some important materials in Bangladesh. • Impart knowledge on analysis and quality control of various industrial products.
Contents

Fundamentals in the Development of Chemical Industries

General ideas about unit processes and unit operations, raw materials, process design, commercial energy sources, skilled manpower, catalysts, water as the basic process fluid, heat transfer, mass transfer, separation processes, concepts of consumption, production, and market evaluation, the balance of supply and demand, safety, environmental considerations, site and technology selection criteria, cost-benefit analysis.

Chlor-alkali Industries

Raw materials, manufacture of caustic soda, soda ash, sodium bicarbonate, chlorine, bleaching powder, sodium chlorite, environmental hazards of these chemicals.

Fertilizer Industries

Plant nutrients, classification of fertilizers, natural inorganic fertilizers, nitrogen fixation, artificial fertilizers, manufacture of ammonia, urea, ammonium sulfate, ammonium nitrate, action of urea as fertilizer, potassium fertilizer, calcium phosphate and other phosphatic fertilizers, potassium fertilizer, NPK fertilizer.

Cement Industries

Portland cement, raw materials, important process parameters for manufacturing a good cement clinker, methods of manufacturing Portland cement, sequence of operations, additives for cement, properties of cement, testing of cement, setting of cement, other types of cement, manufacture of gypsum, Plaster of Paris.

Glass Industries

Properties of glass, raw materials and fundamentals of glass industries, methods of manufacture, choice of the furnace, chemical reactions in the furnace, annealing, special glasses.

Ceramic and Refractory Industries

Ceramics, properties of ceramics, basic raw materials, manufactures of ceramics, refractories, requisites of a good refractory, classification of refractories, properties of refractories, manufacture of refractories, types of refractory products.

Iron and Steel Industry

Fundamentals of metallurgy, ores of iron, three commercial forms of iron, construction and operation of blast furnace, reactions in blast furnace, byproduct in blast furnace, classification of steel, steel manufacturing processes, effects of impurities on steel, phases in Fe-C system.

Water Treatment

Water quality parameters, types of impurities present in water, effects of impurities in natural waters, methods of treatment of water for domestic and industrial purposes.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Handle unit processes and unit operations of major inorganic process industries.	L, D, QA	T, ASG, F

CO2	Describe raw materials, properties, uses, and industrial manufacturing processes of chlor-alkali products, fertilizers, cement, glass, ceramics, and refractories.	L, D, QA	T, ASG, F
CO3	Explain ore processing of iron and the extraction principles of iron and steel industries.	L, D, QA	T, ASG, F
CO4	Analyze the quality of various industrial products.	L, D, QA	T, ASG, F
CO5	Discuss adverse effects of impurities in natural water and describe suitable water-treatment methods.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1				1	
CO2	3	2	2					1	2	
CO3	3		2						1	
CO4	2	3	2	2	3	1		1		
CO5	2		2					1	3	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Chemical Process Industries – R. N. Shreve & J. A. Brink 2. Industrial Chemistry – B. K. Sharma 3. Dryden's Outlines of Chemical Technology – M. Gopala Rao 4. Industrial Inorganic Chemistry – Ullmann's Encyclopedia 5. Fertilizer Manual – United Nations Industrial Development Organization (UNIDO) 6. Cement Data Book – Duda 7. Introduction to Ceramics – W. D. Kingery
Supplementary Readings	1. Industrial Chemistry: A Manual – P. C. Jain 2. Glass Engineering Handbook – McGraw Hill

	3. Water Treatment Principles and Design – MWH 4. Steelmaking – Tupkary 5. Industrial Water Treatment – E. Davis
Others	

Course Code	**0531 CHN 371**		**Course Type**	**Core (Theory)**		**Level 3 Term I**	
Course Title	**Chemical Spectroscopy I**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	This course will provide a foundational understanding of spectroscopy and strengthen their problem-solving abilities related to spectral analysis						
Course Objective							
• Give knowledge on the interactions of electromagnetic radiation with matter • Acquaint with the spectroscopic terms and different components of a spectrophotometer • Give concepts on the existence of different types of energies of matter and their quantization that leads to absorption of different types of radiation leading to the appearance of different types of spectra • Impart knowledge on the principles and applications of spectroscopic techniques like atomic spectroscopy, MW, IR UV-Vis, etc • Demonstrate skills and abilities needed for advanced studies involving spectroscopic techniques.							
Contents							

Electromagnetic Radiation

The nature of electro-magnetic radiation, emission and absorption spectra, spectrometers, basic components of dispersive spectrometers, modulation technique: transmittance and absorbance, Beer-Lambert law: molar absorption cross section, representation of spectra, spectral peaks, intensities, width and resolution, signal to noise ratio and signal averaging, Fourier transform technique and its advantages.

Rotational Spectroscopy

Rotation of molecules and their classification, interaction of rotating molecules with radiation, microwave spectrometer, rotational energies of linear rotors, distribution of molecules and rotational spectra, centrifugal distortion, effect of isotopic substitution, Stark effect and its use in microwave spectrometers, determination of molecular geometry from microwave spectra

Infrared Spectroscopy

Vibration in molecules, normal modes, harmonic and anharmonic, potential-energy diagrams, Morse equation, vibrational energy, dissociation energy of diatomic molecules, population of vibrational levels, transition probabilities, fundamental, overtone and hot band transitions, combination and difference bands, Fermi resonance, vibration-rotation spectra of gaseous molecules, P, Q, and R branches, infrared spectra of polyatomic molecules, characteristic group vibrations and skeletal vibrations, shifts in group frequencies, techniques: radiation sources, optics, monochromators, sample holders, detectors for infrared spectrometers, handling of samples: gaseous, liquid and solid samples, principle of FTIR spectrometer and its advantages.

Characteristics group frequencies, assignment of spectral bands, structural factors, including common organic functional groups, affecting group frequencies, frequency shifts associated with structural changes in the compounds containing hetero atoms, applications in structure elucidation and investigation of reaction mechanism, combined infra-red and Raman spectroscopic studies for structure determination, infra-red spectra of transition metal complexes, infra-red spectra of adsorbed species.

Raman Spectroscopy

Raman effect, classical theory of Raman scattering, criterion of Raman activity, Raman spectrometers, use of laser in Raman spectroscopy, vibrational and rotational Raman spectra, use of polarized light, applications of Raman spectroscopy.

Ultraviolet-visible Spectroscopy

Electronic states of molecules, spectra of simple gaseous diatomic species and their vibrational coarse structure, Franck-Condon principle and intensities of spectral lines, dissociation energy, pre-dissociation spectra of species in condensed phase, various electronic transitions in organic and inorganic species, width of electronic bands, effect of solvent on band width and band position, chromophores, bathochromic and hypsochromic shifts, auxochromes. Woodward-Hoffman rules for the calculation of λ_{max}, solvent effect on band position, conjugated system, chromophore- stereochemical aspects, kinetic studies using uv-visible spectroscopy, spectra of complex compounds- free ions, d-configuration and correlation diagrams, and Tanabe-Sugano diagrams, UPS and XPS.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental principles of electromagnetic radiation and the interaction of atoms and molecules with radiation across microwave, infrared, and UV–Visible regions.	L, D, QA	T, ASG, F
CO2	**Explain** key phenomena such as fine structure, rotational-vibrational coupling, selection rules, Fermi resonance, and electronic transitions, including solvent and conjugation effects.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** rotational, vibrational, electronic, and atomic spectra by applying theoretical concepts such as energy levels, molecular rotations and vibrations, selection rules, and solvent/structural effects.	L, D, QA	T, ASG, F
CO4	**Evaluate** molecular structure, bonding, and geometry using spectroscopic tools, including group-frequency analysis, correlation diagrams, microwave constants and UV–Visible chromophore behaviour.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3				2					
CO2	3		2							
CO3	3				3					
CO4	3				3					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Introduction to Molecular Spectroscopy, G. M. Barrow 2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash 3. Introduction to Spectroscopy: A Guide for Students of Organic Chemistry, D L. Pavia, G. M. Lampman and G. S. Kriz 4. Spectrometric Identification of Organic Compounds,R. M. Silverstein, G. C. Bassler and T. C. Morrill 5. Basic Principles of Molecular Spectroscopy, R. Chang

	6. Electronic Spectra and Electronic Structure of Polyatomic Molecules, G. Herzberg 7. Atkins' Physical Chemistry, P. Atkins and J. De Paula
Supplementary Readings	1. Spectrometric Identification of Organic Compounds,R. M. Silverstein, G. C. Bassler and T. C. Morrill 2. Molecular Structure and Spectroscopy, G. Aruldhas 3. Ultraviolet and Visible Spectroscopy, C. N. R. Rao 4. The Infrared Spectra of Complex Molecules, L. J. Bellamy 5. Spectroscopic Methods in Organic Chemistry, D. H. Williams and I. Fleming. 6. Spectroscopy, B. K. Sharma
Others	-

Course Code	**0531 CHN 302**		**Course Type**	**Core (Sessional / Laboratory)**		**Level 3 Term I**	
Course Title	**Physical Chemistry Sessional II**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**6**
Rational	This sessional course provides hands-on laboratory experience in physical chemistry. It enables students to understand, plan, and conduct experiments involving kinetics, electrochemistry, phase equilibria, adsorption, thermochemistry, and spectroscopy. Students gain competence in experimental design, accurate measurement, data treatment using computational tools, and scientific interpretation of results.						

Course Objective

- Develop knowledge on planning and designing physical chemistry experiments
- Impart practical skills on techniques involving kinetics, adsorption, phase equilibria, spectroscopy, and electrochemistry
- Teach data treatment and analysis using computer programs for kinetic and thermodynamic calculations
- Impart the ability to collect reliable data, analyze uncertainties, interpret results, and present scientific findings clearly

Contents

- **Electrochemical Measurements**

(a) Potentiometric titration involving oxidation-reduction reactions, and acid-base neutralization
(b) Determination of activity coefficients of electrolyte
(c) Determination of transport numbers
(d) Determination of decomposition potentials of the electrolytes
(e) Determination of equilibrium constants from e. m. f. measurements.

- **Study of Kinetics of Chemical Reactions**

Using (a) Polarimeter (b) Dilatometer (c) Conductance bridge (d) Manometer (e) Spectrophotometer and (f) Chemical analysis.

- **Study of Phase Equilibria**

(a) Study of partially miscible system in presence and absence of impurities
(b) Boiling temperature vs. composition diagram of completely miscible binary liquid pairs
(c) Determination of cooling curves of binary solid system.

- **Study of Surface Phenomena**

(a) Study of adsorption on solids from solutions
(b) Study of adsorption at liquid surface by surface tension measurements
(c) Study of surface films using Langmuir trough.

- **Thermochemical Measurements**

Measurement of enthalpies of (a) combustion and (b) reaction.

- **Spectroscopic Experiments**

(a) Study of electronic spectra of selected species
(b) Verification of Beer-Lambert law and its application in quantitative analysis
(c) Determination of the composition of a complex compound
(d) Determination of stability constant of a complex compound
(e) Study of atomic and molecular spectra
(f) Determination of isosbestic point.

7. Measurement of quantum yields of some photochemical reactions.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Apply spectroscopic, polarimetric, and conductometric methods for kinetic studies of reactions.	L, D, LAB, QA	Lab Report and Lab Test
CO2	Understand phase equilibria concepts and interpret cooling curves and phase diagrams of binary systems.	L, D, LAB, QA	Lab Report and Lab Test
CO3	Analyze adsorption phenomena and identify appropriate adsorption isotherms for given systems.	L, D, LAB, QA	Lab Report and Lab Test

CO4	Apply thermodynamic concepts to determine thermodynamic parameters (e.g., partial molar volume, molecular weight).	L, D, LAB, QA	Lab Report and Lab Test
CO5	Understand and apply spectroscopic principles for determining molecular structure, molar extinction coefficient, and other parameters.	L, D, LAB, QA	Lab Report and Lab Test

(L–Lecture, D–Discussion, LAB–Hands-on Laboratory Work, QA–Question & Answer Session, LAB–Lab Record, RPT–Report, VIVA–Viva voce)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2						
CO2	3		3							
CO3	3		3					1		
CO4	3	2	3	2						
CO5	3	2	3	1				1		

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Experiments in Physical Chemistry – Garland, Nibler & Shoemaker 2. Physical Chemistry Practical – N. K. Ghosh 3. Experimental Physical Chemistry – Arthur W. Adamson 4. Measurement and Data Analysis for Engineering and Science – P. Y. Chang 5. Fundamentals of Analytical Chemistry – Skoog, West, Holler & Crouch
Supplementary Readings	1. Principles of Instrumental Analysis – Skoog & Holler 2. Chemical Kinetics and Reaction Dynamics – Paul Houston 3. Thermodynamics and Physical Chemistry Laboratory Manual – Various Authors 4. Research articles and standard laboratory method publications
Others	-

Course Code	0531 CHN 323		Course Type	Core (Theory)		Level 3 Term II
Course Title	**Bioorganic Chemistry**				**Credit Hr**	**2**
Prerequisite	**None**				**Contact Hr**	**2**
Rational	This course introduces the chemistry and biological roles of major biomolecules, including carbohydrates, lipids, proteins, nucleic acids, and related systems, focusing on their structures, properties, and biochemical significance.					

Course Objective

- Impart knowledge on the chemistry, structure, and properties of carbohydrates and polysaccharides, including their synthesis and structural elucidation.
- Provide understanding of biochemical pathways of carbohydrate, lipid, and protein metabolism, and protein biosynthesis.
- Explain digestion and absorption processes of carbohydrates, fats, and proteins.
- Motivate students toward advanced study of biomolecules such as nucleic acids, proteins, enzymes, and related compounds.

Contents

- **Carbohydrates**

Definition, classification, constitution and configuration of monosaccharides, synthesis of monosaccharides, ring structure of monosaccharides and their conformations, action of acids and bases on sugars, epimers, anomers and anomeric configurations, reaction of mono-, di-, tri- and tetrasaccharides, their structures, chemical and physical properties.

- **Polysaccharides**

Definition, constitution classification and importance of polysaccharides, isolation of polysaccharides and their purification using different physical and chemical methods, structural elucidation of polysaccharides using chemical and spectroscopic methods, a brief introduction of some important polysaccharides such as starch, cellulose, pectin, alginic acid, chitin, glycogen, heparin and dermatan sulphates.

- **Amino Acids, Peptides and Proteins**

Definition, sources, classification and importance of amino acids, its buffer action in biological system, structure and configuration of amino acids, isoelectric point, preparations and reactions of amino acids, biosynthesis of amino acids, peptides - its occurrence, constitution and geometry, C-terminal and N-terminal residues of peptides, proteins, their classifications and functions, denatured and conjugated proteins, primary and secondary structure of proteins, a brief treatment of enzymes and coenzymes.

- **Lipids**

Definition, occurrence, classification and function, composition of fats and oils, hydrolysis of fats, saturated and unsaturated fatty acids, phosphoglycerides, phosphate esters, phospholipids and cell membranes, biosynthesis of lipids.

- **Nucleic Acids**

Definition, sources and importance, structure of nucleic acid, nucleosides and nucleotides, DNA and RNA.

- **Purines**

Chemistry of purines and uric acid, purine derivatives, xanthine bases.

- **Glycoconjugates**

A brief introduction of glycoprotein, proteoglycan and glycolipid.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Understand physiological functions and consequences of deficiencies of major biomolecules such as lipids, carbohydrates, proteins, and amino acids.	L, D, QA	T, ASG, F
CO2	Explain the role and impact of nucleic acids in genetics.	L, D, QA	T, ASG, F
CO3	Explain photosynthesis of carbohydrates and the chemistry of polysaccharides.	L, D, QA	T, ASG, F
CO4	Demonstrate awareness about macromolecular organic compounds contributing to environmental pollution.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2		2				1	
CO2	3		2		1					
CO3	3		2		1					
CO4	2		2		1				3	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Lehninger Principles of Biochemistry 2. Fundamentals of Biochemistry, Voet & Voet 3. Organic Chemistry of Biological Pathways, Metzler 4. Biochemistry, Berg, Tymoczko & Stryer 5. Organic Chemistry, Morrison & Boyd

Supplementary Readings	1. Introduction to Biomolecules, Garrett & Grisham 2. Carbohydrate Chemistry, Whistler & BeMiller 3. Protein Chemistry, Creighton 4. Lipid Biochemistry, Vance & Vance
Others	

Course Code	**0531 CHN 341**		**Course Type**	**Core (Theory)**		**Level 3 Term II**	
Course Title	**Crystallography and Solid-State Chemistry**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rational	his course provides fundamental and extended knowledge of solid-state structures, symmetry, X-ray diffraction methods, and the relationship between atomic arrangements and physical properties. It strengthens students' understanding of crystallography and solid-state chemistry necessary for materials science, nanotechnology, inorganic chemistry, and analytical techniques.						

Course Objective

- Deepen knowledge of solid structures and their classifications.
- Provide fundamentals of X-rays, X-ray diffraction, Bragg's law, powder and single-crystal diffraction.
- Introduce principles of crystal optics and crystallographic symmetry.
- Impart knowledge of solid-state structures of ionic, inorganic, and organic materials.
- Familiarize students with solid-state reactions, synthesis methods, and defect chemistry.

Contents

- **Solids**

The solid state, properties of solids, crystalline and amorphous solids, distinction between crystalline and amorphous solids, classification of crystalline solid, isomorphism, polymorphism and allotropy. Structure of Miscellaneous Solids: Close packing, closed-packed structures, packing coefficient, interstitial sites, radius ratio, radius ratio rule, structure of some inorganic solids - NaCl, CsCl, zinc blende, wurtzite, NiAs, CaF_2, TiO_2, perovskite, normal spinel and inverse spinel and ilmenite, Structure of some organic solids -flavones and isoflavones, alkaloids.

- **Bonding and Properties of Solids**

Introduction, bonding in solids, the band theory, electrical conductivity, thermal conductivity, origin of band gap, the hole concept, semiconductors and their types, sensitization and doping, measurement of semiconductivity, Hopping conduction, Hall effect, non-stoichiometric metal oxides, electronic properties of non-stoichiometric oxides, superconductors, SQUID, Optical Properties : Interaction of light with solids, color and photoconductivity, Magnetic and Dielectric Properties: Magnetic susceptibility, classification of magnetic materials, diamagnetism, paramagnetism, ferromagnetism, anti-ferrimagnetism

- **Solid State Synthesis and Reactions**

Introduction, microwave synthesis, sol-gel method, precursor method, hydrothermal method, chemical-vapor deposition Solid-state reactions, role of defects, kinetics of thermal decomposition of solids, the Wagner's theory, tarnishing reactions, kinetics of oxide film growth, photoconductivity, chemistry of photography, photocells for solar energy conversion, dye-sensitized solar cells based on nanocrystalline oxide semiconductor films.

- **Crystal lattice and Crystal Symmetry**

Crystal lattice, unit cell, unit cell volume, crystal systems, Bravais lattices, lattice types, Miller indices, symmetry and symmetry elements, point groups, the Laue classes, space groups, transformation theory, systematic absences and space groups.

- **Elementary Crystal Optics**

Crystal forms, crystal zones and zone symbols, cleavage, parting and fracture, crystal habit, crystal projections, crystal twins.

- **X-ray Diffraction by Crystals**

Generation of X-rays, properties of X-rays, X-ray filters, diffraction of X-rays by crystals, Bragg's equation, reciprocal lattice, Bragg's law in reciprocal lattice, sphere of reflection, limiting sphere.

- **Powder Diffraction Technique**

The powder method – principles and uses, the Debye-Scherrer powder camera, Guinier focusing camera, the powder diffractometer, comparison of diffractometry with film methods, high temperature powder diffraction, effect of crystal size on the powder pattern, measurement of d-values, refinement of unit cell parameters, indexing of powder patterns, structure determination from powder patterns.

- **Single Crystals and Data Collection**

Single crystal, techniques of single crystals growth, choosing a crystal, crystal mounting and alignment, measurement of crystal properties, data collection method –rotation and oscillation technique, precession camera, and four-circle diffractometer, unique data, data reduction, structure factor, electron density mapping, Fourier synthesis, the phase problem, the Patterson synthesis, the overall procedure, computational task.

Course Learning Outcomes (CO)	Teaching Strategy	Assessment Methods

CO1	Classify solids and distinguish their structural types.	L, D, QA	T, ASG, F
CO2	Describe crystal systems, Bravais lattices, and unit cell parameters.	L, D, QA	T, ASG, F
CO3	Identify point group and space group symmetry and explain basic crystal optics.	L, D, QA	T, ASG, F
CO4	Understand X-ray generation and powder diffraction and interpret diffraction patterns; demonstrate basic single-crystal XRD knowledge.	L, D, QA	T, ASG, F
CO5	Apply radius ratio rules and describe solid-state structures of common inorganic compounds using packing concepts and interstitial sites.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO / PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	1							
CO2	3	3	2							
CO3	3	2	2							
CO4	3		3							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Nanotechnology: Principles and Practices – S. K. Kulkarni 2. Introduction to Nanoscience – Gabor Hornyak 3. Chemical Approaches to Nanomaterials – C. N. R. Rao 4. Nanostructures and Nanomaterials – Guozhong Cao

	5. Handbook of Nanophysics – K. D. Sattler
Supplementary Readings	1. Scanning Electron Microscopy and X-ray Microanalysis – Goldstein et al. 2. Transmission Electron Microscopy – D. B. Williams & C. B. Carter 3. AFM Nanomechanics – Bhushan 4. Fabrication Engineering at the Micro- and Nanoscale – Campbell
Others	-

Course Code	**0531 CHEM 365**		**Course Type**	**Core (Theory)**		**Level 3 Term II**	
Course Title	**Organic Chemical Process Industries**					**Credit Hr**	**2**
Prerequisite	**None**					**Contact Hr**	**2**
Rational	This course provides essential knowledge on organic process industries related to daily life and industrial operations. Students will learn unit processes and operations, raw materials, reaction conditions, industrial equipment, production processes, and quality control. The course prepares students for careers involving chemical plants, industrial management, product formulation, organic manufacturing, and environmental considerations associated with industrial organic processes.						

Course Objective

- Provide fundamental knowledge about unit processes and unit operations in organic process industries
- Discuss technological processes used in various organic industries
- Offer knowledge on raw materials, reaction conditions, and manufacturing routes for commercially important organic compounds
- Address quality control, environmental concerns, and maintenance of industrial products

Contents

- **Sugar and Starch Industries**

Steps in the industrial extraction of cane sugar and inversion of sugar, refining of sugar, production of sugar from sugar beet, by products of sugar industries, management of industrial waste of sugar industries, production of starch from corn, production of glucose and dextrin from starch, Starch derivatives and its importance.

- **Pulp and Paper Industry**

Natural sources of cellulose, its constituents and estimation, different processes for the manufacture of paper from pulp, production of paperboard, viscose rayon and other modified cellulose fiber, wood chemistry and wood chemicals.

- **Fuel Industry**

Solid, liquid and gaseous fuels, coal and its constituents, different stages of coal formation, analysis and calorific value of coal and other fuels, carbonization, distillation of coal tar, hydrogenation of coal, manufacture of producer gas and water gas, refining and distillation of crude oil, motor and aviation fuels, thermal and catalytic cracking, production of motor fuels by alkylation, cyclization and polymerization, lubricating agents, hydrocarbons and petroleum, their distribution in Bangladesh, methods of harnessing hydrocarbons in Bangladesh, petrochemicals from liquid and gaseous hydrocarbons, natural gas and its utilization.

- **Fats and Wax Industry**

Extraction and refining of vegetable oils, analysis of fats and oils and their uses, hydrogenation of oils, cotton seed, soybean, sunflower and linseed oils and their uses.

- **Soaps and Detergents**

Methods of fat splitting, manufacture of laundry and toilet soaps, recovery and refining of glycerin, detergent: definition, classification and their manufacture, comparison between soaps and detergents, biodegradability of detergents.

- **Rubber and Plastic Industry**

Natural rubber - its production and processing, synthetic rubber - its classification, production of monomers and their polymerization processes, latex compounds, rubber compounding, vulcanization of rubber, different rubber processing chemicals and their functions, fundamental characteristics, classification, raw materials, and manufacture of plastics, some typical examples of plastics and their uses.

- **Dye Industry**

Fundamentals of dye, Chemical structures and properties, Properties and classification of dyes, Methods and Processes of Dyeing, Quality control, Dye waste management

- **Corrosion, Paint and Coating Industry**

Composition and application of paints, paints - its constituents, varnishes and metallic coatings, methods used in applying coatings on metal surface. printing ink – its classification and manufacture, varnishes, lacquers and enamels and its functions, industrial polishes.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Handle unit processes and operations used in industries such as distillation, extraction, leaching, drying, absorption, and filtration.	L, D, QA	T, ASG, Q, F
CO2	Interpret process flow diagrams and understand essential process parameters.	L, D, CS, QA	T, ASG, Q, F

CO3	Demonstrate knowledge of raw materials, reagents, and reaction conditions for manufacturing products such as sugar, paper, detergents, pigments, paints, varnishes, and explosives.	L, D, QA	ASG, Q, F
CO4	Explain environmental threats related to industrial organic production and propose suitable remedies.	L, D, QA, CS	ASG, Q, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1							
CO2	3		2							
CO3	3		2						1	
CO4	2		2					2	3	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Industrial Organic Chemistry – Wittcoff & Reuben 2. Chemical Process Industries – Shreve & Brink 3. Industrial Chemistry – B. K. Sharma 4. Textbook of Chemical Technology – Bhatt & Goel 5. Industrial Organic Chemicals – Allan Rogerson
Supplementary Readings	1. Introduction to Petrochemicals – Sukumar Maity 2. Rubber Technology Handbook – Werner Hofmann 3. Soap and Detergent Manufacture – S. D. Shukla 4. Wood and Cellulose Chemistry – Hon & Shiraishi 5. Industrial safety manuals, environmental management documents, and case studies
Others	

Course Code	**0531 CHN 373**		**Course Type**	**Core (Theory)**		**Level 3 Term II**	
Course Title	**Chemical Spectroscopy II**					**Credit Hr**	**3.0**
Prerequisite	**Chemical Spectroscopy I**					**Contact Hr**	**3.0**

Rational	This course will equip students with comprehensive knowledge and analytical skills in major spectroscopic techniques to enable accurate interpretation of spectral data and reliable structural elucidation of organic and inorganic molecules.

Course Objective

- Impart knowledge on the interaction of ultra-violet and visible radiation with organic and inorganic molecules, calculation of λ_{max}, analyzing UV-Visible spectrum and predicting the presence of different types of chromospheres and auxochromes.
- Give knowledge on infra-red spectra of molecules, assignment of spectral bands to characteristic functional groups, structure elucidation and investigation of reaction mechanism.
- Acquaint with the principle and various common terms used in NMR spectroscopy, interpretation of NMR spectra and variable temperature spectra, simplification of complex spectra and brief knowledge on two-dimensional NMR.
- Give knowledge on mass spectroscopy to find the molecular mass and structure of compound.
- Give guidelines to elucidate the structure of unknown molecules using a combination of all spectroscopic techniques

Contents

Raman Spectroscopy

Raman effect, classical theory of Raman scattering, criterion of Raman activity, Raman spectrometers, use of laser in Raman spectroscopy, vibrational and rotational Raman spectra, use of polarized light, applications of Raman spectroscopy.

Nuclear Magnetic Resonance Spectroscopy

Nuclear spin, common nuclei with spin (1H, 13C, 15N, 19F, 31P), interaction of magnetic field with nuclear spin, Larmour precession, resonance absorption of radiation, the nmr spectrometer, nmr spectrum, chemical shift, shielding and deshielding of nuclei, spin-spin coupling, coupling constant, vicinal, geminal, ortho, para and meta coupling, proton exchange reactions, rotation about single bonds, variable temperature spectra, geminal coupling non-equivalence of protons, relaxation, NOE, simplification of complex spectra, double irradiation, Fourier transform spectra, two dimensional nmr - a brief treatment of COSY and NOESY.

Mass Spectroscopy

Techniques of ionization, electron impact, fast atom bombardment, field desorption, photoionization, multiphoton ionization, thermal methods, principles of mass separation, sector magnet technique, quadrupole mass separator; time of flight in mass spectrometer, ion optics, sampling for mass spectrometric measurements, molecular beam sampling, ionization potentials and measurements, fragmentation of ions, rearrangement of ions, base peak, molecular mass determination, mass spectra of various classes of compounds, CI, EI and FAB mass spectroscopy.

Combination of Spectroscopic Methods

Structure elucidation of compounds by combined application of UV, IR, NMR (1H and13C) and mass spectroscopy.

ESR Spectroscopy
The g-factor, hyperfine splitting, determination of electron density from ESR spectroscopic studies

Mössbauer Spectroscopy
The nuclear energy levels, the Doppler effect, resonance absorption of γ-radiation by nuclei, Mössbauer spectrometer, the chemical shift, the quadrupole effects, Zeeman splitting, applications in chemistry

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Interpret Raman spectra by assigning characteristic group frequencies, evaluating structural factors and apply this knowledge to elucidate structures and investigate reaction mechanisms.	L, D, QA	T, ASG, F
CO2	Explain and evaluate NMR spectral feature and analyze 1D and basic 2D NMR spectra to determine molecular connectivity and stereochemical relationships.	L, D, QA, CS	T, ASG, F, Pr
CO3	Determine molecular masses and fragmentation pathways using various ionization techniques and integrate spectral data to elucidate the complete structure of unknown compounds.	L, D, CS, QA	T, ASG, F, Pr

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2			3	2						
CO3	2		3							
CO4	3		3							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Introduction to Spectroscopy: A Guide for Students of Organic Chemistry, D. L. Pavia, G. M. Lampman and G. S. Kriz.

	2. Spectrometric Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. C. Morrill. 3. Spectroscopic Methods in Organic Chemistry, D. H. Williams and I. Fleming. 4. Spectroscopy, B. K. Sharma.
Supplementary Readings	1. Fundamentals of Molecular Spectroscopy by C. N. Banwell and E. M. Mccash 2. 6. Physical Chemistry by P. K. Atkins
Others	-

Course Code	**0531 CHN 375**		**Course Type**	**Core (Theory)**		**Level 3 Term II**	
Course Title	**Quantum Chemistry and Statistical Mechanics**					**Credit Hr**	**2**
Prerequisite	**None**					**Contact Hr**	**2**
Rational	This course introduces the foundational principles of quantum chemistry, highlighting the failure of classical mechanics at microscopic scales and the emergence of quantum mechanics. It provides students with the theoretical tools and mathematical framework necessary to understand quantization, wave functions, operators, and solutions of Schrödinger's equation relevant to chemical systems.						

Course Objective

- Give knowledge on several features of classical mechanics and their failure for microscopic systems
- Introduce fundamental principles of quantum chemistry
- Demonstrate the application of quantum mechanical principles to simple chemical systems

Contents

- **Classical Mechanics**

Failures of classical mechanics, black-body radiation, heat capacities of solids, photoelectric effect, the Compton effect, atomic spectra, Planck's quantum theory, Einstein's explanation of photoelectric effect, de Broglie's postulate, Heisenberg's uncertainty principle, wave equation

- **Time Independent Schrödinger Equation and Stationary State**

Interpretation of the wave functions: normalization of the wave functions, orthogonality and completeness of the wave function, significance of wave functions

- **Operators and Observables**

Constitution of quantum mechanical operator, some important operators: Hamiltonian operator, Laplacian operator, operator algebra, eigen functions, eigen values, eigen value equation, expectation values

- **Application of Quantum Mechanics**

Translational motion, particle in a box, properties of solutions and the consequences, vibrational motion, one dimensional harmonic oscillator: the formal solution, the energy levels, the wave functions, properties of the solutions, rotational motion: rotation in two dimensions, the formal solution, significance and application

- **The Structure of Hydrogen and Hydrogen-like Atom**

The formal solution of the Schrödinger equation; the separation of the R, Q and F equations, total wave functions of the hydrogen and hydrogen-like atoms, probability density and radial distribution function, atomic orbitals and their shapes, orthonormality of atomic orbitals, approximation methods, variation principle, perturbation theory.

- **Statistical Mechanics**

Basic concepts, macroscopic system, distribution of molecules, configuration, population, weight, most probable configurations, Boltzmann distribution, molecular partition function, internal energy of a system, the canonical ensemble, FermiDirac and Bose-Einstein statistics, evaluation of partition functions, calculation of thermodynamic functions, applications of statistical mechanics, mean energies and the equipartition principle, heat capacities of solids, Einstein and Debye equations, chemical equilibrium: statistical treatment, evaluation of equilibrium constants.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Understand the failure of classical mechanics for microscopic systems including black-body radiation, heat capacity of solids, photoelectric effect, and Compton effect.	L, D, QA	T, ASG, F
CO2	Explain the development of quantum theory, quantization of energy, and their applications to chemical systems.	L, D, QA	T, ASG, F
CO3	Demonstrate understanding of the dual nature of matter and the basic postulates of quantum mechanics.	L, D, QA	T, ASG, F
CO4	Apply wave theories to solve Schrödinger equation for simple systems such as 1D box, 3D box, and hydrogen atom.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2							
CO3	3		2							

CO4	3		3	2	3					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. **Physical Chemistry** – P. Atkins & J. de Paula 2. **Quantum Chemistry** – Ira N. Levine 3. **Introduction to Quantum Mechanics** – D. J. Griffiths 4. **Quantum Chemistry** – Donald A. McQuarrie 5. **Molecular Quantum Mechanics** – P. W. Atkins & R. Friedman 6. **The Principles of Quantum Mechanics** – P. A. M. Dirac 7. **Quantum Mechanics** – E. Merzbacher
Supplementary Readings	1. Elementary Quantum Chemistry – Frank L. Pilar 2. Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory – Szabo & Ostlund 3. Quantum Mechanics in Chemistry – Jack Simons & Jeff Nichols 4. Problems and Solutions in Quantum Chemistry and Physics – Charles S. Johnson 5. Quantum Chemistry & Spectroscopy – Thomas Engel
Others	-

Course Code	**0531 CHN 383**		**Course Type**	**Core (Theory)**		**Level 3 Term II**
Course Title	**Nanoscale Synthesis, Fabrication and Characterization**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course provides conceptual and practical understanding of nanoscale synthesis, fabrication, and characterization, enabling students to connect synthesis techniques with nanomaterial properties and applications.					

Course Objective

- Provide a comprehensive overview of nanomaterial synthesis and fabrication methods.
- Impart detailed knowledge of physical and chemical synthesis mechanisms and their limitations.
- Familiarize students with thin-film fabrication and lithographic techniques.
- Develop fundamental understanding of morphology-controlled synthesis.
- Introduce major characterization techniques used in nanotechnology.

Contents

- **Classification and Overview of Nanofabrication**

Introduction to nanofabrication strategies: Top-down vs. Bottom-up approaches. Overview of physical, chemical, and biological methods. Factors influencing the choice of synthesis method: scalability, cost, purity, morphology control.

- **Physical Synthesis Methods**

Mechanical milling. vapor phase condensation, Sputtering, Laser ablation, Supercritical fluid synthesis, Electrospinning, Plasma and flame spray synthesis.

- **Chemical Synthesis Methods**

Sol-gel process, Hydrothermal and solvothermal synthesis. Chemical reduction, Pyrolysis. Chemical Vapor Deposition (CVD)

- **Advanced Fabrication and Controlled Synthesis**

Thin film deposition techniques: physical vs. chemical vapor deposition. Nanolithography, Morphology-controlled synthesis: strategies for controlling size, shape, and composition. Synthesis of inorganic (metal, metal oxide) and carbon-based (graphene, CNTs) nanomaterials. Introduction to green synthesis approaches.

- **Nanostructure Characterization**

Microscopy techniques: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Transmission Electron Microscopy (STEM), Atomic Force Microscopy (AFM). Crystallographic analysis: X-ray Diffraction (XRD). Size analysis: Dynamic Light Scattering (DLS). Optical characterization: UV-Visible Spectroscopy.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Classify and explain principles of top-down and bottom-up nanofabrication methods.	L, D, QA	T, ASG, F
CO2	Describe mechanisms, procedures, and applications of physical and chemical synthesis methods.	L, D, QA	T, ASG, F
CO3	Understand principles of thin-film deposition and lithography for device fabrication.	L, D, QA	T, ASG, F
CO4	Design strategies for morphology-controlled synthesis of nanomaterials.	L, D, QA	T, ASG, F
CO5	Select appropriate characterization techniques and interpret resulting data.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping										
Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2							
CO2	3	2	2							
CO3	3		2							
CO4	2	3	2							
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	6. Nanotechnology: Principles and Practices – S. K. Kulkarni 7. Introduction to Nanoscience – Gabor Hornyak 8. Chemical Approaches to Nanomaterials – C. N. R. Rao 9. Nanostructures and Nanomaterials – Guozhong Cao 10. Handbook of Nanophysics – K. D. Sattler
Supplementary Readings	5. Scanning Electron Microscopy and X-ray Microanalysis – Goldstein et al. 6. Transmission Electron Microscopy – D. B. Williams & C. B. Carter 7. AFM Nanomechanics – Bhushan 8. Fabrication Engineering at the Micro- and Nanoscale – Campbell
Others	-

Course Code	**0531 CHN 342**		**Course Type**	**Core (Sessional / Laboratory)**		**Level 3 Term II**	
Course Title	**Organic Chemistry Sessional II**					**Credit Hr**	**3**
Prerequisite	**Organic Chemistry Sessional I**					**Contact Hr**	**6**

Rational	This sessional course develops practical skills in identifying organic compounds, analyzing functional groups, interpreting physical and chemical properties, and synthesizing simple organic molecules relevant to pharmaceutical and industrial applications.

Course Objective

- Provide knowledge of physical and chemical properties and elemental analysis of organic molecules.
- Develop skill in identifying functional groups using classical and instrumental methods.
- Train students in interpreting experimental data to determine molecular structure.
- Acquaint students with practical synthetic procedures for simple organic compounds.

Contents

- **Identification of Organic Compounds**

Detection and identification of different types of organic compounds both solid and liquid by physical and chemical methods, types of organic compounds: hydrocarbons, halogenated compounds, hydroxy compounds (alcohols and phenols), ethers, carbonyl compounds (aldehydes and ketones), carboxylic acids and the derivatives of alpha, beta-unsaturated carbonyl compounds and acids, keto and hydroxy acids, nitro compounds, amino compounds (primary, secondary and tertiary), organo sulphur compounds amides and N-substituted amides.

- **Synthesis of Organic Compounds: Aromatic substitution**

(a)Bromination of acetanilide and phenol,
(b) sulphonation of aniline,
(c) Diazotization of aromatic amines and preparation of (i) phenols, (ii) halobenzenes and azodyes.

- **Hydroxylation**

Hydroxylation of cyclohexene, stereospecific hydroxylation, isolation and purification of the products.

- **Preparation Involving Some Specific Reactions**

Aldol condensation, Perkin reaction, Cannizzaro reaction, Michael reaction.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Detect the presence of different elements in organic compounds.	L, D, P, QA	Lab Report and Lab Test
CO2	Identify functional groups present in organic compounds.	L, D, P, QA	Lab Report and Lab Test
CO3	Elucidate molecular structure from physical and chemical data compared with standard samples.	L, D, P, QA	Lab Report and Lab Test

CO4	Synthesize derivatives of organic compounds with industrial or medicinal importance.	L, D, P, QA	Lab Report and Lab Test
(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2							
CO2	3	2	2							
CO3	3		2							
CO4	2	3	2							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Vogel's Textbook of Practical Organic Chemistry – Vogel 2. Organic Chemistry – Morrison & Boyd 3. Advanced Practical Organic Chemistry – Leonard & Lygo 4. A Textbook of Organic Chemistry – Arun Bahl 5. Practical Organic Chemistry – Mann & Saunders
Supplementary Readings	6. Techniques in Organic Chemistry – Mohrig 7. Experimental Organic Chemistry – Gilbert & Martin 8. Organic Syntheses – Collective volumes
Others	-

Course Code	**0531 CHN 393**		**Course Type**	**Core (Sessional)**		**Level 3 Term II**

Course Title	Industrial Training/ Field Visit	Credit Hr	1.5
Prerequisite	**None**	**Contact Hr**	**3**
Rational	This industrial training provides hands-on exposure to analytical instruments, industrial chemical processes, water treatment technologies, pollution monitoring, and quality control techniques used in chemical industries.		

Course Objective

- Introduce industrial laboratory operations and analytical quality control practices.
- Provide practical experience with major analytical instruments used in chemical industries.
- Train students in water analysis, wastewater treatment, and environmental monitoring.
- Develop skills in industrial chemical analysis, validation, and interpretation of data.
- Familiarize students with operation of pilot-scale units and industrial equipment.

Contents

1. Introduction to Quality Control & Quality Assurance
2. Method Validation in Chemical Analysis
3. Industrial Water Treatment Techniques
4. Principles & Instrumentation of Spectrophotometer
5. Chromatographic Methods of Analysis
6. Wastewater Treatment Techniques
7. Determination of the Hardness of Water
8. Determination of Alkalinity and Acidity in Water
9. Determination of the purity of commercial H_2SO_4/NaOH
10. Determination of Na & K by Flame Photometer
11. Determination of NH_4-N in a water sample
12. Heavy metal analysis by ICP-OES
13. Chemical analysis by GC and data interpretation
14. Operation & Application of HPLC
15. Identification of organic materials by FTIR
16. Elemental Analysis by EDXRF
17. Measurement of pollution parameters: DO, BOD in water
18. Estimation of Vitamin A in edible oil
19. Determination of the alcoholic KOH value of the lubricant
20. Analysis of oils and petroleum: viscosity, flash point, etc.

21. Estimation of Fat in Milk
22. Determination of COD in Wastewater
23. Operation of Water Treatment Plant (Ion Exchange)

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Apply quality control and method validation procedures in industrial chemical analysis.	L, D, TR, P, QA	Lab Report and Lab Test
CO2	Perform water and wastewater analysis, including hardness, acidity, alkalinity, DO, BOD, and COD.	TR, P, QA	Lab Report and Lab Test
CO3	Operate major analytical instruments (AAS, GC, HPLC, FTIR, ICP-OES, EDXRF, spectrophotometer).	TR, P, QA	Lab Report and Lab Test
CO4	Interpret analytical data and evaluate industrial product quality.	L, TR, QA	Lab Report and Lab Test
CO5	Demonstrate understanding of industrial process operations including water treatment plant units.	TR, P, QA	Lab Report and Lab Test

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2							
CO2	3	2	2							
CO3	3		3							
CO4	2	3	2							
CO5	2		2							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	• TICI training manuals and laboratory guidelines • Instrumentation handbooks provided by TICI • Standard Methods for the Examination of Water and Wastewater (APHA) • ASTM and ISO method documents
Supplementary Readings	• *Analytical Chemistry* – Skoog, Holler, Crouch • *Introduction to Environmental Engineering* – Davis & Cornwell • Instrument manufacturer manuals (Shimadzu, Agilent, PerkinElmer)
Others	-

Course Code	**0531 CHN 401**		**Course Type**	**Core (Theory)**		**Level 4 Term I I**
Course Title	**Polymers and Supramolecular Chemistry**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rational	This course introduces the concepts of supramolecular chemistry and polymer science, emphasizing molecular interactions, self-assembly, polymer structure, morphology, and physicochemical properties essential for material design and advanced chemical applications.					

Course Objective

- Provide foundational knowledge of supramolecular chemistry.
- Develop the ability to design and synthesize supramolecular assemblies.
- Understand non-covalent forces and their role in molecular organization.
- Familiarize students with polymer structures, classifications, and macromolecular behavior.
- Provide understanding of polymer properties such as solubility, molecular weight, and thermal behavior.
- Introduce polymer morphology and microscopic structural organization.

Contents

- **Structure of Synthetic and Biological Polymers**

Definitions, difference between polymers and macromolecules, classification of polymers, degree of polymerization, nomenclature and tacticity, basic structure of polymers: linear and branched polymers, moderately cross-linked polymers, number average and weight average molecular weight, Z-average and viscosity average molecular weight, distribution of molecular weight, polydispersity, measurement of number average molecular weight: end group analysis, colligative properties, measurement of number average molecular weight: light scattering, ultracentrifugation, viscometry and gel permeation chromatography.

- **Morphology and Order in Crystalline Polymers**

Configurations of polymer chains, crystal structures of polymers, amorphous polymers, liquid crystalline polymers, morphology of polymer single crystals, structure of polymers crystallized from melt and solution, factors affecting crystallinity.

- **Polymer Solution**

Criteria for polymer solubility, size and shapes of polymers in solution, conformation of dissolved polymer chain, thermodynamics of polymer solutions, Flory-Huggins theory, theta temperature, concepts of a thermodynamically good and poor solvent, fractionation of polymers by solubility.

- **Polymer Structure and Thermal Properties**

The crystalline melting point, the glass transition, factors affecting T_m and T_g, experimental determination of T_g and T_m.

- **Rheology and Mechanical Properties of Polymers**

Introduction to Rheology, definition, Newton's and Hooke's laws, flow behavior of polymers, the ideal fluid, non-Newtonian fluids, viscous flow, relationship between stresses and stain, viscoelasticity, mechanical models –Maxwell and Voigt Boltzmann's superposition principles, stress-strain behavior of elastomers, the mechanical properties of crystalline polymers.

- **Other Polymer Properties**

Thermal stability, flammability and flame resistance, chemical resistance, degradability, electrical conductivity, conducting polymers, vulcanization, physical aspects of vulcanization.

- **Inorganic Polymers**

Concept of inorganic polymers as distinct to organic polymers, classification of inorganic polymers, properties of inorganic polymers, studies of some typical inorganic polymers:
(i) phosphazines, (ii) silicones, and (iii)S-N polymers.

- **Supramolecular Chemistry**

Conceptual foundations of supramolecular chemistry, supramolecular, bioorganic, bioinorganic and biomimetic chemistry, from molecular materials to supramolecular structures, selectivity, supramolecular interactions, supramolecular design.

- **Supramolecular Systems**

Solution host-guest chemistry: guests in solution, macrocyclic vs. acylic hosts, cation binding, anion binding, neutral-molecule binding, self-assembly: rotaxanes, catenanes and knots, organized systems: Surfactants, micelles, vesicles, reverse micelles, microemulsions: preorganization of surface-active

compounds. Interfaces and liquid assemblies, surface self-assembled monolayers, supramolecular liquid crystals

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Acquire fundamental knowledge of supramolecular assemblies.	L, D, QA	T, ASG, F
CO2	Realize the role of non-covalent forces in supramolecular chemistry.	L, D, QA	T, ASG, F
CO3	Gain knowledge of design, synthesis, and applications of supramolecular systems.	L, D, QA	T, ASG, F
CO4	Understand molecular self-assembly including biological systems.	L, D, QA	T, ASG, F
CO5	Describe polymer classifications and molecular-weight determination methods.	L, D, QA	T, ASG, F
CO6	Demonstrate understanding of polymer crystallinity, thermal behavior, and influencing factors.	L, D, QA	T, ASG, F
CO7	Explain polymer solubility and thermodynamic behavior in solution.	L, D, QA	T, ASG, F
CO8	Understand polymer flow behavior and mechanical properties.	L, D, QA	T, ASG, F
CO9	Correlate polymer properties (electrical, degradability, chemical resistance, flame resistance) with monomer structure.	L, D, QA	T, ASG, F

(L–Lecture, D–Discussion, CS–Case Study, QA–Question & Answer Session, T–Test, ASG–Assignment, F–Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2							
CO2	3	2	2							
CO3	3		2							
CO4	2	3	2							

CO5	3	2	2							
CO6	3		2							
CO7	2	3	2							
CO8	2		2							
CO9	2		2							
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. Supramolecular Chemistry – J. W. Steed & J. L. Atwood 2. Polymer Chemistry – Malcolm P. Stevens 3. Introduction to Polymers – Young & Lovell 4. Supramolecular Chemistry: Concepts and Applications – Balzani 5. Principles of Polymer Chemistry – Flory
Supplementary Readings	6. Physical Chemistry of Polymers – Billmeyer 7. Polymer Science and Technology – Fried 8. Advanced Supramolecular Chemistry – Reinhoudt 9. Polymer Solutions – R. Koningsveld
Others	

Course Code	**0531 CHN 421**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Chemistry of Natural Products**					**Credit Hr**	**2.0**
Prerequisite	**Organic Chemistry II**					**Contact Hr**	**2.0**
Rational	This course will provide foundational knowledge of natural product-their classification, isolation, structural analysis, biosynthesis, and biological significance to understand their role in medicinal and biological systems.						
Course Objective							

- Give fundamental concept of natural products with their classification.
- Impart knowledge on isolation, purification and determination of structure by chemical and spectroscopic methods with reference to alkaloids, terpenoids, steroids, hormones etc.
- Realize the biosynthesis of some secondary metabolites such as alkaloids and terpenoids.
- Understand the relationship between color and constituents of organic coloring materials.
- Give knowledge on pheromones, their stereospecificity and action in biological system.

Contents

Natural Products
General methods of isolation, purification and determination of structure of natural products by chemical and spectroscopic methods with reference to alkaloids, terpenes, steroids and hormones, primary and secondary metabolites.

Alkaloids
Definition, isolation of alkaloids from plant sources, test of alkaloids, characterization of alkaloids by chemical, spectroscopic and synthetic methods with reference to ephedrine, adrenaline, nicotine, atropine, quinine and papaverine, biosynthesis of alkaloids.

Terpenoids
Terpenes and terpenoids, classification of terpenoids, isoprene rule, essential oils, detection, isolation and purification of terpenoids, determination of structure of citral, menthol cadenine and camphor by chemical, spectroscopic and synthetic methods, biogenesis of terpenoid compounds.

Steroids and Hormones
Introduction of steroids and hormones, nomenclature and functions of steroids and hormones, cholesterol and its effects in biological systems, steroidal hormones and glycosides,
natural and synthetic hormones.

Organic Coloring Materials
A relationship between color and constitution, anthocyanidines, flavones, xanthenes and other materials, naturally occurring colored compounds: chlorophyll and hemoglobin.

Pheromones
Pheromones, their stereospecificity and actions in biological systems.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Explain the fundamental concepts of natural products and classify them based on their chemical nature, biosynthetic origin, and biological significance.	L, D, QA	T, ASG, F

CO2	Apply suitable extraction, isolation, purification, and spectroscopic techniques to obtain and characterize natural products from plant and animal sources.	L, D, QA	T, ASG, F
CO3	Utilize the understanding of natural product biosynthesis and structural diversity to explore and support drug discovery and development processes.	L, D, QA, CS	T, ASG, F
CO4	Demonstrate the relationship between molecular structure and interpret the basis of their chemical properties	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2				3						
CO3			2	3						
CO4	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	8. Organic Chemistry, I.L. Finar, Vol. 2. 9. Organic Chemistry, T. Morrison and R. N. Boyd. 10. Organic Chemistry - Natural Products, O. P. Agarwal, (Vol. I and II).
Supplementary Readings	1. Natural Products: Chemistry and Biological Significance, J. Mann 2. Chemistry of Natural Products, S.V. Bhat, B.A. Nagasampagi & Meenakshi Sivakumar
Others	-

Course Code	0531 CHN 441		Course Type	Core (Theory)		Level 4 Term I
Course Title	**Nuclear Chemistry**				**Credit Hr**	**2.0**
Prerequisite	**None**				**Contact Hr**	**2.0**
Rational	This course will provide a foundational understanding of nuclear chemistry and radiochemical techniques while fostering awareness of their practical applications, safety measures, and potential risks in scientific and technological contexts.					

Course Objective

- Impart basic knowledge on the different areas of nuclear chemistry including radioactivity, nuclear reactions, radioisotopes, nuclear reactor, radiation detectors, particle accelerators, etc.
- Promote knowledge on radiochemical methods of analysis and their applications.
- Realize the safety and threats of nuclear radiation.

Contents

The Atomic Nucleus and Its Properties

Atomic nucleus and its composition, nuclear radius and nuclear density, nuclear force, mass defect, packing fraction, binding energy, nuclear spin and moments, nuclear potential, concepts of nuclear structure - shell model, nuclear statistics, nuclear stability, nuclidic mass and atomic mass, nuclear mass and energy correlation, classification of nuclides.

Radioactivity and Radioactive Decay Laws

Radioactivity, units of radioactivity, natural and artificial radioactivity, radioactive decay, radioactive decay constant, kinetics of radioactive decay, half-life and average life, radioactive decay series, radioactive equilibria, comparison between radioactive equilibrium and chemical equilibrium.

Nuclear Reactions and Fission

Nuclear reactions and their comparison with chemical reactions, types of nuclear reactions, conservation laws, energetics of nuclear reactions, nuclear reaction cross-section, excitation function, nuclear reactions mechanisms, liquid drop model of nuclear fission and fissionability parameters, general features of mass, charge and kinetic energy distributions in thermal neutron induced fission of ^{235}U and ^{239}Pu.

Interaction of Radiation with Matter and Detection of Nuclear Radiation

Introduction, modes of interactions, interactions of gamma radiations with matters, interactions of charged particles with matters, Bremsstrahlung radiation, Ĉerenkov radiation, beta backscatter, the Auger process, radiation detection, measurements of radiations with ionization chambers, proportional counter, Geiger Müller counter, NaI(Tl) scintillation detectors, solid state semiconductor detector.

Nuclear Reactors and Accelerators

Nuclear reactors – principles, major components of reactors, types of reactors, application of reactors; working principles, basic components and utilization of Van de graaff, tandem Van de graaff and cyclotron accelerators.

Production and Uses of Radioisotopes

General principles of production of radioisotopes, radiochemical separation and purification of isotopes, uses of radioisotopes in chemical, physical, and biological sciences, medicine, agriculture and industry citing illustrations of current interests.

Nuclear, Nuclear-related and Radiochemical Methods of Analysis and Their Applications

Radiotracer, geochronology and radioactive dating, isotope dilution method in chemical analysis, neutron activation analysis of trace elements, PIXE analysis of trace elements, energy dispersive X-ray fluorescence analysis.

Safety

Radiation exposure, radiation dose, dose equivalent, quality factor, simple calculation of radiation exposure and radiation dose for γ-and β-rays, radiation hazards, radioactive wastes and their management.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain the origins of nuclear instability, different types of radioactive decay, nuclear reactions, and their governing principles.	L, D, QA	T, ASG, F
CO2	Describe and analyze the operation of nuclear reactors, particle accelerators, and radiation detectors used in nuclear science	L, D, CS, QA	T, ASG, Q, F
CO3	Apply the acquired knowledge in the analytical applications of nuclear reactions and nuclear materials, and designing of nuclear reactors to generate nuclear fuels	L, D, QA	T, ASG, F
CO4	Evaluate and demonstrate appropriate safety protocols and regulatory practices for handling internal and external radiation, nuclear wastes.	L, D, , QA	T, ASG, Q, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3	2								
CO3				3						
CO4		3								

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Radiochemistry and Nuclear Methods of Analysis, W. D. Ehmann and D. E. Vance. 2. Nuclear and Radiochemistry, G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller. 3. Introduction to Nuclear Physics and Chemistry, B. G. Harvey.
Supplementary Readings	1. Essentials of Nuclear Chemistry, H. J. Arnikar. 2. Nuclear Chemistry and its Applications, G. R. Choppin and J. Rydberg 3. Principles of Nuclear Chemistry, Williams 4. Nuclear Chemistry Vol. I & II, L. Yaffe, 5. 8. Inorganic Chemistry, Catherine E. Housecroft
Others	-

Course Code	**0531 CHN 485**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Applications of Nanoscale Materials**					**Credit Hr**	**3.0**
Prerequisite	**Fundamentals of Nanoscience**					**Contact Hr**	**3.0**
Rational	This course will provide a comprehensive understanding of advanced nanomaterial while emphasizing innovation, commercialization, sustainability, and safe, ethical deployment in modern technology sectors.						

Course Objective

- Gain foundational knowledge of the global nanotechnology landscape, including market trends, technology readiness levels, scalability challenges, and economic feasibility of nanomaterial-based products.
- Understand the role of nanomaterials in modern electronics and photonics, including nanoelectronic devices, advanced display materials, photonic systems, and plasmonic technologies.
- Explore next-generation energy technologies such as nanostructured materials for high-efficiency photovoltaics, catalysis in fuel cells and water splitting, and advanced energy storage systems.
- Examine nanomaterials for environmental protection, including adsorption, photocatalysis, and nanosensing strategies for pollutant detection and remediation.
- Understand key concepts in nanomedicine and theranostics, focusing on targeted drug delivery, bio-imaging techniques, nanobiomaterials, and nanotechnology-enabled cancer therapies.
- Learn the applications of nanomaterials in catalysis and advanced manufacturing, including industrial catalysts, lightweight composites, and protective nanocoatings.
- Evaluate sustainability, ethical issues, and safety practices, including life-cycle assessment, environmental/health impacts, and existing regulatory frameworks guiding nanotechnology use.

Contents

Introduction & Market Landscape

Overview of the global nanotechnology market. From lab-scale innovation to commercial product: understanding technology readiness levels (TRLs), scalability, and cost-benefit analysis.

Nanomaterials in Electronics & Photonics
Nanoelectronics beyond Moore's Law (CNT FETs, 2D material transistors). Nanomaterials for displays (QLEDs), touchscreens (ITO alternatives like silver nanowires, graphene), and data storage (MRAM, phase-change memory). Plasmonics and nanophotonics for sensing and sub-wavelength light manipulation.

Nanomaterials for Energy Conversion and Storage
Next-generation photovoltaics (Perovskite solar cells, quantum dot solar cells). Catalytic nanomaterials for fuel cells and water splitting. Advanced nanomaterials for batteries (Si-anodes, Li-S cathodes) and supercapacitors (graphene, MXenes).

Nanomaterials in Environmental Remediation
Adsorptive nanomaterials for heavy metal and organic pollutant removal (e.g., nanocomposites, MOFs). Photocatalytic nanomaterials (TiO_2, g-C_3N_4 based) for water/air purification and self-cleaning surfaces. Nanosensors for environmental monitoring.

Nanomedicine and Theranostics
Targeted drug delivery systems (liposomes, polymeric nanoparticles). Nanomaterials for bio-imaging (quantum dots, gold nanoparticles for contrast). Nanobiomaterials for tissue engineering and regenerative medicine. Cancer therapy (hyperthermia, photodynamic therapy).

Nanomaterials in Catalysis and Manufacturing
Heterogeneous nanocatalysts for industrial chemical processes. Nanomaterials in lightweight composites for automotive and aerospace sectors. Nanocoatings for corrosion resistance, wear protection, and thermal barriers.

Sustainability, Ethics, and Safety
Life-cycle assessment of nanomaterial production. Environmental, Health, and Safety (EHS) considerations. Ethical implications of nanotechnology. Regulatory frameworks.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Analyze the global nanotechnology landscape and assess the scalability, readiness levels, and economic feasibility of emerging nanomaterial-based technologies.	L, D, QA	T, ASG, F

CO2	Explain and evaluate the functional role of advanced nanomaterials in electronics, photonics, energy conversion, and energy storage systems.	L, D, QA	T, ASG, F
CO3	Apply principles of nanomaterials science to environmental remediation, nanomedicine, catalysis, and advanced manufacturing applications.	L, D, QA	T, ASG, F
CO4	Assess sustainability, ethical concerns, and safety regulations related to nanomaterial production and deployment using life-cycle.	L, D, CS, QA	T, ASG, F, Pr

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3			2						
CO3	3			3						
CO4		3								

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Bhushan, B. (Ed.). (2017). Springer Handbook of Nanotechnology. Springer Berlin Heidelberg. 2. Rogers, B., Pennathur, S., & Adams, J. (2011). Nanotechnology: Understanding Small Systems. CRC Press. 3. Cao, G. (2004). Nanostructures & Nanomaterials: Synthesis, Properties & Applications. Imperial College Press. 4. Recent review articles from high-impact journals like Nature Nanotechnology, ACS Nano, Advanced Materials, and Nano Letters.
Supplementary Readings	
Others	-

Course Code	0531 GESHC 401		Course Type	Core (Theory)		Level 4 Term I	
Course Title	**Chemical Security, Hazard Mitigation, and Chemical Weapon Regulations**					**Credit Hr**	**2.0**
Prerequisite	**None**					**Contact Hr**	**2.0**
Rational	This course will equip students with the essential knowledge and skills to manage chemical risks responsibly, prevent the misuse of hazardous substances, and ensure compliance with national and international chemical safety regulations.						

Course Objective

- To provide basic knowledge and skills to manage chemical risks effectively
- To prevent the misuse of toxic chemicals (including for terrorism or chemical weapons)
- To ensure the compliance with relevant national and international regulations.

Contents

Introduction to Chemical Safety and Hazard Communication

Hazard substance, Hazard Classification, risks, chemical safety and security, hazard communication standard (HCS), pictogram of HCS, SDS sheet, process relation between chemical safety and security practices, modern agreements.

Exposure, Evaluation and Health Risks of Chemical Exposure in Workplace

Methods of identifications of chemicals in work place, route of the exposure of chemicals, health risks, effects, carcinogenic and non-carcinogenic risks in human body, long term effects.

Mitigation of chemical hazard

Chemical accidents, causes of chemical accidents, prevention of chemical accidents and hazardous control; hierarchy of control, EPA segregation guideline, methods for the immediate action of chemical accidents, disposal of chemical agents

Chemical Safety Standards and Regulations

Definition of chemical safety, measureable steps, rules and regulations for chemical safety in national and international level, OSHA, EPA, government’s chemical Daccidents and initiatives in Bangladesh.

Chemical Weapons

Definition, classifications of weapons, classes of chemical weapon agents, schedule chemicals and their effects, harmful effects of CW, chemical weapons in international politics, categories of weaponizable chemical agents.

Organization for the Prohibition of Chemical Weapons (OPCW)

Brief history of chemical weapons, background for the formation of OPCW, organizations for the prohibition of chemical weapons, functions and role of OPCW, chronology of chemical weapon (CW) international control efforts, control over of developed countries on OPCW.

Bangladesh National Authority for Chemical Weapons Convention (BNACWC)

History of BNACWC formation, mission, vision, and motto of BNACWC, organogram of BNACWC, role of BNACWC in national and international level, national legislation on CWC in Bangladesh, chemical weapons (Prohibition) Act-2006.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Overview about the exposure and risks of chemicals in workplace and chemical accidents in workplace.	L, D, QA	T, ASG, F
CO2	Explain the rules and regulations about chemical safety.	L, D, QA	T, ASG, F
CO3	Explain the general concepts of chemical weapons and weaponizable chemical	L, D, QA	T, ASG, F
CO4	Get an idea about the role of various organizations and act for the prohibition of chemical weapons in national and international level.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3									
CO3	3									
CO4	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Davis, H.B. Tyson, J.F. Pechenik, J.A. A Short Guide to Writing About Chemistry, Addison-Wesley, Boston, MA, 2010. 2. Boudah, D.J. Conducting Educational Research: Guide to Completing a Thesis, Dissertation, or Action Research Project, 2nd Edition, Thousand Oaks, CA: Sage, 2020. 3. Pan, M.L. Preparing Literature Reviews: Qualitative and Quantitative

	Approaches, Pyrczak Publishing, 2013
Supplementary Readings	1. Islam, M.N. An Introduction to Research Methods, 4th Edition, Mullick and Brothers, Dhaka, 2018. 2. Creswell, J.W. Research Design: Qualitative, Quantitative and Mixed Methods Approach, 5th Edition, Thousand Oaks, CA: Sage, 2018. 3. Heppner, P.P. Heppner, M.J. Writing and Publishing Your Thesis, Dissertation, and Research: A Guide for Students in the Helping Professions. Belmont, CA: Brooks/Cole-Thomson Learning, 2004.
Others	

Course Code	**0531 GERM 401**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Research Methodology**					**Credit Hr**	**1.0**
Prerequisite	**None**					**Contact Hr**	**1.0**
Rational	The Fundamentals of Research Methodology is a hands-on course designed to impart education in the foundational methods and techniques of academic research in Science and Engineering context.						

Course Objective

- To evaluate/review related extant literature, form a variety of sources, pertinent to the research objectives/questions.
- To expose students to various research methodologies (design), relevant to the research problem needing to be addressed.
- To explain and justify how researchers will collect and analyze research data.
- To educate students in the common mistakes, research misconduct, and ethical considerations in the field of research methodology.

Contents

Foundations of Research: Meaning of Research; Definitions of Research; Objectives of Research; Motivation in Research; General Characteristics of Research; Criteria of Good Research; Types of Research; Concept of theory, empiricism, deductive and inductive theory; Characteristics of scientific method.

Practice session on Foundations of Research

Problem Identification & Formulation: Meaning & need of Review of Literature; How to Conduct the Review of literature; Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance

Practice session on Problem Identification & Formulation

Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

Practice session on Research Design

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

Practice session on Data Analysis

Research Misconduct and Ethics: Understand the research misconduct; type of research misconduct; Ethical issues in conducting research; Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

Practice session on Research misconduct and Ethics

Use of Tools / Techniques for Research: Layout of a Research Paper; Methods to search required information effectively; Reference Management Software like Zotero/Mendeley; Software for paper formatting like LaTeX/MS Office; Software for detection of Plagiarism. Time management and developing Gantt Charts.

Practice session on Use of tools / techniques for Research

Review Session (Theory) – I /Final Presentation

Review Session (Practice) – II /Final Presentation

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Understand the research fundamentals and formulate problem statement and research questions/objectives.	L, D, QA	T, ASG, F
CO2	Formulate and compose a Research proposal considering research activities, background studies, and following standard guidelines.	L, D, QA	T, ASG, F
CO3	Develop writing and presentation skill, and demonstrate ethical considerations in conducting research	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2				3						
CO3				3						

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Engineering Research Methodology: A Practical Insight for Researchers. Springer, by Deb, Dipankar, Dey, Rajeeb, Balas, Valentina E. 2. Research Methods for Engineers, 1st Edition, by David V. Thiel. 3. Handbook of Research Methodology by Talati, J.K. 4. Introducing Research Methodology: A Beginner′s Guide to Doing a Research Project by Uwe Flick 5. Research Methods: Information, Systems, and Contexts by Kirsty Williamson, Graeme Johanson 6. Improving survey questions: design and evaluation. Sage Publications, by Fowler, F. J. 7. Computational handbook of statistics (4th ed.). New York: Longman, by Bruning, J. L. & Kintz, B. L.
Supplementary Readings	
Others	-

Course Code	**0531 CHN 482**		**Course Type**	**Core (Sessional)**		**Level 4 Term I**	
Course Title	**Nanomaterials Synthesis Sessional**					**Credit Hr**	**1.5**
Prerequisite	**Nanoscale Synthesis, Fabrication and Characterization**					**Contact Hr**	**3.0**
Rational	This course will equip students with the theoretical understanding, practical laboratory skills, and safety awareness necessary to synthesize, characterize, and critically evaluate nanomaterials and their properties.						

Course Objective

- Understand the principles behind common chemical and physical nanomaterial synthesis routes.
- Develop practical skills in handling chemicals and operating laboratory equipment specific to nanomaterial fabrication.
- Apply fundamental characterization techniques to analyze the size, morphology, stability, and optical properties of nanomaterials.
- Critically analyze experimental data, identify sources of error, and understand the relationship between synthesis conditions and material properties.
- Adhere to strict safety protocols for handling nanomaterials and chemicals in a laboratory setting.

Contents

A series of laboratory experiments covering fundamental nanomaterial synthesis techniques. This includes:

Bottom-Up Synthesis: Wet-chemical methods such as co-precipitation, sol-gel, hydrothermal, and solvothermal synthesis.

Top-Down Synthesis: Mechanical milling and exfoliation techniques.

Green Synthesis: Environmentally benign synthesis using plant extracts or biological agents.

Functionalization: Surface modification of nanoparticles for enhanced stability and application.

Basic Characterization: Use of UV-Vis Spectroscopy, Dynamic Light Scattering (DLS), and Fourier-Transform Infrared Spectroscopy (FTIR) for preliminary analysis of synthesized nanomaterials.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Perform and adhere to safe laboratory practices while synthesizing nanomaterials using methods such as co-precipitation, sol-gel, and hydrothermal techniques.	L, D, QA, EXP	R, Q, LT
CO2	Operate and utilize fundamental characterization instruments (UV-Vis, DLS, FTIR) to collect and analyze data for evaluating the physical and chemical properties of nanomaterials.	L, D, QA, EXP	ASG, R, LT
CO3	Interpret experimental results and communicate findings effectively through scientifically structured laboratory reports while functioning responsibly and collaboratively in team-based environments.	L, D, QA, EXP	ASG, R

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam, LT- Lab Test)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3								

CO2		3								
CO3				3						

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. *A Laboratory Course in Nanoscience and Nanotechnology* — Gerrard Eddy J. Poinern 2. *Chemical Methods for Processing Nanomaterials* — Vidya Nand Singh (ed.) 3. *Nanomaterials Synthesis, Characterization, and Applications* — A. K. Haghi, Ajesh K. Zachariah & Nandakumar Kalarikkal (eds.) 4. *Synthesis of Nanomaterials: Mechanisms, Kinetics and Materials Properties* — S. Noor Mohammad
Supplementary Readings	
Others	-

Course Code	**0531 CHN 442**	**Course Type**	**Core (Sessional)**	**Level 4 Term I**	
Course Title	**Nuclear Chemistry Sessional**			**Credit Hr**	**1.5**
Prerequisite	**Nuclear Chemistry**			**Contact Hr**	**3.0**
Rational	This course will equip students with the practical skills and theoretical understanding necessary for accurate radiation measurement, environmental radioactivity assessment, instrumentation calibration, radiation protection, and radioisotope separation.				

Course Objective

- To understand the concept of nuclear and radiochemistry.
- To know about the nature of nuclear reaction and reaction mechanisms.
- To understand the concepts of stability of nuclear material.
- To know the application of radioisotope in different sector.
- To know about separation of radioisotopes and introduce different separation method.

Contents

1. Measurement of external dose using Thermoluminesence Dosimeter (TLD).
2. Preparation and measurements for environmental samples using Gamma spectrometry system: soil, water and food stuff.
3. Effect of shielding materials in radiation protection.
4. Calibration of Gamma spectrometry, alpha spectrometry, and ZnS Scintillation Counter in terms of energy and activity.
5. Survey of background radiation using Survey meter and GPS.

6. Separation of radioisotopes i.e. cesium, strontium, plutonium, americium etc.			
Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Apply fundamental concepts of detection and measurement of radioactivity.	L, D, EXP	R, Q, T
CO2	Analyze different separation method like solvent extraction method, ion exchange method etc. for various radioisotopes.	L, D, EXP	R, Q, T
(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	Attila Vértes, Sándor Nagy, Zoltán Klencsár, Rezso György Lovas, Frank Rösch – Handbook of Nuclear Chemistry: Vol. 1 – 2nd Edition, NY, Springer Science & Business Media, 2011
Supplementary Readings	
Others	-

Course Code	0531 CHN 443		Course Type	Core (Theory)		Level 4 Term I
Course Title	Advanced Topics in Inorganic Chemistry				Credit Hr	2.0
Prerequisite	Chemistry of Representative Elements and Inert gas				Contact Hr	2.0
Rational	This course will provide students with a comprehensive understanding of molecular symmetry, organometallic chemistry, metal–ligand interactions, nonaqueous solvent behavior, and non-stoichiometric solid in advanced inorganic and materials chemistry.					

Course Objective

- Introduce with molecular symmetry and symmetry operations, molecular point groups, and character tables.
- Impart knowledge on several aspects of inorganic chemistry such as metal-ligands interactions, organometallic compounds, non-aqueous solvent system, the polymer chemistry of carbon, silicon, boron, phosphorus, Sulphur and nitrogen, electron deficient and nonstoichiometric compounds, cluster compounds.
- Convey knowledge on the product of organometallic reactions based on fundamental principles.
- Discuss some current applications of transition metal complexes in the fields of industrial and medicinal chemistry.

Contents

Molecular Symmetry and Group Theory

Symmetry elements and operations, point groups of molecules, multiplication of symmetry operations, rules for multiplications, symmetry point groups and molecular systems, groups of very high and low symmetry, use of flow chart to identify a point group, optical activity and dipole moments on the basis of point group symmetry, symmetry operations and matrix representations, reducible and irreducible representations, character tables for point groups.

Metal Carbonyls and Nitrosyls

Pi-acid ligands and pi-acid complexes, metal carbonyl and metal nitrosyl complexes, preparation and properties of metal carbonyl and nitrosyl complexes, M-C-O and M-N-O bonding, bridging and terminal COs and NOs, cluster carbonyls and nitrosyls, infrared and 13C NMR analysis, side-on bonding in carbonyls, nitrosyls, biological importance of carbonyls and nitrosyls.

Organometallics and Their Catalytic Aspects

Introduction, general characteristics, stability of organometallic compounds, ligands in organometallic chemistry, classification of organometallic compounds, preparative routes for metal-carbon bond formation, bonding between metal atoms and organic pi systems, structures of Zeise's salt and ferrocene, complexes containing M–C, M=C, and M≡C bonds, organometallic reactions – ligand dissociation and substitution, oxidative addition, reductive elimination, carbonyl insertion, homogeneous catalysis – hydrogenation by Wilkinson's catalyst, hydroformylation, heterogeneous catalysis – Ziegler-Nata polymerizetions, water gas reactions, Fisher-Tropsch reaction.

- **Nonaqueous Solvents**

Classification of solvents, general properties of ionizing solvents, leveling and differentiating solvents, types of chemical reactions in solvents, measurement of solvent strength, liquid ammonia, anhydrous sulfuric acid, liquid SO_2, molten salts as solvents.

- **Non-stoichiometric Compounds**

Introduction, characteristics of nonstoichiometric compounds, structure of non-stoichiometric compounds, methods for studying non-stoichiometric compounds.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Recognize symmetry elements in a molecule and state the point group a molecule belongs to.	L, D, QA	T, ASG, F
CO2	Use molecular symmetry to predict the chemical properties of a molecule, such as dipole moment and allowed spectroscopic transitions.	L, D, QA	T, ASG, F
CO3	Understand the bonding and properties of metal carbonyls and nitrosyls, transition metal organometallics and explain the catalytic cycle for production of alcohol, carbonyls, polymers and the role of metals in living systems.	L, D, QA	T, ASG, F
CO4	Know the nature and properties of non-aqueous solvents.	L, D, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Chemical Applications of Group Theory, F. A. Cotton. 2. Inorganic Chemistry, D. F. Shriver and P. W. Atkins. 3. Concepts and Models of Inorganic Chemistry, B. E. Douglas, D. H. McDaniel and J. J. Alexander. 4. Modern Aspects of Inorganic Chemistry, H. J. Emeleus and A. G. Sharpe. 5. Inorganic Chemistry, G. L. Miessler and D. A. Tarr. 6. The Organometallic Chemistry of the Transition Metals, R. H. Crabtree. 7. Chemistry in Non-aqueous Solvents, H. H. Sisler. 8. A Text Book of Inorganic Polymers, A. K. Bhagi and G. K. Chatwal
Supplementary Readings	
Others	-

Course Code	**0531 CHN 445**		**Course Type**	**Core (Theory)**		**Level 4 Term I**
Course Title	**Green Chemistry for Sustainable Environment**				**Credit Hr**	**2.0**
Prerequisite	**None**				**Contact Hr**	**2.0**
Rational	This course will provide students with the knowledge and skills to understand environmental systems, assess pollution-related chemical processes, and apply green chemistry principles to promote sustainable and environmentally responsible practices.					

Course Objective

- Provide fundamental knowledge of environmental systems and green chemistry principles
- Understand the main environmental segments and chemical processes related to pollution problems
- Develop skills for analyzing environmental problems and applying green chemistry solutions
- Promote sustainable approaches to chemical processes and environmental protection

Contents

Basic Concepts of Environmental Chemistry and Green Chemistry

Fundamental components and structure of the environment: lithosphere, hydrosphere, atmosphere and biosphere. Introduction to Green Chemistry principles and their role in sustainable development.

Water Pollution and Green Treatment Approaches

General causes of water pollution, types of chemical pollutants in water: inorganics, organics, nutrients, pesticides, toxic heavy metals. Conventional and green treatment methods: coagulation, flocculation, adsorption, advanced oxidation processes, and biological treatment.

Atmospheric Chemistry and Sustainable Solutions

Nature of chemical pollutants in the atmosphere and their sources, chemical and photochemical reactions: ozone depletion, greenhouse effect, climate change, acid rain and photochemical smog. Green approaches for air pollution control and prevention.

Sustainable Waste Management and Resource Recovery

Major sources of solid wastes: industrial, municipal, and hazardous waste. Sustainable management approaches: waste minimization, recycling, composting, and energy recovery. Circular economy concepts.

Green Chemistry Principles and Applications

The 12 principles of green chemistry, atom economy, renewable feedstocks, green solvents, and catalysis. Design of safer chemicals and sustainable chemical processes.

Toxic Effects and Green Alternatives

Toxic chemicals and metals: Pb, Cd, Hg, As. Pesticides, chlorinated hydrocarbons, and persistent organic pollutants. Green alternatives and sustainable substitutes.

Environmental Monitoring and Green Technologies

Importance of analytical methods in environmental chemistry. Green analytical techniques and sustainable monitoring approaches. Emerging green technologies for environmental protection.

Sustainable Policies and Global Frameworks

National and international environmental regulations: clean air and water acts, environmental quality standards (EQS). Green chemistry in policy making and sustainable development goals.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Identify the main components of Earth's environment and apply green chemistry principles to environmental protection	L, D, QA	T, ASG, F
CO2	Understand the chemistry of water and air pollution and evaluate sustainable treatment approaches	L, D, QA	T, ASG, F
CO3	Analyze the toxicity of chemical pollutants and propose green alternatives and sustainable substitutes	L, D, QA	T, ASG, F
CO4	Apply waste minimization techniques and resource recovery methods in environmental management	L, D, QA, CS	T, ASG, F
CO5	Understand environmental policies and integrate green chemistry concepts in sustainable development frameworks	L, D, QA	T, ASG, Pr, F
CO6	Design and evaluate chemical processes using green chemistry principles and sustainability metrics	L, D, QA, CS	T, ASG, Pr, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping										
Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	2		3							
CO4	2	3								
CO5	2		3						3	
CO6	3		2						3	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	1. Environmental Chemistry, S. E. Manahan. 2. Air Quality, T. Godish. 3. Fundamental Concepts of Environmental Chemistry, G. S. Sodhi. 4. Environmental Analytical Chemistry, F. W. Fifield and P. J. Haines edited. 5. Environmental Chemistry, A.K. De. 6. Environmental Toxicology, M. Satake, Y. Mido, M. S. Sethi, S. A. Iqbal, H. Yasuhisa and S. Taguchi.
Supplementary Readings	
Others	-

Course Code	0531 CHN 451		Course Type	Core (Theory)		Level 4 Term I
Course Title	Applied Physical Chemistry (Elective)				Credit Hr	2.0
Prerequisite					Contact Hr	2.0
Rational	This course will provide students with the foundational principles of material and energy balances, industrial catalysis, and both conventional and renewable energy technologies to understand, evaluate, and contribute to efficient and sustainable chemical and energy processes.					

Course Objective

- Impart knowledge on balancing energy and materials of a system in operation.
- Acquaint with homogenous and heterogeneous catalysts.
- Give knowledge on energy generation and storage including renewable and alternative sources of energy.

Contents

Fundamentals of Material Balances
Process classification, balances, material balance calculations, balances on multiple-unit processes, recycle and bypass, balances on reactive systems, balances on reactive processes, combustion.

Energy and Energy Balances
Forms of energy, energy balances on closed systems, energy balances on open systems at steady state, energy balance procedures.

Homogeneous and Heterogeneous Catalysis in Chemical Industries
Commonly used catalysts, zeolites, mixed oxides, noble metal catalysts, preparation and characterization, new trends in catalyst development, nano-cluster preparation, micro-porous supports.

Energy
Conventional sources, coal, petroleum, natural gases, fuel cells, modern need of energy forms, commercial production of electricity, gasoline, LPG.

Energy of the Future
The energy crisis, coal gasoline and natural gas-gasoline, underground gasification of coal.

Alternative and Renewable Sources of Energy
Solar energy, solar cells, bio-gas, gasohol, wind energy, energy from waves, geothermal energy.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Realize the energy sources, importance of energy source and crisis sectors.	L, D, QA	T, ASG, F

CO2	Explain the balancing of the mass and energy in an industrial process by applying the concepts of thermodynamics and chemical reactions.	L, D, QA	T, ASG, F
CO3	Recognize different catalysts including shape-selective catalysts and design appropriate catalyst for chemical industries.	L, D, QA	T, ASG, F
CO4	Gain knowledge on different forms of energy, conversion of energies such as chemical (fossil), electromagnetic, electrical, thermal, geothermal, wind, and wave and the conversion of fossil fuels from one form into another.	L, D, QA	T, ASG, F
CO5	Innovate alternative and renewable sources of energy for future	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	2		3							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Elementary Principles of Chemical Processes, R. M. Felder and R. W. Rousseau. 2. Energy and Problems of a Technical Society, J. J. Kraushaar and R. A. Ristinen. 3. Energy Systems and Sustainability: Power for a Sustainable Future, G. Boyle, B. Everett and J. Ramage edited.
Supplementary Readings	
Others	-

<table>
<tr><td>Course Code</td><td>0531 CHN 453</td><td></td><td>Course Type</td><td>Core (Theory)</td><td></td><td colspan="2">Level 4 Term I</td></tr>
<tr><td>Course Title</td><td colspan="5">Medicinal Chemistry (Elective)</td><td>Credit Hr</td><td>2.0</td></tr>
<tr><td>Prerequisite</td><td colspan="5"></td><td>Contact Hr</td><td>2.0</td></tr>
<tr><td>Rational</td><td colspan="7">This course will provide students with essential knowledge of how chemical structure, physicochemical properties, and biological mechanisms govern drug action, enabling a foundational understanding of major therapeutic drug classes and principles of rational drug design.</td></tr>
</table>

Course Objective

- Introduce concepts on medicinal chemistry.
- Give preliminary knowledge on types of drugs, sources, physicochemical properties and their biological activities.
- Acquire knowledge on drug action, drug metabolism, receptor theories and drug design.
- Impart concepts on drug discovery, drug development and production.
- Give knowledge on chemical and biological aspects of different classes of drugs.

Contents

Physico-chemical properties and biological activity.

Structural features and pharmacological activity.

Drug metabolism.

Receptor site theory.
Theoretical aspects of drug design.

Chemical and Biological Aspects of the Following Classes of Drugs:
(a) Anaesthetics (cocaine, ecgonine, procaine, tetracacine, lidocaine),
(b) Antibacterial agents (sulfamethoxazole, sultanilamide, sulfadiazine),
(c) Antibiotics (β-lactam antibiotics ampicillin, amoxycillin, cloxacillin, floxacillin),
(d) Anti-cancer agents (busulfan, mechloromethamine, 5-flurouracil, methotrexale,
(e) Doxorubicin, duanorubicin, dactinomycin, vincristin, venblastin),
(f) Antidiabetic agents (tolbutamide, chlorpropamide, tolazamide, acetohexamide, glyburide),
(g) Cardiac agents (cardiac glycosides and related drugs, digitoxin, digoxin, diglialis, gitalin),
(h) Central nervous system stimulants (amphetamine, strychnine, brucine), and
(i) Depressants (diazepam, oxazepam, clobazam, nitrazepam, barbiturates).

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Understand the fundamental concepts of medicinal chemistry.	L, D, QA	T, ASG, F
CO2	Achieve the knowledge on drug discovery, development and production.	L, D, QA	T, ASG, F

CO3	Impart knowledge on the mechanism of drug receptor interaction, stereochemistry and drug design, structure-activity relationships, drug metabolism, factors affecting the metabolism etc.	L, D, QA	T, ASG, F
CO4	Gain knowledge on chemical and biological aspects of different classes of drugs.	L, D, QA	T, ASG, F
(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Burger's Medicinal Chemistry, M. E. Wolff edited. 2. Principles of Medicinal Chemistry, W. O. Foye, T. L. Lemke and D. A. Williams edited
Supplementary Readings	
Others	-

Course Code	**0531 CHN 455**		**Course Type**	**Core (Theory)**		**Level 4 Term I**
Course Title	**Bioinorganic Chemistry (Elective)**				**Credit Hr**	**2.0**
Prerequisite					**Contact Hr**	**2.0**
Rational	This course will introduce the chemical principles that govern biological systems—covering bioelements, biomolecules, transport proteins, enzymatic catalysis, nitrogen fixation, and photosynthesis.					

Course Objective

- Impart knowledge on the fundamentals of biological systems.
- Promote knowledge on bioelements and their compounds.
- Provide knowledge on biomolecules and their role in biological chemistry and natural chemistry.

Contents

Fundamentals of Biological Systems

Living organisms from water, small organic molecules and inorganic nutrients such as CO_2, NH_3, NO_3^- ,SO_4^{2-} and PO_4^{3-}, energy and the biological systems, proteins and their structures, enzymes, carbohydrates, nucleic acids, lipids, biological membranes, carbohydrate and protein metabolism, photosynthesis and storage of solar energy, burning of carbohydrates.

Bioelements and Their Compounds

Periodic table and the bioelements, essential and trace elements, distribution of elements in biosphere and in biological cells, toxic elements and their regulatory levels, metallobiomolecules and their classification.

Principles of Bioinorganic Chemistry

Choice of elements by the organisms, efficiency and specificity of bioactive elements, fitness of an element and its reduction potential, evolutionary improvement of fitness and specificity.

Ion Pumps and Transport Proteins

Active transport and the energetics, eversion mechanism, selectivity in eversion, Ca^{2+} biochemistry, role of calcium in smooth muscle contraction, oxygen transport, hemoglobin and myoglobin, tertiary structure of myoglobin, oxygen binding curve, electronic structures of oxyhaemoglobin, models of O_2 binding, hindrance of dimer formation and picket fence porphyrins.

Enzyme Catalysis

Oxidoreductases, transferases, hydrolases, lyases, ligases, heme catalysts such as cytochromes, peroxidases and catalases functioning to detoxify substances, decompose hydrogen peroxide and organic peroxides and store energy through ATP synthesis, mechanism of the addition of O_2 to substrate by cytochrome-P450, mechanism of the decomposition of H_2O_2, zinc, manganese and copper catalysts, large number of zinc enzymes and the uniqueness of zinc as a bioelement, mechanism of oxaloacetate decarboxylase, carboxypeptidase and carbonic anhydrase.

Nitrogen Fixation and Photosynthesis

Nitrogenases, structure of the active site, model compounds, iron-sulfur proteins, photosystems and the four-electron oxidation of water to O_2, chloroplasts, chlorophylls, reaction center organization.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Acquire knowledge about biological systems, bioelements and their compounds.	L, D, QA	T, ASG, F

CO2	Gather knowledge about bioinorganic chemistry and role of bioinorganic chemistry in biological system.	L, D, QA	T, ASG, F
CO3	Describe the operation of the sodium potassium pump and the proton pump, and the functions of transport proteins.	L, D, QA	T, ASG, F
CO4	Identify and explain the different classes of enzymes and their catalytic role in biological processes.	L, D, QA	T, ASG, F
CO5	Understand the nitrogen fixation and photosynthesis.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson. 2. Inorganic Chemistry, J. E. Huheey. 3. Inorganic Chemistry, D. F. Shriver, P. W. Atkins and C. H. Langford. 4. Inorganic Chemistry, G. L. Miessler and D. A. Tarr.
Supplementary Readings	
Others	-

Course Code	**0531 CHN 457**		**Course Type**	**Core (Theory)**		**Level 4 Term I**
Course Title	**Nanotechnology for Energy Conversion and Storage**				**Credit Hr**	**2.0**

	(Elective)		
Prerequisite		**Contact Hr**	**2.0**
Rational	This course will provide students with a comprehensive understanding of modern solar, fuel cell, and battery technologies to prepare them for contributing to sustainable energy solutions.		

Course Objective

- To introduce the fundamental principles of solar cells, fuel cells, and batteries, including their working mechanisms and performance characteristics.
- To explore fabrication methods, material requirements, and technological limitations of current and emerging photovoltaic and electrochemical energy systems.
- To examine nanotechnology-driven advancements in next-generation solar cells and their potential for future energy applications.
- To develop an understanding of electrochemical thermodynamics, kinetics, and transport processes that govern modern energy-conversion and storage devices.

Contents

Solar resource, solid state fundamentals, solar cell characteristics, Shockley –Quisser limit, cell fabrication, limitations of current technologies. Nanotechnology inspired first, second and third generation solar cells: design, property, performance and future potential. Thermodynamics and kinetics of fuel cells, working principles, cell components, types of fuel cells and applications, electronic and ionic transportations, I-V characteristics, choice of electrode and electrolyte materials and its future development. Fundamentals of batteries. Standard-state potential, cell structures and working principles. Battery types, construction and performance, capacity, I-V characteristics, life-time issue and its potential.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Explain the principles, structure, and performance characteristics of solar cells, fuel cells, and batteries.	L, D, QA	T, ASG, F
CO2	Analyze the thermodynamics, kinetics, and transport processes that govern energy-conversion and storage systems.	L, D, QA	T, ASG, F
CO3	Evaluate current and next-generation photovoltaic technologies, including nanotechnology-based solar cells, in terms of design, efficiency, and limitations.	L, D, QA	T, ASG, F
CO4	Compare different types of fuel cells and batteries based on materials, construction, I–V characteristics, capacity, and lifetime considerations.	L, D, QA	T, ASG, F
CO5	Assess the potential and challenges of emerging energy technologies for future sustainable applications.	L, D, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3							
CO2	3		3							
CO3	3		3							
CO4			3							
CO5			3							
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. Solar Energy: The Physics and Engineering of Photovoltaic Conversion– Arno H. M. Smets, Klaus Jäger, Olindo Isabella, René van Swaaij, Miro Zeman 2. Fuel Cells: Principles, Design and Analysis–Shripad T. Revankar / K. Scott 3. Nanostructures and Nanomaterials: Synthesis, Properties and Applications–Guozhong Cao, Ying Wang*)* 4. Nanotechnology for Energy Sustainability –*Editors:* Wen Lu, Xiangfeng Duan 5. Principles of Solar Engineering–D. Yogi Goswami, Frank Kreith
Supplementary Readings	
Others	-

Course Code	**0531 CHN 459**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Nanophotonics and Magnetic Nanostructures (Elective)**					**Credit Hr**	**2.0**

Prerequisite		**Contact Hr**	**2.0**
Rational	This course will provide students with a comprehensive understanding of optical and magnetic phenomena in nanostructures covering their principles, fabrication, characterization, and advanced applications for research and innovation in nanophotonic and nanomagnetic technologies.		

Course Objective

- To introduce students to the fundamental principles of nanophotonics and nanomagnetism, including light–matter interactions, plasmonics, metamaterials, and magnetic behavior at the nanoscale.
- To explain the structure, properties, and fabrication of nanophotonic and nanomagnetic materials, along with their characterization techniques.
- To enable students to analyze and model optical and magnetic phenomena in nanostructures, such as quantum confinement, plasmonic resonances, and size-dependent magnetism.
- To explore advanced applications of nanostructured materials in photonics, spintronics, biomedical devices, imaging, and energy-related technologies.

Contents

Types of nanostructures; Light generation by: quantum wells, wires, dots; Light propagation in nanostructures: nano-lasers, photonic crystals; Surface plasmon polariton, localized surface plasmon, phonon polariton, plasmon waveguides, transmission through sub- wavelength aperture; Metamaterials: effective medium theory, negative refractive index, super-lens, transformation optics; Near-field optics; Nanophotonic fabrication; Some application: charge-coupled device, photoconductors, P/N junctions and avalanche photodiodes. Magnetism in nanostructures and mechanism of nanostructure development; Random anisotropy model; Nanocrystalline soft and hard magnetic alloys based on iron, cobalt, rare-earths; Magnetism in oxide nanostructures of both powder and colloidal forms; Effect of particle size on nanomagnetism; Techniques of characterization of magnetic nanostructures; Applications of nanostructured magnetic materials in spintronics, biomedical, therapeutic, imaging and photocatalysis.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain the fundamental optical and magnetic phenomena that arise in nanostructures, including quantum confinement, plasmonics, metamaterials, and size-dependent magnetism.	L, D, QA	T, ASG, F
CO2	Explain the fundamental optical and magnetic phenomena that arise in nanostructures, including quantum confinement, plasmonics, metamaterials, and size-dependent magnetism.	L, D, QA	T, ASG, F
CO3	Evaluate fabrication methods for nanostructures and assess their impact on optical and magnetic performance.	L, D, QA	T, ASG, F

CO4	Apply knowledge of nanostructure principles to real-world technologies such as photonic devices, spintronic systems, biomedical imaging tools, and catalytic applications.	L, D, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	2		3							
CO4	2		3							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Nanophotonics – Paras N. Prasad 2. Plasmonics: Fundamentals and Applications – Stefan A. Maier 3. Metamaterials and Plasmonics: Fundamentals, Modelling, Applications – (Eds. Said Zouhdi, Ari Sihvola, Alexey P. Vinogradov) 4. Semiconductor Nanophotonics: Materials, Models, and Devices – (Springer) 5. Nanomagnetism and Spintronics – Teruya Shinjo (ed.)
Supplementary Readings	
Others	-

Course Code	**0512 BME 487**		**Course Type**	**Core (Theory)**		**Level 4 Term I**
Course Title	**Chemistry of Nano-Biomolecules**				**Credit Hr**	**3.0**

Prerequisite	Fundamentals of Nanoscience	Contact Hr	3.0
Rational	This course will provide students with the molecular and technological foundation needed to understand nucleic acids, biomolecular interactions, recombinant DNA techniques, and nano-biomolecular systems, enabling them to apply these principles in modern biotechnological tools.		

Course Objective

- Give the students in-depth understanding of basic concepts of RNA-DNA structure, the general physiochemical properties of DNA and the techniques used in molecular biology applications of the current techniques used in recombinant DNA technology
- Give the students an introduction to nano-biomolecules, a hybrid system where a biomolecule (like a protein or DNA) is combined with a nanoparticle, or a nanoparticle made from a biomolecule itself
- Study the different approach of interaction of biomolecules
- Deals with design and application of biosensors, lab on a chip device, drug deliver etc.

Contents

Fundamentals of Molecular Biology

Structure and function of biomolecule: Lipids, Proteins, liposomes, enzymes etc. and their specific roles in molecular interactions and signal pathways

Chemistry of Nucleic acid

Classification and composition of nucleic acids, bases, sugars, nucleosides, nucleotides and polynucleotides. Structure of RNA, Watson and Crick model of DNA and its characteristics, isolation of DNA from natural sources, its physicochemical properties. Concept of Recombinant DNA technology. Application in medical and related fields – forensic studies, detection of molar diseases, pharmaceutical production, gene therapy. Polymerase chain reaction, DNA fingerprinting, DNA mapping, use of genetic markers, DNA sequencing

Interaction and Characterization of Nano-biomolecules

Interaction of biomolecules with surfaces. Self-assembly and self-organization, intermolecular interaction and molecular recognition, self-assembled monolayers, protein folding, self-assembled bottom-up approaches of nanomaterial growth and top-down paradigm, bio conjugation, Protein corona, nano-biomolecule characterization techniques

Application of Nano-biomolecules

Artificial Membrane and Cell, Nano drug delivery, DNA for coding and information storage, biosensors, biomimetic, nanostructures, biological nanofabrication, biomotors, miniaturized, devices - lab on a chip concept etc.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain the Watson Crick model of the DNA structure	L, D, QA	T, ASG, F

CO2	Explain and summarize molecular structures of DNA and RNA	L, D, QA	T, ASG, F
CO3	Develop a basic understanding of functional protein biosynthesis in the living organisms Delineate the concept of application of recombinant DNA technology and genetic engineering	L, D, QA	T, ASG, F
CO4	Describe cloning, DNA fingerprinting, and molecular markers and their applications Provide examples of current applications of molecular biology and advances in the different areas like pharmaceutical, medical, microbial, agricultural, plant, animal, and forensic.	L, D, QA	T, ASG, F
CO5	Understand the interaction of biomolecules	L, D, QA	T, ASG, F
CO6	Capable of designing Biosensors, drug delivery system, etc.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test; PR – Project; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									
CO6	2			3						

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	
Supplementary Readings	
Others	-

Course Code	**0413 GELM 475**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Leadership and Management**					**Credit Hr**	**2.0**
Prerequisite	**None**					**Contact Hr**	**2.0**
Rational	The course is designed to make students understand the overlapping connection between engineering and management in an organization through the study of varied management practices and leadership traits as a chemist.						

Course Objective

- To introduce different management functions and approaches.
- To expose students to different views and styles of leadership.
- To understand how an organization functions collaboratively with managers and engineers.
- To understand various personality traits and its impact on leadership and management to solve real-world management problems as a chemist.

Contents

Introduction to Leadership and Management

Definition of leadership and management, basic difference between a leader and a manager, relation of leaders and managers with respect to efficiency and effectiveness, qualities of leader and managers with examples from history.

Management Fundamentals

Definition of management & manager, levels of management, management functions and skills, Mintzberg's managerial roles, Henri Fayol's management principles, strategic management

Leadership & Motivation

Motivation, Maslow's hierarchy needs, theory of X & Y, motivators and hygiene factors, goal setting theory, reinforcement theory, equity theory, expectancy theory, Leadership styles, leadership trait theory, managerial grid, contemporary leadership, conflicts negotiation, leadership issues in 21st century, cross cultural leadership, engineer as a leader and some simple case discussions on leadership (positive and toxic leadership) in the class (Interactive Learning).

Organizational Management

Organization, departmentalization, chain of command, unity of command, cross functional area, authority, centralization and decentralization contemporary organization, matrix project structure, learning structure, organizing collaboration, Planning and goal setting: Foundation of planning, goals of plan, types of goal, types of goal & plans, goal setting, MBO, well written goal.

Control

Controlling process, controlling for organizational performance, types of control: (feed-forward, feedback & concurrent), balanced scorecard, contemporary issues in control, workplace concern & workplace violence.

Change and Innovation

Change and innovation, internal and external for change, changing process, creativity vs innovation. Attitude: Components of Attitude, behavior model and characteristics model, behavior vs. attitude, job attitude, job involvement, job satisfaction and customer satisfaction.

Personality

Personality determinants: heredity and environment, Myers-Briggs Type Indicator, Big five personality model, personality traits (core self-evaluation, Machiavellianism, narcissism, self-monitoring, risk taking, proactive personality).

Perception and Individual Decision Making

Factors influencing perception, attribution theory, errors/biases in attribution, Factors of individual decision making, rational decision making, bounded rationality, satisfice, common errors in decision making, creativity in decision making.

Understanding Work Team

Work group, work team, problem solving team, self-managed work team, cross functional team, virtual team, team effectiveness, team challenges.

HR Management

Process of Human Resource Planning, forecasting demand for labor, staffing, internal supply of labor, performance appraisal.

Operations Management

Project managing basics, goals and boundary of project, WBS, scheduling a project, Demand and supply forecasting, inventory control.

Information Technology and Management

Management Information System (MIS), Enterprise Resource Planning (ERP) - For introductory knowledge.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Understand the fundamental concepts of leadership and management skills	L, D, QA	T, R, F
CO2	Apply the role and contribution of a leader in achieving organizational goals	L, D, QA	T, ASG, R, F
CO3	Understand the contribution of leadership traits and management skills in decision making and solving real life problems	L, D, QA	T, ASG, R, F

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CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1							3	3		2
CO2							3	3		2
CO3							3	3		2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Leadership in Organizations – Gary Yukl 2. Developing Management Skills – David A. Whetten and Kim S. Cameron 3. Engineering Management (Revised Edition) – A.K. Gupta 4. Industrial Engineering and Production Management - Martand T. Telsang
Supplementary Readings	
Others	-

Course Code	**0531 CHN 444**		**Course Type**	**Core (Sessional)**		**Level 4 Term I**	
Course Title	**Advanced Inorganic and Analytical Chemistry Sessional**					**Credit Hr**	**1.5**
Prerequisite	**Inorganic Chemistry Sessional II**					**Contact Hr**	**3.0**

Rational	This course will equip students with a strong theoretical and practical foundation in inorganic and analytical chemistry, enabling them to synthesize, analyze, and characterize compounds and solve experimental problems.

Course Objective

- Provide a firm foundation in the fundamentals and applications of current chemical theories including those in inorganic and analytical chemistry.
- Demonstrate the basic and advanced laboratory procedures used in inorganic compounds synthesis including spectroscopic and analytical techniques for their identification and characterization.
- Demonstrate experimental methods of determining the composition and the stability constant of complex compounds.
- Show how to contribute to solutions of problems encountered in an experiment.
- Explain how to maintain high standards of professional and scientific ethics.

Contents

Preparation and Characterization

(i) Preparation of $CuSO_4.5H_2O$ from metallic copper and its characterization by elemental analysis, IR and UV-visible spectra, and thermal analysis.

(ii) Preparation of $[Co(NH_3)_6]Cl_3$ and its characterization by chemical analysis, infrared spectroscopy and magnetic measurement.

(iii) Preparation and characterization of tris(ethylenediamine)nickel(II) chloride dihydrate, $[Ni(en)_3]Cl_2.2H_2O$.

(iv) Preparation, characterization and structural analysis of *cis*- and *trans* forms of potassium diaquodioxalato chromate(III) dihydrate, $K[Cr(C_2O_4)_2(H_2O)_2]$. $2H_2O$.

Separation

(v) Paper, and thin layer chromatographic separation of metals like Co(II), Cu(II), Fe(II), Mn(II), Ni(II), and Zn(II) from their mixtures.

(vi) Separation and determination of cations (Fe(III) and Cu(II)) and anions (Cl- and Br-) from their mixture using cation exchange chromatography.

(vii) Cell parameters determination of crystalline solids (for example NaCl, KCl, CsCl, $CuSO_4.5H_2O$, etc.) by X-ray powder diffraction method.

Assay

(viii) Determination of the formula and stability constant of the silver ammonia complex.

(ix) An assay of pharmaceutical products: Paracetamol, antacid, ascorbic acids by UV-Visible method.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Design and carry out experiments as well as accurately record and analyze the results of such experiments. •	L, D, QA, EXP	T, Q, R, F

CO2	Learn key concepts of inorganic chemistry including those related to synthesis, reaction chemistry, structure and bonding.	L, D, QA	T, Q, R
CO3	Apply different instrumental methods of chemical analysis, including electronic and vibrational spectroscopy, chromatographic separation methods, thermogravimetry, conductometry, magnetic measurement, and X-ray crystallography.	L, D, QA, EXP	T, Q, R, F
CO4	Gain an understanding of the performance of graphical analysis to analyze laboratory results.	L, D, QA, EXP	T, Q, R, F
CO5	Use the proper scientific style in written reporting of laboratory results.	L, D	R, F

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CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				3						
CO2	3									
CO3	3	3								
CO4		3			3					
CO5				3		3				

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Practical Inorganic Chemistry – Preparations, Reactions and Instrumental Methods, G. Pass and H. Sutcliffe. 2. Experimental Inorganic Chemistry, W. G. Palmer. 3. A Textbook of Quantitative Inorganic Analysis, A. I. Vogel, 3rd edition. 4. Chromatographic Methods, R. Stock and C. B. F. Rice.
Supplementary Readings	
Others	-

Course Code	0531 CHN 484		Course Type	Core (Sessional)		Level 4 Term I
Course Title	Computational Methods in Chemistry and Nanoscience				Credit Hr	1.5
Prerequisite					Contact Hr	3.0
Rational	This course will equip students with essential computational and data-presentation skills by teaching them to analyze and visualize data, and construct and optimize chemical structures using specialized chemistry software.					

Course Objective

- Help students develop the ability to type chemistry texts involving chemical formulas and symbols, and to construct tables and figures within text and presentations.
- Develop skills for data analysis and data presentation.
- Make students able to draw and optimize chemical structures and properties using various chemistry-related software.
- Apply the knowledge of different types of graphical software for chemical data analysis and presentation.

Contents

Introduction

- Brief idea on different parts of a computer and their functions.
- Overview of operating software and application software.

Writing Chemistry Text and Presentation

- Introduction to MS Office: Improving the typing of chemistry texts involving chemical formulas and symbols, constructing tables, and setting figures and diagrams within text.
- Preparation of posters and slides using PowerPoint, based on popular topics in chemistry. Use of Graphical Software:
- Introduction to Sigma Plot, MS Excel, Igor and Origin software's
- Data analysis using the mentioned software's

Use of Chemistry Software

ChemDraw, Chemsketch and Chemwindow.

- Introduction to the software, drawing various 2D and 3D molecular structures, and presentation of 2D and 3D structures.

Computational Software's for calculation

Gaussian2016/ GAMESS/ORCA/VASP/GROMACS/Avogadro etc.

- Geometry optimization of different molecular structures.
- Determining bond length, bond angle, dihedral angle, potential energy, HOMO-LUMO energy,

thermodynamics, electronic, optical and spectroscopic data.

Visualization software's

GaussView, Molekel, Avogadro, VMD, Chemcraft, Discovery studio etc.

- Visualize the input and output structures and data analysis.

	Course Learning Outcomes (CO)	Teaching Strategy	Assessment Methods
CO1	Identify and describe the different parts of a computer system, their functions, and distinguish between operating software and application software.	L, D, EXP	T, Q, F
CO2	Draw and represent 2D and 3D molecular structures using chemical drawing software such as ChemDraw, ChemSketch, and ChemWindow	L, D, EXP	T, Q, PR, R, F
CO3	Create and format chemistry-related documents using MS Office tools, including typing chemical formulas, constructing tables, and embedding figures and diagrams effectively.	L, D, EXP	T, Q, PR, R, F
CO4	Design professional presentations and scientific posters on chemistry topics using PowerPoint.	L, D, EXP	PR, Pr
CO5	Analyze and interpret experimental or computational data using graphical and statistical software such as SigmaPlot, MS Excel, Igor, and Origin.	L, D, EXP	ASG, R, Pr

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CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				3						
CO2					3					
CO3					3					
CO4						3				
CO5				3						

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Quantum Chemistry, 2nd Edition, Donald A. McQuarrie, University Science Books, 2008. 2. Quantum Chemistry, 7th edition, Ira N. Levine, Pearson, 2014. 3. Szabo, N.S. Ostlund, Modern Quantum Chemistry, Dover, 1996. 4. F. Jensen, Introduction to Computational Chemistry, Wiley, 2007. 5. C. Cramer, Essentials of Computational Chemistry, Wiley, 2004. 6. Computational Organic Chemistry (2007) by Steven M. Bachrach 7. Essentials of Computational Chemistry (2002) by Christopher J. Cramer
Supplementary Readings	
Others	-