Comilla University
Bachelor of Science Degree in Chemistry
Curriculum: Sustaining OBE Compliance

Part A: Introduction

1. **Title of the Academic Program:**
   Bachelor of Science (Honours) Degree in Chemistry
2. **Name of the University:**
   Comilla University, Cumilla
3. **Vision of the University:**
   Vision:
   1. Comilla University is committed to empowering society, advancing development, promoting human welfare and a sustainable planet.
4. **Mission of the University:**
   Mission: To meet its vision, Comilla University sets its mission to-
   1. To educate a wide variety of students through effective teaching-learning to achieve academic excellence.
   2. To create an ambience for creative and innovative academic exercise and high-quality research.
   3. To undertake actions regarding collaboration which entails opportunities for long-term interaction with academia and industry for producing competent graduate at workplace.
   4. To develop human potential to its fullest extent so that intellectually capable and socially responsible leaders can emerge in a range of profession.

   Core Value: Comilla University is committed to nurture
   Integrity: The highest level of sincerity and moral, ethical, and professional conducts
   Intellectual Curiosity: Insatiable thirst for knowledge to expand intellectual horizon, go beyond the comfort zone, and bring back wonders for development
5. **Name of the Program Offering Entity:**
   Department of Chemistry
6. **Vision of the Program Offering Entity:**
   - **Vision of the Program:**
     - To be a leading degree program in the field of Chemistry to fulfill the industrial and social needs and contribute to national and global development by producing graduates who excel in knowledge, skills and values in the areas of chemistry.
7. **Mission of the Program Offering Entity**
   - **Mission of the Program:**
     - To produce highly competent and motivated graduates who are fit for industry, teaching, research and community making a significant contribution to sustainable development and well-being of the mankind.
     - To provide suitable teaching-learning environment with innovative pedagogies and authentic assessment designed in outcome-based curriculum
     - To develop research facilities with state-of-art techniques to do need-based research focusing on local and global issues with external collaboration
     - To facilitate the activities regarding collaboration which entails opportunities for long-term interaction with academia of various academic/research institutes and chemical industry for producing competent graduate at workplace

8. **Objectives of the Program Offering Entity:**
   - **Objectives of B.Sc. Degree Program in Chemistry are to**
     - Provide teaching-learning activities with resource materials and tools to help the students to be involved in deep learning process in chemistry through imparting theoretical knowledge on chemistry; and equip students with appropriate tools of analysis to tackle issues and problems in the field of chemistry.
     - Develop the ability of students to apply the acquired knowledge and skills to the solution of specific theoretical and applied problems in chemistry.
     - To acquaint students with chemical product manufacturing process in industrial sectors.
     - To prepare students to acquire life-long learning skills in order to engage in community development.
9. **Name of the Degree:** B.Sc. in Chemistry with Honours or without Honours
10. **Description of the program:**

The duration of the Bachelor Degree Program in Chemistry shall be four academic years divided into eight semesters. Each academic year is divided into two semesters to be called as 1st semester and 2nd semester. An academic semester is comprised of six months. For achieving Degree of Bachelor of Science in chemistry with honours, a student requires to earn a total of 160 credit points successfully with a minimum CGPA of 2.25; and complete the program within six academic years from her/his 1st admission to the program. A student who secures a CGPA below 2.25 but not less than 2.00 will be eligible for a Bachelor of Science Degree in Chemistry.

11. **Graduate Attributes (based on need assessment)**

Attibute-1: Deep subject knowledge and intellectual breadth

Graduates have comprehensive knowledge and understanding on chemistry and its different subfields (physical, inorganic, organic and analytical), and the ability to apply their knowledge and skills in practice including multi-disciplinary or multi-professional contexts.

Attribute-2: Creative & critical thinking and problem solving

Graduates would be effective problem solvers, able to apply critical, creative and evidence-based thinking to conceive innovative to futures challenges.

Attribute-3: Teamwork and communication skills

Graduates disseminate ideas and information effectively both in oral and written ways to a range of audiences for a variety of purposes and contribute in a positive and collaborative manner in both classroom, laboratory and in industry and field-based situations.

Attribute-4: Sense of inquiry

Graduated would be capable for asking relevant/appropriate questions relating to issues and problems in the field of chemistry, and planning, executing and reporting the results of an experiment or investigation.

Attribute-5: Digital capabilities

Graduate would be able of using computers for chemical simulation and computation and appropriate software for analysis of data, and employing modern library search tools to locate, retrieve, and evaluate chemistry-related information.

Attribute-6: Professionalism and Ethical competency

Graduates are responsible and effective global citizens whose personal values and practices are consistent with their roles and engage in professional behavior and have the potential to be entrepreneurial and take leadership roles for their carrier development.

Attribute-7: Lifelong learning and emotional intelligence

Graduates would be capable of self-aware and self-directed learning aimed at personal development and are flexible and resilient and act with integrity and take responsibility for their actions.

12. Program Educational Objectives (PEOs)

PE01	To produce **competent, creative and innovative** graduates who are able to solve chemistry related problems within the national, global and sustainable development context.
PE02	To produce graduates with **good leadership qualities and communication skill** who are able to engage in chemical science to do task both independently and via interdisciplinary teams.
PE03	Graduates will engage in professional activities with **ethical practices** in the field of Chemistry and simultaneously contribute to the **profession and society** at large
PE04	Graduates will be well prepared to adapt to usage of **modern tools & emerging technologies** and contribute to interdisciplinary research with innovative practices.

13. Program Learning Outcomes (PLOs)

PLO1	***Knowledgeable on Chemistry***- Graduate will be physical or inorganic or organic or analytical & environmental chemist with both theoretical and practical knowledge.
PLO2	***Synthesizer***- Graduate will be able to design a synthetic scheme or explore material properties for the preparation of new compounds or materials**.**
PLO3	***Analyzer***- Graduate will be able to analyze the types**,** nature, behavior and/or amounts of chemical components.
PLO4	***Problem solver***- Graduate will be able to solve problems related to chemistry.
PLO5	***Complex problem solution designer***- Graduate will be able to design a solution or replicate new design of similar pattern.
PLO6	***Comfortable with tools and aids-*** Graduate will be able to familiar with all common existing tools and techniques of chemistry.
PLO7	***Environmentally sustainable***- Graduate will be able to adopt policy to solve the environmental problems based on clean, green, and sustainable development.
PLO8	***Communicative***- Graduate will be able to disseminate ideas and information effectively both in oral and written ways to a range of audiences for a variety of purposes and contribute in a positive and collaborative manner in both classroom, laboratory and in industry and field-based situations.
PLO9	***Individually and Team player with versatility***- Graduate will be able to be entrepreneurial, a capacity builder or academic leader.
PLO10	***Accountable and Ethical***- Graduate will be committed, accountable, responsible, and ethical.

14. Mapping mission of the university with PEOs

PEOs	Mission-1	Mission-2	Mission-3	Mission-4	Mission-5
PEO1	2	1	1	-	-
PEO2	-	-	-	3	-
PEO3	-	-	-	-	3
PEO4	-	-	-	-	3

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

15. Mapping PLO with PEOs

PEOs	**PEO-1**	**PEO-2**	**PEO-3**	**PEO-4**
PLO1	1	-	-	-
PLO2	2	-	-	-
PLO3	1	-	-	-
PLO4	3	-	-	-
PLO5	1	-	-	-
PLO6	-	2	-	-
PLO7	-	-	-	3
PLO8	-	3	-	-
PLO9	-	3	-	-
PLO10	-	-	3	3

16. Mapping Courses with the PLOs

SL. No.	**Course Code**	**PLO 1**	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**	**PLO 7**	**PLO 8**	**PLO 9**	**PLO10**
1.	0531-14-111	**X**	**-**	**x**	**x**	**x**	**x**	**x**	**-**	**-**	**-**
2.	0531-14-112	**X**	**x**	**x**	**x**	**x**	**x**	**-**	**-**	**-**	**-**
3.	0531-14-113	**X**	**x**	**-**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
4.	0533-14-114	**X**	**-**	**x**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
5.	0541-14-115	**X**	**-**	**x**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
6.	0312-14-116	**-**	**-**	**x**	**-**	**x**	**-**	**-**	**x**	**-**	**x**
7.	0531-14-117L	**-**	**x**	**x**	**x**	**-**	**x**	**x**	**x**	**x**	**x**
8.	0612-14-118L	**-**	**-**	**x**	**x**	**x**	**x**	**-**	**x**	**x**	**x**
9	0531-14-121	**X**	**-**	**-**	**x**	**x**	**x**	**-**	**-**	**-**	**-**
10.	0531-14-122	**X**	**x**	**-**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
11.	0531-14-123	**X**	**x**	**-**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
12.	0531-14-124	**-**	**x**	**-**	**x**	**x**	**x**	**-**	**-**	**-**	**-**
13.	0531-14-125	**-**	**-**	**-**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
14.	0531-14-126L	**X**	**-**	**x**	**-**	**-**	**x**	**-**	**x**	**x**	**X**
15.	0531-14-127L	**X**	**-**	**x**	**-**	**-**	**x**	**-**	**x**	**x**	**X**
16.	0533-14-128L	**-**	**-**	**-**	**x**	**-**	**x**	**-**	**x**	**x**	**X**
17.	0531-14-100	**X**	**-**	**-**	**-**	**-**	**-**	**-**	**x**	**x**	**X**
18.	0531-14-211	**X**	**-**	**-**	**x**	**x**	**x**	**-**	**-**	**-**	**-**
19.	0531-14-212	**X**	**x**	**-**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
20.	0531-14-213	**X**	**-**	**-**	**x**	**x**	**-**	**-**	**-**	**-**	**-**
21.	0531-14-214	**X**	**-**	**x**	**x**	**x**	**x**	**x**	**-**	**-**	**-**
22.	0531-14-215	**X**	**-**	**-**	**x**	**x**	**x**	**-**	**-**	**-**	**-**

23.	0531-14-216	X	-	-	x	x	-	x	-	-	-
24.	0531-14-217L	X	-	x	-	-	x	-	x	x	X
25.	0413-14-218L	-	-	-	x	x	x	-	x	x	X
26.	0231-14-219L	-	-	-	-	-	-	-	x	x	X
27.	0531-14-221	X	-	-	x	x	x	-	-	-	-
28.	0531-14-222	X	x	-	x	x	-	-	-	-	-
29.	0531-14-223	X	-	-	x	x	-	-	-	-	-
30.	0531-14-224	X	x	-	x	x	-	-	-	-	-
31.	0314-14-225	-	-	-	-	-	-	-	x	x	X
32.	0531-14-226L	X	-	x	x	-	x	-	x	x	X
33.	0531-14-227L	X	x	x	x	-	x	-	x	x	X
34.	0531-14-228L	X	x	x	x	-	x	-	x	x	X
35.	0531-14-200	X	-	-	-	-	-	-	x	-	X
36.	0531-14-311	X	-	-	x	x	x	-	-	-	-
37.	0531-14-312	X	x	-	x	x	-	-	-	-	-
38.	0531-14-313	X	x	-	x	x	-	-	-	-	-
39.	0531-14-314	X	-	-	x	x	-	x	-	-	-
40.	0531-14-315	X	-	x	x	x	x	-	-	-	-
41.	0531-14-316L	X	-	x	x	-	x	-	x	x	X
42.	0531-14-317L	X	-	x	x	-	x	-	x		X
43.	0531-14-318L	X	x	x	x	-	x	-	x	x	X
44.	0531-14-321	X	-	-	x	x	-	-	-	-	-
45.	0531-14-322	X	-	-	x	x	-	x	-	-	X
46.	0531-14-323	X	-	-	x	x	-	-	-	-	-
47.	0531-14-324	X	-	-	x	x	-	-	-	-	-
48.	0531-14-325	X	x	-	x	x	-	-	-	-	-
49.	0512-14-326	-	-	-	x	-	-	-	-	-	X
50.	0531-14-327L	X	-	x	x	-	x	-	x	x	-
51.	0531-14-328L	X	-	x	x	-	x	x	x	x	X
52.	0531-14-300	X	-	-	-	-	-	-	x	-	X
53.	0531-14-411	X	-	x	x	x	x	-	-	-	-
54.	0531-14-412	X	X	-	x	-	-	-	-	-	-
55.	0531-14-413	X	X	x	x	x	-	-	-	-	-
56.	0531-14-414	X	-	x	x	x	-	x	-	-	X
57.	0311-14-415	-	-	x	x	-	-	-	-	-	-
58.	0531-14-416L	X	-	x	x	x	x	-	x	-	-
59.	0531-14-417L	X	X	x	x	x	x	-	x	-	-
60.	0531-14-418L	X	X	x	x	x	x	-	x	-	-
61.	0531-14-421	X	-	-	x	x	-	-	-	-	-
62.	0531-14-422	X	X	-	x	x	x	-	-	-	-
63.	0531-14-423	X	-	-	x	-	-	-	-	-	-
64.	0519-14-424	-	x	x	x	x	-	-	-	-	-
65.	0031-14-425L	-	-	x	-	-	-	x	x	x	X
66.	0417-14-426L	-	-	x	x	x	-	-	x	x	X
67.	0531-14-427L*	X	-	x	x	x		-	x	-	X
68.	0531-14-428L*	X	x	-	-	-	-	-	x	x	X
69.	0531-14-400	X	-	-	-	-	-	-	x	-	X
Total		55	22	31	57	44	30	9	29	20	28

Part B: Structure of the Curriculum

17. **Structure of the Curriculum**

a. Duration of the program: Years: 04 Semesters:08

b. Admission Requirements: Total (both S.S.C and H.S.C in science) minimum GPA 8.0 with minimum GPA 3.0 in Chemistry and 2.50 in Mathematics through qualifying in admission test (As per decision by academic council of Comilla University).

c. Total minimum credit requirement to complete the program: According to BNQF (Part B) for higher Education: 160

d. Total class weeks in a Year/Semester: 14 Weeks

e. Minimum CGPA requirements for graduation: 2.00

f. Maximum academic years of completion: 06

g. Category of Course

i. General Education Course: (interdisciplinary courses, beyond the discipline/program, that provide a well-rounded learning experience to the students of an academic program)

Course Code	Title of the course	Credits	Hrs/Week
0533-14-114	Physics-I: Mechanics and Properties of Matter	3.0	03
0541-14-115	Mathematics-I: Algebra and Geometry	3.0	03
0312-14-116	Emergence of Bangladesh	2.0	02
0612-14-118L	Information and Communication Technology Laboratory	1.5	03
0533-14-124	Physics-II: Electricity and Magnetisms	2.0	02
0541-14-125	Mathematics-II: Calculus and Mathematical Methods	3.0	03
0533-14-128L	Physics Laboratory	2.0	04
0413-14-216	Inroduction to Computer Language	2.0	04
0413-14-218L	Computer Application in Chemistry	2.0	02
0231-14-219L	Functional English for Effective Communication	1.5	03
0314-14-225	Fundamentals of Sociology and Cultural Studies	2.0	02
0531-14-322	Environmental Chemistry	3.0	03
0531-14-328L	Environmental Chemistry Laboratory	1.5	03
0512-14-326	Fundamentals of Biochemistry	3.0	03
0311-14-415	Industrial and Environmental Economics	3.0	03
0519-14-424	Pharmaceutical Chemistry	3.0	03
0031-14-425	Personal Skills and Development	2.0	02
0417-14-426L	Industrial Training/Internship and Entrepreneurship Development	2.0	04
Total Credits =41.5			

ii. Core Courses (Courses that characterize the discipline): 124 Credits

iii. Elective Courses (Courses for specialization within discipline): 6 Credits

iv. Capstone courses/Internship/Thesis/Projects/Portfolio (as applicable for the discipline/academic program): Chemistry Research Project (3 Credits)

18. Year/Level/Semester/Term wise distribution of courses

Semester Wise Course Distribution

1st Year 1st Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-111	Physical States of Matter	3.0	03
0531-14-112	Atomic Structure and Properties of Elements	3.0	03
0531-14-113	Aliphatic and Aromatic Hydrocarbons	3.0	03
0533-14-114	Physics-I: Mechanics and Properties of Matter	3.0	03
0541-14-115	Mathematics-I: Algebra and Geometry	3.0	03
0312-14-116	Emergence of Bangladesh	2.0	02
0531-14-117L	General Chemistry Laboratory	1.5	03
0612-14-118L	Information and Communication Technology Laboratory	1.5	03
Total Credits = 20.0			

1st Year 2nd Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-121	Equilibria Reaction Rates and Electrolytes	3.0	03
0531-14-122	Chemical Bonding and Properties of Molecules	3.0	03
0531-14-123	Functional Derivatives of Hydrocarbons	3.0	03
0533-14-124	Physics-II: Electricity and Magnetisms	2.0	02
0541-14-125	Mathematics-II: Calculus and Mathematical Methods	3.0	03
0531-14-126L	Qualitative Inorganic Analysis Laboratory	1.5	03
0531-14-127L	Qualitative Organic Analysis Laboratory	1.5	03
0533-14-128L	Physics Laboratory	2.0	04
0531-14-100	Oral Presentation	1.0	-
Total Credits = 20.0			

2nd Year 1st Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-211	Chemical Thermodynamics	3.0	03
0531-14-212	Chemistry of Elements	3.0	03
0531-14-213	Bifunctional and Carbonyl Compounds	2.0	02
0531-14-214	Analytical Chemistry	3.0	03
0531-14-215	Nuclear Chemistry and Chemical weapons	2.0	02
0413-14-216	Inroduction to Computer Language	2.0	04
0531-14-217L	Quantitative Organic Analysis Laboratory	1.5	03
0413-14-218L	Computer Application in Chemistry	2.0	02
0231-14-219L	Functional English for Effective Communication	1.5	03
Total Credits = 20.0			

Semester Wise Course Distribution

2nd Year 2nd Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-221	Solution Chemistry	3.0	03
0531-14-222	Inorganic Chemical Reactions	3.0	03
0531-14-223	Stereochemistry	3.0	03
0531-14-224	Organic Reactions and Mechanism-I	3.0	03
0314-14-225	Fundamentals of Sociology and Cultural Studies	2.0	02
0531-14-226L	Physical Chemistry Laboratory-I	2.0	04
0531-14-227L	Inorganic Preparation Laboratory	1.5	03
0531-14-228L	Organic Synthesis Laboratory	1.5	03
0531-14-200	Oral Presentation	1.0	-
Total Credits = 20.0			

3rd Year 1st Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-311	Chemical Kinetics	3.0	03
0531-14-312	Coordination Chemistry	3.0	03
0531-14-313	Organic Reactions and Mechanism-II	3.0	03
0531-14-314	Industrial Chemistry	3.0	03
0531-14-315	Chemical Spectroscopy-I	3.0	03
0531-14-316L	Physical Chemistry Laboratory-II	2.0	04
0531-14-317L	Quantitative Inorganic Analysis Laboratory	1.5	03
0531-14-318L	Organo-Applied Chemistry Laboratory	1.5	03
Total Credits = 20.0			

3rd Year 2nd Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-321	Electrochemistry	2.0	02
0531-14-322	Environmental Chemistry	3.0	03
0531-14-323	Chemical Spectroscopy-II	3.0	03
0531-14-324	Colloid and Surface Chemistry	3.0	03
0531-14-325	Organic Reagent and Synthesis	2.0	02
0512-14-326	Fundamentals of Biochemistry	3.0	03
0531-14-327L	Physical Chemistry Laboratory-III	1.5	03
0531-14-328L	Environmental Chemistry Laboratory	1.5	03
0531-14-300	Oral Presentation	1.0	-
Total Credits = 20.0			

Semester Wise Course Distribution

4th Year 1st Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-411	Solid State and Chemical Crystallography	3.0	03
0531-14-412	Organometallic Chemistry	3.0	03
0531-14-413	Polymer Chemistry	3.0	03
0531-14-414	Research Methodology in Chemistry	3.0	03
0311-14-415	Industrial and Environmental Economics	3.0	03
0531-14-416L	Physical Chemistry Laboratory-IV	2.0	04
0531-14-417L	Industrial Inorganic Synthesis Laboratory	1.5	03
0531-14-418L	Industrial Organic Synthesis Laboratory	1.5	03
Total Credits = 20.0			

4th Year 2nd Semester

Course Code	Title of the course	Credits	Hrs/Week
0531-14-421	Quantum Chemistry and Statistical Mechanics	3.0	03
0531-14-422	Supramolecular and Nano Chemistry	3.0	03
0531-14-423	Chemistry of Natural Products	3.0	03
0519-14-424	Pharmaceutical Chemistry	3.0	03
0031-14-425	Personal Skills and Development	2.0	02
0417-14-426L	Industrial Training/Internship and Entrepreneurship Development	2.0	04
0531-14-427L*	Chemistry Research Project	3.0	06
0531-14-428L*	Experimental Design in Chemistry	3.0	06
0531-14-400	Oral Presentation	1.0	-
Total Credits = 20.0			
Total: 20+20+20+20+20+21+20+20=160			

*Elective course: Any one of the courses (0531-14-427L: Chemistry Research Project or 0531-14-428L: Advanced Chemistry Laboratory) must be taken by the student. Academic committee of the department will decide the number of students who will take the course **0531-14-427L: Chemistry Research Project** based on their academic results.

Course Distribution (Branch-Wise)

Physical Chemistry Branch (Theory Courses)

Course Code	Title of the course	Credits	Hrs/Week
0531-14-111	Physical States of Matter	3.0	03
0531-14-121	Equilibria Reaction Rates and Electrolytes	3.0	03
0531-14-211	Chemical Thermodynamics	3.0	03
0531-14-221	Solution Chemistry	3.0	03
0531-14-311	Chemical Kinetics	3.0	03
0531-14-321	Electrochemistry	2.0	02
0531-14-324	Colloid and Surface Chemistry	3.0	03
0531-14-411	Solid State and Chemical Crystallography	3.0	03
0531-14-421	Quantum Chemistry and Statistical Mechanics	3.0	03
Total Credits = 26.0			

Physical Chemistry Branch (Laboratory Courses)

Course Code	Title of the course	Credits	Hrs/Week
0531-14-226L	Physical Chemistry Laboratory-I	2.0	04
0531-14-316L	Physical Chemistry Laboratory-II	2.0	04
0531-14-327L	Physical Chemistry Laboratory –III	1.5	03
0531-14-416L	Physical Chemistry Laboratory –IV	2.0	04
Total Credits = 7.5			

Total Credits for Physical Chemistry: 26+7.5=33.5

Inorganic and Analytical Chemistry Branch (Theory Courses)

0531-14-112	Atomic Structure and Properties of Elements	3.0	03
0531-14-122	Chemical Bonding and Properties of Molecules	3.0	03
0531-14-212	Chemistry of Elements	3.0	03
0531-14-214	Analytical Chemistry	3.0	03
0531-14-215	Nuclear Chemistry and Chemical Weapons	2.0	02
0531-14-222	Inorganic Chemical Reactions	3.0	03
0531-14-312	Coordination Chemistry	3.0	03
0531-14-412	Organometallic Chemistry	3.0	03
0531-14-422	Supramolecular and Nano Chemistry	3.0	03
Total Credits= 26.0			

Inorganic and Analytical Chemistry Branch (Laboratory Courses)

Course Code	Title of the course	Credits	Hrs/Week
0531-14-126L	Qualitative Inorganic Analysis Laboratory	1.5	03
0531-14-227L	Inorganic Preparation Laboratory	1.5	03
0531-14-317L	Quantitative Inorganic Analysis Laboratory	1.5	03
0531-14-417L	Industrial Inorganic Synthesis Laboratory	1.5	03
	Total	6.0	

Total Credits for Inorganic and Analytical Chemistry: 32.0

Organic Chemistry Branch (Theory Courses)

Course Code	Title of the course	Credits	Hrs/Week
0531-14-113	Aliphatic and Aromatic Hydrocarbons	3.0	03
0531-14-123	Functional Derivatives of Hydrocarbons	3.0	03
0531-14-213	Bifunctional and Carbonyl Compounds	2.0	02
0531-14-223	Stereochemistry	3.0	03
0531-14-224	Organic Reactions and Mechanism-I	3.0	03
0531-14-313	Organic Reactions and Mechanism-II	3.0	03
0531-14-323	Chemical Spectroscopy-II	3.0	03
0531-14-325	Organic Reagent and Synthesis	2.0	02
0531-14-423	Chemistry of Natural Products	3.0	03
Total = 25.0			

Organic Chemistry Branch (Laboratory Courses)

0531-14-127L	Qualitative Organic Analysis Laboratory	1.5	03
0531-14-217L	Quantitative Organic Analysis Laboratory	1.5	03
0531-14-228L	Organic Synthesis Laboratory	1.5	03
0531-14-318L	Organo-Applied Chemistry Laboratory	1.5	03
0531-14-418L	Industrial Organic Synthesis Laboratory	1.5	03
	Total	7.5	

Total Credits for Organic Chemistry: 32.5

Common Chemistry Courses

0531-14-314	Industrial Chemistry	3.0	03
0531-14-315	Chemical Spectroscopy-I	3.0	03
0531-14-413	Polymer Chemistry	3.0	03
0531-14-414	Research Methodology in Chemistry	3.0	03
0531-14-117L	Safe Laboratory Practices in Chemistry	1.5	03
0531-14-428L*	Experimental Design in Chemistry	3.0	06
	Total	16.5	

General Education and Interdisciplinary Courses

Course Code	Title of the course	Credits	Hrs/Week
0533-14-114	Physics-I: Mechanics and Properties of Matter	3.0	03
0541-14-115	Mathematics-I: Algebra and Geometry	3.0	03
0312-14-116	Emergence of Bangladesh	2.0	02
0612-14-118L	Information and Communication Technology Laboratory	1.5	03
0533-14-124	Physics-II: Electricity and Magnetisms	2.0	02
0541-14-125	Mathematics-II: Calculus and Mathematical Methods	3.0	03
0533-14-128L	Physics Laboratory	2.0	04
0413-14-216	Inroduction to Computer Language	2.0	04
0413-14-218L	Computer Application in Chemistry	2.0	02
0231-14-219L	Functional English for Effective Communication	1.5	03
0314-14-225	Fundamentals of Sociology and Cultural Studies	2.0	02
0531-14-322	Environmental Chemistry	3.0	03
0531-14-328L	Environmental Chemistry Laboratory	1.5	03
0512-14-326	Fundamentals of Biochemistry	3.0	03
0311-14-415	Industrial and Environmental Economics	3.0	03
0519-14-424	Pharmaceutical Chemistry	3.0	03
0031-14-425	Personal Skills and Development	2.0	02
0417-14-426L	Industrial Training/Internship and Entrepreneurship Development	2.0	04
Total Credits =41.5			

Course Learning Outcomes (CLOs) Attainment Report Format

Course Learning Outcomes (CLOs)	Assessment										
	SFE (Summative) 80%				CA (Formative) 20%						CLO Attainment (%)
	Mid-Semester (20%)		Final Examination (60%)		MCQ/MQ/ Quiz (10%)		Assignment/ Case Study (5%)		Presentation (5%)		
	M	W	M	W	M	W	M	W	M	W	
CLO1:	78.0	0.20	74.0	0.69	66.21	0.11	-	-	-	-	73.94
CLO2											
CLO3											
CLO4											
CLO5											

Attainment (A) = $\sum_{i=1}^{M}(M_i \times W_i)$

M=Average Marks in % and W = Weightage=AM/T where AM: Actual Marks = (Given Marks) × (% of assessment of the component (Midterm-25%)/Quiz-10%)/Final-40%)/etc) of the Course) and T=Total Given Marks of Component (CLOs)

PLO Measurement and PLO Attainment Report

PLO measurement can be comprised with direct and indirect assessment. Direct assessment method and indirect assessment method may be considered for 80% and 20% weightages respectively.

Part C: Description of all courses of the Bachelor of Science with Honours

B.Sc. in Chemistry
Academic Session: 2024-25, 2025-26 and 2026-27
1st Year 1st Semester

Course Code	Course Title	Credit Hours
0531-14-111	Physical States of Matter	3.0

(a) Rationale:

This course introduces the basic concepts of physical states of matter. It covers solids, liquids, and gases, including their properties, behavior, and related laws. Students will learn about gas and liquid behavior, solid structures, and the classification of physical properties. The course builds a foundation for deeper study in chemistry.

(b) Course Objectives

- To provide knowledge about matter properties in solid, liquid and gas phases.
- To impart technical knowledge to understand the behavior of molecules and their general properties.
- To provide an understanding regarding the basic chemistry of physical states.

(c) Course Contents

1.	**Introduction:** States of matter: solid, liquid, and gaseous state; transition between different states; physical and chemical changes; state variables, standard state; different forms of energy in chemical changes: kinetic, potential, translational, and rotational; Equi-partition of energy; quantization of energy; degrees of freedom of molecule.
2.	**The Gaseous State:** Gases law; ideal and real gases; Gas laws; kinetic theory of gases; kinetic gas equation; Maxwell-Boltzmann distribution of molecular velocities; collision frequency and diameter; mean free path; Brownian movement; Amagat's curves; compression factor; deviation of gases from Ideal behavior; *v*an der Waals equation; critical constants, Kammerilingh-Onnes equation, virial coefficient; Andrew's experiment & critical phenomena; law of corresponding states; Joule-Thomson effect and principle of liquefaction with diverse liquefaction techniques.
3.	**Liquid State:** Physical properties and molecular structure; intermolecular forces in liquids; dipole-dipole forces; London (dispersion) forces; van der Waal's forces; adhesive & cohesive forces; hydrogen bonding; vapour pressure of liquid; measurement of vapor pressure, it's variation with temperature; vapour pressure & boiling point of a liquid; Trouton's rule; interfacial tension; surface tension and its determination; viscosity; Poiseuille equation; Ostwald viscometer; refractive index, molar refractivity and its measurement; dipole moment.
4.	**Solid State:** Properties of solids, crystalline and amorphous solids, distinction between crystalline and amorphous solids, classification of crystalline solid, unit cell, isomorphism, polymorphism and allotropy, law of isomorphism (Mitscherlich Law).
5.	**Physical Properties and Chemical Constitution:** Classification of physical properties: additive, constitutive, intensive, and extensive; some physical properties in relation to molecular structure: molar volume, parachor, rheochor, optical activity, dipole moment, molar polarization, magnetism and magnetic susceptibility.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the scope of interpreting the basic properties of solid, liquid and gases.

CLO-2: Describe the behavior of gases, related isotherms and their critical states to solve the problems.

CLO-3: Illustrate the physical properties and molecular structure and their interactions of liquid molecules.
CLO-4: Explain the properties of crystalline and amorphous solids with different laws.
CLO-5: Explore the various physical properties and chemical constitution with their uses in chemistry.

(e) Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO-1	3	-	-	2	-	-	-	1	-	-
CLO-2	3	-	-	3	-	2	-	-	-	-
CLO-3	3	-	-	3	-	2	1	3	-	-
CLO-4	3	-	2	2	-	2	-	3	-	-
CLO-5	3	-	2	2	2	2	-	3	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lecture and Discussion	Summative (Mid-Semester-1)
CLO-2	Lecture and Discussion	Assignment and Presentation
CLO-3	Review, Lecture and Discussion	Assignment with Rubrics Assessment (Midterm)
CLO-4	Lecture and Discussion	Summative (Mid-Semester-2) Summative (Final Exam)
CLO-5	Review Lecture and Discussion	Summative (Final Exam)

(g) *Learning Materials*

(i) Recommended Readings

- Haque, M.M. and Mollah, M.Y.A., *Principle of Physical Chemistry*, Brothers Pub.
- Peter Atkins & J.D. Paula, *Atkins' Physical Chemistry,* 10th edition; Oxford University Press.

(ii) Supplementary Readings

- Glasstone, S., *Textbook of Physical Chemistry*, 2nd ed., Macmillan & Co Ltd.
- Castellan, G.W., *Physical Chemistry*, 3rd edition, Narosa Pub. House, Delhi.
- Gurdeep Raaz, Advanced Physical Chemistry, 33rd Edition, Krishna Prakashan Media (P) Ltd., India.
- Barrow, G.M., *Physical Chemistry*, 5th edition, Tata McGraw Hill Education Pvt. Ltd.

Course Code	**Course Title**	**Credit Hours**
0531-14-112	Atomic Structure and Properties of Elements	3.0

(a) *Rationale:*

Inorganic chemistry deals with the structure and properties of element, molecule and substance by which matter is consisted. Without knowing the structure of atoms, properties of elements and substances cannot be explained. This course is designed to provide an idea about the development of the electronic structure of atoms. Many of the chemical properties of the elements can be understood in terms of their electronic configuration.

(b) Course Objectives

- To provide knowledge about modern theories on atomic structure
- To impart knowledge regarding the properties of atoms
- To provide an understanding regarding the periodic trends in the physical and chemical properties of elements

(c) *Course Contents*	
1.	**Introduction to Inorganic Chemistry:** What is inorganic chemistry; Contrast with organic and other branches of chemistry; Genesis of the elements and formation of earth; Distribution of elements on earth; Discovery of elements.
2.	**Atomic Structure:** Historical development of atomic theor**y;** Atomic spectra of hydrogen and Bohr's theory; Refinements to Bohr theory; Dual nature of electron; Heisenberg's uncertainty principle; Atomic orbital
3.	**Schrodinger Equation:** Wave functions and its significance; The particle in box; Quantum numbers and atomic wave functions: angular function, radial functions and nodal surfaces.
4.	Aufbau principle; Pauli exclusion principle; Hund's rule; Electronic configuration
5.	**Nuclear Structure of Atom:** Nuclear model of the atom; Nuclear forces; Nuclear binding energy; Nuclear stability; n/p ratio; Radioactivity; Radioactive rays, Half-life, fission reaction, fusion reaction, isotopes, isobar, Nucleus, nuclear radius and density, nuclear mass and energy correlation, nuclear mass defect and packing fraction, nuclear potential barrier, elementary concepts of nuclear structure, nuclear force, nuclear spin.
6.	**Periodic Table and Periodic Relationships:** Development of the periodic table; Periodic classification of the elements; Periodic variation of physical and chemical properties; Diagonal relationships in the periodic table.
7.	**General Properties of the Elements:** Sizes of atoms and ions; Ionization energy; Electron affinity; Electronegativity; Oxidation state; Standard electrode potentials and electrochemical series

(d) *Course Learning Outcomes (CLOs)*:

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the scope of the study of inorganic chemistry and discuss the nature and composition of matter and various atomic theories

CLO-2: Demonstrate the quantum and wave mechanical approach of atomic structure

CLO-3: Write and explain electronic configuration of atoms with necessary principles and rules

CLO-4: Demonstrate the models of nuclear structure of atom, half-life and radioactivity

CLO-5: Predict general properties of elements from electronic structure of atom

CLO-6: Illustrate the classifications of the elements in the periodic table and analyze variations of properties within periods and groups of the periodic table

CLO-7: Explore the periodic trends in the physical and chemical properties of elements from the periodic table

(e) Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	1	-	-
CLO2	3	-	-	-	-	1	-	1	-	-
CLO3	3	-	-	-	2	-	-	1	-	-
CLO4	3	-	-	3	-	-	-	1	-	-
CLO5	3	3	-	-	-	-	-	1	-	-
CLO6	2	-	-	-	-	-	-	1	-	-
CLO7	2	-	1	-	-	-	-	1	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) *Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy*

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Student Activity	Quiz
CLO2	Lecturing and Discussion	Quiz and Summative Exam

CLO3	Lecturing and Discussion	Quiz and Assignment
CLO4	Lecturing and Discussion	Summative Exam
CLO5	Lecturing and Group Discussion	Mid-Semester
CLO6	Lecture and Discussion	Mid-Semester and Summative
CLO7	Student Activity and Discussion	Assignment

(g) *Learning Materials*
(i) Recommended Readings
• Gary L. Miessler, Paul J. Fischer and Donald A. Tarr. *Inorganic Chemistry*, 5th Edition, Pearson, New York, 2014
• J. D. Lee. *Concise Inorganic Chemistry*, 6th Edition, Chapman & Hill, London
(ii) Supplementary Readings
• Bodie E. Douglas, Darl H. McDaniel and John J. Alexander. *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, Delhi, 1994.
• Advanced Chemistry Website, www.pearsonhigered.com/advchemistry
• Solution Manual (ISBN: 0321814134) by Gary L. Miessler, Paul J. Fischer and Donald A. Tarr

Course Code	**Course Title**	**Credit Hours**
0531-14-113	**Aliphatic and Aromatic Hydrocarbons**	**3.0**

(a) Rationale:

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

(b) Course Objectives

- To provide knowledge about the fundamental concepts of organic chemistry.
- To impart knowledge to understand the behavior of organic molecules as well as their properties and reaction mechanisms of alkane, alkene, alkyne and aromatic hydrocarbons.
- Acquire concepts of constitution, configuration and conformation.

(c) Course Contents

1.	**Basics of Organic Chemistry:** Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes). Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.
2.	**Alkanes and Cycloalkanes:** Constitutional Isomerism, cycloalkanes, nomenclature of alkanes and cycloalkanes, configuration and conformations of cycloalkanes and bicycloalkanes, sources and preparation, Wurtz reaction and its importance and mechanism, physical and chemical properties, free radicals, mechanism of halogenation and carbine addition, synthetic importance of radical halogenation, octane number. Types of cycloalkanes and their relative stability, Bayer's strain theory, Methods of formation of cycloalkanes: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms - Relative stability with energy diagrams.
3.	**Alkenes and Dienes:** Structure, nomenclature of C=C compounds, cis/trans or E, Z-nomenclature, preparation of alkenes, physical and chemical properties, mechanism of electrophilic addition, Markovnikov's rule, Anti- Markovnikov's rule, synthetic application of oxidation by O_3, $KMnO_4$, peracids etc, oxymercuration-demercuration, hydroboration oxidation, polymers of alkenes.

	Structure, nomenclature, preparations, reactions, stability of conjugated dienes, Diels-Alder reaction, polymerization of dienes.
4.	**Alkynes:** Structure, nomenclature, preparation, reactions, electrophilic addition reaction, important organic synthesis starting from alkynes, acidity of alkynes.
5.	**Aromatic Hydrocarbons:** Aromaticity: Huckel's rule, aromatic/anti-aromatic/non-aromatic character of arenes, Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.
6.	**Stereochemistry:** Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the course, the student will be able to –

CLO-1: Demonstrate and explain the different nature of reactions intermediate and behavior of organic compounds based on fundamental concepts learnt.

CLO-2: Write down the nomenclature and demonstrate the physical and chemical properties of alkane, Alkene, alkyne and aromatic compounds.

CLO-3: Illustrate the reactions mechanism of alkane, alkene, alkyne and aromatic compounds.

CLO-4: Explain the stability, synthesize and reactivity of cycloalkanes and dienes.

CLO-5: Articulate the structures, reactivity, stability and fundamental concepts of stereochemistry. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature of organic molecules

(e) Mapping of CLOs with Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	1	1	1	-	-	-	-	-	-
CLO3	3	1	-	1	-	-	-	-	-	-
CLO4	3	1	-	1	-	-	-	-	-	-
CLO5	3	1	-	1	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Student Activity	Summative (Mid-Semester-I) and Semester Final, Presentation
CLO2	Lecturing and Demonstration	Summative (Mid-Semester-II) and Semester Final, Presentation
CLO3	Lecturing and Student Activity	Summative (Mid-Semester-II) and Semester Final, Presentation
CLO4	Lecturing and Discussion	Assignment, Semester Final and Presentation
CLO5	Problem Based Learning	Assignment, Presentation and Semester Final

(g) Learning Materials
(i) Recommended Readings
• R. N. Morrison, & R. N. Boyd, *Organic Chemistry*, 6th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• S. H. Pine Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
(ii) Supplementary Readings
• F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).

Course Code	**Course Title**	**Credit Hours**
0533-14-114	**Physics-I: Mechanics and Properties of Matter**	**3.0**

(a) Rationale:

This course provides a foundation in classical and modern physics, including mechanics, oscillations, gravitation, fluid dynamics, and introductions to relativity and quantum mechanics. It develops conceptual understanding, analytical thinking, and problem-solving skills. By linking theory with practical examples, it prepares students to apply physics principles to real-world and interdisciplinary challenges.

(*b) Course Objectives*

- To impart the knowledge on concept of motion of a particle and particles of a system and their associated properties.
- To provide knowledge on laws, theories, and equations relating with mechanics of objects and their applications.
- To study the macroscopic properties of object with conjunction of classical and quantum mechanics.

(c) Course Contents	
1.	**Kinematics and Dynamics of Particles:** Motion in one dimension and plane; Displacement, Velocity, and Acceleration; Freely Falling Bodies and Equations of Motion; Projectile Motion; Relative Velocity and Acceleration; Classical Mechanics and Newton's Laws of Motion; Mass, Force, and Applications of Newton's laws; Frictional Forces; Uniform Circular Motion; Basics of Relativistic and Quantum Mechanics.
2.	**Work, Energy, and Momentum:** Work Done by constant and variable forces; Kinetics Energy and Work-Energy Theorem, Significance of Work-Energy Theorem; Conservative forces and potential energy; One-, Two-, and Three- Dimensional Conservative Systems; Conservation of Energy; Center of Mass; Liner Momentum of a Particle and system of particles; Conservation of Linear Momentum; Applications of Momentum Principles.
3.	**Collisions and Interaction Processes:** Impulse and Momentum; Conservation of Momentum During Collisions; Collisions in One, Two and Three Dimensions; Cross Section; Reactions and Decay Processes.
4.	**Rotational Motion and Dynamics of Rigid Bodies:** Rotational Motion; Rotational Quantities as Vectors; Rotation with Constant Angular Acceleration; Relation between Linear and Angular Quantities; Torque Acting on a Particle; Angular Momentum of a Particle; Kinetic Energy of Rotation and Rotational Inertia; Rotational Dynamics of a Rigid Body; Combined Translational and Rotational Motion of a Rigid Body; Angular Momentum and Angular Velocity; Conservation of Angular Momentum.
5.	**Oscillations:** Simple Harmonic Oscillator; Energy Considerations in Simple Harmonic Motion; Relation between Simple Harmonic Motion and Uniform Circular Motion; Two-Body Oscillations; Forced Oscillations and Resonance
6.	**Gravitation:** Law of Universal Gravitation**;** Inertial and Gravitational Mass; Inertial and Gravitational Mass; Variations in Acceleration Due to Gravity; Gravitational Effect of a Spherical Distribution of Mass; Gravitational Potential Energy; Potential Energy for Many-Particle Systems; Earth as an Inertial Reference Frame; Principle of Equivalence.

7.	**Hydrostatics and Surface Tension:** Hydrostatic Pressure; Change of Pressure with Elevation; Pascal's Law; Hydrostatic Paradox; Centre of Pressure; Equilibrium of Floating Bodies; Surface Tension and Surface Energy; Adhesive and Cohesive Forces; Molecular Theory of Surface Tension; Capillarity; Variation of Surface Tension with Temperature.
8.	**Hydrodynamics and Viscosity:** General concepts of fluid flow, Streamline flow, Equation of continuity, Bernoulli's equation, Viscosity, Critical velocity and Reynolds number, Poiseuille's Formula and Its Correction; Stokes Law; Variation of Viscosity with Temperature.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the course, the student will be able to –

CLO-1: Recall and define the fundamental concepts of mechanics, gravitation, oscillations, and fluid properties.

CLO-2: Explain the principles of motion, forces, energy, momentum, rotation, oscillations, gravitation, and fluid behavior using appropriate physical reasoning.

CLO-3: Solve numerical and conceptual problems using Newton's laws, kinematic equations, conservation laws, Bernoulli's equation, and other mechanical principles.

CLO-4: Analyze physical systems by identifying forces, breaking motion into components, examining energy and momentum transfer, and interpreting fluid flow characteristics.

CLO-5: Evaluate and justify solutions, assumptions, and physical models in mechanics, oscillations, gravitation, and fluid dynamics under various conditions.

CLO-6: Develop and construct mathematical or conceptual models of mechanical, gravitational, oscillatory, or fluid systems to predict physical behavior in real-world scenarios.

(e) Mapping of CLOs with Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	1	1	1	-	1	-	1	-	1
CLO2	3	1	2	1	1	1	1	2	1	1
CLO3	2	2	3	3	2	2	1	1	1	1
CLO4	2	1	3	3	2	2	2	1	1	1
CLO5	1	1	3	3	3	2	2	2	1	3
CLO6	1	3	2	3	3	3	2	2	2	3

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Student Activity	Quiz
CLO2	Lecturing with Guided Discussion	Quiz and Mid-Semester
CLO3	Problem-Solving & Worked Examples	Quiz and Assignment
CLO4	Interactive Lecture & Analytical Discussion	Assignment and Summative Exam
CLO5	Student Activity and Group Discussion	Mid-Semester
CLO6	Group Projects and Collaborative Tasks	Presentation and Summative Exam

(g) Learning Materials

(i) Recommended Readings

- Halliday, D. and Resnick, R.: *Physics*, Part I, Wiley Eastern Private Limited
- Mathur, D.S., Properties of Matter, S. Chand & Company Ltd.

(ii) Supplementary Readings

- Sears, F. W., Mechanics, Wave motion and Heat; Addison Wesley Publishing Company.

Course Code	Course Title	Credit Hours
0541-13-115	Mathematics-I: Algebra and Geometry	3.0

(a) Rationale:

This course covers key mathematical concepts such as logic, inequalities, algebra, series, complex numbers, matrices, vectors, geometry, and trigonometry. It highlights their applications in chemistry, including modeling with power series, molecular symmetry, quantum chemistry, and describing molecular shapes and dimensions.

(b) Course Objectives

- To provide knowledge on some fundamental mathematics like, algebra, geometry and trigonometry.
- To apply the theories and concepts on fundamentals of mathematics in chemistry.

(c) Course Contents

1.	**Elements of Logic:** Mathematical statements; Logical connectives; Conditional and bi-conditional statements; Truth tables and tautologies; Quantifications; Logical implication and equivalence; Deductive reasoning; The logic of relation
2.	**Inequalities:** Number Systems; Field and Order Properties of Real Numbers; Average Mean; Arithmetic Mean; Geometric Mean; Weierstrass Inequality; Cauchy-Schwarz Inequality; Chebyshev's and Holder's Inequalities.
3.	**Theory of Equations:** Equation and Identities; Basic Ideas of Solution of Equations with Graphical Representations; Relation Between Roots and Coefficients of the nth degree equations; Synthetic division. Position of Roots; Multiplicity of Roots; Transformation of Equations.
4.	**Series**: Basic Definition of Series; Techniques of Summing up Series; Tests of Convergence and Divergence of series; Method of Difference; Successive Difference Method.
5.	**Group Theory:** Main Classes of Group; Finite Group Theory; Lie Theory; Combinatorial and Geometric Group Theory; Connection to Symmetry; Application of Group Theory in Chemistry and Material Science.
6.	**Two-dimensional geometry;** Cartesian and Polar coordinate and their Applications in Chemistry; Transformation of Coordinates; Translation and Rotation of Axes; Invariants; Pair of straight lines; General equation of second degree and reduction to standard form; Identification of conic, Circles and System of Circles; Parabola; Ellipse; Hyperbola.
7.	**Three-dimensional geometry**: Three-Dimensional Coordinates; Rectangular; Cylindrical and spherical coordinates; Direction cosine and direction ratios of a straight line; Equation of Planes; Equations lines; Sphere; Conicoid; Paraboloid; Cylinder.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the basic properties of different numbers

CLO-2: Derive and describe theorems to solve various equations

CLO-3: Identify and apply the equation of straight line, circle and conic.

CLO-4: Apply group theory in chemistry and material Science.

CLO-5: Identify and apply the sphere, cone, cylinder, parabolid, ellipsoid and their properties.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	1	-	-	-	-	-	-	-
CLO3	1	-	-	2	-	-	-	-	-	-
CLO4	1	-	-	-	3	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Student Activity	Quiz
CLO2	Lecturing and Discussion	Quiz, Summative Exam and Assignment
CLO3	Lecturing and Discussion	Summative Exam
CLO4	Lecture and Discussion	Mid-Semester and Summative
CLO5	Student Activity and Discussion	Assignment

(g) Learning Materials
(i) Recommended Readings
• Erich Steiner, Chemistry Maths Book, 2nd Edition, Oxford University Press
• Maria Levitus, Mathematical Methods in Chemistry, LibreText
• Askwit, H. M., Analytical Geometry of Conic Section
(ii) Supplementary Readings
• Quddus, D. M. A., Hossain, S. and Rahman, M. M., Fundamentals of Mathematics
• Rahman and Bhattacharjee, Higher Algebra and Trigonometry

Course Code	**Course Title**	**Credit Hours**
0312-14-116	Emergence of Bangladesh	**2.0**

(a) Rationale:

This course offers unique coverage on the founding of a new nation, Bangladesh, including language, power and religion, and provides insights about economic, political, social and cultural developments of Bangladesh. Study of this course highlights multi-disciplinary narratives regarding nation's 50-year journey of socio-economic progress amid many contradictions and paradoxes. The issues of gender, culture, ethnicity, and governance will also be addressed in this course.

(b) Course Objectives

- To study the historical root of Bangladesh as an independent state focusing on the genesis of war and birth of Bangladesh.
- To learn regarding the political, socio-economic, and cultural development of Bangladesh.
- To equip students with the factual knowledge that will enable them to learn and critically analyze regarding the emergence of Bangladesh as a developing nation.

(c) Course Contents	
1.	Introduction to Emergence of Bangladesh: Course objectives and scope of the study
2.	Identity of Bangladesh and its people: Bangladesh Environment as Delta; A region of multiple frontiers;
3.	Colonial Encounter**:** From the Mughal empire to the British empire; British impact; Colonial conflicts; Partition of India
4.	Language Movement and the Rise of Political Identity: Disparity and Quest for autonomy
5.	Evaluation of Nationalism and Movement for Independence
6.	Liberation War and Birth of Bangladesh: Armed conflict; Birth of state; Imagining a new society
7.	Social and Cultural History: National culture; Liberal and Islamic vision of Bangladesh; Social and cultural basis of Bengali nationalism
8.	Education and Health Policy in Bangladesh: State and education; National Education Policy; Politics of learning reforms in Bangladesh; Changing Contexts and Emerging Realities of Bangladesh Education

9.	Economics History of Bangladesh: Concept on macro and micro economics; Overview of Bangladesh economy; Factors effecting economic growth of Bangladesh; Bangladesh economy: navigating the turning point

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the course, the student will be able to –

CLO-1: Identify the specific stages from the ancient, medieval, colonial and post-colonial periods to current situation how Bangladesh came to be and what is today.

CLO-2: Articulate the roots regarding the war and birth of Bangladesh as independence.

CLO-3: Explain the development of political system, socio-economic conditions, islamic propriety, environmental circumstances of pre/post-independence of Bangladesh.

CLO-4: Compare and analyze the indicators regarding the development of social, cultural, economic, educational and political situation of Bangladesh with other nations

CLO-5: Disseminate and communicate ideas and perception both in oral and written ways regarding the strategies to be taken to improve the indicator/factors for development of the state as emerging nation.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	-	-	1	-	-	-	-	-	-	-
CLO2	-	-	-	-	-	-	-	-	-	1
CLO3	-	-	-	-	1	-	-	-	-	-
CLO4	-	-	2	-	-	-	-	-	-	-
CLO5	-	-	-	-	-	-	-	3	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing with power-point presentation	Quiz
CLO2	Demonstration with videos	Quiz and Summative Exam
CLO3	Lecturing and Discussion	Mid-Semester and Summative Exam
CLO4	Discussion and Student Activities	Mid-Semester and Summative exam
CLO5	Lecturing and Group Discussion	Assignment and Summative Exam

(g) Learning Materials

(i) Recommended Readings

- Willem Van Schendel: A History of Bangladesh Published by Cambridge University Press
- Habibul Khondker, Olav Muurlink and Asif Bin Ali (2022): The Emergence of Bangladesh: Interdisciplinary Perspectives Published by Springer Singapore
- Muntassir Mammon and Md. Mahbubur Rahman: History of the Emergence of Independent Bangladesh Published by the University Grants Commission of Bangladesh

(ii) Supplementary Readings

- Sirajul Islam: History of Bangladesh –Volume Three Social and Cultural History-Asiatic Society of Bangladesh
- David Lewis (2011). Bangladesh: Politics, Economy and Civil Society, Cambridge University Press

Course Code	Course Title	Credit Hours
0531-14-117L	General Chemistry Laboratory	1.5

(a) Rationale:

This course introduces students to essential laboratory practices in chemistry, emphasizing safety, accurate measurement, proper handling of reagents, and preparation of standard solutions. Students will gain hands-on experience using common laboratory apparatus, calibrating volumetric equipment. The course also develops a foundational understanding of stoichiometry and its application in laboratory experiments.

(b) Course Objectives

- To gain an understanding of the utility of measurements in chemistry by examining how measurements are made, what the limitations of measurements are, and how the data obtained from measurements can be presented in useful way
- To analyze data to arrive at scientific conclusion
- To communicate effectively through a report to an audience of peers unfamiliar with the experiment

(c) Course Content

1.	**Maintenance of chemistry laboratory** – Laboratory organization, Safety rules and good laboratory practice
2.	**Introduction to common glassware and apparatus** – Identification, proper handling, and standard uses.
3.	**Selection and handling reagents** **-**Techniques for selecting reagents, cleaning glassware, and proper labeling.
4.	**Measuring mass and volumes** – Use of balances, graduated equipment, and precision techniques.
5.	**Calibrating volumetric glassware** – Procedures for ensuring accurate measurement.
6.	**Water for laboratory use** – Preparation and application of distilled and deionized water.
7.	**Analytical Instruments and Solution Preparation** – Use of analytical balance, pipette, and burette; preparation of 0.1 M Na_2CO_3 and 0.1 M HCl standard solutions.
8.	**Determination of the volume of a drop of water** – Measuring the volume of a single drop and calculating the number of drops per milliliter.
9.	**Determination of the formula of a hydrate** – Experimental analysis using mass data and stoichiometric concepts
10.	**Determination of relative atomic mass (i.e. atomic weight) of magnesium**. – Quantitative experiment using chemical reactions and measured data.

(d) Course Learning Outcomes (CLOs):

After completion of the Course, the Student will be able to –

CLO-1: Apply laboratory safety rules and good laboratory practices in routine experimental work.

CLO-2: Identify, operate, and maintain common laboratory glassware and analytical equipment with accuracy and precision.

CLO-3: Prepare, dilute, and standardize chemical solutions using appropriate techniques and calculations.

CLO-4: Perform quantitative measurements (mass, volume, calibration) and interpret the data using stoichiometric principles.

CLO-5: Conduct basic analytical experiments to determine properties such as the formula of a hydrate and the relative atomic mass of a metal, and report findings effectively.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-		-	-	-	1	-	-	-
CLO2	-	-	3	-	-	3	-	-	-	
CLO3	-	-	3	-		3	-	-	-	-
CLO4	-	-	3	-	-	3	-	-	-	-
CLO5	-	-	-	2	-	3	-		-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Demonstration and Student Activities	Quiz
CLO2	Demonstration and Student Activities	Summative Exam
CLO3	Problem Based Learning (PBL) and Student activities	Summative Exam
CLO4	Case-Base Study and Group Work into the laboratory	Mid-Semester
CLO5	Demonstration and Student Activities	Summative Exam

(g) Learning Materials

(i) Recommended Readings

- Bassett, J. , Dinney, R. C. Jeffery, G. H. and Mendham, J., *Vogel's Text Book of Quantitative Chemical Analysis*, Longmen Scientific & Technical

(ii) Supplementary Readings

- Postma, J.M., Roberts, J.L., and Hollenberg, J. Leland, *Chemistry in the laboratory*, W.H. Freeman and Company, New York.
- Sharma, *Practical Physical Chemistry*, Vikas Publishing House Pvt. Ltd.

Course Code	**Course Title**	**Credit Hours**
0531-13-118L	Information and Communication Technology Laboratory	1.5

(a) Rationale:

This course introduces the use of ICT in chemistry education and covers fundamental concepts of information technology. Topics include computer architecture, programming, operating systems, data communication, networking, the OSI model, and network security. It aims to build a basic understanding of how technology supports communication and learning.

(b) Course Objectives

- To provide the theoretical knowledge, tools and techniques to equip students for working on ICT based environment.
- To study and work on ICT tools for developing higher order thinking skills such as inquiry, graphing, and modeling.

(c) Course Contents	
1.	Fundamentals of ICT education; Motivation and Interaction: Arguments for the use o ICT in Chemistry education
2.	Dual-coding- theory and its application for ICT learning
3.	Molecular Modeling and data representation involving in Chemistry Education
4.	Data Communication and Computer Networking**:** Practical concepts of basic Data Communication fundamentals; Generating signals from different modulation techniques such as Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM) and their differences with respect to characteristics.

5.	Data Management System**:** Practice the concepts learnt in the subject DBMS by developing sample databases with given description. Practice the designing, developing and querying in example database using "Mysql" database.
6.	Mobile Communication and Technologies
7.	Concept and application of web technologies
8.	Concept and application of E-commerce & E-Governance: Security Technologies; Electronic Payment Methods
9.	Use of Google Platform; Animated Visuals in Chemistry Teaching; Interactive Whiteboard for teaching and Learning etc.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Develop ICT education in Chemistry

CLO-2: Demonstrate dual-coding molecular modeling in Chemistry

CLO-3: Use data communication, computer networking and data management system

CLO-4: Operate mobile apps and develop application programs

CLO-5: Perform the project on e-commerce and e-governance

CLO-6: Use google platform for teaching and learning

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	-	-	1	1	-	-	-	1	-	-
CLO2	-	-	-	1	1	2	-	2	-	-
CLO3	-	-	-	-	-	-	-	3	-	-
CLO4	-	-	1	-	2	-	-	3	-	-
CLO5	-	-	1	-	-		-	3	3	-
CLO6	-	-	-	-	-	2	-	2	-	-

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO-1	Demonstration	Quiz
CLO-2	Demonstration and conduct the laboratory	Mid-Semester and Summative Exam
CLO-3	Conduct the laboratory and Student activities	Mid-Semester and Summative Exam
CLO-4	Demonstration and Conduct the ICT laboratory	Mid-Semester and Summative exam
CLO-5	Demonstration and Conduct the ICT laboratory	Mid-Semester and Summative Exam
CLO-6	Conduct the laboratory and ICT Student activities	Mid-Semester and Summative Exam

(g) Learning Materials

(i) Recommended Readings

- I. Eilks and A. Hofstein(eds) (2013), Teaching Chemistry-A Study Book, 213-240, Sense Publishers
- Rodrigues, S. (ed.). (2010). Multiple literacy and science education: ICTs in formal and informal learning environments. Hershey: IGI Global.

(ii) Supplementary Readings

- Hollingworth, R. W. (2003). What role for ICT in teaching and learning chemistry? Chemical Education Journal, 6 (2).
- William M. Fouri, Computer and Information Processing.

Course Code	Course Title	Credit Hours
0531-14-121	Equilibria Reaction Rates and Electrolytes	3.0

(a) Rationale:

This course covers the fundamentals of chemical equilibrium, kinetics, and electrochemistry. Topics include the law of mass action, acid–base concepts, pH, buffers, titrations, solubility, and reaction kinetics (zero and first order). It also introduces conductance, electrolysis, and electrochemical cells, providing a foundation for further study in physical chemistry.

(b) Course Objectives

- To understand the fundamental concepts of chemical equilibrium.
- To gather knowledge about acid-base concepts, pH, titration and role of indicators.
- To analyze solubility product, common ion effect and complex ion equilibria.
- To state the elementary concepts of chemical kinetics.
- To understand the fundamental concepts of electrolysis and their mechanism.

(c) Course Contents

1.	**Chemical Equilibrium:** Concept of equilibrium: activation energy, mobile equilibrium; reversible & irreversible reaction; homogeneous and heterogeneous equilibria, law of mass action; factors affecting equilibrium: Le-Chatelier's principle; free energy change and equilibrium constant; degree of dissociation; Ostwald's dilution law and fugacity, activity & activity coefficient.
2.	**Acid-Base Equilibrium:** Modern concepts of acid-base; Arrhenius, Bronsted-Lowry's, Lewis, Hard and soft, Cady-Esley, Lux-Flood and Usanovich concept; conjugate acid-base pairs, dualism of molecules; ionic product of water and pH scale; buffer solution and its mechanism; Henderson-Hasselbalch equation; relative strength of acids and bases; acid-base titration, indicators and its mode of action, theories of acid-base indicators.
3.	**Solubility and Complex Ion Equilibria:** Solubility and solubility product, common ion effect, effect of pH on solubility, precipitation, applications of solubility product principle; complex ion equilibria; complex-ion formation, complex ions and solubility.
4.	**Chemical Kinetics:** Elementary concepts of chemical kinetics; order, molecularity, rate of reaction; rate law; integration of rate equations for model reaction system; zero, first, second and fractional order reaction kinetics, Pseudo molecular reaction, half-life and average life of a reaction, methods of order calculation.
5.	**Electrolytes:** Basics of strong and weak electrolytes, electrochemical series, electrolysis and its mechanism; Faraday's law, electrolytic/electrochemical cell, cell constant. Conductance; electrolytic and metallic conductance, specific and equivalent conductance; migration of ion; transport number, Kohlrausch's law.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the student will be able to –

CLO-1: Define the fundamentals of rate of reaction and chemical equilibrium.
CLO-2: Demonstrate concepts of acid-base equilibria and their titration.
CLO-3: Articulate common ion effect, solubility product and complex ion equilibria.
CLO-4: Interpret reaction kinetics and their methods.
CLO-5: Draw the electrolytic and electrochemical cell using cell reactions.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	2	3	-	-	-	-	-	-
CLO2	3	-	3	3	-	-	-	-	-	-
CLO3	3	-	3	3	-	-	-	-	-	-
CLO4	3	-	-	3	-	-	-	-	-	-
CLO5	3	-	3	3	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Student Activity	Quiz
CLO2	Lecturing and Discussion	Quiz and Summative Exam
CLO3	Lecturing and Discussion	Mid-Semester and Assignment
CLO4	Lecturing and Group Discussion	Summative Exam
CLO5	Student Activity and Discussion	Mid-Semester and Summative

(g) Learning Materials
(i) Recommended Readings
• Haque M. M., Mollah M. Y. A., *Principles of Physical Chemistry*, Brother's publications
• Glasstone S., *A Text Book of Physical Chemistry*, 2nd ed., Macmillan & Co. Ltd., London.
(ii) Supplementary Readings
• Glasstone S., *An Introduction to Electrochemistry*, Norman Oxlahoma Press.
• Laidler K. J., *Chemical Kinetics,* 3rd edition; Dorling Kindersely Pvt. Ltd.
• Atkins P., Paula J.de, *Physical Chemistry*, 10th edition; Oxford University Press.
• Barrow G.M., *Physical Chemistry*, 5th edition, Tata McGraw Hill Education Pvt. Ltd.
• Maron S. H., Lando J. B., *Fundamental of Physical chemistry*, Macmillan Publishing Co.
• Castellan G.W., *Physical Chemistry*, 3rd edition; Narosa Pub. House, Delhi.
• Kundu N., Jain S. K., *Physical Chemistry*, S. Chand & Co, New Delhi.

Course Code	**Course Title**	**Credit Hours**
0531-14-122	Chemical Bonding and Properties of Molecules	3.0

(a) Rationale:

Fundamental questions of chemistry include how atoms are bonded together to form molecules and how the structure of molecules/compounds is dictated by bonding forces. This course treats the nature of bonding involved in forming molecules and ultimately the chemical compounds. Different boding theories will be described, and properties of molecules will be predicted by this course. Nature of chemical reactions will also be explored in which molecules are interacting based on bonding involved.

(b) Course Objectives

- To study the nature of interactions between atoms by which the molecule is made
- To Identify and demonstrate the different types of chemical bonds
- To predict and understand the properties of compounds based on their composition and structure through bonding

(c) Course Contents	
1.	**Introduction to Chemical Bonding:** Octet Rule: Lewis Electron-Dot Diagrams; Valence Shell Electron-Pair Repulsion Theory; Valence Bond Theory; Hydrogen Bond.
2.	**Symmetry and Symmetry Element:** Symmetry Elements and Operation; Symmetry: Point Group and Character Table; Applications of Symmetry: Chirality and Molecular Vibration.
3.	Molecular Orbital Theory: Molecular Orbital Method; Formation of Molecular Orbitals From Atomic Orbitals; Molecular Orbital Theory (MOT); Molecular orbitals for homonuclear and heteronuclear diatomic molecules.
4.	Inorganic Solids: Bonding in Ionic Crystals; Metallic Bonding: Molecular Orbitals and Band Structure; predicting the shape of molecule, determination of point group and character table of molecule, molecular diagram of molecules & predicting the properties of molecule, determination of structure of ionic solids; Demonstration on Molecular structure and exploring properties of molecules.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the bonding theories (Lewis Dot Structure/VSEPR/VBT/MOT).

CLO-2: Determine the point group and derive the character table of the molecule

CLO-3: Apply Molecular Orbital Theory to calculate bond order and to predict the diamagnetic or paramagnetic properties of inorganic molecules.

CLO-4: Analyze nature of bonding and structure involved into the molecules and substances, both ionic and covalent in nature

CLO-5: Compare the bonding theories with advantages and disadvantages

CLO-6: Evaluate the bonding theories by which properties of molecules and substances are explained

CLO-7: Predict the properties of molecules and nature of interactions among the reacting molecules

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-
CLO6	1	-	-	-	3	-	-	-	-	-
CLO7	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Student Activity	Quiz
CLO2	Lecturing and Discussion	Quiz and Summative Exam
CLO3	Lecturing and Discussion	Quiz and Assignment
CLO4	Lecturing and Discussion	Summative Exam
CLO5	Lecturing and Group Discussion	Mid-Semester
CLO6	Lecture and Discussion	Mid-Semester and Summative
CLO7	Student Activity and Discussion	Assignment

(g) Learning Materials

(i) Recommended Readings

- Gary L. Miessler, Paul J. Fischer and Donald A. Tarr. *Inorganic Chemistry*, 5th Edition, Pearson, New York, 2014
- .D. Lee. *Concise Inorganic Chemistry*, 6th Edition, Chapman & Hill, London

(ii) Supplementary Readings

- Bodie E. Douglas, Darl H. McDaniel and John J. Alexander. *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, Delhi, 1994.
- Advanced Chemistry Website, www.pearsonhigered.com/advchemistry
- Solution Manual (ISBN: 0321814134) by Gary L. Miessler, Paul J. Fischer and Donald A. Tarr

Course Code	Course Title	Credit Hours
0531-14-123	Functional Derivatives of Hydrocarbons	3.0

(a) Rationale:

The chemistry of various organic compounds that contain different functional groups will be better understood by students after completing this course. The production of alkyl and aryl halides, alcohols and phenols, ethers and epoxides, amines, and heterocyclic compounds as well as their physical and chemical characteristics is covered in this course.

(b) Course Objectives:

- To learn the chemistry of halide groups of organic compounds
- To write the mechanism for nucleophilic substitution and elimination reactions of alkyl and aryl halides, and be able to predict the products of such reactions.
- To understand the physical and chemical properties of alcohols and phenols
- To gain knowledge of the chemistry of ethers and epoxides.
- To comprehend the synthesis, physical and chemical reactions of amines and diazonium salts.
- To become familiar with the chemistry of heterocyclic organic compounds.

(c) Course Contents

1.	**Alkyl and Aryl halides:** Structure, nomenclature, preparation, physical properties, substitution and elimination reactions with mechanism, Grignard reagent.
2.	**Alcohol and Phenol:** Structure, nomenclature, preparation, physical properties (acidity and basicity of alcohols and phenols), important reactions of alcohols and phenols, substitution, esterification, oxidations, ring substitution, coupling with diazonium salts, Reimer-Tiemann reaction, phenol-formaldehyde resin of phenol, the Pinacol-Pinacolon rearrangement, periodic oxidation of glycols.
3.	**Ethers and Epoxides:** A brief description of synthesis and reaction of ethers and epoxides.
4.	**Amines (Aliphatic and Aromatic) and Nitro compounds:** Nomenclature, basicity and acidity, preparation of amines, quaternary ammonium salts, separation of amines, basicity differences, reactions of amines with various reagents, Schiff's base, Hoffmann degradation of quaternary ammonium hydroxides, Aromatic diazonium salts: Structure, preparation, introduction of functional group in aromatic system, coupling reactions,
5.	**Heterocyclic compounds:** Aromaticity of heterocycles, sources, isolation, reaction and structure of (i) Five membered ring one heterocyclic compounds: Pyrrole, Furan and Thiophene (ii) Six membered ring heterocyclic compound: Pyridine (iii) Fused ring one heterocyclic compounds: Indol, Quinoline and Isoquinoline.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the nomenclature, synthesize and reactivity of alkyl and aryl halides.

CLO-2: Illustrate the products of the reactions of Grignard reagents.

CLO-3: Acquire the knowledge of nomenclature, preparations, physical and chemical properties of alcohols and phenols.

CLO-4: Explain the physical and chemical properties of ethers and epoxides

CLO-5: Demonstrate how aliphatic and aromatic amines, diazonium salts are made and how they reacts with one another and with other substances.

CLO-6: Apply aromaticity, structures and reactions of five, six membered and fused ring heterocyclic compounds.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	1	-	-	-	-	-	-	-	-
CLO2	3	-	-	1	-	-	-	-	-	-
CLO3	3	2	-	1	-	-	-	-	-	-

CLO4	3	-	-	-	-	-	-	-	-	-
CLO5	3	2	2	1	-	-	-	-	-	-
CLO6	3	2	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and **Reciprocal questioning**	Summative (Mid-Semester-1) and Semester Final
CLO2	Lecturing and Group Discussion	Summative (Mid-Semester-1) and Semester Final
CLO3	Lecturing and Students Activity	Summative (Mid-Semester-2) and Semester Final
CLO4	Lecturing and Tasking	Summative (Semester Final) and Assignment
CLO5	Lecturing and Group Discussion	Summative (Semester Final) and Assignment
CLO6	Lecturing and Video mini lessons	Summative (Semester Final) and Assignment

(g) Learning Materials

(i) Recommended Readings

- Morrison R.T., Boyd R. N., Organic Chemistry, 6th edition, Printice-Hall of India Limited, New Delhi, 1992.
- . Graham Solomons T. W., Organic Chemistry, 6th edition, John Wiley and Sons, 1996

(ii) Supplementary Readings

- Hendrickson, Cram And Hammond, *Organic Chemistry,* 3rd Edition, McGraw-Hill Kogakusha, Limited, 1970.
- Francis A. Carey, *Organic Chemistry*, 3rd edition, Tata-McGraw Hill Publications, New Delhi, 1999.

Course Code	**Course Title**	**Credit Hours**
0533-14-124	Physics-II: Electricity and Magnetisms	2.0

(a) Rationale:

This course introduces the basic principles of electricity and magnetism and their interrelation. It covers electrostatics, DC and AC circuits, circuit analysis, capacitors, and electromagnetism. The course builds a strong foundation for understanding and applying electrical and magnetic concepts in science and technology.

(b) Course Objectives

- To introduce students to the fundamentals of Electricity and Magnetism.
- To demonstrate how the various theories can be applied to real life situations.
- To provide an explanation regarding the transition from Newtonian Mechanics to Quantum Mechanics.
- To give students some insight into possible future development in these areas.
- To equip knowledge for selecting the materials with their particular electrical and magnetic properties for their intended use in chemistry

(c) Course Contents	
1.	Electric Charge, Force and field**:** Electric Charge Coulomb's law; Principle of superposition; Electric field: Field strength, point charge in an electric field, dipole in an electric field; Gauss's law: Electric Flux; Applications of Gauss's Law
2.	Electric Potential**:** Electric potential and field strength, potential due to a point charge, electric potential energy, Potential for Continuous Charge Distribution and Energy; calculation of field strength from electric potential.
3.	Capacitors and Dielectrics**:** Capacitance-its calculation, parallel plate capacitor with dielectric, dielectrics and Gauss's law, energy stored in an electric field.
4.	Current, Electromotive force and Circuits**:** Current and current density, resistance, resistivity and conductivity, Ohm's law, electromotive force, potential difference, Kirchhoff's laws, single loop and multi-loop circuits.
5.	Electrolysis and Cells: Faraday's Law of Electrolysis; The Electrochemical Equipment; The Faraday and the Electronic Charge; Polarization; Ionic Theory of Electrolysis; Primary Cells; Secondary Cells
6.	Magnetic field and the Ampere's law: Magnetic field and field strength, magnetic force an a current, torque on a current loop, the half effect, circulating charges, Ampere's law and magnetic field near a long straight wire, two parallel conductors, Biot-savart law.
7.	Magnetic Induction and Inductance**:** Faraday's law of induction, Lenz's law, induction and the electric field, inductance and its calculation, an IR circuit's energy and the magnetic field, energy density and the magnetic field.
8.	Alternating Current Theory: Alternating Current (AC) Voltage; Phase Relation Between *i; V* for R,L and C; Single Loop RLC AC Circuit; Resonance; Power in AC Circuits.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Describe the theory of electricity, magnetism and electromagnetic radiation

CLO-2: Measure and compute electric current in d.c a/a.c. circuit

CLO-3: Illustrate the principles of electromagnetic induction as they apply to both d.c./a.c. generators.

CLO-4: Describe the generation and distribution of electric power

CLO-5: Identify the type of materials with selected electrical and magnetic properties for their intended use in chemistry

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	1	-	-	-	-	-	-	-
CLO3	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	3	-	-	-	-	-
CLO5	1	-	1	1	2	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Discussion	Summative (Midterm-1/ Semester Final) Assignment
CLO2	Lecturing and Discussion	Summative (Midterm-1/ Semester Final) Assignment
CLO3	Lecturing and Discussion	Summative (Semester Final) Assignment
CLO4	Lecturing and Group Discussion	Summative (Semester Final) Assignment
CLO5	Group Discussion and Student Activity	Summative (Midterm-2/ Semester Final) Assignment

(g) Learning Materials
(i) Recommended Readings
• Halliday, D. and Resnick, R.: *Physics*, Part II, Wiley Eastern Private Limited
• Tewari, K.K., *Electricity and Magnetism with Electronics,* S. Chand & Company Ltd.
(ii) Supplementary Readings
• Huq, M. S., Rafiqullah, A. K. and Roy, A. K., *Concept of Electricity and Magnetism*, Student Publications.

Course Code	**Course Title**	**Credit Hours**
0541-14-125	Mathematics-II: Calculus and Mathematical Methods	3.0

(a) Rationale:

Chemists use mathematical and physical tools to predict the properties of chemicals, the path of reactions and to design materials with a particular set of properties. Pharmaceutical companies hire chemists to use computational tools that rely heavily on physics and math to predict the interactions between potential drugs and their targets, so they can concentrate on synthesizing only the ones that show some promise. Mathematics plays a central role in almost any field of modern chemistry. This course is designed to equip students to apply calculus and mathematical methods to apply in physical chemistry in order to calculate thermodynamic, kinetics and quantum mechanical parameters.

(b) Course Objectives:

- To describe and analyze the behavior of functions.
- To gain proficiency in calculus computations.
- Recognize the appropriate methods/tools of calculus to solve applied problems in chemistry.

(c) Course Contents	
1.	Functions: Concepts and Graphical representation of functions; Inverse function; Polynomials; Rational functions; Trigonometric functions; Exponential function and logarithmic function; Hyperbolic function.
2.	Differentiation: Concepts and Process of Differentiation; Continuity; Limit; Differentiation from first principles; Differentiation by rule; Implicit functions; Logarithmic differentiation; Successive differentiation; Maximum and minimum values; Taylor's series; Maclaurin's series; Exponential and trigonometric series.
3.	Integration: Concepts; Indefinite integral; Definite integral; Integral calculus; Methods of integration; Applications.
4.	Differential equations: First-order ordinary differential equation: Concept and application; Second-order differential equation: Concept and application Partial differentiation: Concepts; General solutions; Separation of variables; Applications.
5.	Fourier analysis**:** Fourier series; Fourier coefficients; Dirichlet's condition; Different forms of Fourier integral theorem; Fourier transform; Inverse Laplace transform and convolution; Evaluation of integrals.
6.	Numerical Methods**:** Concepts; Solution of ordinary equation; Interpolation; Numerical Integration; Methods in linear algebra.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Identify and classify the functions, and use formulas to take derivatives of polynomial, radical, exponential, and logarithmic functions.

CLO-2: Solve differentiation, integration and partial differentiation for a particle

CLO-3: Derive Maclaurin and Taylor expansions of different functions.

CLO-4: Use properties to definite integrals to solve graphical net area problems

CLO-5: Compute the Fourier series of periodic functions

CLO 6: Use numerical methods in mathematical equation and describe the probability function for a particle using statistics

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	2	-	-	2	-	-	-	-	-	-
CLO2	1	-	1	-	-	-	-	-	-	-
CLO3	1	-	-	-	2	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-
CLO6	1	-	2	2	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Discussion	Summative (Midterm-1/ Semester Final) Assignment
CLO2	Lecturing and Discussion	Summative (Midterm-1/ Semester Final) Assignment
CLO3	Lecturing and Discussion	Summative (Midterm-1/ Semester Final) Assignment
CLO4	Lecturing and Group Discussion	Summative (Midterm-2/ Semester Final) Assignment
CLO5	Group Discussion and Student Activity	Summative (Midterm-2/ Semester Final) Assignment
CLO6	Lecturing and Discussion	Summative (Midterm-2/ Semester Final) Assignment

(g) Learning Materials
(i) Recommended Readings
• Anton, H., Bivens, I.C. and Davis, S., Calculus. Tenth Edition, John Wiley & Sons, 2021.
• Burden R. L. and Faires J. D., Numerical Analysis, Brooks/Cole, 2011.
• Zill D. G., A first Course in Differential Equations with Modeling Applications, Cengage Learning, 2012.
• Zachmann D. W., and DuChateau P., Partial Differential Equations, McGraw Hill, Third edition, 2011.
(ii) Supplementary Readings
• Matin and Chakraborty, Differential Calculus, 6th edition, 2024
• Matin and Chakraborty, Integral Calculus, 6th edition, 2024
• Sastry S. S., Introductory Methods of Numerical Analysis, Prentice-Hall of India, 2008.
• Raisinghania M. D., Ordinary and Partial Differential Equations, S. Chand, 2004.

Course Code	Course Title	Credit Hours
0531-14-126L	Qualitative Inorganic Analysis Laboratory	1.5

(a) Rationale:

Classical qualitative inorganic analysis is a method of analytical chemistry that seeks to find the elemental composition of inorganic compounds. It is mainly focused on detecting ions in an aqueous solution. The solution is treated with various reagents to test for reactions characteristic of certain ions, which may cause color change, solid forming, and other visible changes. This course will equip students to acquire laboratory skills on qualitative inorganic analysis of real-world samples.

(b) Course Objectives (COs):

- To make connection conceptual understanding regarding chemical composition of materials (and or chemicals) with laboratory analysis of real (and or supplied chemicals) samples.
- To develop laboratory skills on qualitative inorganic analysis
- To perform in laboratory to operate chemical reactions for testing presence of inorganic chemical component.
- To learn laboratory techniques regarding qualitative inorganic analysis
- To relate experience to the real world/make to relevant to future jobs or courses

(c) Course Contents

Introduction to Qualitative Analysis in the Laboratory; Experimental Techniques in Qualitative Inorganic Analysis; Reactions of the Cations and Anions; Systematic Qualitative Inorganic Analysis; Semimicro Qualitative Inorganic Analysis; Reactions of Some Less Common Ions.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate chemical composition of materials (and or chemicals) and required analytical techniques for qualitative analysis. (Cognitive)

CLO-2: Describe how to prepare the experiment for anion and cation analysis and explain the qualitative analysis for anions in preliminary and specific tests (Cognitive)

CLO-3: Separate cations and anions in aqueous solutions. (Skill)

CLO-4: Identify cations and anions in any mixtures by using different qualitative methods. (Skill)

CLO-5: Interpret, report analytical observations/data and make scientific claims that are supported by their data and other observations. (Cognitive).

CLO-6: To perform experiment successfully without supervision (Skill).

CLO-7: To infer such as able to conclude and explain the phenomenon occurred during experiment (Cognitive).

CLO-8: To relate experience to the real-world chemistry issues/make to relevant to future jobs or courses (Affective).

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	3	-	-	-	-	-	-	-
CLO3	3	-	3	-	-	-	-	-	-	-
CLO4	3	-	-	2				3		2
CLO5	3	-	2	-	-	2	-	-	-	-
CLO6	3	-	-	-	2	-	-	-	1	-
CLO7	3	-	-	-	-	-	-	-	-	-
CLO8	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low)

(f) *Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy*		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Formative Assessment (Ungraded Quiz)
CLO2	Lecturing and Demonstration	Mid-Semester Examination
CLO3	Demonstration and Laboratory Activities	Laboratory Final Examination
CLO4	Laboratory Operation and Group Activities	Formative Assessment (Assignment/Report writing)
CLO5	Laboratory Operation and Group Activities	Laboratory Final Examination
CLO6	Demonstration and Group Discussion	Formative Assessment (Assignment/Report writing)
CLO7	Demonstration and Group Discussion	Formative Assessment (Assignment/Report writing)
CLO8	Demonstration and Group Discussion	

(g) Learning Materials
(i) Recommended Readings
• Vogel, Arthur I., *Textbook of Macro and Semimicro Qualitative Inorganic Analysis*, 5th Edition, Longman Group Limited, Great Britain, 1979
(ii) Supplementary Readings
• Clyde Metz, *Chemistry: Inorganic Qualitative Analysis in the Laboratory*, 1st Edition, Elsevier, 1980.
• Huda S. Alhasan, Nadiyah Alahmadi, " Principles of Qualitative Inorganic Analysis: Precipitation, Separation and Identification of Cations ", Bentham Science Publishers, 2021.

Course Code	**Course Title**	**Credit Hours**
0531-14-127L	Qualitative Organic Analysis Laboratory	1.5

(a) Rationale:

This course is introduced to enable the students who have previously attended the organic chemistry course to develop analytical skills in systematic analysis of organic compounds qualitatively.

(b) Course Objectives (COs):

- To enable the students to develop analytical skills in organic qualitative analysis.
- To enable the students to check the purity of organic compounds by determining the melting or boiling points.
- To provide practical training on identification of various functional groups present in organic compounds using chemical methods.
- To deploy the systematic analysis of organic compounds.

(c) Course Contents	
1.	Systematic Analysis of Organic Compounds**:** Preliminary examination of organic compounds: State, Colour, Odour and Solubility test.
2.	Elemental analysis.
3.	Detection of functional group by chemical methods.
4.	Determination of physical constants (m.p and mixed m.p determination).
5.	Naming of the identified compounds

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the course, the Student will be able to –

CLO1 Apply the solubility nature of organic substances of different functional groups.

CLO2 Determine the m.p. and b.p.

CLO3 Detect the hetero-elements (e.g., N, S, X, P, etc.) in organic compounds.

CLO4 Identify functional groups present in the given organic compounds.

CLO5 Perform the derivative preparation for the confirmatory test of functional groups

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	2	3	-	-	-	-	-	-	-	1
CLO3	-	3	-	-	-	-	-	-	-	1
CLO4	-	3	-	-	-	-	-	-	-	1
CLO5	-	3	-	-	-	-	-	-	-	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Demonstration, and student activity	Lab report, lab performance, Midterm and Semester Final Examination
CLO2	Lectures, group discussion, and student activity	Lab report, lab performance, Midterm and Semester Final Examination
CLO3	Lectures, group discussions, and student activity	Lab report, lab performance, Midterm and Semester Final Examination
CLO4	Lectures, group discussion, and student activity	Lab report, lab performance, Midterm and Semester Final Examination
CLO5	Lectures, group discussion, and student activity	Lab report, lab performance, Midterm and Semester Final Examination

(g) Learning Materials

(i) Recommended Readings

- Vogel's Text Book of Practical Organic Chemistry, ELBS with Longman, 5th ed.

(ii) Supplementary Readings

- Experimental Organic Chemistry, McGraw-Hill Book Company, New York. H. D. Durst & G. W. Gokel.
- Systematic Identification of Organic Compounds, John Wiley Sons, Inc. New York. R. L. Shriner, R. C. Fuson & D. Y. Curtin.
- Organic Experiments, D. C. Health & Company Lexington, Toronto. L. F. Fiesser & K. L. Williamson.
- Basic principles of Practical Chemistry, 2nd edition, New Delhi, Sultan Chand & sons, 1997. V. Venkateswaran, R. Veerasamy & A. R. Kulandaivelu.

Course Code	Course Title	Credit Hours
0533-14-128L	Physics Laboratory	2.0

(a) Rationale:

This course is designed so that students gather practical experience in the laboratory experiment of mechanics, electricity and magnetism and relate with the properties of material chemistry.

(b) Course Objectives (COs):

- Help the students gather experience in physics laboratory practices
- Facilitate to equip students how to use apparatus, do measurements, analyze and interpret experimental data
- To introduce with the precautionary measures to take before doing an experiment, safety, cleaning and as a whole laboratory management
- Make them familiar to write a complete report on an experiment

(c) Course Contents

1.	Experiment with spring: (a) To verify Hooke's law for a spring. (b) To determine the spring constant of the spring. (c) To determine the modulus of rigidity of the material of the spring.
2.	Determination of the electrochemical equivalent of copper by a copper voltmeter.
3.	To determine the specific resistance of a wire using a meter bridge.
4.	To determine the internal resistance of a cell.
5.	To verify Ohm's law by using a Tangent Galvanometer.
6.	To determine the thermal conductivity of a good conductor by Searle's apparatus.
7.	To determine the mechanical equivalent of heat 'J' by electrical method.
8.	Determination of the refractive index of a liquid by pin method using plane mirror and convex lens.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Apply electrical and electrochemical principles to determine quantities such as electrochemical equivalent, resistance, and internal resistance through laboratory experiments. *(Skill & Cognitive)*

CLO-2: Analyze and interpret experimental data obtained from electrical, thermal, and optical measurements, and relate these results with real world chemistry problem. *(Cognitive & Affective)*

CLO-3: Demonstrate safe laboratory practice, proper use of instruments, and effective scientific reporting, ensuring accuracy, accountability, and ethical conduct in experimentation. *(Skill & Affective)*

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	-	3	2	-	3	-	1	-	1
CLO2	2	-	3	3	1	2	1	1	-	1
CLO3	1	-	-	1	-	2	1	2	1	3

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Demonstration and Lab activity	Lab Performance (group), lab Report, Viva
CLO2	Lecturing and Demonstration and Lab activity	Lab Performance (group), lab Report, Viva
CLO3	Lecturing and Demonstration and Lab activity	Lab Performance (group), lab Report, Viva

(g) Learning Materials
(i) Recommended Readings
• Worsnop, B.L. and Flint, H.T.: Advanced Practical Physics.
(ii) Supplementary Readings
• **Ahmed, G. and Uddin, M.S.: Practical Physics**
• Arora, C.L., B.Sc. Practical Physics.

Course Code	**Course Title**	**Credit Hours**
0531-14-211	Chemical Thermodynamics	3.0

(a) Rationale:

Chemical thermodynamics is the study of heat energy and work done with the help of laws of thermodynamics. Chemical thermodynamics involves not only practical measurements of various thermodynamic properties, but also the application of mathematical methods to study the spontaneity/equilibrium of the process.

(b) Course Objectives (COs):

- To explain the laws of thermodynamics.
- To determine the feasibility/spontaneity of a chemical reaction.
- To provide knowledge about heat energy transformations of chemical reactions.
- To give you information about the reaction conditions.

(c) Course Contents

1.	**1st Law of Thermodynamics:** Thermodynamics; system, and surrounding, isothermal and adiabatic process, reversible and irreversible process, isobaric, isochoric and cyclic process; intensive and extensive properties, state function; internal energy, enthalpy; 1st law of thermodynamics; work done in isothermal/adiabatic process; heat capacity, Cp, Cv and their relation; Joule-Thomson effect and its coefficient; inversion of temperature.
2.	**Thermochemistry:** Exothermic and endothermic reaction; heat of reactions; temperature effect on heat of reaction, heat of formation; heat of solution; heat of combustion; heat of sublimation; heat of neutralization; standard forms of heats; calculation of enthalpy of reaction; thermochemical laws; Kirchhoff's equation; bond energy; lattice energy.
3.	**2nd Law of Thermodynamics:** 2nd law of thermodynamics; Carnot's cycle, efficiency of Carnot's cycle, entropy and 2nd law, entropy change in reversible and irreversible process; free energy; Gibbs and Helmholtz (work function) free energy, network/maximum work in Gibbs and Helmholtz free energy, condition of spontaneity, Gibbs-Helmholtz equation; Clapeyron equation; Clausius-Clapeyron equation; Van't-Hoff reaction isotherm and isochors; Maxwell's relations.
4.	**3rd Law of Thermodynamics:** Nernst heat theorem; 3rd law of thermodynamics, absolute entropy, entropy and probability, statistical approach to entropy, calculation of entropy for gaseous substance; partial molar quantities; partial molar free energy, chemical potential and its temperature and pressure effect, partial molar volume; intercept method. Gibbs-Duhem equation; Duhem-Margules equation; Konowaloff's rule; Raoults law.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Explain the physical/chemical changes of a reaction.

CLO-2: Determine the heat (ΔH) content of reaction using thermochemical laws.

CLO-3: Explain the laws of thermodynamics.

CLO-4: Illustrate the condition of spontaneity and equilibrium of a chemical reaction.

CLO-5: Determine thermodynamic parameters (ΔE, ΔH, ΔV, ΔS, ΔG, ΔX, ε, etc.) using thermodynamic laws.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	-	-1	-	-	-	-	-	-
CLO3	3	-	-	1	-	-	-	-	-	-
CLO4	3	-	-	-	-	-	-	-	-	-
CLO5	3	-	-	-	-	1	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz Midterm-I and Final Exam. (Summative)
CLO2	Lecturing & discussion	Assignment (with Rubrics) & Final Exam. (Summative) Quiz/presentation (Formative)
CLO3	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO4	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO5	PPT presentation & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)

(g) Learning Materials
(i) Recommended Readings
• Haque M. M., Mollah M. Y. A., *Principles of Physical Chemistry*, Brother's publications
• Glasstone S., *A Text Book of Physical Chemistry*, 2nd ed., Macmillan & Co. Ltd., London.
(ii) Supplementary Readings
• Maron S. H., Prutton C. F., *Principles of Physical Chemistry*, 4th ed.
• McQuarrie A. D., Simon J. D., *Physical Chemistry*, 4th ed., Viva Books Pvt. Ltd.
• Atkins P., Paula J.de, *Atkins Physical Chemistry*, 10th edition; Oxford University Press.
• Glasstone S., *Thermodynamics for Chemistry*, 3rd edition; Affiliated East-West Press Pvt. Ltd.
• Maron S. H., Lando J. B., *Fundamental of Physical chemistry*, Macmillan Publishing Co.
• Castellan G.W., *Physical Chemistry*, 3rd edition; Narosa Pub. House, Delhi.
• Barrow G.M., *Physical Chemistry*, 5th edition, Tata McGraw Hill Education Pvt. Ltd.
• Chatterjee H., *Physical Chemistry*, Vol-1, Revised Reprint; Platinum Pub.

Course Code	Course Title	Credit Hours
0531-14-212	Chemistry of Elements	3.0

(a) Rationale:

This course presents descriptive chemistry for each of the main groups of elements (*s* and *p*-block elements), transition elements (*d*-block elements) and lanthanide and actinide series (*f*-block elements) which emphasize the properties and reactivity of the chemical elements and their compounds. Without knowing the properties of elements, it would not be possible to explore the properties of compounds and hence nature of chemical reactions.

(b) Course Objectives

- To acquire knowledge about the *s, p, d and f*-block elements, their occurrence &abundance, properties, production, reactivity and applications.
- To provide characteristic of main group chemistry with the emphasis of transition metals chemistry

(c) Course Contents

1.	**Introduction to Chemistry of Element**: Genesis of elements; Classification of elements; Electronic structures and position of *s*, *p*, *d* and *f*-block elements in the periodic table
2.	Source/occurrence and abundance of *s*, *p*, *d* and *f*-block elements.
3.	Extraction, Preparation and Uses of elements.
4.	General Properties of Elements: Size, Ionization Energy, Electronegativity and standard reduction potential.
5.	Oxidation States and Chemical Compounds of Elements.
6.	Physical and chemical properties of elements and their associated compounds.
7.	Types of Bond formed and Reactivity of elements with some important reactions.
8.	General Trends in Main Group Chemistry.
9..	Biological and Environmental Roles of Elements and their compounds.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Classify and describe the arrangement of the major groups of elements in the periodic table.
CLO-2: Demonstrate the occurrence and abundance of various elements
CLO-3: Show the trends of atomic and ionic sizes, ionization energies, electronegativity on the periodic table.
CLO-4: Apply physical and chemical properties of elements to distinguish it from another substances and p*redict* the type of *compound formed* from *elements.*
CLO-5: Judge the superiority of extraction/production method of elements compared to other method.
CLO-6: Explore different physical and chemical properties of elements
CLO-7: Anticipate the biological and environmental role of the elements and their compounds

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	-	-	-	-	-	-	-	-
CLO3	3	-	-	-	2	-	-	-	-	-
CLO4	3	-	-	3	-	-	-	-	-	-
CLO5	3	3	-	-	-	-	-	-	-	-
CLO6	2	-	-	-	-	-	-	-	-	-
CLO7	2	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Formative Assessment (Ungraded Quiz)
CLO2	Lecturing and Demonstration	Assignment
CLO3	Demonstration and Group Activities	Summative Examination (Mid-Semester and Final Examination)
CLO4	Discussion and Group Activities	Summative Examination (Mid-Semester and Final Examination)
CLO5	Demonstration and Problem Based Learning (PBL)	Summative Examination (Mid-Semester and Final Examination)
CLO6	Demonstration and Problem Based Learning (PBL)	Formative (Project Submission) and Summative (Final Examination)
CLO7	Demonstration and Case Study	Formative (Case Study Report Submission and Final Examination)

(g) Learning Materials
(i) Recommended Readings
• Greenwood, N.N. and Earnshaw, A. Chemistry of the Elements, 2nd Edition, Published by Butterworth-Heinemann, Printed in Great Britain, 1998.
• Gary L. Miessler, Paul J. Fischer and Donald A. Tarr. *Inorganic Chemistry*, 5th Edition, Pearson, New York, 2014
• J.D. Lee. *Concise Inorganic Chemistry*, 6th Edition, Chapman & Hill, London
(ii) Supplementary Readings
• Bodie E. Douglas, Darl H. McDaniel and John J. Alexander. *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, Delhi, 1994
• Solution Manual (ISBN: 0321814134) by Gary L. Miessler, Paul J. Fischer and Donald A. Tarr

Course Code	**Course Title**	**Credit Hours**
0531-14-213	Bifunctional and Carbonyl Compounds	2.0

(a) Rationale:

This course is designed for students who have previously attended the organic chemistry course creating a strong foundation in carbonyl and bifunctional compounds and a basic concept in spectroscopic techniques. This course able to idea about some drugs preparation and physiological activity.

(b) Course Objectives

- To provide the students with a strong foundation in the key concepts in carbonyl and bifunctional compounds.
- To illustrate the basic principles of a few spectroscopic techniques (e.g., UV-Visible, IR, NMR and mass spectrometry).
- To know the realistic approach to the synthesis of the simple organic drugs.

(c) Course Contents	
1.	**Aldehyde and ketones (Aliphatic and Aromatic):** Nomenclature of aldehydes and ketones, general methods of preparation of aldehydes and ketones, reaction of aldehydes and ketones, nucleophilic addition to carbonyl compounds, a simply study of mechanisms: Aldol condensation reaction, Cannizzaro reaction, Wittig reaction and Haloform reaction.
2.	**Carboxylic Acids (Aliphatic and Aromatic) and Their derivatives**: Nomenclature, acidity, resonance effect and inductive effect on acidity, general methods of preparation and reactions of carboxylic acids, preparation of different acid derivatives (esters, acid halides, anhydrides, amides, nitriles) and their reactions with various nucleophiles, soap and detergents.

3.	**Bi-functional Compounds:** 1, 3-dienes, α, β-unsaturated carbonyl compounds, preparation electrophilic and nucleophilic addition, Michael addition, Diels-Alder reaction, hydroxy ketones, hydroxy acids, unsaturated acids, ketoacids, Application of these difunctional compounds to different synthetic products.
4.	Spectroscopy in analysis of organic compounds: A brief introduction and applications of UV, IR, and NMR of simple organic compounds.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate and explain the physical and chemical properties of carbonyl compounds and carboxylic acid derivatives.

CLO-2: Get a basic concept of soaps and detergents and their applications.

CLO-3: Describe the physical and chemical reactivities of bifunctional compounds.

CLO-4: Acquire knowledge about the basic principles and applications of spectroscopy.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO-1	3	2	-	-	-	-	-	-	-	-
CLO-2	3	2	-	-	-	-	-	-	-	-
CLO-3	3	-	-	-	-	-	-	-	-	-
CLO-4	3	2	1	1	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lecturing and Reciprocal questioning	Summative (Mid-Semester-1) and Semester Final
CLO-2	Lecturing and Group Discussion	Summative (Semester Final) and Assignment
CLO-3	Lecturing and Students Activity	Summative (Mid-Semester-2) and Semester Final
CLO-4	Lecturing and Group Discussion	Summative (Semester Final) and Assignment

(g) Learning Materials

(i) Recommended Readings

- R. J. Fessenden & J. S. Fessenden: Organic Chemistry.
- Atta-Ur-Rehman. One- and two-dimensional NMR spectroscopy.

(ii) Supplementary Readings

- W. H. Brown & C. S. Foote: Organic Chemistry
- R. T. Morrison, and R. N. Boyd: Organic Chemistry
- I. L. Finar: Organic Chemistry (Vol. I & II)
- P. Sykes. A guide book to mechanism in organic Chemistry
- J. March.: Advanced Organic Chemistry
- T. W. G. Solomons.: Advanced Organic Chemistry

Course Code	Course Title	Credit Hours
0531-14-214	Analytical Chemistry	3.0

(a) Rationale:

Analytical chemistry is the measurement of science consisting with methods applied industry, medicine and all fields of science. It is not possible to carry on any chemical process, without analysis of matter. The interdisciplinary nature of chemical analysis makes analytical chemistry a vital tool in science, medical, industrial, government, and academic laboratories throughout the world.

(b) Course Objectives

- To provide a thorough background in those chemical principles that are particularly important to analytical chemistry
- To develop an appreciation for the difficult task of judging accuracy and precision of experimental data and to show how these judgments can be sharpened by the application of statistical methods.
- To introduce a wide range of techniques that are useful in modern analytical chemistry.

(c) Course Contents

1.	**Nature of Analytical Chemistry:** Quantitative analytical methods; A typical quantitative analysis; Choosing method; Calibrating and measuring concentration
2.	**Errors in Chemical Analysis:** Mean and Median, Accuracy and Precision, Types of errors in experimental data; Systematic errors; Reporting computed data: Significant figures, rounding data and expressing results on chemical computations.
3.	**Statistical Data Treatment and Evaluation:** Confidence intervals; Statistical test in hypothesis testing; Analysis of variance; Detection of Gross Errors.
4.	**Sampling, Standardization and Calibration:** Analytical samples and methods; Sampling and sample handling; Standardization and calibration; Figures of merit for analytical methods.
5.	**Gravimetric Methods of Analysis:** Precipitating gravimetry; mechanism of gravimetry, Properties of precipitates and precipitating agents; Particle size and filterability of precipitates; Colloidal precipitates; Crystalline precipitates; Drying and ignition of precipitates; Application of gravimetric methods.
6.	**Titrimetric Methods:** Precipitation titrimetry; Titration curves for mixture of anions; Indicators for Argentometric titrations. Neutralization titration: Acid/base indicator; Titration of strong acids and strong bases; Titration curves for weak acid/bases; Application of neutralization titration; Complexometric titration: Formation of complex; Titrations with inorganic complexing agents; EDTA titration; Indicators for EDTA titration; Titration methods employing EDTA; Determination water hardness; Oxidation-reduction titration: Auxiliary oxidizing and reducing agents; Applying standard reducing agents; Applying standard oxidizing agents; Detection of end point; Application of redox titration.
7.	Electrochemical Methods: Electrochemical cell and electrode potential, Nernst equation –effect of concentration; Potentiometry; Colometry; Voltammetry
8.	Spectrochemical method: Interaction of electromagnetic radiation with mater, electronic spectra and molecular structure, IR and molecular structure and UV visible absorption and molecular structure. Atomic absorption spectroscopy.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Define the terms presented in the course contents

CLO-2: Explain the types of errors in chemical analysis

CLO-3: Describe the different classical methods of analysis as well as spectroscopic method.

CLO-4: Choice a suitable analytical method for specific analysis

CLO-5: Apply suitable statistical methods to treat data in order to get reliable results

CLO-6: Solve the analytical problems regarding the determination of concentration of analyze

CLO-7: Design a scheme to meet the objectives of analysis.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO-1	3	-	1	-	-	-	-	-	-	-
CLO-2	3	-	-	-	-	-	-	-	-	-
CLO-3	2	-	-	-	-	3	-	-	-	-
CLO-4	-	-	-	-	-	1	-	-	-	-
CLO-5	-	-	-	-	-	2	-	-	2	-
CLO-6	-	-	-	2	-	-	2	-	-	-
CLO-7	-	-	-	-	3	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Formative Assessment (Ungraded Quiz)
CLO2	Lecturing and Demonstration	Summative Assessment (Final Examination)
CLO3	Lecturing and Demonstration	Summative Assessment (Final Examination)
CLO4	Process Based Learning and Group Activity	Formative Assessment (Quiz) and Summative Assessment (Final Examination)
CLO5	Case Base Study and Group Activity	Formative Assessment (Assignment)
CLO6	Problem Based Learning (PBL) and Group Activity	Formative Assessment (Assignment)
CLO7	Demonstration and Tutorial	Formative Assessment (Quiz and Presentation) and Summative Assessment (Final Examination)

(g) Learning Materials
(i) Recommended Readings
• Skoog, D.A., West, D.M., Holler, F.J. and Crouch, S.R. Fundamentals of Analytical Chemistry, 9th Edition, Brooks/Cole Cengage Learning, USA, 2014.
• Christian, G. D., *Analytical Chemistry*, Wiley
(ii) Supplementary Readings
• Verma, R.M., *Analytical chemistry*, 3rd Edition, CBS Publishers & Distributors, India
• Bassett, J., Dinney, R. C., Jeffery, G. H., and Mendham, J., *Vogel's Textbook of Quantitative Inorganic Analysis*, Longman.

Course Code	**Course Title**	**Credit Hours**
0531-14-215	Nuclear Chemistry and Chemical Weapons	2.0

(a) Rationale:

Nuclear chemistry deals with the transformations in the nucleus of atoms. This course covers to study the theories of nuclear structure and stability, radioactivity, nuclear reactions, nuclear reactors, and applications of radioisotopes exemplifying peaceful uses of atomic energy. It helps learners to study the use of radioactive isotopes and penetrating and **harmful** effects of radiation on biological systems.

(b) Course Objectives

- To provide fundamental knowledge on nuclear chemistry and radioactivity of isotopes.
- To introduce about nuclear reactions and preparation of nuclear reactor with understanding about the generation of electricity using heat from a controlled chain reaction in a nuclear reactor.
- To impart knowledge on harmful effect of radiation and nuclear waste management for environmental sustainability.

(c) Course Contents	
1.	**Introduction to Nuclear Chemistry:** Nuclear structure and fundamental particles; Classification of nuclides; Nuclear stability: nuclear binding energy; Atomic energy; Nuclear models.
2.	**Radioactivity:** Discovery; Radioactive decay: general characteristics of radioactive decay; Decay kinetics: concept of half-life; Parent-Daughter decay growth relationship; Alpha decay; Beta decay; Gamma radiation; Detection of radiations; Artificial radioactivity.
3.	**Application of Radioactivity and Nuclear Waste Management:** Uses of radioisotopes; Biological effect of radiation; Nuclear waste management: Low, intermediate and high-level wastes and their disposal.
4.	**Nuclear Reactions:** Types of nuclear reactions; Conservation in nuclear reactions; Nuclear reaction cross section; Specific nuclear reactions; Transuraniens; Photonuclear reactions; Thermonuclear reactions; The origin and evolution of elements.
5.	**Nuclear Fission and Fusion:** Process of nuclear fission; fission fragments and their mas and charge distribution; Fission energy; Nuclear fission atom bomb; Nuclear fusion: H-bomb.
6.	**Nuclear Reactor:** Natural uranium reactor; Four reactor formula; Classification of reactor; Graphite reactor; Water reactor; Breeder reactor; Reactor power; Accelerator; Application of nuclear reactor.
7.	**Chemical Weapons Convention:** Chemical weapons: declaration; Chemical weapons production facilities; National implementation measures; Bangladesh national authority for chemical weapon convention; Chemical warfare agents (CWA).

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate basic knowledge on the different areas of nuclear chemistry including radioactivity and decay laws, nuclear reactions, radioisotopes, nuclear reactors, radiation detector etc.

CLO-2: Differentiate between the difference types of nuclear reactions and nuclear reactors

CLO-3: Identify and explain different radiochemical methods of analysis and their applications.

CLO-4: Calculate the age of archaeological objects/earth to establish historical chronologies

CLO-5: Recognize the society awareness and propose nuclear waste management policy to protect the environment.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Quiz & Final Examination (Summative)
CLO2	Lecturing and Video Presentation	Mid-Semester (Formative) & Final Examination (Summative)
CLO3	Demonstration and Process Oriented Learning	Semester Final Examination (Summative)
CLO4	Problem Based Learning and Student Activity	Mid-Semester-II and and Semester Final Examination (Summative)
CLO5	Demonstration and Project Based Learning	Assignment and Semester Final Examination (Summative)

(g) Learning Materials
(i) Recommended Readings
• Arnikar, H.J.Essentials of Nuclear Chemistry, 4th Edition, Wiley
• Friedlander and Kennedy , Nuclear and Radiochemistry,
• Williams R. Principles of Nuclear Chemistry, , Van Nostrand, 1950
(ii) Supplementary Readings
• B.G. Harvey, Introduction to Nuclear Physics and Chemistry, 2012

Course Code	**Course Title**	**Credit Hours**
0413-14-216	Inroduction to Computer Language	2.0

(a) Rationale:

This course covers the use of programming languages in computational chemistry and cheminformatics. Students learn to represent and manipulate molecular structures, calculate chemical properties, and apply algorithms using languages like C++, Python, and R, along with key software tools, through a hands-on approach.

(b) Course Objectives

- To provide an overview idea about computer application in chemistry study through introduction computer language programming.
- To introduce salient features of the C++ programming language and its programming ecosystem, with emphasis on how the language affects software development
- To Make students proficient in working with the Python programming language
- To Familiarize students with core scientific Python libraries and applying them to solve chemical problems
- Teach students to use Jupyter notebooks as an interactive environment for solving chemical problems and to write clear explanatory text
- Enable students to automate the processing and visualization of multiple, analogous data sets.
- To capable to learn about interoperability between C++ and other high-level language commonly used in chemo informatics, machine learning, data processing and statistical computing
- To prepare students for using Gaussian series of computational chemistry programmes to acquaint themselves with program's newest features.

(c) Course Contents	
1.	Introduction to Course: Objectives and learning outcomes; Computer hardware and software; Compiler vs Interpreter; What You Can Do with Computational Chemistry; Tools of Computational Chemistry
2.	Introduction to C and C++: C++: Basic language features; Object-oriented and generic programming; Interoperability between C/C++and other high-level languages; Coding convenience and productivity; C++as a language for scientific software development; C++ tutorial.
3.	Data Structures**:** More on Lists- Using Lists as Stacks, Using Lists as Queues, List Comprehensions, Nested List Comprehensions, The del statement, Tuples and Sequences, Sets, Dictionaries, Looping Techniques, More on Conditions, Comparing Sequences and Other Types.
4.	Basic Python**:** Jupyter Notebooks, Numbers, Variables, Boolean logic, Strings, list, tuples, Loops, Conditions, importing/exporting data from/to text files and functions**;** Matplotlib: Scatter plots, histogram, stream plots and surface plots, importing data from external comma-separated value (CSV) files to plots; NumPy: creation and manipulation of data in NumPy arrays, slicing and reshaping, vectorization, broadcasting, NumPy methods. SciPy: Physical Constants and Special Functions, Integration and Ordinary Differential Equations, Interpolation, Optimization, Data-Fitting and Root-Finding; Data Analysis with pandas: Reading and Writing Series and DataFrames, More Advanced Indexing, Data Cleaning and Exploration, Data Grouping and Aggregation; General Scientific Programming: Floating-Point Arithmetic, Stability and Conditioning, Programming Techniques and Software Development; Solving chemical problem using Python; SymPy tutorial.
5.	Running Gaussian: Tutorial for Unix and VMS systems, Tutorial for Windows system, Studying chemical reactions and reactivity by Gaussian.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate interoperability between computational chemistry and computer programming and denote a set of techniques for investigating chemical problems on computer (Cognitive).

CLO-2: Articulate the salient features of the C++/Python programming language and its application Chemistry (Cognitive)

CLO-3: Install, run and write the program by C++ language and exercise chemistry problems to solve (Psychomotor)

CLO-4: Install, run and operate Python language and exercise chemistry problems (Psychomotor) and Gaussian software for the study of molecular geometries, rates and equilibria, spectra, and other physical properties

CLO-5: Develop a project for designing/constructing a program by C++/Python to solve a specific problem/issue of chemistry. (Psychomotor and Affective) .

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	2	-	-	-	-	-	-	1	-	-
CLO2	2	-	-	-	-	-	-	2	-	-
CLO3	1	-	2	3	1	3	-	2	-	-
CLO4	1	-	2	3	1	3	-	2	-	-
CLO5	1	1	-	2	3	-	-	1	2	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Quiz-1
CLO2	Demonstration with Audio-Visual Presentation	Quiz-2

CLO3	Demonstration with Problem Solving Learning (PBL) and Student activities	Report Submission and Practical Examination:Part-1
CLO4	Demonstration with Problem Solving Learning (PBL) and Student activities	Report Submission and Practical Examination:Part-2
CLO5	Demonstration and Tutorial (Student Activity)	Assignment and Project Submission

(g) Learning Materials

(i) Recommended Readings

- Stroustrup B (1997). *The C++programming language,* 3rd Edition, Addison-Wesley, Boston, p 327
- Christian Hill (2020). *Learning Scientific Programming With Python*, 2nd Edition, Cambridge University Press, United Kingdom.

(ii) Supplementary Readings

- Charles J. Weiss (2017). *Scientific Computing for Chemists: An Undergraduate Course in Simulations, Data Processing, and Visualization*, Journal of Chemical Education, American Chemical Society and Division of Chemical Education, Inc.

Course Code	**Course Title**	**Credit Hours**
0531-14-217L	Quantitative Organic Analysis Laboratory	1.5

(a) Rationale:

This course introduces common methods for analyzing organic compounds in medicine, industry, environment, and food. It covers separation techniques, mass spectrometry, chromatography, electrophoresis, and coupled methods for complex mixtures. Students gain practical skills in UV-Vis and chromatographic techniques for quantitative analysis of real samples.

(b) Course Objectives (COs)

- To impart knowledge on common analytical methods suitable for quantitative organic analysis.
- To equip students to develop capacity for operation of suitable analytical methods to quantify organic compounds with accuracy and precision.

(c) Course Contents

1.	Determination of carbon and hydrogen
2.	Determination of nitrogen: Kjeldah's method
3.	Estimation of carboxylic acid group present in an organic compound by iodometric method; Estimation of hydroxyl and amino groups by acetylating; Estimation of aldehydes group by oxidation; Estimation of adjacent hydroxyl groups by periodic oxidation.
4.	Quantitative analysis of aspirin.
5.	Determination of ascorbic acid in Vitamin-C tablet.
6.	Thin Layer Chromatography (TLC): Preparation of thin layer plates, separation of colored compounds by TLC and detection of the separated compounds by UV light and iodine vapor, separation of colorless compounds by TLC and detection of the separated compounds by using charring reagent (vanilla-sulphuric acid reagent).
7.	Column Chromatography (CC): (i) Separation of colored compounds by column chromatography using alumina silica gel as stationary phase, sample application as solution and by adsorbing the compounds in the adsorbent. (ii) Separation one colored and another colorless compound by column chromatography.
8.	Paper Chromatography (PC): (i) Identification of free sugar by paper chromatography and detection of the separated compounds by dipping spray reagent. (ii) Separation of amino acids by paper chromatography and detection of the separated compounds by using ninhydrin spray reagent.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the common methods for quantitative analysis of organic compounds presents in real-world samples (Cognitive)

CLO-2: Identify/choose a suitable method/technique with effective separation technique (if necessary) for given analytes in real-world samples (Cognitive and skill)

CLO-3: Perform the operation of methods and report the results with interpretation on quantitative organic analysis (Skill).

CLO-4: Relate the significance of analysis with pros and cons of application of analytical methods used quantitative estimation of organic compounds in real-world samples. (Affective)

CLO-5: Disseminate the analysis report and mention the code of conduct on ethical issues (Affective.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	2	-	3	-	-	-	-	-	-	-
CLO2	2	-	3	2	-	3	-	-	-	-
CLO3	2	-	3	2	-	3	-	-	-	-
CLO4	2	-	3	-	-	3	2	-	-	-
CLO5	2	-	3	-	-	-	2	3	-	3

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Quiz
CLO2	Demonstration with Scaffolding Teaching	Mid-Semester
CLO3	Process Oriented and Guided Inquiry Learning Method	Semester Final
CLO4	Project Based Learning Method	Report Writing & Oral Presentation
CLO5	Demonstration and Group Discussion	Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- Arthur I. Vogel (1958). Elementary Practical Organic Chemistry Part Iii Quantitative Organic Analysis
- Daniel C. Harris (2007)Quantitative Chemical Analysis, Craig Bleyer , W. H. Freeman and Company, United States of America

(ii) Supplementary Readings

- James S. Fritz Organic Quantitative Analysis, Journal of Chemical Education, ACS
- Charles J. Varsel Francis A. Morrell, Frank E. Resnik, And W. Allan Powell , Qualitative and Quantitative Analysis of Organic Compounds: Use of Low-Voltage Mass Spectrometry, Analytical Chemistry, Vol. 32, No. 2, February 1960.

Course Code	Course Title	Credit Hours
0531-14-218L	Computer Applications in Chemistry	2.0

(a) Rationale:

This course introduces the basics of computational chemistry and computer science. It covers the history of computing, commonly used software, programming basics, and chemistry-related tools. It also includes 3D molecular modeling for structure drawing and property calculation, providing a foundation for further study in computational chemistry.

(b) Course Objectives (COs):

- To provide knowledge about basic applications of computers in daily life tasks.
- To impart practical knowledge to understand the properties of materials theoretically by assumptions.
- To deliver an understanding regarding the 3D structural patterns of the compounds.

(c) Course Contents

1.	Computer and Information Technology**:** Basic Concepts; History, working principle of computer system; Types of modern digital computers, Hardware, Software, Constituents of a Computer, Configuration etc. Importance of Computational Chemistry, application, and possibilities.
2.	Daily Use Software**:** Microsoft office: Word; Excel; Access; Power point: presentation; managing file; inserting graphics; Video conferencing. Graph drawing by N graph, Origin Lab**,** Sigma Plot.
3.	Language and Chemistry Software**:** An overview idea of computer language and software; Application of FORTRAN language; Writing chemistry texts involving chemical formulae; Molecular structure drawing using Chemwin 2D and 3D
4.	3D Molecular Model Building Software**:** Preparation and application; Solving Chemical equation through computer software, VISTA and its application, 3D structure drawing by Materials studio, Gaussain.

(d) Course Learning Outcomes (CLOs)**:**

After completion of the Course, the Student will be able to –

CLO-1: Explain by interpreting the very basics of computer technology.

CLO-2: Describe the configuration or component to have basic knowledge to set a computer by own self with its uses to run the required software related to science to solve the problems.

CLO-3: Illustrate of the physical properties and molecular structure by using computer technologies.

CLO-4: Explore the properties of solids, crystalline and amorphous solids with different software used.

CLO-5: Describe the various compounds, materials and chemical constitution by using computer with their use in chemistry.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	2	-	-	-	1	-	-
CLO2	3	-	-	3	-	2	-	-	-	-
CLO3	3	-	-	3	-	2	1	3	-	-
CLO4	3	-	2	2	-	2	-	3	-	-
CLO5	3	-	2	2	2	2	-	3	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture & discussion	Midterm-I, Semester-Final
CLO2	Review, Lecture & discussion	Quiz and Semester Final
CLO3	Review, Lecture & discussion	Midterm-II, Semester-Final
CLO4	Lecture & discussion	Semester-Final
CLO5	Review, Lecture & discussion	Semester-Final

(g) Learning Materials
(i) Recommended Readings
• Sarah E. Hutchinson and Glen J. Coulthard, Microsoft Office 2000, McGraw-Hill Irwin, New York
• Kennetc C. Laudon, Interactive Computing, McGraw-Hill Companies, Inc. New York, 1996.
(ii) Supplementary Readings
• Mahbubur Rahman, Microsoft Office 2007/10, Cistech Publication, 38/3 Bangla Bazar, Dhaka
• Molecules-3D: 3D molecular model building software for windows, Quick Start Guide, Version 2.0, Molecular Arts Corporation, USA
• Windows 98, Bruce, A., Hallberg & Joe Casad, Techmedia, 20 Ansari Road, New Delhi-2.

Course Code	**Course Title**	**Credit Hours**
0231-14-219L	Functional English for Effective Communication	1.5

(a) Rationale:

The Functional English for Effective Communication course focuses on improving listening, speaking, reading, and writing skills through practical exercises. Designed for chemistry students, it enhances clarity, confidence, grammar, and error correction, supporting academic, professional communication, and employability.

(b) Course Objectives

- To encourages students to think critically and use English effectively in academic, social and professional contexts
- To improve professional communication and employability skills of students
- To aid self-learning in a creative and competent manner through a required number of practice exercises and activities
- To develop learners to write formal letters and scientific writing in English
- To provides carefully designed units to familiarize students with the test patterns of various competitive examinations such as IELTS ,TOEFL, and GRE

(c) Course Contents	
1.	Vocabulary: Clues to the meaning of a word; Position in the clause, prefixes, suffixes, roots; Revisiting and expanding vocabulary
2.	Grammar: Clause; Tense; Voice; Mood; Modal auxiliaries; Subject-verb agreement; Remedial grammar: identifying and correcting errors and weaknesses; Applications of grammar in communication English: How is grammar helping learner to 4our sections of IELTS.
3.	Listening: English Sound System; General Everyday Topics in social, educational and training situation; conversation between two speakers (for example, a conversation between two university students about everyday life, subject matter about university education); One person speaks on an academic subject
4.	Speaking: How to ask questions, make requests, and give instructions; How to respond queries, invitations and statements; How to introduce and thanks, express gratitude, regret or appreciation; How to communicate in everyday situations; How to express different concepts; Practicing of English phonemes, accent and intonation.

5.	Reading: The texts of narrative, descriptive or discursive/argumentative; Reading for skimming, comprehension and interpretation.
6.	Writing: Spelling, Punctuation, intending, brackets, abbreviation, hyphenation etc.; Organization of writing-of sentences in paragraphs and of paragraphs in essays; Writing a letter asking for information or explaining a situation
7.	IELTS Test Format (Academic): Listening tasks; Reading tasks; Writing tasks and Speaking tasks.
8.	Introduction to test format of TOEFL and GRE.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Answer the MCQ and Matching questions regarding vocabulary and grammar contexts applicable for communicating English as language.

CLO-2: To listen and understand short lectures, descriptions, and narrations/passages efficiently and write to note the important assigned points during listening.

CLO-3: Read to skim and scan through a passage of different subject areas including chemistry.

CLO-4: Speak in English fluently and correctly in person and group with practical ideas of English pronunciation with required accent.

CLO-5: Write and prepare relevant documents on important social issues in addition to chemistry and answer scripts of different subject areas including chemistry with ethical and efficient manner.

CLO-6: Critically analyze and interpret data from a corpus, and use it as empirical evidence for the current state of the English language ethically, and for evaluating the validity of traditional grammar rules.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	-	-	-	-	-	1	-	3	-	-
CLO2	-	-	-	-	-	2	-	3	-	-
CLO3	1	-	-	-	-	2	-	3	-	-
CLO4	-	-	-	-	-	2	-	3	2	-
CLO5	1	-	-	-	1	2	-	3	-	2
CLO6	-	-	1	-	-	1	-	3	-	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing: Demonstration followed by power point presentation	Formative Assessment (MCQ and Matching Questions)
CLO2	Demonstration and Student Activity	Formative Assessment (Class Performance)
CLO3	Tutorial and Student Activity	Formative Assessment (Class Performance) and Final Exam
CLO4	Demonstration sand Group Activity	Formative Assessment (Class Performance) and Final Exam
CLO5	Demonstration and Literature Review	Presentation and Final Exam
CLO6	Process Oriented learning and Tutorial	Assignment and Final Examination

(g) Learning Materials

(i) Recommended Readings

- Ujjwala Kakarla, Tanu Gupta and Leena Pundir (2019). *Functional English for Communication*, 1st Edition, SAGE Publications India Pvt Ltd.
- Soars, J (2007). *New Headway Pre-intermediate Third Edition: Students' Book & Workbook Audio CD*. Oxford university Press

- Hancock, M. (2003) *English Pronunciation in Use*. Cambridge. Cambridge University Press.

(ii) Supplementary Readings

- Sabina K Musthafa (2022). *Functional Grammar and Communication in English*, University of Calicut, Kerala, India
- Swan, M. & Walter, C. (2011) *Oxford English Grammar Course.* Oxford. Oxford University Press.
- Blundell, J & Higgens, J (1982) *Function in English*. Oxford. Oxford University Press.

Course Code	**Course Title**	**Credit Hours**
0531-14-221	Solution Chemistry	3.0

(a) Rationale:

A solution is a homogeneous mixture of solute and solvent, characterized by its concentration. Its physical (colligative) properties depend on intermolecular forces. The phase rule explains equilibrium in heterogeneous systems based on temperature, pressure, and concentration, with important applications in industry and engineering.

(b) Course Objectives (COs)

- To study the colligative properties of solution
- To study thermodynamics and cause of deviation from ideal behaviors of solution
- To understand the spontaneity/direction of chemical reaction and solute-solvent interaction
- To study one, two, three component system along with the accountability of phase, component and degrees of freedom of chemical reaction
- To discuss the philosophy of phase equilibrium and thermodynamic modeling.

(c) Course Contents

1.	**Properties of Dilute solution:** Colligative properties; lowering of vapor pressure; Raoult's law; ideal and non-ideal solutions; elevation of boiling point; depression of freezing point; osmotic pressure & their measurements; semi-permeable membrane and their mechanism, laws of osmotic pressure; thermodynamic treatment of colligative properties.
2.	**Thermodynamics of Solution:** Thermodynamics of ideal and non-ideal solutions; excess thermodynamic functions; solute-solvent interaction; hydrophobic-hydrophilic interaction; micelle; micelle formations by surfactants, thermodynamics of micelle formation, CMC, solubilization of solutions of surfactant; thermodynamics of mixed aqueous micellar systems.
3.	**Phase Equilibrium:** Phase, component, degrees of freedom and their equilibria, phase rule and its thermodynamics, triple point, thermodynamics of phase change; Henry's law; Nernst distribution law; association and dissociation. a) *1-component System*: Solid-liquid-vapour equilibria of water, CO_2, Sulphur and Phosphorus; triple point; metastable system; sublimation; polymorphism and isomorphism; transition point; enantiotropy; monotropy; dynamic allotropy. b) *2 and 3-components System*: Partially miscible liquid pairs, *t-c* diagram and CST, salt and pressure effect on CST, Raoults assumption, azeotropes; solid-gas, solid-solution type (Ni-Cu), solid-liquid systems with and without compound formation; simple eutectic (Sb-Pb) and peritectic (Fe-C) system, system forming compound having congruent (Zn-Mg) & incongruent melting point (Au-Sb, Sn-Mg, Na_2SO_4-H_2O systems). c) Ternary system; CH_3COOH-H_2O-$CHCl_3$, (Ph-OH)-H_2O-$CHCl_3$, H_2O-(Ph-OH)-(Ph-NH_2), succinic nitrile-water-ether, *etc*.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Analyze the colligative properties of liquid-liquid solution and their theories.

CLO-2: Define the thermodynamics of solution and thermodynamics of micellar system.

CLO-3: Gather idea about single/multi-component system using phase rule.

CLO-4: Interpret phase equilibrium, thermodynamic modeling and their laws

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	1	-	-	-	-	-	-	-
CLO3	3	-	1	-	-	-	-	-	-	-
CLO4	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing & discussion	Mid-Semester-1 and Final Exam
CLO2	Lecturing & discussion	Quiz Final Exam
CLO3	Lecturing & discussion	Final Exam
CLO4	Demonstration and Group Discussion	Mid-Semester-2 and Final Exam

(g) Learning Materials

(i) Recommended Readings

- Haque M. M., Mollah M. Y. A., *Principles of Physical Chemistry*, Brother's publications
- Glasstone S., *A Text Book of Physical Chemistry*, 2nd ed., Macmillan & Co. Ltd., London.
- Castellan G.W., *Physical Chemistry*; 3rd edition; Narosa Pub. House, Delhi.

(ii) Supplementary Readings

- P. Atkins, J.de Paula, *Atkins Physical Chemistry*, 10th edition; Oxford University Press.
- Maron S. H., Prutton C. F., *Principles of Physical Chemistry*, 4th ed.
- McQuarrie A. D., Simon J. D., *Physical Chemistry*, 4th ed., Viva Books Pvt. Ltd.
- Ebbing D., *General Chemistry*, Houghton Mifflin Company, Boston, New York.

Course Code	**Course Title**	**Credit Hours**
0531-14-222	Inorganic Chemical Reactions	3.0

(a) Rationale:

Chemical reactions take place all around us. Indeed life itself is a highly organized sequence of chemical reactions. Much of the activity of industrial society depends on chemical reactions particularly inorganic reactions. Acid-base reactions are important throughout chemistry. Many inorganic reactions involve reduction and oxidation in addition with coordination reactions. All chemical reactions take place according to a set of general principles that relate the amounts of materials consumed in a reaction to the amounts of material consumed. This course is designed to study all types of inorganic chemical reactions and learners can use the chemical principles to calculate how much materials is needed to make a desired amount of product.

(b) Course Objectives (COs)

- To understand the concept of stoichiometry and balancing the chemical reactions
- To recognize the types of inorganic chemical reactions particularly acid-base, oxidation-reduction, precipitation reaction and complexation reaction
- To study the factors that determine whether a chemical reactions is possible.
- To impart some important inorganic chemical reactions in real-life situation.

(c) Course Contents	
1.	Types of Chemical Reactions: Reactions among the atoms and molecules of the same kind; Reactions between atoms and molecules of different substances; Miscellaneous types of reactions; Stoichiometry of chemical reactions; Limiting reagent and precursor molecule; Yields of chemical reactions
2.	Acid-Base Reactions: Acid-Base Models: Arrhenius-Ostwald, Brønsted-Lowry and Lewis; Frontier Orbitals and Acid–Base Reactions; Strength of Acids and Bases: Inductive, Resonance, Steric and Solvent Effects; Quantification of Acidity and Basicity; Acid-Base Behavior of Binary Oxides and Aqua Cations; Hard and Soft Acids and Bases: HSAB Quantitative Measures.
3.	Oxidation-Reduction Reactions: Electronic concept of oxidation-reduction; Oxidation number and oxidation state; Balancing oxidation-reduction equations; half-reaction method; Strengths of oxidizing and reducing agents; Oxidation-reduction potential: Relationship between Cell Voltage and Free-Energy Change for the cell REaction; Use of Half-cell emf Data to Predict Chemical Reactions; Pourbaix Diagram; Some Redox Reactions of Nonmetals.
4.	Precipitation and Complexation Reactions: Species in solution; Solubility Guidelines; Solubility of Oxides and Hydroxides; Precipitation Stoichiometry; Synthesis via Precipitation; Complex Formation and Solubility of Solids; Complexation reactions and Titration
4.	Enthalpy-Driven and Entropy Driven Chemical reactions: Spontaneity and Thermodynamics: Internal energies, bond energies, enthalpies and heat of reactions; Concept of Entropy and Free Energy: Prediction of Spontaneous Chemical Reactions; Reduction potentials and Free energies; Energy and Entropy in Noble-Gas Chemistry.
5.	Inorganic Molecules and Synthetic Strategies: Introduction to inorganic molecules and synthesis; Synthetic strategies: Direct combination, Low Temperature, Thin film, combinatorial and Nanosynthesis; Solid State Reactions; Synthesis from liquids; Gas Phase Techniques.
6.	Inorganic Polymerization Reactions: Basics of Inorganic Polymers; Types of Inorganic Polyners Characterization of Inorganic Polymers; Polymer based on Boron, Silicon, Phosphorus and Sulphur; Some Important Inorganic Polymerization Reactions and their Innovative Applications.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Categorize and identify the different types inorganic molecule/reagent and inorganic reactions.

CLO-2: Demonstrate and explain the different inorganic reactions and their synthetic strategies.

CLO-3: Calculate and analyze the strength of acid/base, potentials of redox reaction, formation/stability constant of complexes, solubility products of inorganic reagents

CLO-4: Critically compare and evaluate the required conditions for carrying out different inorganic reactions and their innovative applications.

CLO-5: Predict the direction and spontaneous/possibility of inorganic reactions for their intended innovative applications.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	1	-	-	-	-	-	-	-	-
CLO2	3	3	-	-	-	-	-	-	-	-
CLO3	3	1	1	3	1	-	-	-	-	-
CLO4	3	1	1	1	1	-	-	-	-	-
CLO5	3	1	1	2	2	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Mid-Semester-1 (Formative) and Final (Summative)
CLO2	Demonstration and Group Work	Mid-Semester-2 (Formative) and Final (Summative)
CLO3	Group Discussion and Problem Based Learning	Quiz (Formative)
CLO4	Tutorial and Case Study	Assignment(Formative) and Final (Summative)
CLO5	Project Based Learning	Assignment and Summative Assessment

(g) Learning Materials
(i) Recommended Readings
• Haider, S. Z.Introduction to Modern Inorganic Chemistry (6th Edition), EDEXCEL Publishers, Dhaka
• Gary L. Miessler, Paul J. Fischer and Donald A. Tarr. *Inorganic Chemistry*, 5th Edition, Pearson, New York, 2014
• Bodie E. Douglas, Darl H. McDaniel and John J. Alexander. *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, Delhi, 1994
• Kristi Lew (20028). Chemical reactions, Chelsea House, an imprint of Infobase Publishing, New York.
(ii) Supplementary Readings
• J.D. Lee. *Concise Inorganic Chemistry*, 6th Edition, Chapman & Hill, London
• William W. Porterfield (1993). Inorganic Chemistry: A Unified Approach, 2nd Edition, Academic Press, An Imprint of Elsevier

Course Code	Course Title	Credit Hours
0531-14-223	Stereochemistry	3.0

(a) Rationale:

This course is designed to introduce the basic concepts of stereochemistry to the students who have previously attended the organic chemistry course. Basic organic stereochemistry explains in clear, concise terms the concepts and properties of stereoisomers. In this course, special attention will be paid to the classification, nomenclature of stereoisomers and their properties.

(b) Course Objectives (COs)

- To provide the students with a foundation in the key concepts in stereochemistry.
- To understand configuration/conformation of stereoisomers and its relationship to their properties (e.g., optical, chemical, physical, etc.).
- To apply suitable methods for separation of stereoisomers and describe the principles of CD and ORD with their applications.

(c) Course Contents

1.	Fundamentals of Stereochemistry**:** Stereochemistry, stereoisomerism. stereochemical representation of structures (Flying wedge, Fischer, Newmann, Sawhorse, conversion among these forms).
2.	Configurations**:** D and L, threo-erythro, *R* & *S* configuration, absolute and relative configurations and their correlation.
3.	Optical Activity and Optical Isomerism**:** Cause of optical activity, chirality, prochirality, pseudo chirality, symmetry elements, stereoselective and stereospecific reactions asymmetric synthesis-cram's rule, optical isomers, diastereoisomers, enantiomers, epimers, anomers, meso and racemic modification and their resolution, atropiomerism: biphenyls, allenes and spiranes.
4.	Geometrical Isomerism**:** Conditions, configurations of geometrical isomers: *cis-trans* and *E*/*Z* system, physical properties and assignment of configurational isomers by physical and chemical methods, geometrical isomerism of polyenes, carbon-nitrogen, N-N double bonds and cyclic compounds (*cis-trans* isomerism in di-substituted cyclohexanes and optical activity).
5.	Conformations**:** Conformations and conformers, conformation of propane, butane, ethanediol, their physical properties and stability, stability of threo and erythro, meso and dl compounds, conformation of cyclopropane, cyclobutane, cyclopentane, cyclohexane, decalin and their stabilities, conformation of mono and disubstituted cyclohexanes, 2-alkyl ketone, 3-alkyl ketone and haloketone effects in cyclohexane.
6.	Optical rotation and Rotatory power**:** Factors leading to chirality, molecular dissymmetry, atomic dissymmetry and conformational asymmetry, circular birefringence and circular dichroism (CD), cotton effect, dependence of optical rotation on wavelength-optical rotatory dispersion (ORD) curves and its application, axial haloketone and octant rules.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the fundamental concepts of stereochemistry

CLO-2: Identify and assign absolute and relative configurations and explain the concept of chirality and optical activity and apply principles such as Cram's rule and symmetry analysis in identifying and resolving optical isomers.

CLO-3: Differentiate geometrical isomers based on structural conditions and assign using physical and chemical methods

CLO-4: Analyze the conformational stability of acyclic and cyclic compounds

CLO-5: Explain the principles of optical activity, circular dichroism (CD), optical rotatory dispersion (ORD), Cotton effect, and apply axial haloketone rule and the octant rule to stereochemical analysis.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	1	-	-	-	-	-	-	-
CLO2	3	1	1	3	1	-	-	-	-	-
CLO3	3	-	1	2	-	-	-	-	-	-
CLO4	3	-	3	2	-	-	-	-	-	-
CLO5	3	-	3	3	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO-1	Lecturing, Presentation & discussion Group problem-solving	Summative (Midterm-1 and Final) Assignment, Presentation
CLO-2	Lecturing & discussion Group problem-solving	Summative (Midterm-1 and Final) Assignment, Presentation
CLO-3	Lecturing & discussion problem-solving	Summative (Midterm-2 and Final) Assignment, Presentation
CLO-4	Lecturing & discussion	Summative (Midterm-2 and Final) Assignment, Presentation)
CLO-5	Lecturing, Presentation & discussion Group problem-solving	Summative (Final), Assignment, Presentation

(g) Learning Materials
(i) Recommended Readings
• Eliel, I. L., Stereochemistry of Carbon Compounds, McGraw Hill Edition
• Sykes, P., Stereochemistry, 6th edition
• Morrison, R. T. and Boyd, R. N., Organic Chemistry
(ii) Supplementary Readings
• Carey, F. A., Organic Chemistry, McGraw Hill Higher Education
• Wade, J.R., Organic Chemistry, Pearson

Course Code	Course Title	Credit Hours
0531-14-224	Organic Reactions and Mechanism-I	3.0

(a) Rationale:

The course provides advance knowledge about different classes of organic reactions and their mechanism.

(b) Course Objectives (COs)

- To provide knowledge about the substitution reaction mechanism.
- To give information about the electrophilic substitution and nucleophilic substitution in aromatic system.
- To impart knowledge about the addition reactions of conjugated diene and conjugated unsaturated carbonyl compounds and its mechanism.
- To provide an understanding of some important name reactions and its mechanism.

(c) Course Contents

1.	**Substitution Reaction:** a) Nucleophilic Substitution at a Saturated Carbons: Mechanism of S_N1, S_N2, S_N^i reactions, kinetics, thermodynamics and effect of structure, solvent, leaving group, attacking group, neighboring group in substitution reactions. b) Electrophilic Substitution in Aromatic System: Electrophilic substitution in benzene, formation of π and σ complexes, electrophilic substitution in monosubstituted benzene. c) Nucleophilic Substitution in Aromatic System: Nucleophilic substitution in pyridine and diazonium salts, nucleophilic substitution in substituted benzene through benzyne intermediate.
2.	**Addition Reactions:** Mechanism of Electrophilic addition to carbon-carbon double bonds, 1,2- and 1,4- additions, their stereochemistry, kinetics and thermodynamics, Nucleophilic addition to conjugated dienes and conjugated unsaturated carbonyl compounds, effect of structure on reactivity
3.	**Elimination Reaction:** E1 and E2 reactions, stereo selectivity of E2 reactions, mechanism of E1CB reaction, orientation in E2 reaction, elimination vs. substitution reaction, Saytzev vs. Hofmann product in elimination reactions.
4.	**Mechanism of Some Important Reactions:** Claisen condensation, Benzoin condensation, Perkin reaction, Hell - Volhard – Zelinsky reaction, Birch reduction, Sandmeyer reaction, Fries rearrangement, Dienone-phenol rearrangement, Pinacol-pinacolone rearrangement, Michael and Mannich reaction, Reformatsky reaction, Reimer-Tieman reaction, Arndt Eistert reaction, Clemmensen, Wolf Kishner reduction and Oppenauer oxidation reaction.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Describe about the mechanism of S_N1, S_N2 and S_Ni reactions and explain the effect of structure, solvent, leaving group, attacking group and neighboring group in substitution reactions.

CLO-2: Demonstrate the electrophilic and nucleophilic substitution reaction in aromatic system with its mechanism.

CLO-3: Demonstrate the addition reactions of conjugated diene and conjugated unsaturated carbonyl compounds with its mechanism

CLO-4: Able to assign the mechanism of E1, E2 and E1CB reactions.

CLO-5: Explore the some important name reactions.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	2	2	1	-	-	-	-	-	-
CLO2	3	2	2	1	-	-	-	-	-	-
CLO3	3	2	2	1	-	-	-	-	-	-
CLO4	3	2	2	1	-	-	-	-	-	-
CLO5	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO-1	Lecturing and Demonstration	Summative (Mid-Semester-1) and Semester Final
CLO-2	Lecturing, Group Discussion and Problem Based Learning	Summative (Mid-Semester-1) and Semester Final
CLO-3	Lecturing and Students Activity	Summative (Semester Final) and Assignment
CLO-4	Lecturing and Group Discussion	Summative (Mid-Semester-2) and Semester Final
CLO-5	Lecturing and Project Based Learning	Summative (Semester Final) and Assignment

(g) Learning Materials
(i) Recommended Readings
• Peter Sykes, A Guide Book to Mechanism in Organic Chemistry,6th edition, Pearson: New York, 2016.
• Finar I. L., Organic Chemistry (Volume II), 5th edition, Pearson, New
• Elial E. L., Stereochemistry for Carbon Compounds, McGraw-Hill, 1962
(ii) Supplementary Readings
• Gould E. S., Mechanism and Structure in Organic Chemistry, Holt, Rinehart and Winston, 1962
• Morrison R. T. and Boyd's R. N., Organic Chemistry, 6th edition, Prentice Hall, 1962

Course Code	**Course Title**	**Credit Hours**
0314-14-225	Fundamentals of Sociology and Cultural Studies	2.0

(a) Rationale:

Systematic study of social behavior and human groups. It focuses on the influence of social relationships upon people's attitudes and behavior and on how societies are established and changed. This course provides students with both methodologies and knowledge of the study of critical social issues ranging in scope from family to global.

(b) Course Objectives (COs):

- Develop effective communication, written and oral, about the field of sociology Obtain sociological knowledge of core areas and substantive topics and the ability to think critically about them
- Understand the role of theory in the application of conceptual frameworks in the research process
- Understand the role of evidence in the social sciences and the application of systematic empirical inquiry

- Provide opportunities that are linked with the University's Mission Pillars to stress multiculturalism, community engagement, international experience, and interdisciplinary studies
- Be able to effectively engage with and apply their "sociological imagination" to think critically about the social world and what separates sociology from other social science disciplines

(c) Course Contents	
1.	Foundations of Sociology: Define sociology and explain the significance of empirical research on social issues to explain society, socila phenomenon, and the social world
2.	Culture and Society: Conceptualizing culture, Basic elements of culture, Cultural diversity, Multiculturalism, Cultural pluralism, and Cultural change.
3.	Socialization and Social Interaction: Socialization, Enculturation, Acculturation Social institution, organization. Mobility and social dynamics
4.	Society and social structure: Human societies from Hunting gathering to contemporary industrialization
5.	Social Stratification and Inequality: Various measures of social stratification in the Bangladesh and globally, with an emphasis on social class and poverty.
6.	Race and Ethnicity: Relative experiences of ethnic groups in the Bangladesh while demonstrating an understanding of race, ethnicity, majority and minority groups, stereotypes, prejudice, discrimination, and racism. Debate of aboriginal and constitution of Bangladesh
7.	Gender, Sex, and Sexuality: Gender and gender identity, feminism, and sexuality
8.	Marriage and Family: Family, marriage and Kinship
9.	Religion Society and Culture: The triadic relation in understanding social phenomenon
10.	Health, culture and Health: Explaining diseases, illness and sickness of Human health.
11.	Population, Urbanization, and the Environment: Demographic and epidemiological transition, Climate change and environmental sustainability
12.	Role of mass media in social movement and change: Contemporary case studies

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Correctly identify causes of critical social issues through a systematic study of social behavior and social change.

CLO-2: Demonstrate comprehension of roles and functions of various social institutions and relationships among them.

CLO-3: Demonstrate understanding of several sociological theories and apply them to explain social phenomena or situations.

CLO-4: Demonstrate interest in taking part in social activities.

CLO-5: Use sociological imagination to explain their life experience in a broader social context.

CLO-6: Interpret the existing social problems of Bangladesh.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	-	-	-	-	-	-	-	-	-	1
CLO2	-	-	-	-	-	-	-	-	2	-
CLO3	-	-	-	-	-	-	-	2	-	1
CLO4	-	-	-	-	-	-	-	1	1	2

CLO5	-	-	-	-	-	-	-	-	-	2
CLO6	-	-	-	-	-	-	-	1	-	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Class Test
CLO2	Lecturing and Demonstration	Midterm and Summative
CLO3	Group Study	Midterm and Summative
CLO4	Demonstration and power-point presentation	Midterm and Summative
CLO5	Case Study and Group Discussion	Assignment and Presentation
CLO6	Lecturing and Demonstration	Midterm and Summative

(g) Learning Materials
(i) Recommended Readings
• Schaefer, R.T. (2018). Sociology: A brief introduction (13th ed.). McGraw-Hill.
• Henslin, J.M. (2015). Essentials of sociology: A down-to-earth approach (11th edition), Pearson.
• Guhathakurta, M., and Schendel, W.V. (2013). The Bangladesh reader: History, Culture, politics, Duke University Press
(ii) Supplementary Readings
• Matras, J. (1973). Population and Societies, Prentice Hall.

Course Code	**Course Title**	**Credit Hours**
0531-14-226L	Physical Chemistry Laboratory-I	2.0

(a) Rationale:

This course emphasizes practical work in chemistry to build skills, understanding, and problem-solving ability. It provides hands-on training with essential tools and techniques in physical chemistry, preparing students to perform laboratory experiments effectively.

(b) Course Objectives

- To guide you in developing efficient lab. techniques and in making your laboratory a pleasant place
- To gather knowledge in physical chemistry for analyzing and proposing methods
- To solve experimentally in the field of thermodynamics and solution chemistry

(c) Course Contents	
1.	Determination of the integral heat of solution of solids calorimetrically
2.	Determination of the heat of solution from solubility measurement
3.	Verification of the Hess's law of constant heat summation
4.	Determination of the phase diagram of 2-component system for phenol-water system
5.	Determination of the equilibrium constant for the reaction. $I^- + I_2 = I_3$
6.	Determination of the molecular weight of a given liquid by steam distillation method
7.	Determination of the molecular weight of a volatile substance by Victor Mayer's method
8.	Determination of heat of neutralization of a strong base by a strong acid.

***(d) Course Learning Outcomes (CLOs)*:**
After completion of the Course, the Student will be able to –
CLO1: Demonstrate the safety rules, handling of chemicals and glassware during practical class
CLO2: Perform experiments to determine the thermodynamic parameters (ΔH)
CLO3: Conduct experiments on liquid-liquid solution

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	1	2	-	1	-	-	1	-
CLO3	3	-	1	2	-	1	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz and safety awareness
CLO2	Lab. activities and data reporting	Lab. report (with Rubrics) & Midterm exam. (Formative)
CLO3	Lab. activities and lab. report evaluation	Final lab. exam. (Summative)

(g) Learning Materials

(i) Recommended Readings

- Findlay A., Longmans, *Practical Physical Chemistry*, Green **&** Company Ltd.
- Palit, *Practical Physical Chemistry*, Science Book Agency, Calcutta
- Sharma, *Practical Physical Chemistry*, Vikas Publishing House Pvt. Ltd.
- Yadav J. B., *Advanced Practical Physical Chemistry*

(ii) Supplementary Readings

- Viswanathan B., Raghavan P. S., *Practical Physical Chemistry*, Science Book Agency, Calcutta
- Athawale V.D., Mathur P., *Experimental Physical Chemistry*, New Age International Pvt. Ltd, New Delhi.

Course Code	**Course Title**	**Credit Hours**
0531-14-227L	Inorganic Preparation Laboratory	1.5

(a) Rationale:

This course provides a great opportunity for students to learn and practice the skills and knowledge of chemistry by performing inorganic preparation laboratory work. This course includes a practical idea about synthetic methods used in the preparation of inorganic compounds and organometallic compounds, synthesizing isomeric compounds, and distinguishing those using spectroscopic techniques. The characteristics of a lab experiment also include the problem/question, theory/background, procedures/design, results analysis, results communication, and conclusions. Students will also learn about writing reports of publishable quality.

(b) Course Objectives (COs)

- To provide tools and techniques for preparation of inorganic compounds, organometallic compounds with isomers and their purification.
- To characterize the synthesized compounds through providing required tools and techniques.
- To develop a synthetic scheme to prepare a new/novel compounds

(c) Course Contents	
1.	Purification of commercial NaCl by recrystallization and salting out process,
2.	Preparation of ferrous sulphate $FeSO_4.7H_2O$, Mohr's salt $[FeSO_4.6H_2O]$, Potash alum $[K_2SO_4.Al_2(SO_4)_3.24H_2O]$, Sodium carbonate Na_2CO_3, Sodium cobaltnitrate $Na_3[Co(NO_2)_6]$
3.	Preparation and characterization of tris (thiourea) copper(I) sulphate,$[(Cu(NH_2CSNH_2)_3]SO_4$
4.	Preparation and characterization of potassium trioxalatochromate (III), $K_3[Cr(C_2O_4)_3]$
5.	Preparation and characterization of tris (ethylenediamine) nickel (II) chloride dihydrate, $[Ni(en)_3]Cl_2 \cdot 2H_2O$.
6.	Preparation, characterization and structural analysis of cis- and trans forms of potassium diaquodioxalatochromate(III)dihydrate $K[Cr(C_2O_4)_2(H_2O)_2] \cdot 2H_2O$.
7.	The preparation of tris (acetylacetonato) manganese (III) and comparison of its IR spectra with that of the ligand.
8.	Preparation of Al^{3+} and Cu^{2+} complexes with acetylacetone and comparison by IR spectra.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Handle laboratory glassware, equipment, and chemical reagents safely using general guidelines and basic knowledge about common hazards often encountered in a synthetic chemistry laboratory.

CLO-2: Prepare, purify and characterize the inorganic complexes in a synthetic inorganic chemistry laboratory.

CLO-3: Interpret laboratory results and data correctly within inherent limitations on precision and report findings in a scientific notebook using acceptable appropriate notational and descriptive content that is in turn understandable and reproducible.

CLO-4: Apply procedures from literature sources to synthesize a given compound

CLO-5: Write reports which clearly present scientific data and which include discussion with logical conclusions based on the experimental data.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Demonstration with Power Point Presentation	Quiz and Oral/Viva (Formative)
CLO2	Laboratory Activities and Observation/Data Reporting	Final Laboratory Examination (Summative)
CLO3	Report Writing and Analyzing the data and Submission	Laboratory Report (Formative) and Final Laboratory Examination (Summative)
CLO4	Case Study and Problem Based Learning	Assignment (Formative)
CLO5	Report Presentation and Group Discussion	Oral Presentation (Formative)

(g) Learning Materials
(i) Recommended Readings
• Geoffry and Haydn Sutcliffe (1974). *Practical Inorganic Chemistry-Preparations, Reactions and instrumental methods*, Scinec Paperbacks.
• Szfran, Z., Pike, R. M. and Mono, M. S., *Microscale Inorganic Chemistry*, John Wiley & Sons, New York.
• V.I. Spitsyn (1987). Practical Inorganic Chemistry, MIR Publisher, Moscow.
(ii) Supplementary Readings
• Chun Chu,a Jessica L Dewey,b Weiwei Zheng . An Inorganic Chemistry Laboratory Technique Course using Scaffolded, Inquiry-Based Labs and Project-Based Learning, Department of Chemistry, Syracuse University, Syracuse, New York 13244, United States and Duke Learning Innovation, Duke University, Durham, North Carolina 27708, United States
• Pass, G., Sutcliffe, H. (1974). The preparation of some manganese compounds. In: Practical Inorganic Chemistry. Springer, Dordrecht.

Course Code	**Course Title**	**Credit Hours**
0531-14-228L	Organic Synthesis Laboratory	1.5

(a) Rationale:

Organic preparation laboratory course includes the synthesis and purification of organic compounds using various laboratory techniques. These laboratory activities are essential for understanding the principles of organic chemistry and developing practical skills in the lab.

(b) Course Objectives (COs)

- To acquaint students with some experimental techniques in organic chemistry
- To give the practical skills for handling and carrying out the single and two steps preparation
- To develop the skill to carry out one step organic synthesis to prepare simple but chemically important molecules

(c) Course Contents	
1.	Synthesis of Aspirin: o-acetylation (esterification) of salicylic acid
2.	Synthesis of acetanilide: N-acetylation of aniline
3.	Synthesis of p-nitroacetanilide: nitration of acetanilide.
4.	Alkaline hydrolysis of aspirin.
5.	Acidic hydrolysis of p-nitroacetanilide.
6.	Preparation of dibenzalacetone (condensation reaction between benzaldehyde and acetone)
7.	Oxidation of cyclohexanol to cyclohexanone.
8.	Reduction of 3-nitroacetophenone with Sn/HCl.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO1. Design the experimental set up for the common single and two steps preparation

CLO2. Carry out reaction and work-up procedure, separation and purification of organic compounds and check the purity of the products prepared in the Lab

CLO3. Prepare aspirin and acetanilide. *p*-nitoacetanilide, cyclohexanone, dibenzalacetone, 3-nitroacetophenone successfully in the laboratory as the sample compounds**.**

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	3	-	-	-	-	-	-	-	-
CLO2	1	3	-	-	-	-	-	-	-	-
CLO3	1	3	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Discussion	Laboratory Class Test
CLO2	Hands-on Experiments: Conducting Experiments	Laboratory Mid-Semester Exam
CLO3	Process Oriented and Guided Inquiry Learning (POGIL)	Semester Final Examination (Summative)

(g) Learning Materials
(i) Recommended Readings
• Vogel's Text Book of Practical Organic Chemistry, ELBS with Longman, 5th edition
• Fiesser, L.F. and Williamson, K.L., *Organic Experiments*, D.C. Health & Company Lexington, Toronto
• Clark F. Most, *Experimental Organic Chemistry*
(ii) Supplementary Readings
• Louis F. Fieser, Kenneth L. Williamson, *Organic Experiments*, D. C. Health & Company Lexington, Massachusetts, Toronto (4th edition)

Course Code	**Course Title**	**Credit Hours**
0531-14-311	Chemical Kinetics	3.0

(a) Rationale:

This course covers chemical kinetics and catalysis, including reaction rate theories, photochemical reaction mechanisms, and catalyst behavior. It provides a foundation for understanding how reaction rates are influenced and is essential for both basic and advanced chemistry studies.

(b) Course Objectives (COs)

- To provide knowledge about reaction kinetics, modern theories of reaction kinetics.
- To impart knowledge regarding the photoactivity of molecules and their reactions.
- To provide an understanding regarding the catalysis process in chemical reactions.

(c) Course Contents	
1.	**Reaction Kinetics:** Rate of reaction; rate law, factors of reaction rate; change of reaction order; Pseudo-unimolecular reaction, 1st, 2nd, 3rd and fractional order reaction; methods of order and rate constants measurement.
2.	**Theories of Reaction Rate: S**imple collision theory; uni-/bi-molecular reaction kinetics; Arrhenius theory; activation energy and activated complex; frequency factor; absolute reaction rate theory; chain reaction: characteristics of chain reaction, mechanism of chain reaction, kinetics of chain reaction, Bodenstein & Linds hypothesis; Hinshelwood mechanism (steady-state approximation);

	parallel reaction; consecutive, successive and opposing reaction; Lindeman-Hinshelwood mechanism (Hinshelwood-Christiansen hypothesis).
3.	**Photochemistry:** Photochemistry; photo-physical/chemical process, quantum yield and its determination; laws of photochemistry; Grothus-draper law, Beer-Lambert law, Law of photochemical equivalence; Kinetics of photochemical reaction; decomposition of HI, O_3, photosynthesis of HCl, HBr, dimerisation of anthracin, photolysis of acetone and NH_3; kinetics of thermal reaction; decomposition of acetaldehyde, N_2O_5, iodination of aldehyde/ketone.
4.	**Catalysis:** Catalysis and its mechanism; characteristics of catalysis, theories of catalysis; acid-base catalysis, autocatalysis, enzyme catalysis; Key-Lock theory, Michael-Menten equation, Line-Weaver & Burk plot; pH on enzyme kinetics; enzyme inhibition; competitive, non-competitive and uncompetitive inhibition; allosterism; homotropes and heterotropes, Hill plot and its significance.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Explain the rate of reaction with laws, factors of reaction rate and change of reaction order

CLO-2: Demonstrate and illustrate the different theories of reaction rate and derive the mechanism as well as hypothesis of different reactions based on reaction rate theory

CLO-3: Define Photochemistry and the processes, quantum yield and laws of photochemistry.

CLO-4: Explain the kinetics, mechanism, and process of photochemical reaction.

CLO-5: Demonstrate catalysis and its mechanism, characteristics, and different theories of catalysis.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing, demonstration ppt presentation, Problem Based Learning	Semester Final Exam
CLO2	Lecturing, demonstration ppt presentation, Problem Based Learning	Mid-Semester
CLO3	Lecturing, demonstration ppt presentation, Problem Based Learning	Semester Final Exam
CLO4	Lecturing, demonstration ppt presentation, Problem Based Learning	Assignment and Presentation
CLO5	Lecturing, demonstration ppt presentation, Problem Based Learning	Semester Final Exam

(g) Learning Materials

(i) Recommended Readings

- Laidler K. J., *Chemical Kinetics*, 3rd edition; Dorling Kindersely Pvt. Ltd.
- Hinshelwood C. N., *Kinetics of Chemical Change*.

(ii) Supplementary Readings

- Kundu N., Jain S. K., *Physical Chemistry*, S. Chand & Co, New Delhi.
- Eyring E., Glasstone S., Laidler Keith J., *Chemical Kinetics*, McGraw Hill Book Co, New York.
- P. Atkins, J.de Paula, *Atkins Physical Chemistry*, 10th edition; Oxford University Press.
- Christian G., *Physical Chemistry*.
- Castellan G.W., *Physical Chemistry*; 3rd edition; Narosa Pub. House, Delhi.
- Bajpai D. N., *Advance Physical Chemistry*, S. Chand & Co Pvt. Ltd, Delhi.
- A. Donald McQuarrie, Simon J. D., *Physical Chemistry*, 4th ed., Viva Books Pvt. Ltd.

Course Code	**Course Title**	**Credit Hours**
0531-14-312	Coordination Chemistry	3.0

(a) Rationale:

The course is outlined for the students to acquire knowledge about the different advanced theories describing the bonding, structure, magnetic and thermodynamic properties of coordination compounds, stability of complex compounds, different reaction mechanisms of complex compounds, and the structure, preparation, bonding and properties of metal carbonyls, phosphine and phosphorus trihalides, π-acid complexes of nitrogen, metal nitrosyls, π-acid complexes of unsaturated hydrocarbons, π-allyl and π-aromatic complexes.

(b) Course Objectives

- To study the theories describing the bonding, structure and properties of coordination compounds.
- To study the preparation scheme and reaction mechanisms of coordination complex.

(c) Course Contents	
1.	Transition Elements**:** General characteristics, Shape and function of d-orbitals, Magnetism in transition metal chemistry: origin of paramagnetism, diamagnetism, Ferromagnetism and antiferromagnetism, Magnetic susceptibility, Curie law.
2.	Elements of Coordination Chemistry**:** Definition and scope of coordination chemistry, Coordination compounds, ligands and their types, coordination number; Classification of coordination compounds, Nomenclature of coordination compounds, Theories of complex compounds: Bolmstrand and Jorgensen's chain theory, Werner's theory, Sidgwick's electronic interpretation: EAN of metals, Pauling's valence bond theory and its limitations, Isomerism stereochemistry of 4- and 6-coordinated complexes, Chelate complexes, Stabilization of unusual oxidation states by complexation, Application of coordination compounds.
3.	Concepts of Modern Bonding in Coordination Compounds**:** The crystal field theory and ligand field theory for octahedral and tetrahedral complexes, Crystal field stabilization energy, Effects of crystal field splitting, Consequences of ligand field splitting: magnetic properties, electronic properties, spectrochemical series, Structural and thermodynamic effect of ligand field splitting, d-d transition, C-T transition. Tetragonal distortion of octahedral complexes: Jahn-Teller distortion, Square planner complexes, Tetrahedral complexes, Molecular orbital theory
4.	Stability of complexes**:** Factors influencing the stability of complexes, Stability constant, Effect of ligand on the stability of complexes, Measurement of Stability constant.
5.	Reaction Mechanism of Coordination Complexes**:** Inert and labile complexes, (i) Ligand substitution reactions: substitution in square-planar complexes, the *trans* effect, its application and mechanism, substitution in octahedral complexes, (ii) Redox reaction: inner-sphere and outer -sphere mechanism.
6.	Complexes of π-acid Ligand**:** Structure, preparation, bonding and properties of metal carbonyls, phosphine and phosphorus trihalides, π-acid complexes of nitrogen, metal nitrosyls, π-acid complexes of unsaturated hydrocarbons, π-allyl and π-aromatic complexes.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Describe and list different types of coordination compounds, ligands and their applications

CLO-2: Apply VBT, CFT and MOT to octahedral, tetrahedral and square planar complexes to explain the electronic configuration, structure, electronic, thermodynamic, magnetic and spectral properties of complex compounds

CLO-3: Predict and analyze the different types of stabilities of complex compounds and correlate the stability constants to complex's reaction pathways.

CLO-4: Discuss different reaction mechanisms accompanied by the coordination compounds and apply the knowledge to design new reaction routes to develop complex compounds.

CLO-5: Explain the structures, preparation, bonding and properties of the complexes of π-acid ligands and list their applications.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration with Power-Point Presentations	Mid-Semester-1 (Formative) and Final Examination (Summative)
CLO2	Lecturing and Problem Based Learning	Mid-Semester-2 (Formative) and Final Examination (Summative)
CLO3	Demonstration and Group Discussion with Activity	Final Examination (Summative)
CLO4	Lecturing and Project Based Learning	Final Examination (Summative)
CLO5	Lecturing and Tutorials	In Class Assessment/Presentation (Formative)

(g) Learning Materials

(i) Recommended Readings

- Geoffrey A. Lawrance (2010). Introduction to Coordination Chemistry, John Wiley & Sons Ltd, n Great Britain by CPI Antony Rowe, Chippenham, Wiltshire.
- Gary L. Miessler, Paul J. Fischer and Donald A. Tarr. *Inorganic Chemistry*, 5th Edition, Pearson, New York, 2014
- J.D. Lee. *Concise Inorganic Chemistry*, 6th Edition, Chapman & Hill, London
- Cotton F. A. and Wilkinson G., *Advance Inorganic Chemistry*

(ii) Supplementary Readings

- Bodie E. Douglas, Darl H. McDaniel and John J. Alexander. *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, Delhi, 1994
- Kundu K., *Coordination Chemistry*, Bangla Academy, Dhaka (in Bengali)
- Advanced Chemistry Website, www.pearsonhigered.com/advchemistry
- Solution Manual (ISBN: 0321814134) by Gary L. Miessler, Paul J. Fischer and Donald A. Tarr

Course Code	Course Title	Credit Hours
0531-14-313	Organic Reactions and Mechanism-II	3.0

(a) Rationale:

This course is designed to provide an idea about the reaction mechanism of pericyclic, photochemistry and molecular rearrangement reactions. Isomerization reactions of aromatic compounds are discussed in this course. Free radical reactions mechanism also described in this course. Some important name reactions will also be addressed in this course.

(b) Course Objectives

- To provide knowledge about kinetic control and thermodynamic control over product formation, salts effects. Primary and secondary kinetic isotope effects.
- To know the symmetry of molecular orbital (MO) and gathering knowledge about electrocyclic reaction, cycloaddition and sigmatropic rearrangement in thermal and photochemical conditions.
- To give information about the free radical formation and reactions and also gives idea about the autoxidations, radical initiators and radical scavengers.
- To gather idea about Light absorption, fluorescence and phosphorescence, singlet and triplet states, photosensitization reactions.
- To impart knowledge about the different types of photochemical reactions and its mechanism.
- To provide an understanding of some important name reactions and its mechanism

(c) Course Contents

1.	**Kinetic and Energetic in Reaction Mechanism:** Mechanistic implication of rate-law, energy of activation and entropy of activation in chemical reactions; kinetic control and thermodynamic control over product formation; salts effects. Primary and secondary kinetic isotope effects.
2.	**Free radical Reaction:** Definitions, generation and detection of free radicals. Long- and short-lived free radicals, configuration of free radicals, types of free radical reactions, examples & mechanism. Autoxidations, radical initiators and radical scavengers.
3.	**Photochemical Reaction:** Light absorption, fluorescence and phosphorescence, singlet and triplet states, photosensitization reactions. Photochemical reaction: (i) photorearrangement, (ii) photoaddition, (iii) photosubstitution, (iv) photooxidation/reduction, photocyclization, (v) photoelimination, Norrish I & II type reactions, (vi) photochemistry of aromatic compounds.
4.	**Pericyclic Reactions:** Concept of HOMO, LUMO, symmetry properties of MO. Electrocyclic and cycloaddition both in thermal and photochemical methods, Stereochemistry and mechanisms. Woodward-Hofmann rule, sigmatropic changes (both carbon and H-shift). Conrotation, disrotations.
5.	**Molecular Rearrangement:** Base-catalysed rearrangement; Rearrangements involving migration to electron-deficient nitrogen and oxygen atoms; rearrangement passing through " No mechanism pathways" Hofmann, Lossen, Schmidt, Beckmann, Curtius, Claisen, Cope and related rearrangements & stereochemistry.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the kinetic control and thermodynamic control over product formation, salts effects. Primary and secondary kinetic isotope effects.

CLO-2: Be able to write and explain autoxidations, radical initiators, radical scavengers and the free radical creation, reactions and its mechanism

CLO-3: Know and understand about fluorescence, phosphorescence, photosensitization and the different types of photochemical reactions and its mechanism.

CLO-4: Describe the mechanism of electrocyclic reaction, cycloaddition and sigmatropic rearrangement in thermal and photochemical conditions.

CLO-5: Explore some important name reactions.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	2	2	1	-	-	-	-	-	-
CLO2	3	-	2	1	-	-	-	-	-	-
CLO3	3	2	2	1	-	-	-	-	-	-
CLO4	3	2	2	1	-	-	-	-	-	-
CLO5	3	-	1	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Summative (Semester Final)
CLO2	Lecturing and Problem Based Learning	Summative (Mid-Semester-1) and Semester Final
CLO3	Lecturing and Tasking	Summative (Mid-Semester-2) and Semester Final
CLO4	Lecturing and Project Based Learning	Summative (Semester Final) and Assignment
CLO5	Lecturing and Group Discussion	Summative (Semester Final) and Assignment

(g) Learning Materials
(i) Recommended Readings
• Peter Sykes, A Guide Book to Mechanism in Organic Chemistry,6th edition, Pearson: New York, 2016
• Finar I. L., Organic Chemistry (Volume II), 5th edition, Pearson, New
• Elial E. L., Stereochemistry for Carbon Compounds, McGraw-Hill, 1962
(ii) Supplementary Readings
• Gould E. S., Mechanism and Structure in Organic Chemistry, Holt, Rinehart and Winston, 1962
• Morrison R. T. and Boyd's R. N., Organic Chemistry, 6th edition, Prentice Hall, 1962

Course Code	**Course Title**	**Credit Hours**
0531-14-314	Industrial Chemistry	3.0

(a) Rationale:

The course is designed to give students a comprehensive idea on different industrial process giving special emphasis on the industries of Bangladesh.

(b) Course Objectives:

- To give a general understanding of industrial raw materials, classification, properties, uses and industrial manufacturing processes of few important materials in Bangladesh.
- To gain knowledge on physical and chemical analysis and the quality of various industrial products.

(c) Course Contents	
1.	**Fundamental in the Development of Chemical Industries**: General ideas about unit processes and unit operations, raw materials, flow sheet, by product, heat transfer, mass transfer, market evaluation, environmental considerations, site and technology selection criteria, cost-benefit analysis. **Industrial Management:** Testing and Quality control, Industrial Management and Entrepreneurship Development, Environmental & Pollution in industries.

2.	**Glass and Ceramic Industry:** Definition, Types of ceramic products, Basic raw materials, White wares, Manufactures of porcelain, Chemical conversion including basic ceramic industry, Heavy clay products, Manufacture of refractory, enamels, Ceramic industries in Bangladesh, Definition of glass, Classification of glass, Physical and Chemical properties of glass, Raw materials, Manufacturing methods of glass, Some special glass and their properties, Refractory's. Heavy clay product.
3.	**Cement Industry:** Raw materials, Portland cement manufacture, Types of Portland cement, Theory of setting and hardening of cement, Different types of cement, Characteristic of good cement, Testing of cement, Cement factory in Bangladesh.
4.	**Textile dyeing technology**: Dyes and their properties, relationship between colour and constitution, classification of dyes, Chemistry associated with the dyeing of fibres, composition of cotton, silk and wool, preparation of fibres for dyeing, methods of dyeing of dried and cured products. Spoilage of oils, bottled beverages, spices, etc.
5.	**Coating technology:** (a) Resin: Definition, classification and applications of resins, alkyd resin: classification, raw materials and chemistry associated with preparation, phenol-formaldehyde resin and modified resins. (b) Paints and Varnishes: Definitions, classification, constituents, purpose of coating, compounding, methods of applications, cure and paint failure, enamels and lacquers.
6.	**Agrochemicals and Pesticides:** Pesticides and their classifications, preparation of some common organo-chlorinated and organo phosphorous insecticides: BHC, DDT, parathion, methyl parathion, paraoxon and malathion, herbicides: trichloro phenoxy compounds, properties, uses and mode of action.

***(c) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Evaluate to importance of chemistry in Industrial Chemistry and the position of chemist in industry. Study on inorganic materials, unit process and unit operation of industrial importance.

CLO-2: Explain the production of inorganic and organic industrial products such as dyes, resin paints and varnishes. Study surface chemistry and interfacial phenomena, adsorption\isotherm, emulsions etc.

CLO-3: Gain sound knowledge of inorganic and organic materials and chemical reactions involve in Glass, Ceramic, Cement, and Textile dying industries.

CLO-4: Develop skills to estimate various components of Pesticides and Analysis of various pollutants in pesticide and industrial ingredients, etc.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	-	-	-	-	-	-	-	-
CLO3	3	-	-	-	-	-	-	-	-	-
CLO4	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Demonstration	Summative (Semester Final) and Assignment
CLO2	Lecturing and Discussion	Summative (Mid-Semester-1) and Semester Final
CLO3	Lecturing and Students activity	Summative (Mid-Semester-1I) and Semester Final
CLO4	Lecturing and Project Based Learning	Summative (Semester Final) and Assignment

(g) Learning Materials
(i) Recommended Readings
• R.N. Shreve: Chemical Process Industries, McGraw-Hill
• R.K. Das (1987): Industrial Chemistry (Part I & II), Kalyani Publishers
(ii) Supplementary Readings
• Rogers Manual of Industrial Chemistry (Vol. I & II), Edited by Eurna

Course Code	**Course Title**	**Credit Hours**
0531-14-315	Chemical Spectroscopy-I	3.0

(a) Rationale:

This course introduces chemical spectroscopy, covering the interaction of compounds with electromagnetic radiation, spectrometer components, and analysis of atomic and molecular spectra. It analyzes Raman effect and its spectra.

(b)Course Objectives (COs)

- To understand the nature of electromagnetic radiation and how it interacts with matter.
- To acquire the basic knowledge of the fundamentals, device mechanism, and analytical applications of spectroscopic techniques.
- To explain electronic, vibration, rotation, Raman and other types of transitions with device principle and to learn how to analyze different types of spectrums.

(c) Course Contents	
1.	**Electromagnetic Radiation:** The nature of electromagnetic radiation; Emission and absorption spectra; Spectrometers: basic component of dispersive spectrometers, Beer-Lambert law: molar absorption cross section. representation of spectra, transmittance and absorbance, width and resolution, signal to noise ratio.
2.	**Atomic Spectroscopy:** Origin of atomic spectra; Spectra of H and H-like elements, energy level diagrams, angular momentum of atoms, coupling of spin and angular momentum, term symbols, isotopic effect on the spectra of elements, fine structure of atomic spectra.
3.	**Rotational Spectroscopy:** Rotation; Rotation of molecules and their classification, interaction of rotating molecules with radiation, rotational spectrometer, rotational energies of rigid diatomic rotator, rotational energy levels, intensities of rotational spectral lines, isotopic substitution effect in rotational spectra, calculation of bond distance from MW spectroscopy, centrifugal distortion and non-rigid rotors, symmetric top molecules.
4.	**Vibrational 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, transition combination and difference bands, vibration-rotation spectra of gaseous molecules; P, Q, R branches, parallel and perpendicular vibrations; IR spectra of polyatomic molecules; handling of samples, FTIR and its advantages.
5.	**UV and Visible Spectroscopy:** The absorption laws; Principle and Instrumentation; Born-Oppenheimer approximation; Frank-Condon principle and intensities of spectral lines; Types of electronic transition, transition probability.

6.	**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

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the region of spectrum and quantization of energy and recognize how electromagnetic radiation interacts with atoms/molecules.

CLO-2: Draw an energy level diagram and identify the transitions and describe spectral terms & apply to atomic systems.

CLO-3: Demonstrate working principles, taking spectrum and outline of spectroscopic device.

CLO-4: Explain microwave, infrared, electronic and raman spectroscopy for chemical analysis.

CLO-5: Apply & analyze electronic spectra of diatomic molecules; estimate the electronic bands, heat of dissociation

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	2	-	-	-	-	-	-	-
CLO3	3	-	3	-	-	-	-	-	-	-
CLO4	3	-	2	2	-	-	-	-	-	-
CLO5	3	-	-	3	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing, demonstration ppt presentation, Spectra Analysis, Problem Based Learning	Mid-Semester-1
CLO2	Lecturing, demonstration ppt presentation, Spectra Analysis, Problem Based Learning	Semester Final Examination
CLO3	Lecturing, demonstration ppt presentation, Spectra Analysis, Problem Based Learning	Semester Final Examination
CLO4	Lecturing, demonstration ppt presentation, Spectra Analysis, Problem Based Learning	Semester Final Examination
CLO5	Lecturing, demonstration ppt presentation, Spectra Analysis, Problem Based Learning	Mid-Semester-2

(g) Learning Materials
(i) Recommended Readings
• Banwell C. N., E. M. McCash E.M., *Fundamental of Molecular Spectroscopy*. 4th Edition, Tata McGraw-Hill, New Delhi.1994
• Donald L. Pavia, Gary M. Lampan, George S. Kriz. *Introduction to Spectroscopy*, 3rd Edition
(ii) Supplementary Readings
• Barrow G., *Introduction to Molecular Spectroscopy* John Wiley and Sons Inc., 1963
• J. Michael Hollas *Modern Spectroscopy*, Willey
• G. Chatwal & Shan Anand. *Spectroscopy (Atomic and Molecular*)

Course Code	**Course Title**	**Credit Hours**
0531-14-316L	Physical Chemistry Laboratory-II	**2.0**

(a) Rationale:

By carrying out practical work, students gain insight and are more able to solve the problems in chemistry. Hands on training are pre-requisite to perform experiments successfully with fulfilling the intended objectives on chemistry laboratory. There are some tools and techniques in chemistry which must be acquired and be skilled through used to these tools before real life experiments. This course includes some tools and techniques covering basically physical chemistry practical specially on electrochemistry.

(b) Course Objectives (COs)

- To guide you in developing efficient lab. techniques and in making your laboratory a pleasant place
- To gather knowledge in physical chemistry for analyzing and proposing methods
- To solve experimentally in the field of electrochemistry and solution chemistry

(c) Course Contents	
1.	Determination of velocity constant of alkaline/acid hydrolysis of an ester through conductometric/pH-metric titration
2.	Draw a phase diagram of 2-component system like phenol-water system with impurities
3.	Determination of density and viscosity of liquid at different temperatures
4.	Determination of viscosity of glycerin solution in water at different compositions and calculate the area of cross-section
5.	Determination of partition coefficients of I_2 between H_2O and CCl_4
6.	Determination of partition coefficients of C_6H_5-COOH between H_2O and C_6H_5-CH_3 and study of the association of C_6H_5-COOH
7.	Determination of activation energy of a liquid (propanol-1/2)
8.	Measurement of quantum yields of some photochemical reactions.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO1: Demonstrate the safety rules, handling of chemicals and glassware during laboratory class

CLO2: Perform electrochemical experiments in aqueous/buffer solution

CLO3: Conduct physicochemical experiments in binary/ternary solution

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	1	2	-	2	-	-	1	-
CLO3	3	-	1	2	-	2	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz and safety awareness
CLO2	Lab. activities and data reporting	Lab. report (with Rubrics) & Midterm exam. (Formative)
CLO3	Lab. activities and lab. report evaluation	Final lab. exam. (Summative)

(g) Learning Materials

(i) Recommended Readings

- Findlay A., Longmans, *Practical Physical Chemistry*, Green & Company Ltd
- Daniel, Mathews and William, *Experimental Physical Chemistry*.
- Bell and New Combe, *Experiments in Physical Chemistry*.

(ii) Supplementary Readings

- Viswanathan B., Raghavan P. S., *Practical Physical Chemistry*, Science Book Agency, Calcutta

Course Code	Course Title	Credit Hours
0531-14-317L	Quantitative Inorganic Analysis Laboratory	1.5

(a) Rationale:

Quantitative inorganic chemical analysis is vital for quality control, environmental safety, and industrial applications. This course covers the basic principles and methods of chemical analysis, focusing on applying chemical equilibrium concepts. Topics include data and statistical analysis, equilibrium in separations and titrations (acid–base and redox), and analytical instrumentation.

(b) Course Objectives (COs)

- Provide understanding regarding the selection of suitable quantitative inorganic methods for quantitative chemical analysis
- Equip students by analytical techniques to analyze the samples and determine the concentration of analytes with accuracy and precision
- Develop the capacity the students to analyze & evaluate the data with statistical test and write the laboratory report
- to enable students to more efficiently process, analyze, and visualize digital data and to extract more information from the available data.

(c) Course Contents

1.	1. Oxidation-Reduction Titrations: (i) Determination of ferrous iron by oxidation with standard $K_2Cr_2O_7$ solutions. (ii) Determination of ferric iron with standard $K_2Cr_2O_7$ solutions. (iii) Determination of total iron with standard $K_2Cr_2O_7$ solutions. (iv) Determination of ferrous iron by oxidation with standard $KMnO_4$ solutions.
2.	Gravimetric determination of cation and anion
3.	Determination of Na, K, Ca, and Li by flame photometer
4.	UV-Visible spectrophotometric determination of metals
5.	Potentiometric determination of calcium in drinking water using a ion-selective electrode
6.	Determinations of inorganic ions by AAS/ICP/Chromatographic techniques.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Analyze and accurately determine the concentration of analyte in a given sample using suitable analytical laboratory method/techniques.

CLO-2: Evaluate experimental data using statistical and error analysis methods.

CLO-3: Predict the results and identify errors associated with a chemical analysis based on the analytical technique and nature of the sample

CLO-4: Communicate results of chemical analyses and report the relative error associated with these results.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	3	-	-	3	-	-	-	1
CLO2	3	-	3	-	-	-	-	-	-	-
CLO3	3	-	1	1	1	-	-	-	-	-
CLO4	3	-	-	2	-	-	-	3	-	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Demonstration and Laboratory Activity	Laboratory Final Examination (Summative)
CLO2	Scaffolding and Inquiry Based Learning	Quiz based Mid-Semester Exam (Formative)
CLO3	Demonstration and Project Based Learning	Assignment (Formative)
CLO4	Group Discussion and Presentation	Oral Presentation (Summative)

(g) Learning Materials
(i) Recommended Readings
• Vogel's Quantitative Chemical Analysis, G. H. Jeffery, J. Bassett, J. Mendham and R.C. Denney, Longman Scientific & Technical, New York.
• A. Khalique. A Text Book of Practical Chemistry, Ideal Library, Bangla Bazar, Dhaka.
• Christian, G. D., *Analytical Chemistry*, Wiley
(ii) Supplementary Readings
• Skoog, D.A., West, D.M., Holler, F.J. and Crouch, S.R. (2012). *Fundamentals of Analytical Chemistry*, 8th ed., Cengage Learning, Printed in India.
• Stock, R. and Rice, C. B. F., *Chromatographic Methods*, Chapman and Hall.

Course Code	**Course Title**	**Credit Hours**
0531-14-318L	Organo-Applied Chemistry Laboratory	1.5

(a) Rationale:

This course is designed to develop practical knowledge on quantitative analysis of organic compounds.

(b) Course Objectives (COs)

- Provide experimental knowledge on assay of tablets such as Vitamin C and aspirin.
- Lay foundation on quantitative analysis of different types of functional groups.
- Give working experience to determine saponification number of oil.

(c) Course Contents	
1.	Assay of L-ascorbic acid
2.	Assay of vitamin C-tablets
3.	Assay of aspirin tablets
4.	Quantitative estimations of organic acid
5	Determination of saponification number and iodine value of soyabean oil
6	Quantitative estimations of OH/NH_2 groups.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the importance of analysis of organic compounds with suitable analytical method for real-world samples

CLO-2: Assay tablets like vitamins and aspirin tablets

CLO-3: Determine and calculate the saponification and iodine value of soyabean oil

CLO-4: Know the process how to estimate functional groups.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	3	-	-	3	-	-	-	1
CLO2	3	-	3	-	-	2	-	-	-	-
CLO3	3	-	1	1	1	2	-	-	-	-
CLO4	3	-	-	2	3	-	-	3	-	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Demonstration and Laboratory Activity	Laboratory Final Examination (Summative)
CLO2	Scaffolding and Inquiry Based Learning	Quiz based Mid-Semester Exam (Formative)
CLO3	Demonstration and Project Based Learning	Assignment (Formative)
CLO4	Project Based Learning (PBL) and Presentation	Laboratory Final Examination (Summative)

(g) Learning Materials
(i) Recommended Readings
• Vogel's Quantitative Chemical Analysis, G. H. Jeffery, J. Bassett, J. Mendham and R.C. Denney, Longman Scientific & Technical, New York.
• Lisa Nichols (2016). Organic Chemistry Laboratory Techniques, Butte Community College in Northern California
• S. Suzanne Nielsen (2017). Food Analysis, Springer
(ii) Supplementary Readings
• Vogel's Text Book of Practical Organic Chemistry, ELBS with Longman, 5th edition
• Fiesser, L.F. and Williamson, K.L., *Organic Experiments*, D.C. Health & Company Lexington, Toronto

Course Code	**Course Title**	**Credit Hours**
0531-14-321	Electrochemistry	**2.0**

(a) Rationale:

This course covers the fundamentals of electrochemistry, including ion movement in solutions, electrode construction and chemistry, and electrode processes in practical applications. It provides a foundation for understanding electrochemical principles related to energy use and production.

(b) Course Objectives (COs):

- To provide knowledge about electrolysis in solution, modern theories of electrolysis.
- To impart knowledge regarding the Nernst equation and related thermodynamics.
- To provide an understanding regarding the electrodes, their working process, and the related chemical reactions.

(c) Course Contents	
1.	**Electrolysis and Electrical Conductance:** Electrolysis: Arrhenius theory of electrolytic dissociation; Debye-Huckel theory, migration of ions, relative speeds of ions, laws of independent migration of ions; application of conductance measurement; transport number; determination of transference number, factors affecting transport numbers, pH and buffer effect on electrolysis.
2.	**Electrochemical Cells:** (a) Galvanic/voltaic cell; half-cell, reversible and irreversible cells; standard hydrogen electrode; secondary standard electrodes; e.m.f., Nernst equation; thermodynamic functions from e.m.f.; free energy and e.m.f. of cells, solubility constants, measurement of pH and pK value, liquid junction potentials, salt bridge (b) Types of electrochemical cells; concentration cell with and without transference, different types: Daniel cell, glass electrode, Quinhydrone electrode, lead storage battery, hydrogen electrode, calomel electrode; Application of e.m.f. measurements, potentiometric titrations.
3.	**Electrode Processes:** Working electrode: glassy carbon and graphite, FTO, ITO; reference electrode: Ag/AgCl, Hg/HgCl (SCE); Auxiliary electrode: Pt wire, Au wire, *etc.*; three electrode system; CV, LSV, DPV, bulk electrolysis, stripping potential; Faradaic efficiency; ionic atmosphere; relaxation of ionic atmosphere; theories of strong electrolytes with special reference of Debye-Huckel theory; concept of activity and activity coefficient and their measurements; dissociation constants of monobasic and polybasic acids and their measurements; polarization; concentration polarization, activation polarization, ohmic polarization and over voltage.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Define electrochemistry with explanation of different theories of electrolysis in solution

CLO-2: Explain the concepts of migration or transport of ions during electrolysis

CLO-3: Apply the Nernst equations to electrochemical functions to describe the difference between equilibrium properties and electrochemical systems.

CLO-4: Evaluate electrodes/cells with their construction and working mode and apply them for different e. m. f. measurements, potentiometric and conductometric titrations

CLO-5: Explain the measurements of the dissociation constants of monobasic and polybasic acids

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Demonstration	Class Test/Quiz
CLO2	Lecturing and Group Discussion	Mid-Semester-1/Semester Final
CLO3	Problem Based Learning (PBL)	Mid-semester-2/ Semester Final
CLO4	Case Study	Semester Final
CLO5	Process Oriented and Guided Inquiry Learning (POGIL)	Semester Final

(g) Learning Materials
(i) Recommended Readings
• Glasstone S., *An Introduction to Electrochemistry*, Norman Oxlahoma Press.
• Glasstone S., *A Textbook of Physical Chemistry*, 2nd ed., Macmillan & Co. Ltd., London.
• Bockris and Reddy, *Advanced Electrochemistry*
(ii) Supplementary Readings
• Glasstone S., Lewis D., *Introduction to Electrochemistry*.
• Bockris and Reddy, *Advanced Electrochemistry*
• Crow D. R., Principle and Application of Electrochemistry.

Course Code	**Course Title**	**Credit Hours**
0531-14-322	Environmental Chemistry	**3.0**

(a) Rationale:

Environment is continuously changing from its natural state on which living being are surviving. It is important to know the processes that operate within and between various environmental compartments and the ways in which human activities interact with the natural processes. Environmental chemistry involves attempts to integrate the particular ideas into a comprehensive picture of how the natural environment functions and responds to stresses.

(b) Course Objectives (COs):

- To study about the chemical composition of a particular compartment of the environment
- To understand the chemical reactions that are a part of the environmental processes
- To examine the effects of human (anthropogenic) activities on the natural process which are always on-going
- To develop ideas as remedial actions to minimize the problems

(c) Course Contents	
1.	**Environmental Chemistry:** Definition and scope of the study; Early earth history; Environmental segments; Species distribution; Chemical process; Anthropogenic effects; Pollutant and contaminant; Types of pollutants.
2.	**Earth's Atmosphere:** Region of the atmosphere; Solar influence on the chemical composition of the atmosphere; Reactions and calculations in atmospheric chemistry; Photochemical reactions; Free-radical reactions; Concerns about stratospheric ozone; Formation and turnover of ozone; Processes for catalytic decomposition of ozone; Antarctic and Arctic 'ozone hole' formation.
3.	**Tropospheric Chemistry**: Nature of chemical pollutants in the atmosphere and their sources, composition of atmosphere, environmental effect of the oxides of carbon, nitrogen, sulphur and hydrocarbons, chemical and photochemical reactions, their consequent effect-ozone depletion, acid rain and Chemistry of photochemical smog, Exhaust gases from the internal combustion engine.
4.	**Chemistry of Global Climate:** Composition of the Earth's atmosphere; Greenhouse gases and and aerosols; Relative instantaneous radiative forcing and global warming potential; Geenhouse gases associated with the use of fossil fuels; Consequences of greenhouse effect: global and Bangladesh perspective; Remedial actions to be taken for offsetting the greenhouse effect; Sequestration of carbon dioxide.
5.	**Environmental Chemistry of Water:** The properties of water; Chemical composition of natural water; Sources and uses of water: hydrological cycle; Dissolved carbonate equilibria (closed system); Dissolution of CO_2 (open system); Conservative quantities of water: alkalinity, acidity and C_T. Buffering.
6.	**Water Pollution:** General causes of water pollution, types of water pollutants, nutrients, PCBs, PAHC, detergents etc.
7.	**Water Treatment:** Primary and secondary treatment; Coagulation, flocculation and filtration techniques.

8.	**Advanced Water Treatment:** ion-exchange purification of water, electrochemical processes for water purification and reverse osmosis technology, sewerage and industrial waste water management.
9.	**Pesticides:** Definition and types; Structure and properties of different pesticides; Mode of action of pesticides; Behavior of pesticides in soil, effects of organochlorine, organophosphorus, and carbonates compounds, effect of pesticides in environment.
10.	**Soil Pollution:** Causes and effect of soil pollution, industrial wastes, urban water, and radioactive pollutants, chemical and metallic pollutants.
11.	**Solid Waste Management:** Major sources of solid wastes-industry; Municipality, household, nuclear and hospital waste *etc*.; Incineration process and filtration; Sanitary landfills and oxidation ponds; Composting; Sewerage treatment.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate an understanding of atmospheric chemistry and air pollution

CLO-2: Explain the fate of chemical reactions happening in particular segment of the environment.

CLO-3: Describe the greenhouse effect, climate change; and distinguish between fossil fuels and renewable energy technologies.

CLO-4: Explain basic concepts of water chemistry and water pollution.

CLO-5: Analyze environmental scientific data using the scientific method to apply the effects of environmental chemistry on the ecosystems.

CLO-6: Analyze mode of interactions of chemicals in the pathways of the environment.

CLO-7: Design treatment scheme to reduce the pollution.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-
CLO6	1	-	-	-	3	-	1	-	-	-
CLO7	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Quiz/Semester Final Exam
CLO2	Demonstration and Demonstration	Mid-Semester-1/Semester Final
CLO3	Modeling and Simulation	Semester Final
CLO4	Demonstration and Student Activity	Semester Final
CLO5	Case Base and Problem Base Study	Mid-Semester-2/Semester Final
CLO6	Case Study and Group Discussion	Semester Final
CLO7	Project Base Learning (PBL)	Project and presentation

(g) Learning Materials

(i) Recommended Readings

- Gary W. vanLoon & Stephen J. Duffy (2011). Environmental Chemistry-a global perspective, 3rd edition, Oxford University Press, Printed in Idia.
- Stanley E. Manahan (1993). Fundamentals of Inorganic Chemistry, Lewis Publishers, CRC Press LLC.

(ii) Supplementary Readings
• A. K. Dev Environmental Chemistry, New Age Publication, India
• Andrews, J.E. et.al. (2004). An Introduction to Environmental Chemistry, Blackwell Publishing,

Course Code	**Course Title**	**Credit Hours**
0531-14-323	Chemical Spectroscopy-II	**3.0**

(a) Rationale:

This course is designed to create a strong foundation within the students about spectroscopic techniques. In this course, special attention will be paid to how to analyze and interpret spectroscopic spectra to determine the structure of an organic compound.

(b) Course Objectives (COs)

- To illustrate the basic aspects and principles of a few spectroscopic techniques (e.g., UV-Visible, IR, ESR, and NMR) and mass spectrometry.
- To analyze UV-Visible, IR and NMR spectral data to elucidate the structure of compounds.
- To use mass spectral data and fragmentation pattern to determine the molecular weight and structure.

(c) Course Contents

1.	**Ultra-Violet and Visible Spectroscopy:** Transitions in organic molecules, chromophores, auxochromes, blue shift, red shift, hypo and hyperchromic effect, solvent effect on band position, Woodward-Hoffman rules for the calculation of λ_{max} of conjugated dienes, unsaturated carbonyl groups, extended conjugation and aromatic sterically hindered systems, stereochemical aspects (differentiation of isomers), study of simple and complex molecules, applications: qualitative and quantitative.
2.	**Infra-red Spectroscopy:** Introduction, basic principles of IR spectroscopy, the IR absorption process, instrumentation, sampling techniques, factors influencing vibrational frequencies, frequency shift associated with structural changes in the compounds containing hetero atoms, applications of IR spectroscopy in structure elucidation and investigation of reaction mechanism as well as transition metal complexes.
3.	**Nuclear Magnetic Resonance Spectroscopy (^{1}H and ^{13}C NMR):** Nuclear spin, common nuclei with spin (^{1}H, ^{13}C, ^{15}N, ^{19}F, ^{31}P), interaction of magnetic field with nuclear spin, Larmour precession, resonance absorption of radiation, continuous wave and pulsed NMR experiments, NMR solvents and reference substances, chemical shift and its measurements, factors influencing chemical shift, anisotropic effect, shielding and deshielding of nuclei, van der Walls deshielding, integrals of protons, spin-spin coupling- splitting theory, coupling constant, vicinal, geminal, -ortho, -para, and -meta coupling, proton exchange reactions, rotation about single bond, variable temperature spectra, non-equivalence of protons, relaxation, signal-to-noise ratio (SNR), simplification of complex spectra (lanthanide shift reagents), introduction to ^{13}C NMR: NOE, DEPT, APT, application of NMR spectroscopy in structural elucidation of simple compounds, 2D-NMR: A brief treatment of COSY and NOESY, principle and instrumentation of NMR.
4.	**Electron Spin Resonance (ESR) Spectroscopy:** Introduction, principles, instrumentation, spectrum, the g-factor, relaxation processes, anisotropy, fine structure, Zeeman effect, hyperfine splitting, relation between hyperfine splitting and unpaired electron density, radicals, anions of aromatic hydrocarbons, interpretation of ESR spectra, ESR spectra of transition metal complexes as single crystal, determination of electron density from ESR spectroscopic studies.
5.	**Mass Spectrometry:** Ionization of a molecule on electron impact (EI), the mass spectrum, determination of molecular formula, detection of the presence of the isotopes, recognition of molecular ion peak, meta-stable ions, general rules predicting the fragmentation patterns, McLafferty rearrangement, nitrogen rule, index of H deficiency, fragmentation patterns for organic compounds

	(such as aliphatic compounds, amines, aldehydes, ketones, esters, amides, nitriles, carboxylic acids ethers, aromatic compounds, etc.), mass spectra of different classes of organic and organometallic compounds, applications of mass spectrometry in research.
6.	**Combination of Spectroscopic Methods:** Structure elucidation of compounds by combined application of UV, IR, NMR (^{1}H & ^{13}C) and mass spectrometry.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Describe the basic principles of UV, IR, NMR spectroscopic techniques and Mass spectrometry.

CLO-2: Explain the factors affecting the $\lambda_{max,}$ stretching frequency, chemical shift.

CLO-3: Calculate λ_{max} value, stretching frequency, chemical shift and mass/charge ratio and natural abundances of elements.

CLO-4: Interpret UV, IR, ESR, NMR spectra and Mass spectrometry.

CLO-5: Elucidate the structures of organic compounds by spectroscopic techniques.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Demonstration	Summative (Mid-Semester-1) and Semester Final
CLO2	Lecturing and Discussion	Summative (Mid-Semester-1) and Semester Final
CLO3	Lecturing and Students activity	Summative (Mid-Semester-1I) and Semester Final
CLO4	Lecturing and Project Based Learning	Summative (Mid-Semester-1I) and Semester Final
CLO5	Lecturing and Group Discussion	Assignment and Semester Final

(g) Learning Materials

(i) Recommended Readings

- D. L. Pavia, G. M. Lampman and G. S. C. Kriz Introduction to Spectroscopy.

(ii) Supplementary Readings

- Molecular Spectroscopy, P. S. Sindhu.
- Molecular Spectroscopy, J. D. Graybeal.
- Nuclear Magnetic Resonance Spectroscopy, R. K. Harris.
- Elementary Organic Spectroscopy Y. R. Sharma.
- NMR Spectroscopy, H. Gunther.
- Modern NMR Spectroscopy, J. K. M. Sanders and B. K. Hunter.

Course Code	Course Title	Credit Hours
0531-14-324	Colloid and Surface Chemistry	**3.0**

(a) Rationale:

This course covers colloid mixtures with dispersed particles that do not settle quickly—and surface chemistry, focusing on phenomena at interfaces such as corrosion, catalysis, crystallization, and adsorption.

(b) Course Objectives (COs)

- To have a clear information about colloidal solution, gold number and the application of colloids
- To study the properties of colloids, thermodynamics, Zeta potential and their CMC measurement
- To gather idea how to prepare emulsion, microemulsion, gel, *etc*. and their uses
- To account the adsorption isotherm, surface film and electrocapillary phenomena
- To analyze the chemistry of interface and to accumulate gas/liquid on solid/liquid surface forming a molecular/atomic film

(c) Course Contents

1.	**Colloids: S**ize/shape/types/preparation of colloids: lyophilic and lyophobic sol: mechanical dispersion method, Bredig's Arc method, peptization, dispersion by ultrasonic wave, removal of aggregating substances; association and disintegration method, purification: dialysis, electro-dialysis, ultra-centrifuge method, properties and stability of colloids: application of colloid.
2.	**Micelle & their Thermodynamics:** Optical properties: Tyndall effect, ultra/electron microscope; kinetic properties: Brownian movement, diffusion, sedimentation, osmotic pressure, Donnan membrane effect. Electrical properties: electrical double layer, Zeta potential. Colloidal electrolytes and surfactants; micelle; shapes of micelle, CMC; thermodynamics of micellization; phase separation and mass action model.
3.	**Emulsion and Gel**: Emulsion: preparation and stability of emulsion, emulsifying agent, application of emulsion, coagulation/flocculation value; Schulze-Hardy law, kinetics of coagulation. Gel: preparation and stability of gel, syneresis, thixotropy, swelling. soaps; cleaning action of soaps; peptization, viscosity, solvation.
4.	**Surface Phenomena:** Adsorption: adsorption on solid surfaces, types of adsorptions, adsorption isotherm; Langmuir, Freundlich and BET; surface films, adsorption by solids from solution, electrocapillary phenomena. Interfacial tension; methods of surface and interfacial tension: capillary rise method, Drop-volume method, Maximum bubble pressure method, Ring detachment and Wilhelmy plate method.
5.	**Chemistry of Interfaces:** Thermodynamics of interface, interfacial tension; free energy of interface; Gibb's adsorption isotherm; choice of a dividing surface. Liquid interface: interface and interphase, interfacial/surface free energy, treatment of curved surface; Kelvin's equation; Young-Laplace equation; cohesion and adhesion; condition of miscibility, spreading of liquids, kinetics of spreading, control of spreading.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to-

CLO-1: Analyze colloidal solution and evaluate their shapes, properties, purification and their application.

CLO-2: Evaluate the micelle, emulsion & gel and their thermodynamics.

CLO-3: Demonstrate surface chemistry with their theories.

CLO-4: Predict adsorption isotherms and the probability of miscibility using spreading coefficient data.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	1	-	-	1	-	-	-	-
CLO3	3	2	-	-	-	1	-	-	-	-
CLO4	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz Midterm-I and Final Exam. (Summative)
CLO2	Lecturing & discussion	Assignment (with Rubrics) & Final Exam. (Summative)
CLO3	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO4	PPT presentation & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)

(g) Learning Materials

(i) Recommended Readings

- Weiser A. B., *Text Book of Colloidal Chemistry*
- Adamson A. W., Gas A. P., *Physical Chemistry of Surface*
- Glasstone S., *A Text Book of Physical Chemistry*, 2nd ed., Macmillan & Co. Ltd., London.
- Haque M. M., Mollah M. Y. A., *Principles of Physical Chemistry*, Brother's publications

(ii) Supplementary Readings

- Maron S. H., Prutton C. F., *Principles of Physical Chemistry*, 4th ed

Course Code	**Course Title**	**Credit Hours**
0531-14-325	Organic Reagents and Synthesis	2.0

(a) Rationale:

The course is aimed to identify organic reagents in synthesis lies in their ability to facilitate specific chemical transformations to create desired organic molecules. These reagents, carefully chosen for their reactivity and selectivity, enable the chemists to design specific target molecules from simpler starting materials, which is the core of organic analysis.

(b) Course Objectives (COs)

- To impart knowledge on synthetic organic reactions.
- To provide in-depth understanding of structure reactivity principles in a variety of chemical structures.
- To make students capable of developing strategies and design complex molecular constructions.

(c) Course Contents	
1.	**Oxidation:** Oxidation reactions with Cr, Mn compounds, SeO_2, $Pb(OAc)_4$, peracid and periodate.
2.	**Reduction Reaction:** Catalytic hydrogenation, reduction with dissolving metals, metal hydrides $LiAlH_4$, $NaBH_4$
3.	**Interconnection of Functional Groups**: (a) Interco version of functional group-transformation of alcohols, phenols, halogenocompounds, nitrocompounds, acids and acid derivatives, (b)

	Protective groups: the strategy, protection of alcohols, diols, carboxylic acids, amino groups, carbonyl groups. The application in organic synthesis.
4.	**Design of Organic Synthesis:** Design of a synthesis, Initial consideration of the retrosynthetic approach, starting materials, yield and reaction; Synthesis of monofunctional and bifunctional compounds
5.	**Strategies in Synthesis**: The disconnection approach to synthesis, concepts of synthon, functional group interconversions, reagent, synthetic equivalent and target molecule.
6.	**Formation of Carbon-Carbon Bonds**: The principles reactions of elonate ions, Grignard reagents, organocoper reagents. The use of stabilized carbanions, and related nucleophiles, formation of carbon-hetero atom bonds, Umpolung, Ylides, stereoselective enolates reactions, enamines; Robinson annulation, Heck reaction, Suzuki reaction, Stille coupling, Sonogaschira coupling. Hartwig reaction, Stll coupling Sonogashira coupling, Hartwig reaction, Hyper-valent iodines and their applications.

***d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Gain the good knowledge about the specific oxidation and reduction reactions mechanism.

CLO-2**:** Predict either the product or reactant from given a structure on the basis of the knowledge obtained from the study of the reactions and protecting group transformations.

CLO-3: Design retrosynthesis analysis using the disconnection approach and Convert retrosynthetic analysis to a forward multistep synthesis. .

CLO-4: Plan the synthesis of Carbon-Carbon new bond formation with respect to reagents and reaction conditions.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	1	1	-	-	-	-	-	-	-
CLO2	3	1	3	2	-	-	-	-	-	-
CLO3	3	1	2	2	-	-	-	-	-	-
CLO4	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Demonstration	Summative (Semester Final) and Assignment
CLO2	Lecturing and Students Activity	Summative (Mid-Semester-1) and Semester Final
CLO3	Lecturing and Group Discussion	Summative (Mid-Semester-1I) and Semester Final
CLO4	Lecturing and Project based learning	Summative (Semester Final) and Assignment

(g) Learning Materials

(i) Recommended Readings

- Carruther, W., *Some Modern Methods of Organic Synthesis* (Cambridge)
- Finar, I. L., *Organic Chemistry* VOL. I (Longman group Ltd.)

(ii) Supplementary Readings

- House, H. O., *Modern Synthesis Reactions* (W. A. Benjamin, New York)
- Guenther Jung, Combinatorial ChemistryWiley-VCH,

Course Code	Course Title	Credit Hours
0512-14-326	Fundamentals of Biochemistry	3.0

(a) Rationale:

This Fundamentals of Biochemistry explores the molecules of life, starting at simple building blocks and culminating in complex metabolism.

(b) Course Objectives (COs):

- Fundamental concepts of biochemistry
- To demonstrate the knowledge on occurrence, classification, chemical structure, physical properties and biological importance of different types of carbohydrates and lipids
- To understand the basic concepts related to structure and function of amino-acids and proteins
- To acquire the knowledge of chemistry of nucleic acids
- To introduce the concept of enzymatic reactions mechanism

(c) Course Contents

1.	**Carbohydrates:** Definition, classification, constitution, conformations and configurations of monosaccharides, synthesis of monosaccharides, ring structures of monosaccharides, actions of acids and bases on sugars, epimers, anomers and anomeric configurations, reactions of mono-, di-, tri- and polysaccharides, their structures, chemical and physical properties.
2.	**Amino Acids, Peptides and Proteins:** Definition, sources, classification and functions of amino acids, structure and configuration of amino acids, isoelectric point, preparation and reactions of amino acids, peptides, its occurrence, constitution and geometry, C-terminal and N-terminal residues of peptides, proteins, classification and functions, denatured and conjugated proteins, primary, secondary and tertiary structures of proteins.
3.	**Lipids and Nucleic Acids:** Definition, occurrence, classification and function, composition of fats and oils, hydrolysis of fats, saturated and unsaturated fatty acids. Definition, importance and structures of nucleic acids, nucleosides and nucleotides, DNA and RNA.
4.	**Metabolism:** (a) Carbohydrate: glycolytic pathway, TCA Cycle, (b) lipid: beta oxidation, biosynthesis of fatty acid and cholesterol, (c) protein: transamination, deamination, decarboxylation; urea cycle.
5.	**Biochemical aspects of enzymes:** Characterization and classification; coenzyme and prosthetic group.
6.	**Enzymatic reaction:** Brief treatment on enzymatic reaction mechanism and its regulation
7.	**Vitamins:** Chemical structure, Physiological action and sources of Vitamin A.D.K. and thiamine, riboflabin, niacin, pantothenic acid, cyanocobalmine, folic acid and ascorbic acid.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the knowledge on occurrence, classification, chemical structure, physical and chemical properties and biological importance of different types of carbohydrates.

CLO-2: Describe the basic concepts related to structure, physical and chemical properties and synthesis of different amino acids and proteins.

CLO-3: Explain the structure of different nucleosides, nucleotides, DNA, RNA and solid phase synthesis of oligonucleotides.

CLO-4: Describe the metabolism of carbohydrates, proteins, fatty acids.

CLO-5: Demonstrate the catalytic properties and mechanism of enzyme action.

CLO-6: Draw the chemical structure and physiological properties of different vitamins.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	1	-	-	-	-	-	-	-	-
CLO2	3	1	-	1	-	-	-	-	-	-
CLO3	3	-	1	-	-	-	-	-	-	-
CLO4	3	-	-	-	-	-	-	-	-	-
CLO5	3	-	1	-	-	-	-	-	-	-
CLO6	3	-	-	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Asking	Summative (Mid-Semester-1) and Semester Final
CLO2	Lecturing and Demonstration	Summative (Mid-Semester-2) and Semester Final
CLO3	Lecturing and Group Discussion	Summative (Semester Final) and Assignment
CLO4	Lecturing and Project Based Learning	Summative (Semester Final) and Assignment
CLO5	Lecturing and Discussion	Summative (Semester Final)
CLO6	Lecturing and Project Based Learning	Summative (Semester Final) and Assignment

(g) Learning Materials
(i) Recommended Readings
• Biochemistry, Lehninger.
• Biochemistry, Styer.
(ii) Supplementary Readings
• Outlines of Biochemistry, Chon & Stumpt

Course Code	**Course Title**	**Credit Hours**
0531-14-327L	Physical Chemistry Laboratory-III	**1.5**

(a) Rationale:

This course provides hands-on training in physical chemistry experiments, focusing on electrochemistry, spectroscopy, kinetics, solution, and surface chemistry. Students develop practical skills with essential tools and techniques to perform laboratory experiments effectively.

(b) Course Objectives (COs):

- To guide you in developing efficient lab. techniques and in making your laboratory a pleasant place
- To gather knowledge in physical chemistry for analyzing and proposing methods
- To solve experimentally in the field of electrochemistry/spectroscopy, solution chemistry, and kinetics.

(c) Course Contents	
1.	Determination of strength of a) strong/weak acid and b) mixture of acids by strong base using potentiometric/conductometric/pH-metric titration.

2.	Determination of equilibrium constant of a reaction by the measurement of e.m.f. through conductometric/pH-metric method.
3.	Draw a phase diagram of 3-component system like water-chloroform-acetic acid ternary system
4.	Draw the phase diagram of 3-component system: water-chloroform-propanol/water-toluene-*n*-propanol and calculate CST.
5.	Determination of CMC of surfactants by conductometric/pH-metric/spectrometric/surface tension measurement.
6.	Determination of area of cross-section of the experimental liquid (butanol-1/2) by drop volume method.
7.	Determination of kinetics of chemical reactions using spectrophotometric/chemical analysis.
8.	Determination of the activation energy of a chemical reaction.

***(d) Course Learning Outcomes (CLOs)*:**

Upon successful completion of this course, students will have the knowledge and skills to-

CLO1: Demonstrate the safety rules, handling of chemicals and glassware during practical class
CLO2: Perform electrochemical/spectroscopic experiments in aqueous/buffer solution
CLO3: Conduct physicochemical experiments in liquid-liquid solution
CLO4: Execute kinetics experimentally in aqueous/buffer solution

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	2	2	-	1	-	-	1	-
CLO3	3	-	2	2	-	1	-	-	1	-
CLO4	3	-	2	2	-	1	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing	Course preparatory quiz and safety awareness
CLO2	Lab. activities and data reporting	Lab. report (with Rubrics) & Midterm exam. (Formative)
CLO3	Lab. activities and data reporting	Final lab. exam. (Summative)
CLO4	Lab. activities and lab. report evaluation	Final lab. exam. (Summative)

(g) Learning Materials

(i) Recommended Readings

- Findlay A., Longmans, *Practical Physical Chemistry*, Green & Company Ltd
- Daniel, Mathews and William, *Experimental Physical Chemistry*
- Athawale V.D., Mathur P., *Experimental Physical Chemistry*, New Age International Pvt. Ltd, New Delhi

(ii) Supplementary Readings

- Viswanathan B., Raghavan P. S., *Practical Physical Chemistry*, Science Book Agency, Calcutta

Course Code	Course Title	Credit Hours
0531-14-328L	**Environmental Chemistry Laboratory**	**1.5**

(a) Rationale:

Measuring concentrations of and changes to environmental pollutants in air, water, soil, and consumer products is central to understanding the impact of the environment on human health. This laboratory course will explore sampling methods and measurement techniques, which are important when considering different exposure to pollutants in the environment.

(b) Course Objectives (COs)

- Train students in hands-on operation of a range of methods and instrumentation used in air quality, water quality, and consumer products testing.
- Teach students to develop sampling plans and approaches to study design.
- Provide students practical experience with conducting research in a laboratory setting.
- Explore the challenges and decisions that must be made when conducting ambient sampling, particularly in a restricted time window.
- Gain experience transforming data from instrument outputs to presentable technical material.

(c) Course Contents

1.	Environmental Sampling: Introduction to water, soil and air quality guidelines
2.	Design of Water Quality Monitoring and In-Situ Measurement of Physicochemical Water Quality Parameters
3.	Water Quality Monitoring and Assessment: Biological and Chemical
4.	Biomarker Approaches for Ecotoxicological Biomonitoring at different Levels of Biological Organization
5.	Sediment Sampling, Sample Preparation, Grain Size Correction and Chemical Criteria
6.	Sediment and Soil Quality Criteria
7.	Surface-Atmosphere Exchanges of Chemical Compounds and Global Change
8.	Air Sampling and Analysis: Trace Gas Emission Measurement
9.	Introduction To Data Analysis: Chemometric Analysis

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Collect and properly prepare environmental samples

CLO-2: To identify suitable analytical method/s and utilize for measuring environmental parameters and use a standard piece of laboratory equipment in the completion of a routine task and to handle any chemicals used in conjunction with the equipment with an appropriate level of care.

CLO-3: To carry out simple multistage chemical calculations quickly and accurately and lay out an answer so that the reasoning at each stage of the calculation is clear and easy to follow, and to employ an appropriate use of units.

CLO-4: To examine typical results from an experiment and perform a series of tasks to explain and contextualize the results

CLO-5: To demonstrate their ability to use literature and computational resources to accurately retrieve and record simple chemical and physical data and reference materials.

CLO-6: To communicate results through laboratory and project (if any) report and demonstrate and cause and effect relationship for real-world scenarios including proper safety procedures and ethical considerations involved in environmental monitoring and analysis.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	1	-	-	-
CLO2	1	-	-	-	-	-	1	-	-	-
CLO3	1	-	1	-	-	-	1	-	-	-
CLO4	1	-	-	2	-	-	1	-	-	-
CLO5	1	-	-	-	-	-	1	-	-	-
CLO6	1	-	-	-	3	-	1	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Hands-on-Laboratory/Field Exercise	Assignment
CLO2	Scaffolding and Collaborative Laboratory Learning Methods	Summative Examination
CLO3	Using Technology like data analysis software	Formative Examination
CLO4	Laboratory Activities and Data analysis software	Summative Examination
CLO5	Demonstration and Online Simulation	Assignment and Presentation
CLO6	Problem Solving and Active Learning Discussion	Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- Laboratory Manual on Environmental Chemical Analysis, Department of Chemistry, Comilla University
- H.H. Rump (1999). Laboratory Manual for the Examination of Water, Wastewater and Soil (3rd Ed.), , Wiley-VCH, New York.
- Frank R. Burden, Environmental Monitoring Handbook, McGraw-Hill, Singapore
- Standard Methods for the Examination of Water and Wastewater (21st Ed.), APHA, 2005.

(ii) Supplementary Readings

- C.E. Boyd, C.S. Tucker (1992). Water Quality and Pond Soil Analysis for Aquaculture, Auburn University
- B.A. Hauser (2001). Drinking Water Chemistry: A Laboratory Manual, , Lewis Publishers, Boca Raton, 2001.

Course Code	**Course Title**	**Credit Hours**
0531-14-411	Solid State & Chemical Crystallography	**3.0**

(a) Rationale:

Solid-state chemistry and Crystallography deals with the synthesis, structure, and characteristics of solid phase materials and crystal system. However, it reveals how crystal defects affect the physical properties of solids. Furthermore, crystallography displays how to fix up the crystal forms and their properties using X-ray diffraction. Semiconductors, Hall Effect, and superconductors, and their numerous applications, are explored clearly. This course will help the students to carry out a thorough survey of solid state and crystallography which may affect the renewable and sustainable energy generation/consumption.

(b) Course Objectives (COs):

- To understand the structural properties of crystal system and crystal lattice in order to understand the bulk imperfections in solids.
- To explain the thermodynamics of point defects in crystalline solids and to evaluate crystal structure with the help of X-ray diffraction.
- To apply band theory for explaining the operational technique of modern semiconductors and superconductor devices.

(c) Course Contents	
1.	**Solids:** Solid state; Properties of solids, crystalline and amorphous solids, distinction between crystalline and amorphous solids, classification of crystalline solid, isomorphism, polymorphism and allotropy, law of isomorphism (Mitscherlich Law), test for isomorphism, liquid crystal; Types of liquid crystal, Swarm theory of liquid crystal, application of liquid crystal.
2.	**Unit Cell and Symmetry Elements:** Space lattice; Weiss indices, Miller indices; Hauy's law; unit cell; Different types of unit cell, calculation of number of atoms in unit cell, radius ratio and coordination number; symmetry of elements; Plane of symmetry, axis of symmetry, centre of symmetry, structure of crystals; NaCl, AgCl, MgO, CsCl, $TlCl_3$, ZnS, $CuCl_2$, HgS, CaF_2 and Na_2O.
3.	**Crystal Defects:** Perfect crystal, defects in solids, vacancies, classification of crystal defects; Point defects, intrinsic and extrinsic point defects, line defects, plane defects, electronic defects, excitation state of crystal, transient defects, stoichiometric and non-stoichiometric defects; Schottky defects, Frenkel defects, influence of defects on the physical properties of solids, color centers.
4.	**X-Ray Crystallography:** Crystallography; Crystal systems, crystallographic axes and axial ratio, law of constancy of interfacial angles, X-ray diffraction of crystal; Rotating crystal method; Bragg's law, important of Bragg's law, Laue photograph method, oscillating crystal method, powder method, structure of NaCl, CsCl and CaF_2 by Bragg's law, application of x-ray diffraction.
5.	**Electrical Properties of Crystals:** Binding forces in crystals; Ionic forces, covalent bonds, van der Waals forces, hydrogen bonds, metallic bonds; Electro-gas model, Hall effect, Hall effect and types of semiconductor, Band theory, origin of band gap; conductor, semiconductor and insulator, hole concept, doping, impurities on semiconductor; intrinsic and extrinsic semiconductor: p-type and n-type semiconductor, non-stoichiometric metal oxides, superconductor.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Predict the properties and interactions of chemical substances

CLO-2: Define, classify, determine and differentiate between amorphous and crystalline substances.

CLO-3: Specify atomic planes, directions, and families of planes and directions using Miller indices.

CLO-4: Compare the qualitative and quantitative representation of defects in solids

CLO-5: Apply crystallography on different unknown compounds to analyze for semiconductor and superconductors.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	2	-	-	-	-	-	-	-
CLO2	3	-	2	-	-	-	-	-	-	-
CLO3	3	-	3	2	-	-	-	-	-	-
CLO4	3	-	3	3	-	-	-	-	-	-
CLO5	3	-	3	1	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing with demonstration through power point presentation	Mid-Semester-1
CLO2	Lecturing with demonstration through power point presentation	Semester Final Examination
CLO3	Videos demonstration and lecturing with demonstration through power point presentation	Semester Final Examination
CLO4	Provide different crystal models and lecturing with power point presentation.	Semester Final Examination
CLO5	Lecturing with demonstration through power point presentation	Quiz/Class Test

(g) Learning Materials
(i) Recommended Readings
• Haque M. M., Mollah M. Y. A., *Principles of Physical Chemistry*, Brother's publications
• D.K. Chakrabarty, *Solid State Chemistry* 2nd Edition 2010, New Age international (P) Ltd., Publishers
(ii) Supplementary Readings
• West A. R., *Solid State Chemistry and its Application*
• Hannay N. B., *Solid State Chemistry*
• Keer H. V., *Principles of Solid State*
• N. N. Greenwood, *Solid State Chemistry*

Course Code	**Course Title**	**Credit Hours**
0531-14-412	Organometallic Chemistry	**3.0**

(a) Rationale:

Organometallic chemistry, the chemistry of cluster compounds, that contain metal-carbon bonds, encompasses a wide variety of compounds including clustuer compounds, containing one or more metal-metal bonds. Organometallic compounds, focusing on the ligands and how they interact in sigma and pi fashions with metal atoms and ions, form useful catalysts and are of industrial interest.

(b) Course Objectives (COs):

- Impart knowledge on synthesis, structures and bonding of some main group, transition metal organometallics and metal clusters.
- Convey knowledge on bonding, structures and reactions of different classes of organometallics.
- Promote knowledge on the fundamental organometallic reaction, such as insertion, oxidative-additive, reductive-elimination, and how these key reactions operate in various important catalytic processes

(c) Course Contents

1.	Introduction: Historical background, Classification of organometallic compounds by bond type, Difference between main groups and transition metal organometallics, The stability of organic compounds.
2.	Main Group Organometallics**:** Synthesis of Organometallic compounds containing Lithium, Magnesium, Cadmium, Copper, Zinc and their synthetic utility.
3.	Transition Metal Organometallics**:** Classification of organic ligands, 18-electron rule and its basis, application and exceptions.
4.	Metal carbonyls, Metal nitrosyls and Metal Phosphines**:** Synthesis, Structures, bonding and reactions
5.	Synthesis, Bonding, Structures and Properties (including fluxional behavior) of the Following Types Transition Metal Organometallics: (a) Compounds with 1-electron ligands: σ-alkyl, aryl, and halide complexes. (b) Compounds with 2-electron ligands: alkene compounds. (c) Compounds with 3-electron ligands: η^3-allyl complexes. (d) Compounds with 4-electron ligands: tricarbonyliron complexes of dienes and alkynes. (e) Compounds with 5-electron ligands: cyclopentadienyl complexes.
6.	Metal-Metal Bonding and Metal Clusters: (a) Transition Metal Carbonyl Clusters: Structure, Synthesis and Reactions, (b) Synthesis, Structure and Substitution Reactions of Trimetallic Dodecacarbonyls of Osmium, Ruthenium.
7.	(a) Stoichiometric Reactions of Transition Metal Organometallics**:** Oxidative addition, Reductive elimination and Insertion reactions. (b) Catalytic Reactions of Transition Metal Organometallics: Water gas shift reaction, Fischer-Tropsch synthesis, Hydroformylation reaction, Homogeneous hydrogenation of unsaturated compounds, Ziegler-Natta polymerization of ethylene and propylene.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Explain the definition of organometallics and clustered compounds

CLO-2: Describe and use 18 electron rule and demonstrate the bonding between M-L (M=Metal, L=Ligand e.g. CO, NO, phosphine)

CLO-3: Explore the various reaction mechanisms of organometallic reactions.

CLO-4: Apply the organometallic and clustered compounds as catalyst

CLO-5: Design the scheme of synthesis of intended organometallic compounds

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	-	2	-	-	-	-	-	-
CLO4	1	-	-	-	-	-	-	-	-	-
CLO5	1	-	-	-	3	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) *Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy*		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration with Power-Point Presentations	Mid-Semester-1 (Formative) and Final Examination (Summative)
CLO2	Lecturing and Problem Based Learning	Mid-Semester-2 (Formative) and Final Examination (Summative)
CLO3	Demonstration and Group Discussion with Activity	Final Examination (Summative)
CLO4	Lecturing and Project Based Learning	Final Examination (Summative)
CLO5	Lecturing and Tutorials	In Class Assessment/Presentation (Formative)

(g) Learning Materials
(i) Recommended Readings
• , G.E. Coates, M.L. Green, P. Powell and K. Wade: Principles of Organometallic Chemistry
• M. Bochmann: Complexes with transition metal-carbon σ-bonds, , Oxford Science Publications, Macmillan
(ii) Supplementary Readings
• M. Bochmann: Complexes with transition metal-carbon Π-bonds, Oxford Science Publications, Macmillan

Course Code	**Course Title**	**Credit Hours**
0531-14-413	Polymer Chemistry	3.0

(a) Rationale:

This course is designed to offer a general idea of different polymers including preparation, classification and its physical, chemical and mechanical properties.

(b) Course Objectives (COs):

- To learn the basic concepts of polymers.
- To illustrate types of polymerizations and polymerization techniques.
- To acquire the measurement of molecular weight and size, glassy solids and polymer crystallization

(c) Course Contents	
1.	**Basic Concepts of Polymers**: Monomer, repeat unit, difference between polymers and macromolecules, degree of polymerization, classification of polymers on different basis, forms of polymer, stereochemistry of polymer, nomenclature of stereoregular polymers.
2.	**Types of Polymerizations and Polymerization Techniques**: Addition polymerization: mechanism and kinetics of free radical polymerization, monomers and initial dependence of rate on the initiator and monomer concentrations, ionic addition polymerization and mechanism; condensation polymerization: types of polycondensation reactions, mechanism of condensation polymerization, kinetics of catalyzed and non-catalyzed polycondensation, distinction between addition and condensation polymerization; coordination and ring opening polymerizations; polymerisation techniques: bulk, solution, suspension and emulsion polymerization.
3.	**Copolymerization**: Mechanism and kinetics of binary free radical co-polymerization, application of co-polymerization, composite equation.
4.	**Molecular Weight, Size and Shape of Polymer Molecules**: Average molecular weight, number average, weight average, Z- average, viscosity average molecular weight, polydispersity and molecular weight distribution in polymers, determination of molecular weight of polymers: end group analysis, colligative method.

5.	**Thermal Properties**: Glassy solids and glass transition, concepts of glass transition temperature (T_g) and associated properties, factors influencing the glass transition temperature, importance of glass transition temperature. Crystallinity in polymers: polymer crystallization, structural and other factors affecting crystallisability, effect of crystallinity on the properties of polymers. Melting point of polymer.
6.	**Polymer Processing**: Types of polymer processing, plastics, elastomers and fibers, plasticization and plasticizers, characteristics of plasticizers, some important plasticizers, role of plasticizers in processing of polymers.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Know about the types of polymers with some specific examples of each.

CLO-2: Learn about the types of polymerizations and the different mechanisms involved in polymer preparation.

CLO-3: Explain the different polymerization techniques.

CLO-4: Illustrate the molecular weight concepts in polymers and the measurement of molecular weight.

CLO-5: Acquire in detail the glass transition temperature and the factors affecting it.

CLO-6: Describe the types of polymer processing, processing polymers, some important plasticizers and their roles in the processing of polymer.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	2	-	1	-	-	-	-	-	-
CLO3	3	-	-	-	-	-	-	-	-	2
CLO4	3	-	-	2	-	-	-	-	-	-
CLO5	3	-	-	-	-	-	-	-	-	-
CLO6	3	-	2	-	-	-	-	-	-	2

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing and Discussion	Summative (Mid-Semester-1) and Semester Final, Presentation
CLO2	Lecturing and Demonstration	Summative (Mid-Semester-1) and Semester Final, Presentation
CLO3	Lecturing and Group Discussion	Semester Final, Assignment and Presentation
CLO4	Lecturing and Students Activity	Summative (Mid-Semester-2) and Semester Final, Presentation
CLO5	Lecturing and Discussion	Summative (Mid-Semester-2) and Semester Final, Presentation
CLO6	Lecturing and Project based learning	Semester Final, Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- Bilmeyer: Textbook of Polymer Science,
- Gauriker: Textbook of Polymer Science,
- D. Margerison & G. C. East : Introduction to Polymer Chemistry,.

(ii) Supplementary Readings
• A. Ravve Principles of Polymer Chemistry,.
• R. J. Young & P. A. Powell. Introduction to Polymers,

Course Code	**Course Title**	**Credit Hours**
0531-14-414	Research Methodology in Chemistry	**3.0**

(a) Rationale:

Research methodology in chemistry mainly deals with the identification of research problems or issues regarding chemical science and research design employing the pertinent research methods through hypothesis setting. It includes experimental designs, data collection, data analysis and report/article writing. By studying the course, it would be possible to address/define the problems or issues related to chemical phenomena and to design the framework in order to solve the problems/issues through writing/dissemination.

(b) Course Objectives (COs)

- To understand the meaning of research, types and processes in chemical science
- To provide knowledge to formulate research problems and hypothesis
- To make research design with appropriate experimental designing with data collection and analyses strategies and synthesis of information to provide valid conclusions.
- To impart knowledge regarding research proposal preparation and report writing

(c) Course Contents:

1.	**Introduction to Research:** Meaning of Research; Types of research: Basic research; Applied research; objectives of research; Importance of research; Steps of research.
2.	**Defining Research Problem:** Literature Review**:** Sources of literatures; Literature research methods; Collection of literatures; Chemical abstract; Journals related to chemical science; Reports; Thesis/dissertation; Books review.
3.	**Hypothesis:** Research Question; Types of Hypotheses; Formulation of hypothesis; Introduction to hypothesis testing; General procedures for hypothesis testing.
4.	**Research Design:** Definition and objectives; Classification; Exploratory research; Descriptive research; Causal research; Qualitative vs quantitative research; Descriptive research design; Causal research design.
5.	**Experimental Design:** Chemical Reaction Optimization; Design of Experiments; Optimization Methods; Factorial Design, Face Centered Design; Mixture Design; Experimental Techniques and Tools.
6.	**Research Area:** Synthesis and Analysis; Inorganic, Organic, Physical, Analytical and Environment Research; Molecular Modeling; Retro- synthesis; Nanosynthesis; Green synthesis.
7.	**Sampling Design**: Census and Sample survey; Sampling: Sampling statistics; Statics of Sampling; Sample Design: Types; Complex Random Sampling design.
8.	**Data Collection and Analysis**: Types of Data; Methods of Data Collection: Selection of Appropriate Methods for Data Collection; Analysis of Data: Treatment of Data, Multivariate Analysis of Data.
9.	**Research Proposal Preparation:** Background and Justification of the study; Statement of the problem; Materials and methods; Description of the process; Work-activity schedules; Budget preparation; References.
10.	**Writing thesis, scientific papers and reports:** Research reporting; Criteria for selecting suitable means of presentation and their explanation; Citing references by ACS and other standard styles.

11.	**Quality of Publishers and their Evaluation**: ISSN/ISBN, Impact Factor, Indexing Journal and Their Quality, Research Gate, Google Scholar, h-index, i-10.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate the overview concepts of research and its importance in chemistry

CLO-2: Explain the types of research applicable to chemical science

CLO-3: Identify research question and state research problem

CLO-4: Formulate research hypothesis and test the hypothesis

CLO-5: Describe data collection methods and analyze the data

CLO-6: Design of Experiments with different methods for chemical research.

CLO-7: To wright and demonstrate research synopsis, research proposal, research report, and impact of research

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	-	-	-	-	-		-	-
CLO4	1	-	2	1	-	1	-	-	-	-
CLO5	1	-	-	-	-	1	-	-	-	-
CLO6	1	-	2	1	-	1	-	-	-	-
CLO7	1	-	1	1	-	1	-	1	2	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing with demonstration	Class Test/Semester Final Examination
CLO2	Demonstration and Group Discussion	Semester Final Examination
CLO3	Problem Based Learning:	Mid-Term-1(Class Test/Quiz)
CLO4	Inquiry Based Learning	Semester Final Examination
CLO5	Demonstration with use of statistical tools	Semester Final Examination
CLO6	Lecturing and Project Based Learning	Mid-Term-2(Class Test/Quiz)/Semester Final Exanation
CLO7	Demonstration and Case Study Method: Using real world examples from relevant research can help student to connect theory to practice	Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- Chakraborty, T. and Ledwani, L. Research Methodology in Chemical Science: Experimental and Theoretical Approach, CRC Press
- Kothari, C.R. Research Methodology, 2nd Edition, New Age International (P) Limited, New Delhi, 2004

(ii) Supplementary Readings

- Ranjit Kumar. Research Methodology, 4th Edition, Sage Publications Asia-Pacific Pte Ltd, Singapore, 2014.

- Nehru, R.S.S. and Suryanway, N.V.S. Research Methodology, A P H Publishing Corporation, New Delhi, 2012.
- Cochran, W.G. and Cox, G.M., Experimental Design, , John Wiley and Sons Inc., London

Course Code	**Course Title**	**Credit Hours**
0531-14-415	Industrial and Environmental Economics	**3.0**

(a) Rationale:

This course is designed to study economic concepts, methods, tools and techniques for analyzing environmental phenomena and to conceptualize the students about the interaction and interdependency between economics and industry. Specifically, it focuses on industrial classification, efficiency, location, concentration, diversification and finance related issues. It also highlights on industrial, particularly chemical industry sector of Bangladesh.

(b) Course Objectives (COs)

- Develop understanding of the interrelationship between environment and economics.
- Train up students to identify the impact of externality on market failure.
- Motivate students to address environmental pollution in Bangladesh from economic viewpoint.
- Conceptualize the nature of interdependence between industry and economics.
- Give an orientation of industrial efficiency, concentration and location choice.
- Develop understanding of industrial finance. and address industrial sector of Bangladesh.

(c) Course Contents:

1.	Introduction: Relation between economics and the environment; Material Balance Model; Scope of environmental damage; Damage function; Environmental quality; Sustainable development; Risk analysis; Pollution reduction versus pollution prevention.
2.	Dealing with Resources: Market Failure; Conventional Solution to Environmental Problems; Command and control approach; Environmental standard; Cost effectiveness; Equi-marginal principle of optimality. Economic Solution to Environmental Problems: Pollution permit trading system. and interrelationship between economics, environment and resources.
3.	Environmental Decision Making: Environmental public policy development; Key players in environmental decision making – environmentalists, private firms, govt., scientists and economists. Valuation of Environmental Benefits and Costs: Present value of benefits and costs; Benefit-cost ratio; Allocative efficiency and cost effectiveness. Strategic Planning for Sustainable Development: Sustainable development; Conflict between economic gain and environmental quality; Industrial ecosystem; Industry's response to pollution; Agenda 21. Environmental Pollution in Bangladesh: Major polluting sources; Threats; Environmental pollution – local, national and global perspectives; Impacts of pollution; Environmental policy.
4.	Introduction: Microeconomics versus industrial economics; Scope of industrial economics; History of industrial economics; Objective of industrial units; Firm versus industry; Market structure, conduct and performance – SCP paradigm. Classification and Size of Firms: Classification – size, use, input and proprietorship-based; Firm size – small, medium and large scale.
5.	Industrial Sector of Bangladesh: Major industries; Contribution to the economy; History of industrialization in Bangladesh; Government initiatives; Industrial policy; EPZ; Private sector and international response; Sick industries; Problems and potentials of industrialization in Bangladesh.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Demonstrate interrelationship between economics, environment and resources.

CLO-2: Apply economic approaches and instruments to solve environmental problems.

CLO-3: Estimate environmental benefits and costs.

CLO-4: Diagnose causes and extent of environmental pollution in Bangladesh.
CLO-5: Classify firms and quantify efficiency of manufacturing units.
CLO-6: Explore the factors determining industrial location.
CLO-7: Examine inter-industry relationship.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	1	1	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	1	1
CLO4	1	-	-	-	-	-	-	-	-	-
CLO5	1	-	-	-	-	-	-	-	-	-
CLO6	1	-	1	1	-	-	-	-	-	1
CLO7	1	-	1	-	-	-	-	2	2	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecturing with demonstration	Class Test/Semester Final Examination
CLO2	Demonstration and Group Discussion	Semester Final Examination
CLO3	Problem Based Learning:	Mid-Term-1(Class Test/Quiz)
CLO4	Inquiry Based Learning	Semester Final Examination
CLO5	Demonstration with use of statistical tools	Semester Final Examination
CLO6	Lecturing and Project Based Learning	Mid-Term-2(Class Test/Quiz)/Semester Final Examination
CLO7	Demonstration and Case Study Method: Using real world examples from relevant research can help student to connect theory to practice	Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- :M.L. Jhingan, and Chandar K. Sharma (2015): Environmental Economics: Theory, Management and Policy, Vrinda Publications P Ltd., India
- P. J. Devine, N. Lee, R. M. Jones and W. J. Tyson (2018): An Introduction To Industrial Economics, Taylor & FrancisTaylor & Francis Group http://taylorandfrancis.com.
- w. Stewart Howe (1978). Industrial Economics An Applied Approach, ©W. Stewart Howe 1978

(ii) Supplementary Readings

- P. J. Devine, N. Lee, R. M. Jones and W. J. Tyson (2018). An Introduction To Industrial Economics, 4th Edition, Routledge 711 Third Avenue, New York, NY 10017
- R.R. Barthwal (2000). Industrial Economics: An Introductory Text Book, 2nd Edition, New Age International (P) Limited Publishers, New Delhi.

Course Code	Course Title	Credit Hours
0531-14-416L	Physical Chemistry Laboratory-IV	2.0

(a) Rationale:

This course provides hands-on training in advanced physical chemistry experiments, including electrochemistry, solution chemistry, thermodynamics, refractive index, and kinetics. Students gain practical skills with sensitive tools and techniques essential for successful laboratory work.

(b) Course Objectives (COs):

- To guide you in developing efficient lab. techniques and in making your laboratory a pleasant place
- To gather knowledge in physical chemistry for analyzing and proposing methods
- To solve electrochemical, optical and physicochemical problems in the field of physical chemistry

(c) Course Contents

1.	Verification of the Debye-Huckel-Onsager slope.
2.	Determination of activity coefficient from e.m.f. measurement electrochemically.
3.	Determination of dissociation constant of chloroacetic acid by conductometric/pH-metric/potentiometric method.
4.	Determination of association constant of C_6H_5-COOH in C_6H_6/C_7H_8.
5.	Determination of refractive index of binary liquid mixtures by Abbe Utility Refractometer.
6.	Determination of specific rotation of the inversion of sucrose in presence of an acid by polarimeter.
7.	Determination of physical (volumetric/viscometric/optical) and thermodynamic parameters of binary liquid mixtures.
8.	Determination of adsorption isotherm of acetic acid on charcoal.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO1: Demonstrate the safety rules, handling of chemicals and glassware during practical class

CLO2: Perform electrochemical experiments in aqueous/buffer solution

CLO3: Conduct optical experiments in liquid-liquid solution

CLO4: Execute physicochemical experiments in liquid-liquid solution

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	1	2	-	2	-	-	1	-
CLO3	3	-	2	2	-	1	-	-	-	-
CLO4	3	-	2	2	-	2	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) *Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy*		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz and safety awareness
CLO2	Lab. activities and data reporting	Lab. report (with Rubrics) & Midterm exam. (Formative)
CLO3	Lab. activities and data reporting	Final lab. exam. (Summative)
CLO4	Lab. activities and lab. report evaluation	Final lab. exam. (Summative)

(g) Learning Materials
(i) Recommended Readings
• Findlay A., Longmans, *Practical Physical Chemistry*, Green & Company Ltd
• Daniel, Mathews and William, *Experimental Physical Chemistry*.
• Bell and New Combe, *Experiments in Physical Chemistry*.
• Palit, *Practical Physical Chemistry*, Science Book Agency, Calcutta.
• Sharma, *Practical Physical Chemistry*, Vikas Publishing House Pvt. Ltd.
(ii) Supplementary Readings
• Viswanathan B., Raghavan P. S., *Practical Physical Chemistry*, Science Book Agency, Calcutta
• Athawale V.D., Mathur P., *Experimental Physical Chemistry*, New Age International Pvt. Ltd, New Delhi.

Course Code	**Course Title**	**Credit Hours**
0531-14-417L	Industrial Inorganic Synthesis Laboratory	**1.5**

(a) Rationale:

Industrial inorganic synthesis deals with commercial production of inorganic chemicals and related products from natural raw materials and their derivatives. This course comprises with manufacturing process of basic heavy inorganic chemicals such as sodium hydroxide, hydrochloric acids, chlorine, etc. and chemical product such as cement, fertilizer, glass and ceramics etc. This course is designed with three components, namely in-depth study of industrial inorganic manufacturing processes prevailing in real-world chemistry including Bangladesh, industry visit/training/Case-study and quality control analysis in laboratory.

(b) Course Objectives (COs)

- To provide opportunity to visit industry to observe the inorganic manufacturing chemicals.
- To equip students to characterize the synthesized compounds through providing required tools and techniques.
- To acquaint students with synthetic scheme to prepare a new/fabricated inorganic compound.

(c) Course Contents	
1.	Manufacturing sulfuric/ hydrochloric/Nitric acids
2.	Manufacture of caustic soda and chlorine products
3.	Synthesis of ammonia
4.	Synthesis of inorganic fertilizer (Such as TSP, potassium nitrate etc.)
5.	Manufacturing of lime and Cement
6.	Manufacture of Inorganic Polymers (Such as silicate, ion-exchange resign etc.)
8.	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

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Classify the chemical industry in terms of products, raw materials, scale and types of transformations.

CLO-2: Describe the operation principles of selected unit operations and unit processes and operate the unit process.

CLO-3: Discuss with the help of relevant flow diagrams, equations, operating conditions and equipment principles, the manufacture of chlorine, sodium hydroxide, ammonia, sulphuric acid, fertilizer and cement.

CLO-4: Discuss fermentation theory and its application in ethanol manufacture, the production of some pharmaceuticals, soaps and detergents.

CLO-5: Test the chemical composition of inorganic manufacturing product and analyze the quality assurance of the analysis

CLO-6: Communicate results of chemical analyses and compare the state of art methods used in manufacturing process through laboratory report.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	-	-	-	-	-	-	-	-
CLO3	3	-	-	2	-	-	-	-	1	-
CLO4	3	-	-	-	-	-	-	-	-	-
CLO5	3	-	-	1	-	-	-	-	-	-
CLO6	3	-	-	1	-	-	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Demonstration and Group Activities	Formative Assessment
CLO2	Demonstration and Experimental Design	Formative Assessment
CLO3	Hands-on-Laboratory Activity	Assignment and Presentation
CLO4	Demonstration and Laboratory Activity	Formative Assessment
CLO5	Hands-on-Laboratory Activity and Process Oriented Learning	Summative Examination
CLO6	Demonstration and Group Activity	Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- Industrial inorganic Synthesis Manual, Department of Chemistry, Comilla University
- Helen Njeri Njenga, Industrial Chemistry, **African Virtual university**

(ii) Supplementary Readings

- Karl Heinz Buchel Hans-Heinrich Moretto Peter Woditsch (2000). Industrial Inorganic Chemistry, WILEY-VCH Verlag CmbH. D-69469 Weinheim (Federal Republic of Germany),

Course Code	Course Title	Credit Hours
0531-14-418L	Industrial Organic Synthesis Laboratory	1.5

(a) Rationale:

The course deals with the conversion of the basic processes of organic chemistry into industrial processes. A short review of traditional processes is given, followed by the introduction of the technologies utilized in industrial chemistry to improve reaction rate, conversion, yield, selectivity, purity, separability, etc.

(b) Course Objectives (COs)

- To provide opportunity to visit industry to observe the organic manufacturing chemicals
- To equip students to characterize the synthesized compounds through providing required tools and techniques.
- To acquaint students with synthetic scheme to prepare a new/fabricated organic compounds.

(c) Course Contents

1.	Preparation of soap.
2.	Manufacture of cream.
3.	Preparation of shampoo.
4.	Preparation, purification and characterization of the following: (i) Benzopinacol from benzophenone. (ii) Two or three step synthesis of organic compounds of commercial and medicinal importance.
5.	Quantitative separation of saturated and unsaturated acids in oils/fats
6.	Identification of sugar in fruit juices using TLC.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Prepare of soaps, creams, paste and shampoo.

CLO-2: Prepare, purification and characterization of several organic compounds of commercial and Industrial Importance

CLO-3: Analysis of saturated and unsaturated acids in oils/fats, sugar in fruit juice, natural and synthetic organic compounds.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	2	-	-	-	-	-	-
CLO2	3	2	-	2	-	-	-	-	-	-
CLO3	3	-	-	2	-	-	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Demonstration and Group Activities	Formative Assessment
CLO2	Demonstration and Experimental Design	Formative Assessment
CLO3	Hands-on-Laboratory Activity	Assignment and Presentation

(g) Learning Materials

(i) Recommended Readings

- Industrial organic Synthesis Manual, Department of Chemistry, Comilla University

(ii) Supplementary Readings

- Karl Heinz Buchel Hans-Heinrich Moretto Peter Woditsch (2000). Industrial organic Chemistry, WILEY-VCH Verlag CmbH. D-69469 Weinheim (Federal Republic of Germany),

Course Code	Course Title	Credit Hours
0531-14-421	Quantum Chemistry and Statistical Mechanics	**3.0**

(a) Rationale:

Quantum chemistry applies quantum mechanics to chemical systems, focusing on electronic structure and molecular dynamics via the Schrödinger equation. It provides the theoretical foundation for chemistry, while statistical mechanics uses probability to explain macroscopic behavior from microscopic particles.

(b) Course Objectives (COs):

- To understand perfect blackbody and its radiation including relevant theories
- To solve Schrodinger wave equation for H/He-atom in polar/cartesian coordinates and to draw different orbital structures
- To know how operators operate any function
- To illustrate methods of probability theory and statistics, and particularly the mathematical tools for dealing with large populations and approximations
- To generalize Newtonian mechanics into conservative systems

(c) Course Contents

1.	**Quantum Chemistry** **(a) Wave Mechanics:** de Broglie's hypothesis; dual nature of electron; Davisson and Germer's experiment; nature of classical mechanics; failure of classical mechanics; black body radiation; photoelectric effect; Einstein's explanation of photoelectric effects; Compton effect; Plank's quantum theory; heat capacities of solids; atomic spectra; Heisenberg's uncertainty principle.
	(b) Schrodinger Wave Equation: Polar and Cartesian co-ordinates; time dependent and time independent wave function: its significance and characteristics; normalization; orthogonalization; probability of finding electron; boundary condition of ψ.
	(c) Operator and observable: Definition, rules of operator, some important quantum mechanical operators; commutator, vector, Laplacian, linear, non-linear, Hamiltonian, Hermitian and unitary operators; eigen value and eigen function; Schrodinger wave equation as eigen function; postulates of quantum mechanics in operator: modification of 2^{nd} postulate; orthogonality and normalization.
2.	**Statistical Mechanics:** Basic concepts of statistical mechanics; macroscopic system; Stirling approximation; distribution of molecules; configuration; thermodynamic probability; entropy and probability, residual entropy, distribution of molecular velocities, distribution laws; Bose-Einstein statistics, Fermi-Dirac statistics, Maxwell-Boltzmann statistics; Fermi energy; statistical mechanical equilibrium; partition function; translational, vibrational, rotational and electronic partition functions; thermodynamic parameters in terms of partition function; Sackur-Tetrode equation; ensembles; canonical, grand canonical and micro-canonical ensemble.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Account the fundamental concepts of black body radiation using their laws.

CLO-2: Solve SWE for H/He-atom and find out the orbital structures with quantum numbers.

CLO-3: Apply operators to find out the eigen values and condition of orthogonality/normalization.

CLO-4: Illustrate statistical mechanics as logical consequences of the theories of *statistical mechanics.*

CLO-5: Demonstrate proficiency in mathematical concepts and generalize Newtonian mechanics into conservative systems.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	-	-	-	-	-	-	-	-
CLO3	3	-	-	2	-	-	-	-	1	-
CLO4	3	-	-	-	-	-	-	-	-	-
CLO5	3	-	-	1	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz Midterm-I and Final Exam. (Summative)
CLO2	Lecturing & discussion	Assignment (with Rubrics) & Final Exam. (Summative) Quiz/presentation (Formative)
CLO3	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO4	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO5	PPT presentation & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)

(g) Learning Materials
(i) Recommended Readings
• Gupta, Kumar, Sharma, *Quantum Mechanics*, 15th ed., Jai Prokash Nath & Co
• Singh S. P., Badge M. K., *Quantum Mechanics*, S. Chand & Co Ltd., N. Delhi
• Kamal Singh, Singh S.P., *Elements of Quantum Mechanics*, S. Chand & Co Ltd., Delhi
(ii) Supplementary Readings
• Chandra A. K*., Introductory Quantum Chemistry*, 4th ed., Tata McGraw Hill Education Pvt. Ltd.

Course Code	**Course Title**	**Credit Hours**
0531-14-422	Supramolecular and Nano Chemistry	3.0

(a) Rationale:

Nanochemistry and supramolecular chemistry are two strongly interrelated cutting edge frontiers in research in the chemical sciences. This course traces the fascinating modern practice of the chemistry of the non-covalent bond from its fundamental origins through to it expression in the emergence of nanochemistry. Fusing synthetic materials and supramolecular chemistry with crystal engineering and the emerging principles of nanotechnology, this course is an ideal introduction to current chemical thought for students entering these exciting areas for the first time.

(b) Course Objectives:

- To study the particle's size, size distribution, molecular weight, density, surface area, porosity, hydrophilicity, surface charge density, purity, surface chemistry, and stability.
- To study of systems which contain more than one molecular assembly, and it aims to understand the structure, function, and properties of these assemblies, protein folding, molecular recognition, host-guest chemistry, mechanically-interlocked molecular architectures, and dynamic covalent chemistry

(c) Course Contents	
1.	**Development of Supramolecular Chemistry:** Host-Guest concept & classification, Receptors, Coordination & Lock and key analogy, Chelate & Macrocyclic effects, Preorganization & Complementarity, Thermodynamic & Kinetic selectivity, Supramolecular interactions, Host design strategy.
2.	**Cation-Anion & Neutral Molecule Binding Hosts:** Synthesis of Crown ethers, Lariat ether & podand, Cryptands, Spherands, Solution behavior, Macrocyclic, Macrobicyclic & Template effects, Thermodynamic & Kinetic effect, soft ligand-soft metal, Complexation of organic Cations, Calixarenes, Carbon donor & π-acid ligands. Anion Host design, Anion receptors, Guadinium based receptors, Organometallic receptors, Neutral receptors, Hydride sponge & other Lewis Acid Chelates, Coordination interactions, Anti-crowns. Inorganic Clathrate compounds, zeolites, Clathrates of Organic hosts, Molecular Clefts & Tweezers, Cyclophanes, Supramolecular Chemistry of Fullerenes as Host & Guest.
3.	**Templates and Self-assembly:** Biochemical Self-assembly; Strict & Serendipitous assembly, Self-assembly in Porphyrin complexes, Self-assembly in coordination complexes; Cubes, Molecular squares & Boxes, Self-assembly by hydrogen bonding, Catenanes, Rotaxanes & Pseudo-rotaxanes, Helicates, Nanocycles, Molecular Knots.
4.	**Liquid Crystals and Crystal Engineering:** Intermolecular interactions, role of Hydrogen bonding, Crystal growth, CCSD, Hydrogen bonds to CO, Weak Hydrogen bonds, Hydrogen bonds to metals & metal Hydrides, order in Liquids, Surfactants & interfacial ordering, Design of Liquid Crystalline Material, Liquid Crystal Display (LCD).
5.	**Molecular Devices:** Philosophy & Design of Molecular Devices, photochemically active Bimetallic systems, Bipyridine & Bipyridyl based photo and electronic devices, photochemical & Electrochemical sensors, Molecular Switches, wires & Rectifiers, machines based on Catenanes & Rotaxanes, Non-linear Optical Devices.
6.	**Introduction to Nanomaterials:** About size scales, history, Feynman scorecard, Schrodinger's cat-quantum mechanics in small systems, fluctuations and "Darwininian nanoscience", quantum effects and fluctuations in nanostructures, microscopy and manipulation tools in nanochemistry. **Environmental implications:** Nanotoxicology, risk assessment and environmental aspects.
7.	**Synthesis of Nanomaterials**: Top-down approach: Photolithography, electron beam lithography, micromechanical structures, thin film technologies, molecular beam epitaxy, focused ion beam milling, Bottom-up approach: Common aspects of all assembly methods, laser vaporization technique, chemical bath deposition method, chemical vapor deposition technique, laser ablation technique, organic synthesis, electrodeposition, spin coating, DNA nanotechnology.
8.	**Chemical Interaction:** Chemical interaction at the nanoscale: electrostatic interaction, hydrogen bonding, van der Waals attractions, hydrophobic effects.
9.	**Nanomaterials for Sensors and Electronic Device:** Fullerenes, carbon nanotubes, graphene, dianmondoids, application of nanomaterials in catalysis, oxide reactions, in sensors and electronic devices, photochemistry, composite, coatings, energy, environment, food, agriculture, textile and medicine.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Apply relevant chemical concepts to explain the nature and origins of supramolecular interactions.

CLO-2: Choose classical and modern synthetic routes for the synthesis molecular receptors and building blocks of molecular devices.

CLO-3: Design Nanosystems for biological, medical, chemical, catalytic, energy and environmental applications, Nanodevices for electronic, photonic, magnetic, imaging, diagnostic and sensor applications.

CLO-4: Synthesis nanosized materials, supramolecular cation and anion binding host.

CLO-5: Evaluate and apply synthetic methods such as template-controlled reactions for the synthesis of supramolecular building blocks.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	2	-	-	-	-	1	-	-	-	-
CLO2	2	-	-	-	-	-	-	-	-	-
CLO3	2	1	1	-	-	1	-	-	-	-
CLO4	2	1	1	1	-	1	-	-	-	-
CLO5	2	-	1	-	-	-	-	2	2	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing	Course preparatory quiz Midterm-I and Final Exam. (Summative)
CLO2	Lecturing & discussion	Assignment (with Rubrics) & Final Exam. (Summative) Quiz/presentation (Formative)
CLO3	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO4	Lecturing & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)
CLO5	PPT presentation & discussion	Midterm-II & Final Exam. (Summative) Quiz/presentation (Formative)

(g) Learning Materials

(i) Recommended Readings

- Geoffrey A. Ozin, André C. Arsenault, Ludovico Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, 2nd Edition, Royal Society of Chemistry
- Catherine Bréchignac, Philippe Houdy, Marcel Lahmani, Nanomaterials and Nanochemistry, 1st Edition, Springe
- Katsuhiko Ariga, Toyoki Kunitake, Supramolecular Chemistry – Fundamentals and Applications, 1st Edition, Springer

(ii) Supplementary Readings

- H. Watarai, N. Teramae, T. Sawada, Interfacial Nanochemistry: Molecular Science and Engineering at Liquid-Liquid Interfaces,1st Edition, Springer
- Jonathan W. Steed, David R. Turner, Karl J. Wallace, Core Concepts in Supramolecular Chemistry and Nanochemistry, 1st Edition, Wiley

Course Code	Course Title	Credit Hours
0531-14-423	Chemistry of Natural Products	3.0

(a) Rationale:

This course is integrated of convey the fundamental concept of natural products, extraction, isolation and structure elucidation of different natural products and their properties.

(b) Course Objectives(COs):

- Acquaint the students with the fundamental ideas of natural product chemistry.
- Demonstrate the extraction, isolation, and structural elucidation of terpenoids, purines, alkaloids, steroids and antibiotics.
- Explain the physical and chemical properties of terpenoids, purines, alkaloids, steroids and antibiotics.

(c) Course Contents

1.	**Introduction of Natural Products:** Definition, occurrence and importance of some natural products, General methods of isolation, purification and determination of structure of natural products by chemical and spectroscopic methods.
2.	**Alkaloids:** Occurrence, classification, extraction and purification of alkaloids, General methods of determining structure, Biosynthesis of alkaloids chemistry of ephedrine, nicotine, atropine, cocaine and morphine.
3.	**Terpenoids and Purines**: The essential oils, Classification of terpenes, Isoprene rule, Isolation and purification, General methods of determining structures of terpenoids, Detailed studies of some monoterpenes, (i) acyclic monoterpene: citral, (ii) bicyclic monoterpene like camphor, Biosynthesis of monoterpenes. Purine and Uric acid Derivatives: Adenine, hypoxanthine, xanthine, guanine, caffeine, theobromine and theophylline
4.	**Steroids and Hormones:** Introduction of steroids and hormones, Nomenclature and functions of steroids and hormones, Structure of Cholesterol and its effect in biological systems, Steroidal hormones and glycoisides, Natural and synthetic hormones.
5.	**Antibiotics and Drugs:** Chemistry of penicillin and chloramphenicol, Synthesis of Drugs, Classification and their Mode of Action.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Describe the fundamentals of natural product chemistry.

CLO-2: Demonstrate the classification, extraction, isolation, structural elucidation and purification of terpenoids, purines, alkaloids, steroids and antibiotics.

CLO-3: Determining the physical and chemical properties of terpenoids, purines, alkaloids, steroids and antibiotics.

CLO-4: Carry out the biosynthesis of natural products.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	-	-	-	-	-	-	-	-	-
CLO2	3	-	2	-	-	-	-	-	-	-
CLO3	3	-	2	1	-	-	-	-	-	-
CLO4	3	-	1	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) ***Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy***		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Demonstration	Summative (Semester Final) and Assignment
CLO2	Lecturing and Discussion	Summative (Mid-Semester-1) and Semester Final
CLO3	Lecturing and Students activity	Summative (Mid-Semester-1I) and Semester Final
CLO4	Lecturing and Project Based Learning	Summative (Semester Final) and Assignment

(g) Learning Materials
(i) Recommended Readings
• I.L. Finar, Organic Chemistry Vol. II, Longmans, Green & Co
• K.B.G. Torssell, Natural Product Chemistry, John Wiley and Sons, New York
• G.A. Wawan, An Introduction to the Alkaloids, Blackwell
(ii) Supplementary Readings
• S.W. Pettetier, Chemistry of the Alkaloids, von Nostrand Renihold

Course Code	**Course Title**	**Credit Hours**
0519-14-424	Pharmaceutical Chemistry	**3.0**

(a) Rationale:

This course focuses on the study of the processes of drug design and development; physicochemical and structural features that can influence the processes of ADME and drug target binding; and in the establishment of structure activity relationships. Likewise, notions of computer-aided drug design, representing the future of the pharmaceutical chemistry are introduced. Given that most drugs are of organic nature, Pharmaceutical Chemistry is based in the knowledge of Organic Chemistry.

(b) Course Objectives (COs)

- To impart knowledge **on** physicochemical and structural features of molecules by which drug is designed.

To equip students to design drug molecules computationally

(c) Course contents	
1.	Introduction to Pharmaceutical Chemistry: Concepts and definitions. Historical overview. Aims of Pharmaceutical Chemistry. Relationships with other disciplines. Drug and Active Principle. Phases in Drug development, costs and Classification of drugs; Synthesis: strategies and most relevant processes
2.	Origins and Development of Drugs. Drug discovery: Finding a lead. From hit to lead. Screening of Natural Products. Combinatorial chemistry. Improvement of existing drugs. Rational Drug design.
3.	Chemical, physicochemical and structural properties of Drugs: molecular recognition and drug-receptor interactions; Relevant physicochemical properties in drug-receptor binding; pKa and distribution coefficient; Lipinski's Rules; Geometry of the interaction; Stereochemistry and pharmacological activity; Conformation and pharmacological activity; Rigid analogues.
4.	Drug Metabolism. Phase I transformations. Reactions of oxidation, reduction and hydrolysis. Phase II transformations. Reactions of conjugation. Consequences of metabolic processes
5.	Prodrugs and their applications. Prodrug: concept and types of prodrugs. Improvement of absorption, bioavailability, solubility and stability. Drug target access improvement. Chemical or enzymatic drug degradation improvement. Drug vectorization. Drug toxicity decrease
6.	Molecular modification and prototype optimization. Strategies in drug design. Structure simplification. Structure extension. Extension/contraction of chains and cycles. Ring variation. Ring fusion. Substituent variation. Bioisosterism. Rigidification and conformational blocking. Other resources. Siamese drugs.
7.	Structure-Activity Relationship (SAR): Pharmacophore identification; Quantitative structure-activity relationship (QSAR); Physicochemical parameters; Methods used to correlate physicochemical parameters with biological activity; Computer-based methods of QSAR related to receptor binding: 3D-QSAR.
8.	Computer-Aided Drug Design. Introduction to the computational methodologies used in drug design. Direct and indirect design. Molecular modelling. Pharmacophore search. Binding mode prediction: Docking. Virtual screening.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: To propose the existing relationship between the structure, the physicochemical properties and the activity (QSAR) of a series of molecules

CLO-2: To apply the methods and strategies used in the design and synthesis of new drugs, and to analyse the interactions between drugs and their biological targets.

CLO-3: To propose structural modifications that affect different drug properties.

CLO-4: To write the synthetic scheme of the most representative drugs of the main therapeutic families, as well as to name and formulate drugs using the systematic nomenclature rules

CLO-5: To analyze the fundaments of the computational techniques used in rational drug design.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	2	1	1	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	1	-	-	-	-	-	1	-
CLO5	1	1	2	1	-	-	-	-	1	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing, Cooperative Learning, Problem Based Learning, and Tutorials	Class test (Short Q and MCQ)
CLO2	Lecturing, Cooperative Learning, Problem Based Learning, and Tutorials	Mid-semester-1/Semester Final
CLO3	Lecturing, Cooperative Learning, Problem Based Learning, and Tutorials	Mid-Semester-2//Semester Final
CLO4	Lecturing, Cooperative Learning, Problem Based Learning, and Tutorials	Semester Final Examination.
CLO5	Lecturing, Cooperative Learning, Problem Based Learning, and Tutorials	Semester Final Examination

(g) Learning Materials
(i) Recommended Readings
• Patrick G. L. (2013): An Introduction to Medicinal Chemistry. 5th Ed., Oxford University Press. Oxford.
• Lemke Thomas (2017): Foye's Principles of Medicinal Chemistry. 7th Ed. Lippincott, Williams & Wilkins.
(ii) Supplementary Readings
• Silverman, R. B. (2004): The Organic Chemistry of Drug Design and Drug Action, 2nd Ed., Academic Press, USA.
• Katzsung, B.G.: Basic and clinical pharmacology, 9th edition, McGraw Hill, New York.

Course Code	**Course Title**	**Credit Hours**
0031-13-425	Personal Skills and Development	**2.0**

(a) Rationale:

A growing body of evidence has shown that, although equipped with theoretical knowledge, most chemistry graduates lack skills that are essential for being efficient and productive members of the workforce. These set of skills have been collectively called "transferable skills" and may include effective oral- and written-communication skills, critical-thinking skills, effective team working, ability to use data acquisition systems, and data manipulation and analytical skills. A survey of educational journals shows that some chemistry departments have started to address this issue and have included various critical thinking as well as communication-skills courses in their undergraduate curricula. For Chemistry professional to know and practice the personal behaviors and professional ethical issues and societal challenges derived are very important for professionalism.

(b) Course Objectives (COs)

- To introduce the students with the personal behaviors and basics of ethical framework that guides professional chemists in the conduct of their duties,
- Make them able to focuses on solving practical issues that arise in professional practice,
- To make them prepared to practice the fundamental principles, ethical behavior, social responsibility of organizations

(c) Course Contents	
1.	**Introduction**: Definition of ethics and morality, relativist and absolute visions of ethics, difference between believes, behavior and aims of moral values, personal and social ethics

2.	**Profession and Ethics**: Introduction to Professional Ethics for Chemists *and Professionalism, Professional Conduct and Ethics*
3.	**Interpersonal Relations:** Interpersonal Behavior, Formation of Personal Attitudes, Language and Communication, Motivations and Emotions, Public Opinion
4.	**Social Ethics**: Aristotle Nsicomachean Ethics (selection), Doing One's Duty, Creating Ourselves, Hearing the Feminine Voice
5.	**Introduction to Organizational Behavior**: Organizational Disciplines and topics, Psychological Perspective, Social-Psychological Perspectives
6.	**Individual Differences**: Personality and its factors, Personality dimensions and social learning, Intelligence
7.	**Ethics for Research and Scientific Communication**: Plagiarism and improper authorship; falsification of data; misappropriation of the ideas of others; non-disclosure of information; misrepresentation of scientific experiments, funds or other resources; misrepresentation of qualifications; the violation of generally accepted research practices.
8.	**Commitment to Society**: Roles and commitments of Chemistry professionals and the ethical issues involved to serve society. False Qualifying and certifying of consumer products, Chemical safety measures, wastage and wastage management issues, etc.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Define and realize the of ethics, morality, ethical judgment, freedom of the will, and role of ethics in professional development

CLO-2: Describe and classify the individual attitude and organizational behavior

CLO-3: Identify, discuss and relate basic ethical terminology and concepts to ethical problems in Chemistry related professions and professionalism

CLO-4: Follow and implement the acquired knowledge of ethical skills in practical situations

CLO-5: Debate and recognize conflicts in an ethical way at national and international level

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	1	-	-	-	-	1	-	2
CLO2	1	-	1	-	-	-	-	-	-	-
CLO3	1	-	-	-	-	-	-	1	-	1
CLO4	1	-	-	-	-	-	-	1	-	1
CLO5	1	-	1	1	-	-	-	1	2	1

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CLO2	Lecture, Demonstration, Discussion	Quiz, assignment

CLO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CLO4	Lecture, Group discussion	Essay type test.
CLO5	Lecture, presentation, Journal article reviews, problem analysis	Essay type test, problem solving

(g) Learning Materials
(i) Recommended Readings
• R.S. Naagarazan (2006). Professional ethics and Human values, New Age International (P) Ltd., Publishers
• L. Ann Masters and Harold R Wallace (2011). Personal Development for Life and work, 10th Edition, South-Western Cengage Learning
(ii) Supplementary Readings
• The Skills You Need Guide to Personal Development, Skills You Need Limited

Course Code	**Course Title**	**Credit Hours**
0417-14-426L	Industrial Training/Internship and Entrepreneurship Development	**2.0**

(a) Rationale:

This course is designed with two components namely 'Industrial Training/Internship' and Entrepreneurship Development' which is based on workplace learning. Industrial training in chemical industries will be carried out in order to develop skills in the application of theory of industrial chemistry to practical work-place situations. Internship component would be considered an industrial (Chemistry or allied industry/organization) attachment as work-place learning. Entrepreneurship development component will be comprised with working for a small to medium sized enterprise (SME) in the Chemical and Allied Industries in order to Demonstrate knowledge of the skills that might be required for working in an SME and evaluate these against their own skills set.

(b) Course Objectives (COs)

- To provide students the opportunity to test their interest in a particular career before permanent commitments are made.
- To equip students with the ability to understand and apply chemical processes with an industrial setting.
- to equip students with the ability to understand and apply chemical processes within an industrial setting

(c) Course Contents	
1.	**Organizational Orientation:** Introduction to the company structure, vision, mission, and industrial practices.
2.	**Technical Hands-on Experience:** Exposure to industry-specific machinery, tools, software, and production cycles.
3.	**Analytical Techniques & Instrumentation:** Hands-on experience with tools like HPLC (High-Performance Liquid Chromatography), GC (Gas Chromatography), NMR (Nuclear Magnetic Resonance), LCMS, UV-Vis spectroscopy, and FTIR.
4.	**Lab Operations & SOPs:** Adherence to Good Laboratory Practice (GLP) and Good Manufacturing Practice (GMP), following Standard Operating Procedures (SOPs), and managing laboratory data.

5.	**Project-Based Work:** Participation in specific projects, including design, planning, or maintenance work.
6.	**Safety Training:** Instruction on Occupational Safety and Health (OSH) environments.
7.	**Soft Skills Development:** Improvement in teamwork, professional communication, and problem-solving techniques.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Describe use of advanced tools and techniques encountered during industrial training and visit.

CLO-2: Develop awareness about general workplace behavior and build interpersonal and team skills.

CLO-3: Identify the pressures and opportunities facing SMEs in the chemical and allied industries

CLO-4: Demonstrate knowledge of the skills that might be required for working in an SME and evaluate these against their own skills set.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	-	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	1	-	-	-	-	-	-	-
CLO4	1	-	-	2	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, ppt, Demonstration	Class test (Short Q and MCQ)
CLO2	Familiar with tools and technique	Formative (Assignment)
CLO3	Experimental work	Summative (Midterm and Semester Final)
CLO4	Experimental work and Group Discussion	Summative (Midterm and Semester Final)

(g) Learning Materials

(i) Recommended Readings

- Karl Heinz Buchel Hans-Heinrich Moretto Peter Woditsch (2000). Industrial organic Chemistry, WILEY-VCH Verlag CmbH. D-69469 Weinheim (Federal Republic of Germany),
- Karl Heinz Buchel Hans-Heinrich Moretto Peter Woditsch (2000). Industrial Inorganic Chemistry, WILEY-VCH Verlag CmbH. D-69469 Weinheim (Federal Republic of Germany),
- Findlay A., Longmans, *Practical Physical Chemistry*, Green & Company Ltd

(ii) Supplementary Readings

- Relevant SCI/EI Articles

Course Code	Course Title	Credit Hours
0531-14-427L*	Chemistry Research Project	3.0

(a) Rationale:

In order to conduct original research in accordance with their ability and background, research student/s has to prepare a research proposal in prescribed format approved by the department under the supervision of a faculty of the department. Synopsis should provide an overview of the research project and should describe its main features, including the wider and specific objectives, principal outcomes and outputs. Proposed project claims to deal with research question that may lead to significant new knowledge/product. Justification of the need, which should be in line with the national agenda and departmental research policy has to be mentioned

(b) Course Objectives (COs)

- To familiarize students with academic and industrial research
- To guide to develop research proposal in order to meet the aim and objectives of the project.
- To equip students to develop competency in apparatus assembly and handling conducive to solve problem.
- To make them able to collect, analyze, interpret and report data and communicate the scientific results in written and orally.
- To pave the way of life-long learning.

(c) Course Contents

Undergraduate research allows students to integrate and reinforce chemistry knowledge from their formal course work, especially 'chemistry research methodology' to further develop their scientific and professional skills, and to create new scientific knowledge. Conducting undergraduate research in close collaboration with a faculty mentor allows a student to draw on faculty expertise. Such research should be well-defined, stand a reasonable chance of completion in the allotted time, apply, and develop an understanding of in-depth concepts, use a variety of instrumentation and methods, promote awareness of advanced scientific practice, and be thoroughly grounded in the chemical literature. Overall, the research project should be viewed as a component of a publication in a peer-reviewed journal.

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: ***Scientific reasoning and quantitative analysis***: To identify problems, and generate hypothesis, develop and way to implement experimental methods to test their hypothesis.

CLO-2: ***Laboratory practice and safety***: To interpret chemical and physical phenomena through experimental investigations with appropriate laboratory skills and instrumentation to solve chemical problems, while recognizing the uncertainties and errors in experimental measurements with laboratory safety regulations.

CLO-3: ***Chemical Information and literature skill***: To use chemical database and retrieve peer-reviewed scientific literature and to evaluate critically chemistry related information from variety of sources.

CLO-4: ***Communication skills***: To present information in a clear and effective manner, write reports in scientific style, use appropriate technology in their communication, and to work effectively in a diverse group to solve scientific problems.

CLO-5: ***Impact and application***: To apply chemical principles to address current problems in a variety of fields and to assess the impact of chemistry on society both locally and globally ethical attributes.

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):										
CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	2	-	-	-	-	-	-	-	-	-
CLO2	2	1	2	2	1	2	-	-	-	-
CLO3	2	-	2	2	2	-	-	-	-	-
CLO4	2	-	-	-	-	-	-	1	2	-
CLO5	2	-	-	-	-	-	-	-	-	2

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Literature Review and Lab Preparation	Summative Assessment
CLO2	Demonstration and Group Activity	Summative Assessment
CLO3	Experimental Design	Summative Assessment
CLO4	Hands on Lab Activity	Summative Assessment
CLO5	Thesis Writing	Summative Assessment

(g) Learning Materials
(i) Recommended Readings
• Chakraborty, T. and Ledwani, L. Research Methodology in Chemical Science: Experimental and Theoretical Approach, CRC Press
• Kothari, C.R. Research Methodology, 2nd Edition, New Age International (P) Limited, New Delhi, 2004
• Relevant Articles
(ii) Supplementary Readings
• Ranjit Kumar. Research Methodology, 4th Edition, Sage Publications Asia-Pacific Pte Ltd, Singapore, 2014.

Report Evaluation (Marks: Supervisor, Examiner 30)			
	Excellent	**Good**	**Poor**
Project Title *Title of the needs to match with the objectives and should reflect the activities and expected outcomes.*	Project Title matches very perfectly and reflects the overall activities of the project	Project Title matches with objectives but do not reflect the overall activities of the project	Project Title does not match with the activities of the project
Background *Student should present a brief background on the significance of the project and the current research related to the topic.*	Background and significance of project fully explained	Background or significance given but not explained	No background or significance of project given
Purpose for choosing project *Student should share personal reasons for choosing this project.*	Purpose for choosing project explained	Purpose for choosing project mentioned	No purpose for choosing project given

Hypothesis *Student should state and explain the hypothesis.*	Hypothesis is clearly stated in the correct form, demonstrates a cause-and-effect relationship, and is testable	Hypothesis stated but not in the correct form	No hypothesis stated
Methodology and Experimental Procedure *Student should summarize the experimental procedure, including pictures.*	Experimental procedures thoroughly described and picture(s) present	Experimental procedures described and picture(s) present	Experimental procedures not described and no pictures presented
Presentation of Results *Student should use data tables to show the results of the experiment.*	Data tables present, properly titled and labeled, and thoroughly explained	Data tables present, properly labeled, and described	Data tables present but not described OR not properly labeled
Discussion and Conclusion *Student should explain whether the results support or refute the hypothesis and explain their conclusions.*	Hypothesis supported or refuted and conclusions demonstrate deep understanding of the project	Hypothesis supported or refuted and conclusions are thoughtful	Surface level conclusions reached but no mention of original hypothesis

Course Code	**Course Title**	**Credit Hours**
0531-14-428L*	Experimental Design in Chemistry	**3.0**

(a) Rationale:

Hands on training are pre-requisite to perform experiments successfully with fulfilling the intended objectives on Chemistry Laboratory. There are some techniques and tools in chemistry which have to be acquired and be skilled through used to these tools before real life experiments. This course includes some advanced techniques and tools covering broadly physical, inorganic organic and analytical chemistry practical. Techniques for synthesis include the use of high or low pressure, high or low temperature, microwave synthesis, and/or inert atmospheres. Techniques for characterization of synthetic products include electrical conductance; optical rotation NMR; UV-VIS, IR, and/or mass spectra.

(b) Course Objectives (COs)

- To provide guidelines to perform experiments in laboratory for advanced chemistry practical
- To synthesis, separate, purify, analyze and characterize the chemical compound.
- To develop report writing skills and ability with good concluding remarks for chemistry laboratory experiments.

(c) Course Contents	
1.	Potentiometric titration of a strong/weak acid by strong base
2.	Determination of intrinsic viscosity of ploystyrene in toluene by viscometric method
3.	Determination of limit of homogenous phase in a three-component system water-chloroform-propanol-2
4.	Determination of pKa value of weak acid (propanoic acid) at different temperature by conductometric method
5.	Preparation, separation, purification and characterization of organic compounds

6.	Design, synthesis, characterization and application (such as biological, catalytic etc.) study of inorganic compounds
7.	Analyses of water and water softening by ion exchange
8.	Design of Experiment: Optimization of synthetic parameters or controlled parameters for better analysis

***(d) Course Learning Outcomes (CLOs)*:**

After completion of the Course, the Student will be able to –

CLO-1: Apply procedures from laboratory manual perform the experiment such as Potentiometric Titration, Viscometric and Conductometric Measurements.

CLO-2: Separate mixture of chemical compounds by chromatographic tools and techniques.

CLO-3: Synthesize, purify and analyze the chemical compounds (both organic and inorganic)

CLO-4: Elucidate the structure of chemical compounds with spectral analysis

CLO-5: Write report, scientific article which clearly present scientific data and which include logical conclusions based on the experimental data

(e) Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	1	-	-	-	-
CLO2	1	-	-	-	-	-	-	-	-	-
CLO3	1	-	-	-	-	-	-	-	-	-
CLO4	1	1	-	-	-	-	-	-	-	-
CLO5	1	-	2	-	-	-	-	-	-	-

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

(f) Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Demonstration and Laboratory Activities	Final Laboratory Examination (Summative
CLO2	Process-Oriented Guided Inquiry (POGIL)	Final Laboratory Examination (Summative)
CLO3	Demonstration and Problem Based Learning (PBL)	Final Examination (Laboratory/Field Work in Summative form
CLO4	Scaffold Project Based Learning (PjBL)	Assignment and Presentation
CLO5	Demonstration and Case-Based Study	Quiz, Assignment and Oral

(g) Learning Materials

(i) Recommended Readings

- Girolami, Gregory S., et al. *Synthesis and Technique in Inorganic Chemistry : a Laboratory Manual.* 3rd ed. / Gregory S. Girolami and Thomas B. Rauchfuss, Robert J. Angelici., University Science Books, 1999.
- Daniel, Mathews and William, *Experimental Physical Chemistry*. 3rd Edition, McGraw-Hill Book Company, Inc
- Nicolaou KC. Organic synthesis: the art and science of replicating the molecules of living nature and creating others like them in the laboratory. Proc. R. Soc. A 470: 20130690. 2014.

(ii) Supplementary Readings

- Birendra Kumar. Advanced Chemistry Lab Manual Vol 2, 2017
- Adams, D. M., and John Barrie Raynor. *Advanced Practical Inorganic Chemistry*. Wiley, 1965.

Part D: **Grading/Evaluation**

1). Evaluation Strategy

Each theoretical course offered should be composed of either 50 (for 02 credits) or 100 (03 credits) marks. Grades will be calculated as per the university grading structure and individual students will be evaluated based on the following criteria with respective weights.

Descriptions	**Evaluation (%)**
Class Test/PowerPoint Presentation	10%
Assignment/Quiz/Tutorial test	05%
Mid Semester Examination (At least 2 mid-semester examinations). An average of all examinations will be calculated.	20%
Class Attendance	05%
Semester-Final Examination: An Average of the marks given by the internal and external examiners will be calculated.	60%
Total:	**100%**

Each Lab course offered should be composed of either 50 (for 02, 1.5 credits) or 100 (for 03 credits) marks. Grades will be calculated as per the university grading structure and individual students will be evaluated based on the following criteria with respective weights.

Descriptions	**Evaluation (%)**
Midterm	20%
Lab Attendance	10%
Lab Report	10%
Semester-Final Examination: An Average of the marks given by the internal and external examiners will be calculated.	60%
Total:	**100%**

2). Grading Scale and Grades

1) Letter Grade and Grade point: Total marks obtained in each course, oral (viva-voce) examination and practical courses shall be converted into LG (Letter Grade) and GP (Grade point) as follows:

Numerical Grade	**Letter Grade**		**Grade point**	**Interpretation**
80% and above	A+	(A Plus)	4.00	Outstanding
75% to less than 80%	A	(A regular)	3.75	Excellent
70% to less than 75%	A-	(A minus)	3.50	Very Good
65% to less than 70%	B+	(B Plus)	3.25	Good
60% to less than 65%	B	(B regular)	3.00	Satisfactory

Numerical Grade	Letter Grade		Grade point	Interpretation
55% to less than 60%	B-	(B minus)	2.75	Below Satisfactory
50% to less than 55%	C+	(C Plus)	2.50	Average
45% to less than 50%	C	(C regular)	2.25	Pass
40% to less than 45%	D	.....	2.00	Poor
Less than 40%	F	.....	0.00	Fail

2) Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA)
Grade Point Average (GPA) / Cumulative Grade Point Average (CGPA) will be calculated up to the second decimal points. If the third decimal point is 0.5 or above it shall be rounded up to following second decimal points.
3) Course Withdrawal
4) Incomplete (I) courses
5) Retake
6) Grade Improvement

IMPROVEMENT/F-REMOVAL OF GRADES

(I) F-REMOVAL: A student having earned 'F' grade in any course in any semester shall be required to remove the 'F' grade. Removal of 'F' grade in any course is permitted only for two (2) times excluding the regular examination. This has to be done within his academic tenure.

(ii) IMPROVEMENT: A student having earned letter grade **'B-' (GP- 2.75)** or below in any course may be allowed to improve the grade by appearing in the semester-final examination with the next available batch[7]. S/he can avail this opportunity only once for a course. In such case the best GPA from the improvement or the regular examination of the concern subject shall be calculated for tabulation.

(iii) No improvement shall be allowed in ^{8th} semester**.**

(iv) For appearing in the improvement examination, a student shall have to pay fees for the course prescribed for the purpose.

(v) A student willing to improve grade should apply to the controller of examination through the chairman of the department within 01 (one) week after the publication of the results of the semester.

(vi) No improvement shall be allowed in continuous assessment (mid-term/class-test/assignment/ fieldwork/ monograph/ project/ practical/case-study/term-paper/quiz test/etc.).

(vii) The concerned (current) examination committee to that semester will take necessary actions to arrange the improvement examinations, tabulation and posting of marks.

(viii) Dropout

If a student re-admitted twice in any semester fails to earn minimum required credits[6] for promotion shall be dropped out from the program.