Outcome Based Curriculum for
Bachelor of Science (Honours) in Chemistry

Learn Lead Live

Chemistry Discipline
Khulna University

Table of Contents

20. Grading And Evaluation

PART A

1. TITLE OF THE ACADEMIC PROGRAM	Bachelor of Science (Honours) in Chemistry

PROGRAM OVERVIEW	
Degree	Bachelor of Science (Honours) in Chemistry
Abbreviated form of the Degree	B.Sc. (Hons.) in Chemistry
Discipline/Program Offering Entity (POE)	Chemistry Discipline
School	Science, Engineering and Technology School
Awarding Institution	Khulna University
Location	Khulna, Bangladesh
Bangladesh National Qualifications Framework (BNQF) Level	7
International Standard Classification of Education (ISCED) Code	0531
Mode of Study	Full Time
Language of Study	English
Applicable Session	2021-22

2. NAME OF THE UNIVERSITY	Khulna University

3. VISION OF THE UNIVERSITY
Creation of global leaders who will contribute to make knowledge-based just society through accelerating inclusive and transformative growth of Bangladesh and the world. The university aims to achieve this vision through scholarly enquiry and contribution to the global knowledge pool.

4. MISSION OF THE UNIVERSITY	
Mission	**Description**
UM 1	Explore human potential to the fullest extent and produce self-motivated, aspiring leaders to work for the betterment of the humankind based on wisdom, freethinking, creativity and unhindered intellectual exercises.
UM 2	Ensure a transformative educational experience that enables creative learning, entrepreneurship and inquisitiveness among the students.
UM 3	Create an inclusive research environment that enables graduates to make demonstrable economic and social impacts through translating knowledge and innovation into practice driven by moral values and professional ethics.

***** UM = University Mission

5. NAME OF THE DISCIPLINE OR POE	Chemistry Discipline

6. VISION OF THE DISCIPLINE OR POE
Chemistry Discipline endeavours to be a nationally recognized model for educating and graduating students prepared to compete in and contribute to the ever-changing, technology-centred world. Our focus is to achieving excellence and leadership in chemistry-based teaching, fundamental research and innovative applications to ensure industrial and socio-economic development of Bangladesh.

7. MISSION OF THE DISCIPLINE OR POE	
Mission	**Description**
M1	To provide students with educational and research experience in a specialized branch in Chemistry
M2	To build talent in innovation, self-learning and career competitiveness
M3	To expertise students on experiment designing, execution, analysis with relevant instrumentation and troubleshooting
M4	To contributes in scientific progress and environmental adaptation for socio-economic enhancement

M = Mission of the Discipline/POE

8. OBJECTIVES OF THE DISCIPLINE	
Objectives	**Description**
O1	To offer both basic and advanced chemistry courses, lab experiences, and research activities
O2	To develop students' ability and skill to acquire expertise over solving both theoretical and applied chemistry problems
O3	To enable students to undertake further studies in multidisciplinary areas
O4	To provide an environment that ensures development of students in a holistic manner
O5	To enable the graduates to overcome the national as well as international competitive environment
O6	To enable the graduates for self-employment/entrepreneurship

O = Objective of the Discipline/POE

9. NAME OF THE DEGREE	Bachelor of Science (Honours) in Chemistry

10. DESCRIPTION OF THE PROGRAM

Chemistry is the rudimentary branch of science that basically existing on experimental work and innovation of new knowledge. Generally, chemistry deals with matters and investigation of their characteristics. This wing of science has vast applications in wide range of industrial, social, and industrial demands. The erudite persons in chemistry may initiate new term of knowledge through the experimental and research works that may be benign for human being. Moreover, this subject may flourish the problem-solving caliber of a person in laboratory affairs, research collaborations, production sector, quality control, quality assurance, and entrepreneurs in industrial sector.

To keep pace with global demand, Chemistry Discipline in Khulna University was first launched in July, 2009. With the passage of time, the overall amenities mainly research and academic affairs of the discipline have been enhanced. Students get their B.Sc. degree in Chemistry after the successfully completion of integrated four-year courses and laboratory practices. This degree provides the fundamental and modern concept in chemistry that ameliorates the capability of students to cope with the global situation. Furthermore, the myriad laboratory practices ensure their perpetuation of knowledge in chemistry. The students can correlate their gained concepts in related fields subsuming, agricultural, biotechnology, pharmacy, material science, medicine, and so on.

Chemistry discipline has launched this program with contemporary contents in chemistry having minimum 152-credit-hours where 176 credits (44 general education credits and 132 chemistry credits) are available. These credit hours contain theory course, and enormous laboratory work in addition to industry training. This diversification may component the students in research and career-oriented fields. Students generally get idea

about basic and advanced knowledge of chemistry. So, one can easily adapt to higher study in home and abroad. At present era, the environmental safety has become a great challenge for us. The offered environmental safety related course may be salubrious for a student to protect the environment. Beside these, all branches of knowledge are interlinked with each other. Therefore, general education has also kept at a minimum level so that the graduates can conduct their research and correlate their occupations to multidisciplinary level.

11. **Graduate Attributes**

Graduate Attributes (GA)	Description	Domain Name
GA1	**Disciplinary Knowledge and Skill:** A graduate student are expected to possess adequate knowledge and comprehension of both theoretical and experimental/applied chemistry in various fields like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. as well as relevant practical skills in the laboratory.	**Fundamental Domain**
GA2	**Intellectual breadth:** The ability to apply knowledge in practice including in multi-disciplinary contexts and the ability and motivation to participate responsibly both in team and independently, to provide leadership.	**Fundamental Domain**
GA3	**Ethics:** A well-developed capacity to demonstrate a sense of societal and ethical responsibility in professional and social contexts and apply ethical principles while making decisions and take responsibility for the outcomes associated with the decisions.	**Personal Domain**
GA4	**Critical Analysis and Evaluation:** A dextrous capability of critical thinking, strategic planning, and creative quest by the way of solving problems/numeric using basic chemistry knowledge and concepts as well as the ability to analyse and apply information with depth, insight, and intellectual maturity.	**Thinking Domain**
GA5	**Knowledge of Research Principles and Methods:** Utilize the principles and methods of research for the purpose of accountable research from an applied perspective in the field of chemistry.	**Thinking Domain**

Graduate Attributes (GA)	Description	Domain Name
GA6	**Communication:** Ability to communicate effectively in written and verbal forms as well as the ability to comprehend and write effective reports, make effective presentations and documentation, and an ability to respond respectfully.	**Social Domain**
GA7	**Professional and Career Success:** Be able to demonstrate their abilities successfully to solve important chemistry problems, to solve problems in areas different from their training, and to develop new and valuable ideas.	**Social Domain**
GA8	**Diverse Cultural Adaptability:** Ability to appreciate multiple perspectives and consider things differently in terms of cultural diversity, linguistic difference, and the complex nature of our world. It also means behaving appropriately towards colleagues and the community and being sensitive to local and global social justice issues.	**Social Domain**
GA9	**Self-Management:** Recognize the need and the ability to be engaged in independent and life-long learning including self-awareness, self-reflection, flexibility, and resilience and have the capacity to accept and give constructive feedback; act with integrity and take responsibility for self-actions.	**Personal Domain**

GA = Graduate Attributes

12. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)		
Objectives	**Description**	**Domain**
PEO 1	To provide knowledge in all the major branches of chemistry to understand the key concepts, principles and theories associated with life nature and society.	Fundamental
PEO 2	To provide the opportunity of conducting numerous scientific experiments with effective scientific communication skills	Social
PEO 3	To equip the graduates with research-oriented skills including research proposal writing, research design, method validation and analyses, report writing and presentation of research outcome	Thinking

Objectives	Description	Domain
PEO 4	To develop problem-solving, group work and communication skills so that they can operate with a high degree of autonomy	Fundamental
PEO 5	To develop professionalism, resilience, and morality as well as to infuse an understanding of the culture, sustainability and human rights	Personal

PEO = Program Educational Objective

13. PROGRAM LEARNING OUTCOMES (PLOs) After successful completion of the degree, the learner will be able to:	
A. Fundamental Skills	
A1	formulate and explain the fundamental concepts in the core areas of the discipline (organic, inorganic, analytical, physical, and/or biological chemistry).
A2	identify and locate current, reliable and accurate sources of scientific knowledge and apply knowledge and relevant skill to solve chemistry-related problems.
A3	employ critical thinking and scientific inquiry into the design, performance, interpretation and documentation of laboratory experiments at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.
A4	work effectively with others in various situations, including a laboratory setting, classroom setting, or a team research project.
B. Social Skills	
B1	clearly communicate the results of the scientific work in oral, written, and electronic formats to both scientists and the public at large.
B2	convey ideas and information effectively to a range of audiences for a variety of purposes and contribute in a positive and collaborative manner to achieve common goals.
B3	participate in career planning, club activities, societies, co-curricular activities, internships, and different social as well as workplace settings and demonstrate the ability to incorporate entrepreneurial skills within the scope of different activities.
C. Thinking Skills	
C1	use critical thinking skills and scientific reasoning to evaluate arguments and address complex issues based on facts, experiments and observations.
C2	demonstrate the ability to think in an integrated manner and look at problems from different perspectives.
C3	design and carry out scientific experiments as well as accurately record and analyze the results of such experiments in both chemistry and allied fields of science and technology.

D. Personal Skills	
D1	engage in self-guided learning.
D2	appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals in contemporary environmental and global issues.
D3	demonstrate discipline-specific computer skills, including use of software for word processing, spreadsheet calculations, database applications, graphing and curve fitting, data acquisition, and instrument control.

PLO = Program Learning Outcome

14. Mapping Mission of the University with PEOs			
Missions / **PEOs**	UM1	UM2	UM3
PEO1	**3**	**3**	**1**
PEO2	**2**	**3**	**3**
PEO3	**2**	**3**	**3**
PEO4	**3**	**3**	**2**
PEO5	**3**	**2**	**3**

Level of Association: 3=High, 2=Medium, 1=Low

15. MAPPING PLOs WITH PEOs													
Program Education Objectives (PEO)	Program Outcomes												
	Fundamental Domain				Social Domain			Thinking Domain			Personal Domain		
	A 1	A 2	A 3	A 4	B 1	B 2	B 3	C 1	C 2	C 3	D 1	D 2	D 3
PEO 1	●	●				●						●	
PEO 2	●	●				●		●	●	●		●	●
PEO 3		●	●					●	●	●	●		●
PEO 4		●	●	●	●	●	●		●	●		●	●
PEO 5				●		●	●		●		●	●	

16. MAPPING COURSES WITH PLO

Course Code and Course Title	PLOs												
	Fundamental Domain				Social Domain			Thinking Domain			Personal Domain		
	A 1	A 2	A 3	A 4	B 1	B 2	B 3	C 1	C 2	C 3	D 1	D 2	D 3
First Year First Term													
0531 18 Chem 1101 Atomic Structure and Chemical Bonding	●			●	●			●		●			
0531 18 Chem 1102 Fundamental Laboratory Practices Sessional	●			●	●					●	●	●	
0531 18 Chem1103 Introduction to Physical Chemistry	●	●				●		●	●			●	
0531 18 Chem 1104 Introduction to Physical Chemistry Sessional		●	●	●	●			●	●		●		
0541 18 Math 1151 Differential and Integral Calculus	●							●			●		●
0533 18 Phy 1153 Properties of Matter	●	●						●		●			
0533 18 Phy 1154 Physics Sessional-I			●							●			
0231 18 Eng 1155 Communicative English	●				●	●	●				●		
0611 18 CSE 1157 Computer Fundamentals			●		●	●		●	●				●
0611 18 CSE 1158 Computer Fundamentals Sessional		●		●	●								●
First Year Second Term													
0531 18 Chem 1201 Solution and Phase Equilibrium Chemistry	●	●		●				●			●		
0531 18 Chem 1202 Physical Chemistry Sessional-II	●	●				●					●		
0531 18 Chem 1203 Chemistry of Inorganic Reactions	●	●				●			●	●	●	●	
0531 18 Chem 1204 Qualitative Inorganic Analysis Sessional-I	●	●							●		●		
0531 18 Chem 1205 Introduction to Organic Chemistry	●	●	●		●							●	
0531 18 Chem 1206 Identification of Organic Compound Sessional	●	●	●							●		●	
0541 18 Math 1251 Algebra and Vector Analysis	●	●				●		●			●	●	
0533 18 Phy 1253 Electricity and Magnetism	●	●	●		●	●					●		
0533 18 Phy 1254 Physics Sessional-II			●				●				●		
0311 18 Econ 1259 Principles of Economics	●	●			●	●	●		●		●	●	

Course Code and Course Title	PLOs												
	Fundamental Domain				Social Domain			Thinking Domain			Personal Domain		
	A 1	A 2	A 3	A 4	B 1	B 2	B 3	C 1	C 2	C 3	D 1	D 2	D 3
Second Year First Term													
0531 18 Chem-2101 Chemical Thermodynamics	●	●	●			●		●	●	●			
0531 18 Chem-2102 Chemical Thermodynamics Sessional	●	●		●		●	●	●		●			
0531 18 Chem-2103 Chemistry of Elements	●	●		●				●	●	●	●	●	
0531 18 Chem-2104 Quantitative Inorganic Analysis Sessional-I		●			●					●	●		
0531 18 Chem-2105 Chemistry of Aliphatic and Aromatic Compounds	●	●	●					●	●	●		●	●
0531 18 Chem-2106 Qualitative Analysis of Organic Compounds Sessional	●	●	●							●		●	
0541 18 Math-2151 Differential Equation and Numerical Analysis	●							●		●	●	●	
0542 18 Stat-2161 Statistics		●	●			●	●	●		●			●
0542 18 Stat-2162 Statistics Sessional		●	●			●	●	●		●			●
Second Year Second Term													
0531 18 Chem-2201 Chemical Kinetics and Photochemistry	●	●	●	●		●		●		●			
0531 18 Chem-2202 Chemical Kinetics and Photochemistry Sessional		●	●			●	●	●	●	●			
0531 18 Chem-2203 Coordination Chemistry	●	●	●						●	●		●	
0531 18 Chem-2204 Coordination Chemistry Sessional	●		●						●	●		●	
0531 18 Chem-2205 Stereochemistry and Heterocyclic Compounds	●	●	●		●					●	●	●	●
0531 18 Chem-2206 Organic Synthesis Sessional -I	●			●				●		●	●	●	
0531 18 Chem-2207 Analytical Chemistry	●	●	●					●	●	●	●	●	
0531 18 Chem-2208 Analytical chemistry sessional	●	●			●	●	●	●		●		●	
0222 18 HC-2263 Emergence of Bangladesh	●	●		●		●	●	●		●	●	●	
0411 18 BA-2265 Marketing Principle	●		●			●					●		

Course Code and Course Title	PLOs												
	Fundamental Domain				Social Domain			Thinking Domain			Personal Domain		
	A 1	A 2	A 3	A 4	B 1	B 2	B 3	C 1	C 2	C 3	D 1	D 2	D 3
Third Year First Term													
0531 18 Chem 3101 Electrochemistry	●		●							●		●	
0531 18 Chem 3102 Electrochemistry Sessional	●		●							●		●	
0531 18 Chem 3103 Solid State Chemistry and Chemical Crystallography	●	●	●					●		●			
0531 18 Chem 3104 Solid State Chemistry and Chemical Crystallography Sessional	●									●			●
0531 18 Chem 3105 Chemistry of Biomolecules	●		●					●			●	●	●
0531 18 Chem 3106 Biomolecules Analysis Sessional					●			●		●	●		
0531 18 Chem 3107 Introduction to Chemical Spectroscopy	●		●			●			●				●
0531 18 Chem 3108 Chemical Spectroscopy Sessional-I			●		●		●				●		
0531 18 Chem 3109 Environmental Chemistry		●		●				●		●	●	●	
0531 18 Chem 3110 Environmental Chemistry Sessional					●			●				●	●
0421 18 Chem 3167 Environmental Law in Bangladesh		●				●		●	●	●	●	●	
0811 18 AT 3169 Agricultural Technology	●	●	●						●	●	●	●	
Third Year Second Term													
0531 18 Chem 3201 Organometallic Chemistry	●		●					●		●	●		
0531 18 Chem 3202 Organometallic Chemistry Sessional			●	●				●		●			●
0531 18 Chem 3203 Advanced Organic Chemistry	●	●	●		●	●						●	
0531 18 Chem 3204 Advanced Organic Chemistry Sessional	●	●				●		●	●	●		●	
0531 18 Chem 3205 Advanced Chemical Spectroscopy	●	●	●			●		●		●			●
0531 18 Chem 3206 Chemical Spectroscopy Sessional-II			●		●		●				●		●
0531 18 Chem 3207 Industrial and Pharmaceutical Chemistry	●		●					●		●	●		
0531 18 Chem 3208 Industrial and Pharmaceutical Chemistry Sessional and Field Visit	●		●					●		●	●	●	
0531 18 Chem 3209 Colloid and Adsorption Chemistry	●	●			●	●		●			●		
0531 18 Chem 3210 Colloid and Adsorption Chemistry Sessional			●				●	●					
0531 18 Chem 3211 Microbiology	●			●				●				●	

Course Code and Course Title	PLOs												
	Fundamental Domain				Social Domain			Thinking Domain			Personal Domain		
	A 1	A 2	A 3	A 4	B 1	B 2	B 3	C 1	C 2	C 3	D 1	D 2	D 3
Fourth Year First Term													
0531 18 Chem 4100 Project Design Sessional	●	●			●			●					
0531 18 Chem 4101 Chemical Weapons Convention and Basics of Chemical Hazards and Safety	●	●				●				●		●	
0531 18 Chem 4103 Reactions Mechanism	●	●	●		●	●			●			●	
0531 18 Chem 4105 Statistical and Quantum Mechanics	●	●			●		●	●		●			
0531 18 Chem 4108 Instrumental Analysis and Research Methodology Sessional	●	●			●	●		●	●	●		●	
0531 18 Chem 4109 Introduction to Material Science	●	●		●	●					●		●	
0531 18 Chem 4111 Advanced Inorganic Chemistry	●		●			●		●	●	●	●	●	
0531 18 Chem 4113 Computational Chemistry		●	●					●		●	●		●
Fourth Year Second Term													
0531 18 Chem 4200 Thesis				●	●					●	●		●
0531 18 Chem 4201 Polymer Chemistry	●	●	●	●				●	●	●		●	
0531 18 Chem 4203 Chemistry of Natural Products	●	●				●		●		●		●	
0531 18 Chem 4205 Nuclear Chemistry	●		●		●					●		●	
0531 18 Chem 4207 Green Chemistry	●	●	●				●	●				●	
0531 18 Chem 4209 Supramolecular Chemistry	●	●			●	●		●			●		
0531 18 Chem 4211 Advanced Physical Chemistry	●	●	●			●		●	●				

PART B

17. STRUCTURE OF THE CURRICULUM		
a. Duration of the Program	4 Years	08 Terms
b. Admission Requirements	The applicants having HSC or equivalent degree will be eligible for admission into this program. Other terms and conditions are set or revised periodically by the appropriate authority.	
c. Available Credits	176	
d. Graduating Credits	152	
e. Total Class Weeks in a Term*	14	
e. Minimum CGPA Requirements for Graduation	2.50	
f. Maximum Years of Completion	7 Years	

*TERM DURATION				
Teaching and Learning	Preparatory Leave	Term Final Examination	Term Break	Total
14 Weeks	2 Weeks	4 Weeks	2 Weeks	22 Weeks

g(1) Area-wise Credit Distribution				
Area	Type	Number of Courses	Credits	Total Credit
General Education (GED) Courses** (Core)	Theory	7	21	44
	Sessional	03	04	
General Education (GED) Courses** (Optional)	Theory	06	18	
	Sessional	01	01	
Core/Compulsory Courses	Theory	27	79	104
	Sessional	23	25	
Optional/Elective Courses	Theory	08	24	25
	Sessional	01	01	
Capstone Courses***	Sessional	01	03	3
Total		**77**	**176**	**176**

** 25% from GED Courses *** Thesis, project, internship etc. courses

g(2) Category of Courses			
Area	Course Type	Course Title	Credit
General Education (GED) Courses (Core)	Theory	1. Differential and Integral Calculus 2. Properties of Matter 3. Communicative English 4. Computer Fundamentals 5. Algebra and Vector Analysis 6. Statistics 7. Emergence of Bangladesh	21
	Sessional	1. Physics Sessional -I 2. Computer Fundamentals Sessional 3. Statistics Sessional	4
General Education (GED) Courses (Optional)	Theory	1. Electricity and Magnetism 2. Principles of Economics 3. Differential Equation and Numerical Analysis 4. Marketing Principle 5. Environmental Law in Bangladesh 6. Agricultural Technology	18
	Sessional	1. Physics Sessional-II	1
Core/ Compulsory Courses	Theory	1. Atomic Structure and Chemical Bonding 2. Introduction to Physical Chemistry 3. Solution and Phase Equilibrium Chemistry 4. Chemistry of Inorganic Reactions 5. Introduction to Organic Chemistry 6. Chemical Thermodynamics 7. Chemistry of Elements 8. Chemistry of Aliphatic and Aromatic Compounds 9. Chemical Kinetics and Photochemistry 10. Coordination Chemistry 11. Stereochemistry and Heterocyclic Compounds 12. Analytical Chemistry 13. Electrochemistry 14. Solid State Chemistry and Chemical Crystallography 15. Chemistry of Biomolecules 16. Introduction to Chemical Spectroscopy 17. Environmental Chemistry 18. Organometallic Chemistry 19. Advanced Organic Chemistry 20. Advanced Chemical Spectroscopy 21. Industrial and Pharmaceutical Chemistry 22. Chemical Weapons Convention and Basics of Chemical Hazards and Safety 23. Reactions Mechanism 24. Statistical and Quantum Mechanics	79

g(2) Category of Courses			
Area	Course Type	Course Title	Credit
Core/ Compulsory Courses	Theory	25. Polymer Chemistry 26. Chemistry of Natural Products 27. Nuclear Chemistry	
	Sessional	1. Fundamental Laboratory Practices Sessional 2. Physical Chemistry Sessional-I 3. Physical Chemistry Sessional-II 4. Qualitative Inorganic Analysis Sessional 5. Identification of Organic Compound Sessional 6. Chemical Thermodynamics Sessional 7. Quantitative Inorganic Analysis Sessional 8. Qualitative Analysis of Organic Compounds Sessional 9. Chemical Kinetics and Photochemistry Sessional 10. Coordination Chemistry Sessional 11. Organic Synthesis Sessional 12. Analytical chemistry sessional 13. Electrochemistry Sessional 14. Solid State Chemistry and Chemical Crystallography Sessional 15. Biomolecules Analysis Sessional 16. Chemical Spectroscopy Sessional-I 17. Environmental Chemistry Sessional 18. Organometallic Chemistry Sessional 19. Advanced Organic Chemistry Sessional 20. Chemical Spectroscopy Sessional-II 21. Industrial and Pharmaceutical Chemistry Sessional and Field Visit 22. Project Design Sessional Instrumental Analysis and Research Methodology Sessional	25
Optional/ Elective Courses	Theory	1. Colloid and Adsorption Chemistry 2. Microbiology 3. Introduction to Material Science 4. Advanced Inorganic Chemistry 5. Computational Chemistry 6. Green Chemistry 7. Supramolecular Chemistry 8. Advanced Physical Chemistry	24
	Sessional	1. Colloid and Adsorption Chemistry Sessional	01
Capstone Courses	Sessional	1. Thesis	03
Total			**176**

18. Year/Term-wise Distribution of Courses

First Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 1101	Atomic Structure and Chemical Bonding	Core	3.0	-	3.0	None
0531 18 Chem 1102	Fundamental Laboratory Practices Sessional	Core	-	1.5	1.0	None
0531 18 Chem 1103	Introduction to Physical Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 1104	Physical Chemistry Sessional -I	Core	-	1.5	1.0	None
0541 18 Math 1151	Differential and Integral Calculus	Core	3.0	-	3.0	None
0533 18 Phy 1153	Properties of Matter	Core	3.0	-	3.0	None
0533 18 Phy 1154	Physics Sessional-I	Core	-	1.5	1.0	None
0231 18 Eng 1155	Communicative English	Core	3.0	-	3.0	None
0611 18 CSE 1157	Computer Fundamentals	Core	3.0	-	3.0	None
0611 18 CSE 1158	Computer Fundamentals Sessional	Core	-	1.5	1.0	None
Total	Core Courses: 10, Optional Courses: 00 Theory Courses: 06 , Sessional Courses: 04		18.0	6.0	22.0	
			24			

First Year Second Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 1201	Solution and Phase Equilibrium Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 1202	Physical Chemistry Sessional-II	Core	-	1.5	1.0	None
0531 18 Chem 1203	Chemistry of Inorganic Reactions	Core	3.0	-	3.0	None
0531 18 Chem 1204	Qualitative Inorganic Analysis Sessional	Core		1.5	1.0	None
0531 18 Chem 1205	Introduction to Organic Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 1206	Identification of Organic Compound Sessional	Core	-	1.5	1.0	None
0541 18 Math 1251	Algebra and Vector Analysis	Core	3.0	-	3.0	None
0533 18 Phy 1253	Electricity and Magnetism	Optional	3.0	-	3.0	None
0533 18 Phy 1254	Physics Sessional-II	Optional	-	1.5	1.0	None
0311 18 Econ 1259	Principles of Economics	Optional	3.0	-	3.0	None
Total	Core Courses: 07, Optional Courses: 03, Theory Courses: 06, Sessional Courses: 04		18.0	6.0	22	
			24			

18. Year/Term-wise Distribution of Courses

Second Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 2101	Chemical Thermodynamics	Core	3.0	-	3.0	None
0531 18 Chem 2102	Chemical Thermodynamics Sessional	Core	-	1.5	1.0	None
0531 18 Chem 2103	Chemistry of Elements	Core	3.0	-	3.0	None
0531 18 Chem 2104	Quantitative Inorganic Analysis Sessional	Core	-	1.5	1.0	None
0531 18 Chem 2105	Chemistry of Aliphatic and Aromatic Compounds	Core	3.0	-	3.0	None
0531 18 Chem 2106	Qualitative Analysis of Organic Compounds Sessional	Core	-	1.5	1.0	None
0541 18 Math 2151	Differential Equation and Numerical Analysis	Optional	3.0	-	3.0	None
0542 18 Stat 2161	Statistics	Core	3.0	-	3.0	None
0542 18 Stat 2162	Statistics Sessional	Core	-	4.0	2.0	None
Total	Core Courses: 08, Optional Courses: 01, Theory Courses: 05, Sessional Courses: 04		15.0	8.0	20	
			23.0			

Second Year Second Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 2201	Chemical Kinetics and Photochemistry	Core	3.0	-	3.0	None
0531 18 Chem 2202	Chemical Kinetics and Photochemistry Sessional	Core	-	1.5	1.0	None
0531 18 Chem 2203	Coordination Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 2204	Coordination Chemistry Sessional	Core	-	1.5	1.0	None
0531 18 Chem 2205	Stereochemistry and Heterocyclic Compounds	Core	3.0	-	3.0	None
0531 18 Chem 2206	Organic Synthesis Sessional	Core	-	1.5	1.0	None
0531 18 Chem 2207	Analytical Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 2208	Analytical chemistry sessional	Core	-	1.5	1.0	None
0222 18 HC 2263	Emergence of Bangladesh	Core	3.0	-	3.0	None
0411 18 BA 2265	Marketing Principle	Optional	3.0	-	3.0	None
Total	Core Courses: 09, Optional Courses: 01, Theory Courses: 06, Sessional Courses: 04		18.0	6.0	22	
			24			

18. Year/Term-wise Distribution of Courses

Third Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 3101	Electrochemistry	Core	3.0	-	3.0	None
0531 18 Chem 3102	Electrochemistry Sessional	Core	-	1.5	1.0	None
0531 18 Chem 3103	Solid State Chemistry and Chemical Crystallography	Core	3.0	-	3.0	None
0531 18 Chem 3104	Solid State Chemistry and Chemical Crystallography Sessional	Core	-	1.5	1.0	None
0531 18 Chem 3105	Chemistry of Biomolecules	Core	3.0	-	3.0	None
0531 18 Chem 3106	Biomolecules Analysis Sessional	Core	-	1.5	1.0	None
0531 18 Chem 3107	Introduction to Chemical Spectroscopy	Core	3.0	-	3.0	None
0531 18 Chem 3108	Chemical Spectroscopy Sessional-I	Core	-	1.5	1.0	None
0531 18 Chem 3109	Environmental Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 3110	Environmental Chemistry Sessional	Core	-	1.5	1.0	None
0421 18 Law 3167	Environmental Law in Bangladesh	Optional	3.0	-	3.0	
0811 18 AT 3169	Agricultural Technology	Optional	3.0	-	3.0	None
Total	Core Courses: 10, Optional Courses: 02, Theory Courses: 07, Sessional Courses: 05		21.0	7.5	26.0	
			28.5			

Third Year Second Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 3201	Organometallic Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 3202	Organometallic Chemistry Sessional	Core	-	1.5	1.0	None
0531 18 Chem 3203	Advanced Organic Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 3204	Advanced Organic Chemistry Sessional	Core	-	1.5	1.0	None
0531 18 Chem 3205	Advanced Chemical Spectroscopy	Core	3.0	-	3.0	None
0531 18 Chem 3206	Chemical Spectroscopy Sessional-II	Core	-	1.5	1.0	None
0531 18 Chem 3207	Industrial and Pharmaceutical Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 3208	Industrial and Pharmaceutical Chemistry Sessional and Field Visit	Core	-	2.0	1.0	None
0531 18 Chem 3209	Colloid and Adsorption Chemistry	Optional	3.0	-	3.0	None
0531 18 Chem 3210	Colloid and Adsorption Chemistry Sessional	Optional	-	1.5	1.0	None
0531 18 Chem 3211	Microbiology	Optional	3.0	-	3.0	None
	Core Courses: 08, Optional Courses: 03, Theory Courses: 06, Sessional Courses: 05		18.0	8.0	23.0	
			26			

18. Year/Term-wise Distribution of Courses

Fourth Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 4100	Project Design Sessional	Core	-	6.0	3.0	None
0531 18 Chem 4101	Chemical Weapons Convention and Basics of Chemical Hazards and Safety	Core	1.0	-	1.0	None
0531 18 Chem 4103	Reactions Mechanism	Core	3.0	-	3.0	None
0531 18 Chem 4105	Statistical and Quantum Mechanics	Core	3.0		3.0	None
0531 18 Chem 4108	Instrumental Analysis and Research Methodology Sessional	Core	-	1.5	1.0	None
0531 18 Chem 4109	Introduction to Material Science	Optional	3.0	-	3.0	None
0531 18 Chem 4111	Advanced Inorganic Chemistry	Optional	3.0	-	3.0	None
0531 18 Chem 4113	Computational Chemistry	Optional	3.0	-	3.0	None
Total	Core Courses: 05, Optional Courses: 03, Theory Courses: 06, Sessional Courses: 02		16.0	7.5	20.0	
			23.5			
Fourth Year Second Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 4200	Thesis	Core	-	6.0	3.0	None
0531 18 Chem 4201	Polymer Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 4203	Chemistry of Natural Products	Core	3.0	-	3.0	None
0531 18 Chem 4205	Nuclear Chemistry	Core	3.0	-	3.0	None
0531 18 Chem 4207	Green Chemistry	Optional	3.0	-	3.0	None
0531 18 Chem 4209	Supramolecular Chemistry	Optional	3.0	-	3.0	None
0531 18 Chem 4211	Advanced Physical Chemistry	Optional	3.0	-	3.0	None
Total	Core Courses: 04, Optional Courses: 03, Theory Courses: 06, Sessional Courses: 01		18.0	6.0	21.0	
			24.0			

PART C

18. COURSE DESCRIPTION BY TERM

First Year First Term

Course No : 0531 18 Chem 1101	**Credit**: 3	**Year**: First	**Term:** First
Course Title: Atomic Structure and Chemical Bonding		**Course Status**: Core	
Prerequisite	None		
Rationale	The course will provide the overview of the structure and properties of elements and their bonding.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Introduction:** The nature of chemistry, fundamental laws of Chemistry, the conservation of mass, definite and multiple proportions, matter and its composition, the atomic theory.	1
2	**Structure of the Atom:** Atomic structure, Rutherford's atom model, fundamental particles of atom, atomic spectra and electronic structure, Bohr's model of the atom, origin of hydrogen spectrum, quantum numbers, Bohr-Sommerfield model	1,2
3	**Wave Mechanical approach of Atomic Structure:** Wave nature of electron, the Schrodinger wave equation, the nature of atomic orbital: Heisenberg Uncertainty principle, Pauli exclusion principle, Hund's rule, Aufbau principle, electronic configuration of atoms.	1
4	**Periodic Table and Periodic properties:** Periodic law, classification of the elements in the periodic table, variation of properties within periods and groups: atomic sizes, ionization energy, electron affinity, electro negativity etc.	3
Section B		**CLOs**
5	**Introduction to Bonding:** Overview definition of bond, types of bond, transition between main types of bonding, comparison among intra-molecular forces.	4
6	**Ionic Bonding:** General properties of ionic bond, structure of ionic compounds, ionic radii, radius ratio rules, lattice energy and BornHaber cycle, application of lattice energies, stability of solids, Fazan's rule, covalent character of ionic bond and polarization effects.	4
7	**Covalent and coordination bonding:** Introduction of covalent bond, Lewis and Sedgwick-Powel theory, valence shell electron pair repulsion (VSEPR) theory, hybridization, resonance concept, bond polarity and dipole moment, Introduction to VBT and MOT.	4,5
8	**Metallic Bonding:** Favorable condition of metallic bond, general properties of metals, theories of bonding in metals: free electron theories, conductors, insulators, semiconductor and superconductivity, alloys.	4,5

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	discuss about the nature and composition of matter and various atomic theory	A1, C3
	CLO 2	explain electronic configuration of atoms with necessary principles and rules	B1, C1
	CLO 3	illustrate the classifications of the elements and their properties in the periodic table	A4
	CLO 4	classify bonds in common compounds along with covalent, ionic, and metallic bond	C3
	CLO 5	explain the various theory about the structure of the molecules	A4

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Lee, J.D. Concise Inorganic Chemistry, 5th Edition, John Wiley and Sons, 2008. 2. Haider, S.Z. Introduction to Modern Inorganic Chemistry, 2nd Edition, Noor Card Board Offset Press, Bangladesh, 2000. 3. Madan, R.D. Modern Inorganic Chemistry, S Chand & Co: India, 2013.
Supplementary Readings	1. Huheey, J.E. Keiter, E.A. Keiter, R.L. Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2006. 2. Earnshaw, A. Greenwood, N.N. Chemistry of Elements, Elsevier, 2011. 3. Douglas, B.E. Mc Daniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970. 4. Shriver, D.D. Atkins, P. Inorganic Chemistry, 2nd Edition, Oxford University Press, 1994.

Course No: 0531 18 Chem 1102	Credit: 1	Year: First	Term: First
Course Title: Fundamental laboratory practices Sessional		Course Status: Core	
Prerequisite	None		
Rationale	This course is designed to gather idea about laboratory apparatus as well as qualitative analysis.		

COURSE CONTENTS	CLOs
1. Introduction to laboratory safety and chemical **2.** Management Introducing some common apparatus and reagents **3.** Preparation of standard solutions of some chemical compounds **4.** Systematic qualitative analysis of inorganic substances **5.** Analysis of insoluble substances	1-5

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	discuss about the general laboratory safety and chemical management process	A1, B1, D1, D2
	CLO 2	explain the applications of apparatus and reagents in various experiments	B1, D1, D2
	CLO 3	prepare the primary and secondary standard substances	A4, B1, C3, D1, D2
	CLO 4	analysis of inorganic substances using dry and wet test	A4, B1, C3, D1, D2
	CLO 5	explain the nature and properties of inorganic insoluble substances	A4, D1, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Oral and Written Examinations, Discussion, Video
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Oral and Written Examinations, Discussion, Video
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Jeffery, G.H. Bassett, J. Mendham, J. Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons, 1989.
Supplementary Readings	1. Wulfsberg, G. Inorganic Chemistry, Viva Books Private Limited, 2002.

	2. Miessler, G.L. Fischer P.J. Tarr, D.A. Inorganic Chemistry, 5th Edition, Pearson, 2014.

Course No: 0531 18 Chem 1103	**Credit:** 3	**Year:** First	**Term:** First
Course Title: Introduction to Physical Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide a correlation between theoretical basis of interaction of matter and biomimetics.		

	COURSE CONTENTS	**CLOs**
	Section A	
1	**States of Matter:** Solid liquid and gaseous state, liquid crystal plasma state, state variables, standard state and reference state, transition between different state, physical principles involved in physical and chemical changes intermolecular interactions, types of bonding, melting and boiling points.	1
2	**Ideal and Real Gas Law:** Perfect & real gases, ideal and real gas laws, combined gas law, equation of state, Dalton's law of partial pressure, perfect gas equation, units and significance of R, PV isotherms of real gases, continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state.	1, 2, 3
3	**Kinetic Theory of Gases:** Kinetic theory of gases, collision diameter, mean free path, average molecular velocities: root mean square, average and most probable velocities, qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter.	3
4	**Liquefactions of Gas:** Avogadro's theory, diffusion and effusion of gases, Graham's law, thermal conductivity of gases, principles of liquefaction, Andrew's experiment & critical phenomena**.**	2
	Section B	**CLOs**
5	**Intermolecular Forces in Liquid:** Dipole-dipole forces, London dispersion forces, Van der Waal's forces, in-dipole forces, hydrogen bonding, properties of liquid, surface tension, adhesive & cohesive forces, viscosity, relative viscosity measurement, viscosity co-efficient, temperature dependence of viscosity.	3, 4, 6
6	**Basic Concept of Liquid:** Vapor pressure of liquid, measurement of vapor pressure & its variation with temperature, kinetic theory of vapor pressure, boiling point of liquid, Trouton's rule**.**	5
7	**System in Equilibrium:** Introduction to equilibrium, types of equilibrium, physical and chemical equilibrium, equilibria in ionic solution, acid-base equilibria, homogeneous & heterogeneous system.	3, 6
8	**Chemical Equilibrium:** Laws of mass action, equilibrium constant, properties of equilibrium constant, criteria of chemical equilibrium, Le-Chatelier principle, effect of concentration, temperature, pressure & catalyst on equilibrium constant, application of Le-Chatelier principle.	3, 5, 6

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the fundamental knowledge about the characteristics of matter at different states.	A1
	CLO 2	explain and apply laws that describe the behavior of gases.	B2
	CLO 3	analyze and manipulate different parameters of gas.	A2, C2
	CLO 4	compare different intermolecular forces and different states and chemical changes.	A2, B2
	CLO 5	explain the vapor pressure of liquids and their variation with temperature.	A1
	CLO 6	analyze different real-life phenomena connected to liquids and gases.	B2, C1, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study Question & Answer Session,	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Session, Team/Group Work, Problem Solving, Brain Storming, Case Study, Question & Answer	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Atkins, P. Paula, J. Physical Chemistry, 8th Edition, Oxford University Press, New York, 2006. 2. Kapoor, K.L. A Textbook of Physical Chemistry: Volume-2, McGraw Hill Education, 2019.
Supplementary Readings	1. Laidler, K.J. Meiser, J.H. 1st Edition, CBS Publishers & Distributors, New Delhi, 2006. 2. Kundu, N. Jain, S.K. Physical Chemistry, 1st Edition, S. Chand & Co. Ltd., New Delhi, 1996. 3. Glasstone, S. Text Book of Physical Chemistry, 2nd Edition, (reprint), The Macmillan Press Ltd., London, 1972. 4. Gordon M Barrow, Physical Chemistry, 5th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009. 5. Bahl, A. Bahl B.S. Tuli, G.D. Essentials of Physical Chemistry, 1st Edition, S. Chand and Co Ltd., New Delhi, 2011.

Course No: 0531 18 Chem 1104	Credit: 1	Year: First	Term: First
Course Title: Physical Chemistry Sessional-I		Course Status: Core	
Prerequisite	None		
Rationale	This course will provide the practical demonstration of experimental techniques of determining physical parameters matter.		

COURSE CONTENTS	CLOs
1. Measurement of density of solution at different molar concentration and at different temperature and determine the density of unknown solution from calibration curve. **2.** Determination of relative viscosity coefficient. **3.** Determination of molecular radius of polymer from viscosity measurement. **4.** Determination of the cross-section area of a surface-active molecule by surface tension measurements. **5.** Determination of equilibrium constant of a reaction.	1-4

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	organize the handling of small but sophisticated instruments.	A4, D1
	CLO 2	perform identifying the important issues to be considered during laboratory work.	A2, C2
	CLO 3	to do scientific calculations.	C1
	CLO 4	justify the theoretical values of physical parameters with experimentally obtained values.	A2, A3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
2	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
3	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
4	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
5	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Khosla, B.D. Garg, V.C. Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co, India, 2018. 2. Garland, C.W. Nibler, J.W. Shoemaker, D.P. Experiments in Physical Chemistry. 8th Edition, McGraw-Hill, New York, 2009.

Supplementary Readings	1. Halpern, A.M. McBane, G.C. Experimental Physical Chemistry, 3rd Edition, W.H. Freeman & Co., 2006. 2. Sindhu, P.S. Practical's in Physical Chemistry, Macmillan Publishers India Limited, 2005. 3. Wilson, J.M. Newcombe, R.J. Denaro, A.R. Experiments in Physical Chemistry, 2nd Edition, Elsevier Science, 2013. 4. Viswanathan, B. Raghavan, P.S. Practical Physical Chemistry, 1st Edition, Viva Books Pvt. Ltd, New Delhi, 2009. 5. Athawale, V.D. Paul Mathur, Experimental Physical Chemistry, 1st Edition, New Age International Pvt. Ltd, New Delhi, 2001.

Course No: 0541 18 Math 1151	**Credit:** 3	**Year:** First	**Term:** First
Course Title: Differential and Integral Calculus		**Course Status:** Core	
Prerequisite	None		
Rationale	The concept of the rate of change of one quantity with respect to another quantity and finding the area are the fundamental problems in the branch of mathematics which is studied in the name of Calculus. Generally, the part of calculus concerned with finding tangent lines and rates of change is called differential calculus and that part concerned with finding areas is called integral calculus.		

COURSE CONTENTS		**CLOs**
Section A		
1	Understanding the geometric behavior of elementary functions and families of curves- $y = mx + c,\ y = x^n, y = \left(1/x\right)^n, y = e^x, y = \log_a x$ etc.	1, 2, 3
2	Basic concepts of limit, continuity	1, 2
3	Differentiation of different types of functions e.g. parametric, explicit etc. Differentials, differentiability and physical meaning of differentiation, applications of differentiation	4, 5
4	Successive and Partial differentiation	4, 5
5	Expansion of functions: Rolle's theorem, Mean value and Taylor's theorem	2, 3
6	Maxima and minima: single variable and it's applications	
Section B		**CLOs**
4	Basics of Integration: definite and indefinite, proper and improper integrals, antiderivative and physical meaning of integration	5, 7
5	Integration by method of substitution	5, 7
6	Integration by parts	7
7	Special Trigonometric functions	1, 3
8	Definite integrals	6
9	Application of definite integral in geometry science and engineering: Area between two curves, volumes by slicing, solids of revolution, area of a surface of revolution, length of a curve	6, 7

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	state various elementary functions both algebraically and graphically.	A1
	CLO 2	explain the graph of the equation which follow function or inverse function.	C1
	CLO 3	identify the behavior of a function and continuity of various types of functions.	A1
	CLO 4	illustrate the application of differentiation in real world problem.	D1
	CLO 5	explain the computation of differentiation of a function many times and partially.	C1
	CLO 6	describe the real understanding of the connection between area and integration.	D3
	CLO 7	manipulate different integration by various methods.	C1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations
6	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations
7	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Thomas, G.B. Calculus, 11th Edition, Addison Wesley Publishing Company, 2005. 2. Anton, H. Bevens, I. Davis, S. Calculus, 8th Edition, John Wiley & Sons, Inc. 2005 3. Maccullum, W.G. Quinney, D. Flath, D. Hallett, D.H. Calculus Single and Multivariable, 3rd Edition, John Wiley & Sons Inc., 2002.
Supplementary Readings	1. Mohammad, K. A. Textbook of Co-ordinate Geometry and Vector Analysis, The University Press, 2012. 2. Ayres, F.J. Schaum's Outlines of Theory and Problems of Matrics, 4th Edition, 1999

	3. Edward C.H. Penney, E.D. Calculus and Analytics Geometry, Prentice Hall Inc., 1988. 4. Swokowski, E.W. Calculus with Analytic Geometry, PWS Publishers, Boston, Massachusetts, 1983.

Course No : 0533 18 Phy 1153	**Credit:** 3	**Year:** First	**Term:** First
Course Title: Properties of Matter		**Course Status :** Core	
Prerequisite	None		
Rationale	This is the rudimentary course of physics, which covers mechanics, waves, and oscillation. It will lead students to an understanding of physical quantities and gain solid knowledge about the basic properties of matter.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Vector Analysis:** Definition, vector and scalar quantities; vector addition and subtraction; vector and dot product of two vectors; triple products, derivatives of vector, gradient, divergence and curl of a vector.	1
2	**Conservation of Energy and Linear Momentum:** Conservative and non-conservative forces and systems; conservation of energy and momentum, center of mass, collision problem.	2, 3
3	**Rotational Motion:** Rotational quantities as vectors, rotational variables, torque and angular momentum, moment of inertia, parallel axis and perpendicular axis theorem, combined translational and rotational motion of rigid body.	4, 5
4	**Elasticity:** Moduli of elasticity, Poison's ratios, relation between elastic constants and their determination, Cantilever, flat spiral spring.	6
Section B		**CLOs**
5	**Surface Tension:** Molecular theory, surface tension and surface energy, adhesive and cohesive forces, pressure inside a soap bubble, contact angle.	7
6	**Fluid Dynamics:** Viscosity and coefficient of viscosity, Posseule's equation, determination of the coefficient of viscosity of liquid by Stock's method; Bernoulli's theorem and its applications; Torricelli's theorem, venturimeter.	8
7	**Oscillatory Motions:** Hook's law; simple harmonic motion; combination of harmonic motions; damped harmonic motion; forced oscillation and resonance.	9
8	**Waves in Elastic Media:** Physical description of a wave, types of waves, traveling waves, equation of a traveling wave; speed of propagation of waves in a stretched string; transmission of energy of a traveling wave; superposition principle; group and phase velocity.	10
9	**Sound Waves:** Audible, ultrasonic and infrasonic waves; propagation and speed of longitudinal waves; vibrating systems; source of sound, beats, doppler effect; acoustics.	11, 12

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	describe vectors, addition, subtraction, and scalar multiplication, gradients, divergence,	A1

		and curl.	
	CLO 2	explore the properties of matter.	A1
	CLO 3	apply the conservation of angular momentum to different dynamical problems.	C1
	CLO 4	determine the modulus of rigidity of the materials.	C1
	CLO 5	demonstrate how surface tension relates directly to a wide range of practical relationships and applications.	C3
	CLO 6	explain a wide variety of applications of fluid dynamics, such as calculating force and moments, determining the mass flow rate of oil through pipelines.	A2
	CLO 7	explain of SHM and its applications.	A1
	CLO 8	describe the basic characteristics of wave motion: wavelength, amplitude, period, frequency, and wave speed	A1
	CLO 9	explain the properties of musical sound.	A1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture and Team Teaching	Quiz and Class Test
2	Problem-based Learning & Presentation	Assignment and Final Exam
3	Problem-based Learning & Presentation	Quiz and Class Test
4	Problem-based Learning & Presentation	Assignment and Final Exam
5	Lecture and Group Discussion, Question & Answer Session	Viva voce and Final Exam
6	Lecture & Team Teaching	Assignment and Final Exam
7	understand of SHM & its applications	Quiz and Class Test
8	describe the basic characteristics of wave motion: wavelength, amplitude, period, frequency & wave speed	Viva voce and Final Exam
9	Explain the properties of musical sound.	Assignment and Final Exam

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Mathur, D.S. Elements of Properties of Matter, S. Chand Publishing India, 2008. 2. Halliday, D. Resnick, R. Fundamental of Physics, John Wiley & Sons, New York, 2003. 3. Main, I.G. Vibrations and Waves in Physics, 3rd Edition, Cambridge University Press, 1993. 4. Puri, S.P. Vibrations and Waves, Macmillan Publishers India, 2004. 5. Pain, H.J. Physics of Vibrations and Waves, 6th Edition, John Wiley & Sons, 2005.

Supplementary Readings	1. Bajaj, N.K. The Physics of Waves and Oscillations, Tata McGraw Hill, 1998. 2. Symon, K.R. Mechanics, 3rd Edition, Addison-Wesley, 1971. 3. Spiegel, M.R. Vector Analysis, 2nd Edition, McGraw-Hill, 2009. 4. French, A.P. Vibrations and Waves, CBS Publishers & Distributors Pvt Ltd. India, 2003. 5. Morse, P.M. Vibration and Sound, 2nd Edition, McGraw-Hill, 1948.

Course No: 0533 18 Phy 1154	**Credit:** 1	**Year:** First	**Term:** First
Course Title: Physics Sessional-I		**Course Status:** Core	
Prerequisite	None		
Rationale	This course introduces the experiments on elasticity, rotational mechanics, gravitation and fluid mechanics. In this course students will learn to operate and work with Searle's apparatus, fly wheel, compound pendulum, capillary tubes and traveling microscope etc.		

COURSE CONTENTS	**CLOs**
1. Determination of the Young's modulus & rigidity modulus of a short wire by Searle's dynamic method. 2. Determination of the moment of inertia of a fly wheel about its axis of rotation. 3. Determination of the value of g', acceleration due to gravity, by means of a compound pendulum. 4. Determination of the surface tension of water by capillary tube method. 5. Determination of the co-efficient of viscosity of a liquid by its flow through a capillary tube.	1-5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	calculate the young's and rigidity moduli by using searle's apparatus.	A3, C3
	CLO 2	find the moment of inertia of a fly wheel about its axis of rotation.	A3, C3
	CLO 3	estimate the value of g using a compound pendulum.	A3, C3
	CLO 4	determine surface tension of water using capillary tube.	A3, C3
	CLO 5	evaluate the coefficient of viscosity of a liquid and find its variation with temperature.	A3, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
2	Lecture, Discussion & Conduct	Assignments, Oral and Practical

	Experiment	Examinations
3	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
4	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
5	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Mathur, D.S. Elements of Properties of Matter, S. Chand Publishing India, 2008. 2. Halliday, D. Resnick, R. Fundamental of Physics, John Wiley & Sons, New York, 2003. 3. Main, I.G. Vibrations and Waves in Physics, 3rd Edition, Cambridge University Press, 1993. 4. Puri, S.P. Vibrations and Waves, Macmillan Publishers India, 2004. 5. Pain, H.J. Physics of Vibrations and Waves, 6th Edition, John Wiley & Sons, 2005.
Supplementary Readings	1. Bajaj, N.K. The Physics of Waves and Oscillations, Tata McGraw Hill, 1998. 2. Symon, K. R. Mechanics, 3rd Edition, Addison-Wesley, 1971. 3. Spiegel, M.R. Vector Analysis, 2nd Edition, McGraw-Hill, 2009. 4. French, A.P. Vibrations and Waves, CBS Publishers & Distributors Pvt Ltd. India, 2003. 5. Morse, P.M. Vibration and Sound, 2nd Edition, McGraw-Hill, 1948.

Course No: 0231 18 Eng 1155	**Credit:** 3	**Year:** First	**Term:** First
Course Title: Communicative English		**Course Status:** Core	
Prerequisite	None		
Rationale	This course is designed to provide an opportunity to enrich the skills of English Language and their proper uses and development of communicative competence.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Development of Vocabulary:** Processes of Word Formation and Transformation; Proper use of parts of speech.	1, 2
2	**Sentence Structure:** Structures of Basic Sentences, Identification of Clauses and Phrases, Joining sentences, Transformation of Sentences, Framing W/H Questions.	3
3	**Reading and Understanding:** Perspectives on reading comprehension; Elements of reading: vocabulary, syntax and meaning; Reading strategies: intensive and extensive reading; scanning and skimming; prediction and inference; reader's expectation and interpretation; contextual understanding and understanding the whole text; effective note-taking.	4, 5, 6
Section B		**CLOs**

4	**Development of Speaking Skills:** Art of Good Speaking, Notions and Functions, Speaker-listener Rapport, Intonation and Stress	7, 8
5	**Development of Writing Skills:** Process of writing	9, 10
6	**Understanding Academic Writing:** features and elements, Mechanics in Writing: Capitalization and Punctuation; Generating ideas for a writing task; Drafting and Supporting ideas with evidence; Integrating data and graphics in texts; Modes of writing, Writing tasks: Paragraph, Essay, Summary, Précis, Report, Abstract, Letter of Application, Assignment, Examination Paper	9, 10
7	**Development of Listening Skills:** Guide Lines for Developing Listening Skills, Role of a Good Listener, Listening Comprehension	11

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	learn about the proper use of parts of speech.	A1
	CLO 2	apply how to transform one part of speech into another part.	A1
	CLO 3	frame w/h questions.	A1
	CLO 4	explain about the perspectives on reading comprehension.	A1
	CLO 5	learn about the elements of reading.	A1, D1
	CLO 6	evaluate the reading strategies.	A1, D1
	CLO 7	attain the art of good speaking.	A1, B2
	CLO 8	apply practically different notions of speaking.	A1, B2, B3
	CLO 9	identify the mechanics in writing.	A1, B1, B2, D1
	CLO 10	implement practically different structures of writing.	A1, B1, B2, D1
	CLO 11	become skilled at how to develop listening skill.	B1, B3, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1-2	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
3-4	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
5-6	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
7-8	Discussion, Team/Group Work, Problem Solving, Brain Storming, Case Study, Question & Answer Session,	Assignments, Term papers, Oral and Written Examinations
9-11	Problem Solving & Brain Storming	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Lewis, N. Word Power Made Easy: The Most Effective Vocabulary Builder in the English Language, Bloomsbury Publishing PLC, 1990. 2. Thomson, A.J. Martinet, A.V.A Practical English Grammar, Oxford University Press, 1960. 3. Swan, M. Practical English Usage, 3rd Edition, Oxford University Press, 2005.
Supplementary Readings	1. Leech, G. Svartvick, J.A. Communicative Grammar of English, Routledge, 2004. 2. Eastwood, J. Oxford Practice Grammar, Oxford University Press, 2014. 3. Swan, M. Practical English Usage, OUP, 1995. 4. Wood, F.T. Remedial English Grammar, Macmillan, 2007. 5. Lyons, L.H. Heasly, B. Study Writing, Cambridge University Press, 2006.

Course No : 0611 18 CSE 1157	**Credit :** 3	**Year :** First	**Term:** First
Course Title : Computer Fundamentals		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental understanding of computer: hardware, and software to better equip students for using computers efficiently in further education.		

COURSE CONTENTS		CLOs
Section A		
1	**Introduction to Computers:** History, uses, introduction to computer organization, types of computers, different types of microcomputers, characteristics of computers, limitations of computers.	1
2	**Computer Hardware:** Overview, main components of a computer: CPU, ALU, BUS, registers, primary memory, secondary memory, RAM, ROM; optical storage devices: CD, DVD etc.; input and output devices: keyboard, mouse, scanners, printers, plotters, clock speed vs memory size.	1,2
3	**Number System**: Decimal, binary, octal, hexadecimal and conversion among them; alphanumeric codes, Binary arithmetic.	3
4	**Multimedia**: Types of media: Text, Audio, Video, Animation, Graphics, Virtual Reality; Multimedia Applications.	4
Section B		**CLOs**
5	**Operating System and computer software:** Definition, function and classification of operating system, Software and it's classification, use of software, types of software: system software, application software; opensource software, Viruses and Anti-virus software, utility software, driver software, overview of programming languages	4
6	**Networks and Internet:** Types of networks: LAN, PAN, WAN, WLAN. Networking devices: router, switch, hub; Fiber optic network and basic	5

	devices: ONU, Fiber optic cable, splitter, media converter, active vs passive devices, basic services of the internet: Communication, File Transfer, TELNET; Domains, DNS, Benefits of a network, Ip address, mac address. Internet Policies: AUP, Privacy policy, Benefits of a network, Uses of internet, website, web browser.	
7	**Email**: traditional mail vs e-mail, e-mail fields**:** from, to, cc, bcc, digital signature, Sending and receiving emails**,** email forwarding, Basic email Protocols: POP3, SMTP, IMAP; Threats to email security: Phishing, spoofing, malware, ransomware, email etiquettes, SPAM mail, anti-spam techniques.	6

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the basic concepts of various key aspects of a computer and related technologies	C1, C2, D3
	CLO 2	test and analyze an existing computer-based system, process, component or program	A3, D3
	CLO 3	use current techniques, skills and tools for computing practice	A3, D3
	CLO 4	discuss and use different types of operating system, related software and multimedia	C1, B2, D3
	CLO 5	demonstrate how do network, and internet work and its policy	B2, D3
	CLO 6	communicate through email and Protect computers from different types of viruses	B1, B2, D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Multimedia Presentation	Term papers, Oral and Written examinations
2	Lecture, Multimedia Presentation, Group discussion	Assignments, Term papers, Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Lecture, Discussion, Question & Answer Session, Case Study	Term papers, Oral and Written examinations
5	Lecture, Multimedia Presentation, Group discussion	Assignments, Term papers, Oral and Written examinations
6	Lecture, Multimedia Presentation	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Goel, A. Computer Fundamentals, Pearson publishers, India, 2010. 2. Ram, B. Kumar, S. Computer Fundamentals: Architecture & Organization, 6th Edition, New Age International, India, 2020. 3. Bangia, R. Computer Fundamentals and Information Technology. Firewall Media, India, 2008.
Supplementary Readings	1. Das, S. A Complete Guide to Computer Fundamentals, University Science Press, India, 2010. 2. Norton, P. Introduction to Computers, 6th Edition, McGraw-Hill companies, New York, 2006. 3. Rajaraman, V. Fundamentals of Computers, 3rd Edition, Prentice-Hall of India, 1999. 4. Arora, A. Computer Fundamentals and Applications. Vikash publishing house, India, 2015. 5. Nagpal, D.P. Computer Fundamentals: Concepts, Systems and Application, S Chand and Company Limited, India, 2018.

Course No : 0611 18 CSE 1158	**Credit :** 1	**Year :** First	**Term:** First
Course Title : Computer Fundamentals Sessional		**Course Status :** Core	
Prerequisite	None		
Rationale	This course will provide an opportunity to develop practical experience in operating computers and to better equip students for using computers efficiently in further education.		

COURSE CONTENTS	CLOs
Exploring Microsoft Office: Detail learning and practice of word processing, multimedia presentation, spread sheet analysis and effective web search using contemporary packages.	1
Writing chemistry texts involving chemical formulae: Molecular structure drawing using chemwin 2D and 3D.	2

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	Analyze data and write reports based on online materials and make presentation	A4, B1, D3
	CLO 2	Draw 2D and 3D molecular structure of different molecules	A2, D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1, CLO2	Lecture, Discussion, Question & Answer Session, Practical classes	Sessional Examination, Viva Voce

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Maidasani, D. Learning Computer Fundamentals: MS Office and Internet & Web Tech, Firewall Media, India, 2006. 2. Moorning, K.M. Computer Fundamentals: A Practical Guide, Kendall Hunt Publishing Company, 2009.
Supplementary Readings	1. Kumari, R. Computers and Their Applications to Chemistry, Alpha Science International Limited, England, 2002. 2. Kevin, W. Exploring Microsoft Office, Elluminet Press, 2020. 3. Weverka, P. Office 365 All-in-One for Dummies, John Willey and Sons, 2019.

First Year Second Term

Course No: 0531 18 Chem 1201	Credit: 3	Year: First	Term: Second
Course Title: Solution and Phase Equilibrium Chemistry		Course Status: Core	
Prerequisite	None		
Rationale	This course is designed to increase fundamental understanding of the equilibrium properties of solutions.		

COURSE CONTENTS		CLOs
Section A		
1	**Solution:** Types of solution, solubility and solubility product, effect of temperature and pressure on solubility; common ion effect; Different forms of Henry's law, limitation of Henry's law, Distribution law and saturated solution, thermodynamic and kinetic derivation of distribution law, Application of distribution law: determination of equilibrium constant, molecular weight of a polymer, extraction of a component from a solution mixture, limitation of distribution law.	1
2	**Ideal Solution:** Completely soluble, partially soluble and immiscible liquids, distribution of solid between two immiscible liquids, Vapor pressure of ideal solution, vapor pressure of actual liquid pairs; azeotropic mixture; distillation of binary miscible solutions, distillation of immiscible liquids, fractional and steam distillation, different types of fractionating column, critical solution temperature (CST), effect of pressure on CST, solution of gases in water, effect of temperature, nature of gas and presence of a salt in water on the solubility of Absorption coefficient.	2, 3
3	**Solvent System:** Protic and aprotic Solvents; non-aqueous solvents (liquid ammonia, HF, liquid di nitrogen tetra oxide (N_2O_4), BF_3, anhydrous sulfuric acid).	4
Section B		**CLOs**
4	**Colligative Properties of Solution:** Vapor pressure of solution; Rault's law of vapor pressure; Elevation of boiling point, Boiling point diagrams; Depression of freezing point; osmotic pressure, mechanism of osmosis, thermodynamic derivation of laws of osmotic pressure, The molecular Sieve theory, Membrane Solution theory, Vapor pressure theory, Membrane-Bombardment theory, Van't Hoff-Boyles law, Pressure-temperature law of solution, Van't Hoff-Avogadro's law, Degree of dissociation, and degree of association.	5
5	**Solution of Electrolyte:** Colligative properties of electrolyte, Arrhenius theory of electrolytic dissociation, Debye-Huckel theory of inter ionic attraction.	6
6	**Phase Equilibria and phase rule:** Phase, component and degree of freedom, deduction of phase rule and its applications; one component system like water, sulfur and phosphorus, Solid – liquid equilibria, liquid-liquid equilibria and liquid-vapor equilibria; Phase diagrams for partially miscible liquid systems, Salt and water system, Sulfur-naphthalene system; efflorescence and deliquescence; principle of the phase diagram	7

	for three component system.	

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain different types of solutions and effect of temperature and pressure on the solubility.	A1, A4
	CLO 2	conceptualize the azeotropic mixture	A1, C1
	CLO 3	organize an experiment to separate immiscible solvents by distillation process.	A1, A2, C1
	CLO 4	describe protic, aprotic and non-aqueous solvent systems.	A1
	CLO 5	explain colligative properties of solution.	A1
	CLO 6	interpret Debye-Huckel theory of interionic interaction.	A1
	CLO 7	assemble phase diagram of one or two component system	A2, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work	Assignments, Term papers, Oral and Written Examinations
5	Presentation, group discussion, Problem Solving	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
7	Presentation, group discussion	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Atkins, P. Paula, J. Keeler, J. Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2017. 2. Nagi, A.S. Anand, S.C.A. Textbook of Physical Chemistry, Wiley Eastern Ltd, India, 2004.
Supplementary Readings	1. Kheterpal, S.C. Pradeep's Physical Chemistry, Volume-1&2, Pradeep Publications, India, 2022. 2. Mortimer, R.G. Physical Chemistry, 2nd Edition, Elsevier, 2000. 3. Ball, D.W. Physical Chemistry, 1st Edition, Thomson Press, 2011. 4. Engel, T. Reid, P. Physical Chemistry: Thermodynamics,

	Statistical Thermodynamics, and Kinetics, 4th Edition, Pearson, 2018. 5. Bahl, B.S. Tuli, G.D. Bahl A. Essentials of Physical Chemistry, 11th Edition, S. Chand & Company Ltd, New Delhi, 2011. 6. Huque, M.M. Auni A. Advanced Physical Chemistry, Volume-1&2, ADS printing press, Bangladesh, 2018.

Course No: 0531 18 Chem 1202	**Credit:** 1	**Year:** First	**Term:** Second
Course Title: Physical Chemistry Sessional-II		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide understanding of solubility product of different compounds in different solvents as well as phase diagram of various systems.		

COURSE CONTENTS	**CLOs**
Section A	
1. Determination of the solubility product of ionic salt in water and the effect of another salt on the solubility of targeted salt. 2. Evaluation and illustration of the phase diagram of two-component system. 3. Evaluation of the partition co-efficient of a substance in two immiscible solvents 4. Determination of the partial molar volume of a component in a binary mixture.	1-4

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain solubility products of various compounds in different solvents.	A1, A2, D1
	CLO 2	construct phase diagram of different systems.	A1, B2, D1
	CLO 3	measure partition co-efficient between two immiscible solvents.	A1, D1
	CLO 4	compute partial molar volume of a component in a binary mixture.	A1, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO 1-4	Class Lecture, Practical Experiments & Teamwork	Report writing, Final examination, and viva voice

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Nibler, J.W. Garland, C.W. Stine, K. Kim, J. Experiments in Physical Chemistry, 9th Edition, McGraw Hill, USA, 2014. 2. Vishwanathan, B. Raghavan, P.S. Practical Physical Chemistry. Viva Books, 2017.

	3. Firth, J.B. Practical Physical Chemistry, Ulan Press, 2012.
Supplementary Readings	1. Wilson, J.M. Newcombe, R.J. Denaro, A.R. Rickett, R.M.W. Experiments in Physical Chemistry, 2nd Edition, Pergamon Press Ltd, USA, 1968. 2. Dogbevia, M.K. Agbo, J.K. Selected Laboratory Experiments in Physical Chemistry, Hastings College Press, 2005. 3. Findlay, A. Practical Physical Chemistry, Legare Street Press, 2021. 4. Athawale, V.D. Experimental Physical Chemistry. New Age International, India, 2001. 5. Abdelfattah, M. Practical Physical Chemistry. LAP Lambert Academic Publishing, 2018.

Course No: 0531 18 Chem 1203	**Credit:** 3	**Year:** First	**Term:** Second
Course Title: Chemistry of Inorganic Reactions		**Course Status:** Core	
Prerequisite	None		
Rationale	This course provides fundamental concepts of inorganic reactions and their applications.		

COURSE CONTENTS		**CLOs**
Section A		
1	**An Overview idea about Chemical Reactions:** Historical overview, basic concept of chemical reactions, classifications of chemical reactions considering by type of product and by reaction outcome. Reactions among the atoms and molecules of the same kind; reaction between atoms and molecules of different substances; miscellaneous types of chemical reactions.	1
2	**Acids-Bases:** Modern concepts of acids and bases; acidbase properties of water; strength of acids and bases; molecular structure and strength of acids; leveling effect, super acids, hard and soft acids and bases; periodic trends in aqua acid strength; acidic, basic and amphoteric oxides; basic and amphoteric hydroxides.**:** Definition of strong acid and strong base,	2, 3
3	**Acid base reactions and titration**: Indicator, weak acid and weak base; pH scale; reactions of strong acids with strong bases; reactions of weak acids with strong bases, reactions strong acids with weak base, reactions weak acids with weak bases; buffer solution and its preparation, buffer action.	3
4	**Oxidation and Reduction Reaction:** Electronic concept, oxidation state and oxidation numbers, assignment of oxidation numbers; auto oxidation, induced oxidation, balancing of redox reactions, oxidation-reduction potentials, oxidizing and reducing agents; prediction of redox reaction. Significance of electrochemical series, Nernst law, applications of electrochemical series Titration curve; change of the electrode potential during redox titration; redox indicator, titration curve, detection of end point in oxidation-reduction titrations; iodometric and iodimetric titration	3, 4
Section B		**CLOs**
5	**Complexmetric reactions and titration:** Definition and classification of ligands; introduction and nomenclature of coordination complex, coordination number and coordination sphere. Complexes in analytical	3, 4

	chemistry, a simple complexation titration, titration curve; types of EDTA titration; titration of mixtures, selectivity, masking and de-masking agents; metal ion indicators; detection of end point	
6	**Inorganic catalysis:** Definition, classifications, applications of inorganic catalysis, homogeneous and heterogeneous catalysis, theory of heterogeneous and homogeneous catalysis	5
7	**Inorganic free radical reactions:** Effects of photon for free radical generations, Methods of generation of free radicals, techniques of study of free radicals; reactions and properties of free radicals.	5
8	**Nuclear reaction:** Radioactivity, classifications of nuclear reactions, Fusion, fission, radioactive decay, apha, beta, and gamma emission, transformation of elements, Applications, properties of radiation, artificial radioactivity,	6

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain a chemical reaction and classification	A1
	CLO 2	determine whether a given chemical substance is an acid or base and their properties	A2, D1
	CLO 3	estimate the concentration of unknown inorganic compounds	C2
	CLO 4	identify redox reaction	C3
	CLO 5	explain the mechanism of inorganic free radical reactions and catalysis	C3, D1
	CLO 6	explain the basic concept of nuclear reaction	A1, B2, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Session, Team/Group Work, Problem Solving, Brain Storming, Case Study, Question & Answer	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended	1. Lee, J.D. Concise Inorganic Chemistry, 5th Edition, John Wiley &

Readings	Sons, 2008. 2. Haider, S.Z. Introduction to Modern Inorganic Chemistry, 2nd Edition, Noor Card Board Offset Press, Bangladesh, 2000. 3. Madan, R.D. Modern Inorganic Chemistry, S Chand & Co: India, 2013.
Supplementary Readings	1. Huheey, J.E. Keiter, E.A. Keiter, R.L. Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2006. 2. Earnshaw, A. Greenwood, N.N. Chemistry of Elements, Elsevier, 2013. 3. Douglas, B.E. Mc Daniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970. 4. Shriver, D.D. Atkins, P. Inorganic Chemistry, 2nd Edition, Oxford University Press, 1994.

Course No: 0531 18 Chem 1204	**Credit:** 1	**Year:** First	**Term:** Second
Course Title: Qualitative Inorganic Analysis Sessional-I		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide an idea about qualitative analysis of inorganic compounds from their mixture.		

COURSE CONTENTS	**CLOs**
1. Identification of inorganic cations and anions in mixture by semi-micro qualitative inorganic analysis. 2. Purification of commercial sodium chloride by (i) Recrystallization and (ii) Salting out processes.	1-3

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	conceptualize the concepts of qualitative analysis.	A1, A2
	CLO 2	develop a capability of systematic semi micro qualitative analysis of cations.	A2, D1
	CLO 3	identify individual ions from mixed salts.	C2, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Laboratory work, Question & Answer Session	Assignments, Report writing, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Laboratory work, Question & Answer Session	Sample analysis, Report writing, Term papers, Oral Examinations
3	Lecture, Discussion, Laboratory work, Case Study, Question &	Sample analysis, Report writing, Term papers, Oral Examinations

	Answer Session	

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Jeffery, G.H. Bassett, J. Mendham, J. Denney, R.C. Vogel's Text Book of Quantitative Chemical Analysis, 5th Edition, Pearson Education, 1989.
Supplementary Readings	1. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996. 2. Verma, R.M. Analytical Chemistry: Theory and practice. CBS Publishers & Distributors India, 2010.

Course No: 0531 18 Chem 1205	**Credit:** 3	**Year:** First	**Term:** Second
Course Title: Introduction to Organic Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental concepts of simple organic compounds (hydrocarbon) as well as organic chemistry.		

COURSE CONTENTS		CLOs
Section A		
1	**Organic Chemistry and Life:** Origin of organic chemistry, functional groups; electronic structure of carbon, covalent bond and shapes of hydrocarbon molecules, formal charge and Lwis structure, general discussion of isomerism and physical properties of organic compounds; electron displacement effect; general mechanism of organic reactions.	1, 2, 3
2	**Alkanes and Cycloalkanes:** Structure and nomenclature of alkane & cycloalkane; sources, preparations, physical and chemical properties of alkanes, reactions of alkanes; knocking and octane number.	3, 4, 5
3	**Alkenes:** Nomenclature, physical and chemical properties of alkenes, classification by structure and preparation; reactions of the carbon-carbon double bond: electrophilic and free radical addition, analysis of alkenes.	3, 4, 5
4	**Alkynes:** Nomenclature, physical and chemical properties of alkynes; source, structure, bonding and preparations of alkynes, reaction of alkynes; acidity of alkynes, analysis of alkynes.	3, 4, 5
Section B		**CLOs**
5	**Alcohols and Ethers:** Structure and classification of alcohols, nomenclature, physical properties and isomerism of alcohols, sources and preparation of alcohols; reactions of alcohol; structure and nomenclature of ether, sources and properties of ether; preparation and reactions of ethers; analysis of alcohols and ethers	2, 3, 4, 5
6	**Organic Compounds Containing C-X:** Classification and nomenclature, physical properties and isomerism; preparations, reactions: nucleophilic aliphatic substitution, kinetics of nucleophilic aliphatic substitution, SN1 and SN2 reactions; cabocations, stability of carbocations, structure and physical properties of aryl halides, preparation and reactions of aryl halides; nucleophilic aromatic substitution; reactivity and orientations.	2, 3, 4, 5
7	**Organic Compounds Containing C-S:** Organo sulpher compounds, nomenclature, physical properties and isomerism, preparation and	2, 3, 4, 5

	reactions of mercaptans, thioetehrs, thio aldehyde, thioketone, thio acids.	
8	**Organic Compounds Containing C-M:** Occurrence, physical properties, preparation and common reactions, applications.	2, 3, 4, 5

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the historical background, fundamental concept, and scope and aim of organic chemistry.	A1, B1
	CLO 2	clarify the bonding, functionalization, and isomerism involves in organic compounds.	A2
	CLO 3	about the properties and nature of organic compounds and their interpretation.	A1, B1, D2
	CLO 4	narrate different methods of preparation and reaction of organic compounds.	A1, A3, B1
	CLO 5	conceptualize the mechanisms of major reaction involves in organic chemistry.	A2, A3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Bahl, A. Bahl, B.S. Advanced Organic Chemistry, 3rd Edition, S. Chand & Company Ltd., New Delhi, 1987. 2. Solomons, T.W.G. Fryhle, C.B. Snyder, S.A. Solomons' Organic Chemistry, 12th Edition, John Wiley & Sons, Inc., 2017. 3. Bahl, A. Bahl, B.S. A Text Book of Organic Chemistry, 22nd Edition, S. Chand & Company Ltd., New Delhi, 2019.
Supplementary Readings	1. Morrison, R.T. Boyd, R.N. Organic Chemistry, 7th Edition, Pearson Education India, 2010. 2. Finar, I.L. Organic Chemistry: Volume 1, 6th Edition, Pearson Education India, 2002. 3. Wade, L.G. Organic Chemistry, 8th Edition, Pearson Education, 2016. 4. Clayden, J. Greeves, N. Warren, S. Organic Chemistry, 2nd Edition, Oxford University Press, 2014.

Course No: 0531 18 Chem 1206	Credit: 1	Year: First	Term: Second
Course Title: Identification of Organic Compound Sessional		Course Status: Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental concepts of practical knowledge on properties, nature, and identification of unknown solid organic compounds.		

COURSE CONTENTS	CLOs
Identification of an unknown organic compound (solid) and evaluate the plausible structure on the basis of the following step: 1. Visual observation, color, and odor of the unknown compounds 2. Perform the solubility test of the unknown organic compounds and classify them 3. Determination of melting point of the unknown organic compounds. 4. Elementary analysis in the unknown organic compounds. 5. Analysis of some basic functional groups depends on element present. 6. Propose a plausible structure of the unknown organic compounds	1-4

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	determine the nature of an unknown organic compound and classify them on the basis of nature.	A1
	CLO 2	explain the role of melting point and boiling point to identify an unknown organic compound.	A1, A2, D2
	CLO 3	identify the elements and simple functional groups present in an unknown organic compound.	A1, A3, D2
	CLO 4	evaluate the plausible structure of an unknown organic compound.	A1, A3, C3

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Shriner, R.L. Fuson, R.C. Curtin, D.Y. Morrill, T.C. Systematic Identification of Organic Compounds, 8th Edition, Wiley & Sons, 2004. 2. Skoog, D.A. West, D.M. Holler, F.J. Crouch, S.R. Fundamentals of Analytical Chemistry, 9th Edition, Thomson Books/Cole, 2014. 3. Lehman, J.W. Operational Organic Chemistry, 4th Edition, Pearson, 2008. 4. Agarwal, O.P. Advanced Practical Organic Chemistry, 1st Edition, Krishna Prakashan Media (P) Ltd. India, 2014.
Supplementary Readings	1. Morrison, R.T. Boyd, R.N. Organic Chemistry, 7th Edition, Pearson Education India, 2010. 2. Finar, I.L. Organic Chemistry: Volume 1, 6th Edition, Pearson Education India, 2002. 3. Bahl, A. Bahl, B.S. A Text Book of Organic Chemistry, 22nd

	Edition, S. Chand & Company Ltd., New Delhi, 2019. 4. Solomons, T.W.G. Fryhle, C.B. Snyder, S.A. Solomons' Organic Chemistry, 12th Edition, John Wiley & Sons, Inc., 2017.

Course No: 0541 18 Math 1251	**Credit:** 3	**Year:** First	**Term:** Second
Course Title: Algebra and Vector Analysis		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to develop the intuitive understanding and computational skills necessary for the concepts of calculus of functions of several variables by tying together vector calculus and vector algebra.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Theory of equation:** Fundamental theorem, roots of polynomials and relation with coefficient, Descart's sign rule, synthetic division.	1
2	**Complex number system:** Field of complex number, geometric representation, De-Moivere's theorem and its applications.	2
3	**Matrix and system of equation:** Definition, different types of matrix, inverse matrix, solution of system of equation by using matrix, rank of matrix, Gaussian elimination.	1
4	**Eigen values and Eigen vector:** Definition, characteristic equation, characteristic equation and Eigen vectors.	4
Section B		**CLOs**
5	**Vector Algebra:** Definitions, properties, vector products and applications.	1,3
6	**Vector differentiations:** Gradients, divergence and curl with physical significance.	4
7	**Geometry in 2D:** Change of axes, pair and straight lines, general equation of second degree.	3
8	**Geometry in 3D:** Basic concept, direction cosines, direction ratios, the equation of plane and straight line.	1, 5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	acquire knowledge about system of linear equations and its real-life applications	A1, B2
	CLO 2	explain about matrices and determinants.	A1, A2
	CLO 3	apply vector to geometry and mechanics	A2, C1
	CLO 4	learn about gradient, curl and divergence.	D1
	CLO 5	adapt with gaussian elimination.	A1, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Group problem solving, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Lecture, Question & Answer Session, Team/Group Work, Case Study	Assignments, Term papers, Oral and Written examinations
5	Lecture, Problem Solving, Brain Storming	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Ellis, R. Gulick, D. Calculus with Analytical Geometry, 4th Edition, Harcourt College Pub, New York, 1989. 2. Khosh, M.A Text Book of Co-ordinate Geometry and Vector Analysis, 5th Edition, The University Press, Dhaka, 2002. 3. Steiner, E. The Chemistry Math Book, 2nd Edition Oxford University Press, New York, 2008.
Supplementary Readings	1. Rahman, A.F.M. Bhattacharjee, P.K. A Text Book on Co-ordinate Geometry with Vector Analysis: Two and Three Dimensions, 9th Edition, S Bhattacharjee, Dhaka, 1995. 2. Thurston, W.P. Three-Dimensional Geometry and Topology, Volume-1, Princeton University Press, New Jersey, 1997. 3. Khan, R.M. Analytical Geometry of Two and Three Dimensions and Vector Analysis, 5th Edition, NCBA, 2017.

Course No: 0533 18 Phy 1253	**Credit:** 3	**Year:** First	**Term:** Second
Course Title: Electricity and Magnetism		**Course Status:** Optional	
Prerequisite	None		
Rationale	Students will learn about voltage, current, electricity, electric circuits. They are familiar with how to connect circuit elements and electricity and magnetism are closely related		

COURSE CONTENTS		CLOs
	Section A	
1	**Electrostatistics:** Charge & matter; Coulomb's law, electric field, electric dipole, electric field due to dipole; dipole in an external electric field; electric flux, Gauss's law and its applications.	1
2	**Capacitance:** Parallel plate capacitors with dielectrics; dielectrics and Gauss's law; dielectric constant, energy stored in an electric field.	1,2
3	**Electric Current:** Electron theory of conductivity; conductor, semiconductor, insulators and superconductors; current and current density; resistivity and conductivity; Kirchhoff's law and its applications.	3

4	**Thermoelectricity:** Thermal e.m.f, Seeback, Peltier and Thomson effects; thermoelectric thermometer.	4
Section B		**CLOs**
5	**Magnetism:** Magnetic field, magnetic force on charge and current; Lorenz force; magnetic materials & their properties.	5
6	**Electromagnetic Induction:** Faraday's experiment, Faraday's law of electromagnetic induction; Lenz's law, Ampere's law, self and mutual inductance.	5
7	**DC circuits:** DC circuits with LR, RC, LC and LCR in series; AC circuits with LR, RC, LC, and LCR in series.	6
8	**AC and DC meters:** Ammeters, voltmeter, ohmmeter, watt meter, frequency meter, AC/DC bridge, digital voltmeter	6

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the concept of electric charge so they can describe the types of charge and the attraction and repulsion of charges.	B1
	CLO 2	calculate the magnitude and direction of the electric field produced by two or more-point charges.	B2
	CLO 3	compare conductivity, resistivity, and resistance, so they can relate current and voltage for a resistor.	A1, B1
	CLO 4	derive an expression for the capacitance of a parallel-plate capacitor.	D1
	CLO 5	distinguish Faraday's law and Lenz's law, so they can recognize situations in which changing flux through a loop will cause an induced emf or current in the loop.	A2, A3
	CLO 6	design a DC circuit diagram with LR, RC, LC and LCR and also AC circuit diagram with LR, RC, LC and LCR.	A2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming,	Assignments, Term papers, Oral and Written Examinations

	Case Study	
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. D. Halliday, D. Resnicks, R. Physics Part II, John Wiley & Sons, Inc., New York, 1968. 2. Huq, M.S. Rafiullah, A.K. Roy, A.K. Concept of Electricity and Magnetism, 1st Edition, Students' Publications, Dacca, East Pakistan, 1969.
Supplementary Readings	1. Kip. F. Fundamentals of Electricity and Magnetism, McGraw-Hill, 1968. 2. Tewari, K.K. Electricity and Magnetism with Electronics, S. Chand Publishing, 1995.

Course No: 0533 18 Phy 1254	**Credit:** 1	**Year:** First	**Term:** Second
Course Title: Physics Sessional-II		**Course Status:** Optional	
Prerequisite	0531 18 Phy-1116		
Rationale	Student will learn how to use various instruments to measure resistance.		

COURSE CONTENTS	**CLOs**
a. Determination of the end correction of a meter bridge. **b.** Determination of the specific resistance of a wire by a meter bridge. **c.** Determination of the value of an unknown resistance by a post office box. **d.** Determination of the resistance of a galvanometer by half deflection method. **e.** Verification of the Ohm's law by using a tangent galvanometer.	1-5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	Solve the end correction of a meter bridge.	A3, B3, D1
	CLO 2	Determine the value of an unknown resistance by a post office box.	A3, B3, D1
	CLO 3	Observe the specific resistance of a wire by a meter bridge.	A3, B3, D1
	CLO 4	Evaluate the galvanometer resistance by half deflection method.	A3, B3, D1
	CLO 5	Verify the ohm's law by using a tangent galvanometer.	A3, B3, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations

2	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
3	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
4	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
5	Lecture, Discussion, & Conduct Experiment	Assignments, Oral and Practical Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Ahmed, G. Shahabuddin, M. Practical Physics for Degree Students, Hafiz Book Center, 2020. 2. Halliday, D. Resnicks, R. Physics Part II, John Wiley & Sons, Inc., New York, 1968. 3. Huq, M.S. Rafiullah, A.K. Roy, A.K. Concept of Electricity and Magnetism. 1st Edition, Students' Publications, Dacca, East Pakistan, 1969.
Supplementary Readings	1. Arora, C.L. B.Sc. Practical Physics, S. Chand Publishing, 2001. 2. Kip. F. Fundamentals of Electricity and Magnetism. McGraw-Hill, 1968. 3. Tewari, K.K. Electricity and Magnetism with Electronics, S. Chand Publishing, 1995.

Course No: 0311 18 Econ 1259	**Credit:** 3	**Year:** First	**Term:** Second
Course Title: Principles of Economics		**Course Status:** Optional	
Prerequisite	None		
Rationale	Understanding principles of economics has immense importance for scientific solution of the problems of resource allocation. By conducting this course students will be acquainted with a thorough grounding in the basic principles of economics and an exposure to a range of applications of the theory in real world problems.		

COURSE CONTENTS		**CLOs**
	Section A	
1	**Introduction:** Definition of economics; nature and scope of economics; micro versus macroeconomics; economic good versus free good.	1
2	**Demand and Supply:** Concepts of demand and supply; law of demand and supply; determinants of demand and supply; movement along demand and supply curves; shifting of demand and supply curves; market demand curve; market equilibrium; shift of equilibrium; consumers' surplus and producers' surplus.	1, 2
3	**Economics of Production, Cost and Revenue:** Factors of production; production function; total, average and marginal products; stages of production; law of diminishing return; returns to scale; isoquant, isocost line and producers' equilibrium. Concept of cost; Short-run and long-run cost; Fixed and variable cost; Total, average and marginal cost; Shape of and inter-relationship between different types of cost curves; Concept of – total, average and marginal revenue.	3

4	**Basic Macro Economic Concepts:** GNP, GDP, NNP, NI; circular flow of income; inflation; unemployment; business cycle; fiscal policy; monetary policy.	2,3,4
Section B		**CLOs**
5	**Economics of Industry:** Concept of firm and industry;measuring the size of firms: small, medium and large scale firms; concept of optimum firm; input-output analysis of inter-industry relation, study of major industrial countries: background, effects, current economic situation; industrialization in Bangladesh; government measurement.	3, 4
6	**Resource Economics:** Definition; types of resources; relation between economics and ecology; categories of resources on the basis of degree of economic importance and discovery; theory of optimal harvest of renewable resources; forest and energy resource of Bangladesh.	4, 5
7	**Environmental Economics:** Concepts of environmental economics; Material Balance Model; role of economics in environmental managements; cost-benefit analysis in environmental decision making.	4, 5
8	**Economics of Regional and Global Pollution:** Types of pollutant; sources of pollution; pollution heaven hypothesis; scope of environmental damage; damage function; environmental quality; sustainable development; risk analysis; pollution reduction versus pollution prevention; economic approaches to greenhouse effect.	3, 4, 5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain the key ideas that define the economic way of thinking as chemist and policy advisers.	A1
	CLO 2	demonstrate substantial knowledge on fundamental economic question of allocating scarce resources, principles of demand, supply, market price and quantity determination.	A2, B1, B2, D1
	CLO 3	grasp the knowledge of production theory, firm behavior and cost.	A1, B2, C2
	CLO 4	analyze the measurement of macroeconomic aggregates and recognize the role of economic activity in environmental management.	A2, B2, D1
	CLO 5	evaluate various policy decisions related to global pollution.	B3, C2, D1, D2,

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study,	Assignments, Term papers, Oral and

	Question & Answer Session	Written Examinations
4	Discussion, Session, Team/Group Work, Problem Solving, Brain Storming, Case Study, Question & Answer	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Mankiw, G.N. Principles of Microeconomics, Volume-1, The Dryden Press, 1991. 2. Robert, E. Lieberman, M. Economics: Principles and Applications, 2nd Edition, South-Western College Pub, 2000. 3. Sowell, T. Applied Economics: Thinking Beyond Stage One, 2nd Edition, Basic Book, 2003.
Supplementary Readings	1. Atkinson, B.A. Public Economics in Action: The Basic Income/Flat Tax Proposal, Oxford University Press, USA, 1997. 2. Sowell, T. Basic Economics, Basic Book, 2003. 3. Sowell, T. Weiner, T. Basic Economics, Fifth Edition: A Common-Sense Guide to the Economy, Blackstone Audio, Inc., 2014 4. Larouche, H.L. Basic Economics for Conservative Democrats, 2nd Edition, New Benjamin Franklin House, 1980.

Second Year First Term

Course No : 0531 18 Chem 2101	Credit : 3	Year : Second	Term: I
Course Title : Chemical Thermodynamics		Course Status : Core	
Prerequisite	None		
Rationale	This course will give an overview of the mathematical relation between thermodynamic properties and equilibrium of different system.		

COURSE CONTENTS		CLOs
Section A		
1	**Introduction:** Systems and surroundings, state and state functions, work, energy, and heat; the first law: statement and formulation; derivation of expression for expansion work and its application at different conditions; reversibility and maximum work; the enthalpy of a system, heat capacity, dependence of state functions on variables.	1,4
2	**Thermochemistry:** Energy changes in chemical reactions, heat of reaction, enthalpy; standard states, standard enthalpy changes (enthalpy of ionization, enthalpy of neutralization, enthalpy of a reaction, enthalpy of vaporization); heat of combustion, heat of solution, integral heat.	2
3	**Thermochemical Equations:** Hess's law of heat summation; heat of formation, thermoneutrality of salt solution; heat of neutralization of acids and bases; heat of formation of ions, heat of reaction from bond enthalpies; variation of heat of reaction with temperature: Kirchhoff equation.	3
4	**Second Law of Thermodynamics:** Spontaneous process and reversible process; second law: statement; heat engine, Carnot cycle, application of Carnot cycle.	1,2,5
Section B		**CLOs**
5	**The Third Law of Thermodynamics:** Entropy, entropy change in isolated systems; dependence of entropy on variables of a system; entropy change in ideal gases; entropy change in physical transformation; entropy change in chemical reactions, evaluation of absolute entropies; use of absolute entropies.	1
6	**Free Energy:** The Gibbs energy and the Helmholtz energy, properties and significance of Gibbs and Helmholtz energy; Gibbs energy and reversible work; Maxwell relation, thermodynamic equation of states, mathematical relationship between different thermodynamic quantities, Gibbs-Helmoltz equation, dependence of free energy on pressure and temperature.	1,2
7	**Chemical Potential:** Fugacity, activity, activity coefficient, Clapeyron equation, Clausius-Clapeyron equation, chemical potential of a substance in pure state and in a mixture; thermodynamic limitations to energy conversion (refrigeration and liquefaction, heat pumps, chemical conversion).	1,2
8	**Thermodynamic Equilibrium Constant:** Equilibrium constant from thermal data; Ellingham's diagram; ATP –the carrier of energy; thermodynamics of solution.	2, 3,

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	describe and use the concepts of internal energy, enthalpy, entropy, free energy and chemical potential	A1, C2
	CLO 2	analyze chemical equilibria in ideal and non-ideal systems	A3, C3
	CLO 3	use the theoretical work in different chemical systems	A2, B2, C3
	CLO 4	apply the first law of thermodynamics on closed and control volume systems	A3, C1
	CLO 5	implement second law of thermodynamics and entropy concepts in analyzing the heat engines and refrigerators	A3, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Atkins, P. Paula, J. Physical Chemistry, 8th Edition, Oxford University Press, New York, 2006. 2. Levain, I.R. Physical Chemistry, 6th Edition, McGraw-Hill Education, USA, 2009.
Supplementary Readings	1. Mahan, B.H. Elementary Chemical Thermodynamics, 2nd Edition, Courier Corporation, New York, 2013. 2. Rankin, W.J. Chemical Thermodynamics: Theory and Applications, 1st Edition, CRC Press, 2019. 3. Stolen, S. Grande, T. Chemical Thermodynamics of Materials: Macroscopic and Microscopic Aspects. John Wiley & Sons, UK, 2004.

Course No : 053118 Chem 2102	Credit : 1	Year : Second	Term: I
Course Title : Chemical Thermodynamics Sessional		Course Status : Core	
Prerequisite	None		
Rationale	This course will provide the practical demonstration of experimental techniques for analyzing the basic laws of heat transfer.		

COURSE CONTENTS	CLOs
1. Determine the heat of neutralization of hydrochloric acid with sodium hydroxide 2. Determine the integral heat of solution of solids calorimetrically 3. Determination of heat of solution from solubility measurement 4. Verification of the Hess's law of constant heat summation	1-5

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	identify the important issues to be considered during laboratory work	A1
	CLO 2	justify the theoretical values of physical parameters with experimentally obtained values	A2, C1
	CLO 3	account for the consequence of heat transfer in thermal analyses of engineering systems	A4
	CLO 4	explain the fundamentals of convective heat transfer process	B2
	CLO 5	evaluate heat transfer coefficients for different systems	B3, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Discussion, Team/Group Work, Problem Solving	Assignments, Oral test, Lab test
2	Discussion, Team/Group Work, Problem Solving	Assignments, Oral test, Lab test
3	Discussion, Team/Group Work, Problem Solving	Assignments, Oral test, Lab test
4	Discussion, Team/Group Work, Problem Solving	Assignments, Oral test, Lab test
5	Discussion, Team/Group Work, Problem Solving	Assignments, Oral test, Lab test

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Atkins, P. Paula, J. Physical Chemistry, 8th Edition, Oxford University Press, New York, 2006.

	2. Garland, C.W. Nibler, J.W. Shoemaker, D.P. Experiments in Physical Chemistry. 8th Edition, McGraw-Hill, New York, 2009.
Supplementary Readings	1. Mahan, B.H. Elementary Chemical Thermodynamics, 2nd Edition, Courier Corporation, New York, 2013. 2. Rankin, W.J. Chemical Thermodynamics: Theory and Applications, 1st Edition, CRC Press, 2019. 3. Stolen S. Grande T. Chemical Thermodynamics of Materials: Macroscopic and Microscopic Aspects, John Wiley & Sons, UK, 2004.

Course No : 0531 18 Chem 2103	**Credit :** 3	**Year :** Second	**Term:** First
Course Title : Chemistry of Elements		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to deliver details chemistry about transition elements, lanthanides and actinides		

COURSE CONTENTS		**CLOs**
Section A		
1	**Alkali and Alkaline Earth Metal:** Occurrence and abundance; electronic structure; physical properties; common reactions; oxides, hydroxides, peroxides, and superoxides; hardness of water.	1, 2
2	**Chemistry of Carbon and Phosphorous:** Occurrence; extraction; general properties; oxidation states; chemical reactivity; allotropy; oxides and oxy-acids; radicals.	1, 2
3	**Chemistry of Chalcogen and Halogen:** Abundance; extraction; uses, physical & chemical properties; oxy-acids, hydrogenous compounds and oxides.	1, 2, 3
4	**Chemistry of Inert elements:** Recovery and uses of inert elements; physical and chemical properties of the noble gases; clathrates, condition for the formation of clathrates; structure and bonding of inert gases compounds.	1, 2,
Section B		**CLOs**
4	**Chemistry of Manganese and Iron:** Occurrence; abundance; extraction and uses; oxidation states; general properties; reactivity; some common compounds; biological importance and steel making properties of iron.	1, 2, 3, 4
5	**Chemistry of Cobalt and Nickel:** Occurrence, abundance, extraction and uses, oxidation states, general properties, reactivity, some common compounds, horizontal comparisons in the iron and cobalt and nickel group.	1, 4, 5
6	**Chemistry of Copper and Zinc:** Occurrence; abundance; extraction and uses, oxidation states; general properties; reactivity and some common compounds.	1, 4, 5
7	**Chemistry of Lanthanides and Actinides:** General features; lanthanides and actinides contractions; separations; variable valency; magnetic and spectral properties; common lanthanide and actinides compounds; comparison of lanthanide ions and transition metal ions and super actinides**.**	1, 3, 4, 5

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain about the occurrence and abundance of various elements	A1, D1
	CLO 2	explain different physical and chemical properties of elements	A1, D1, D2
	CLO 3	comment about hardness of water and way of solving	A2, D2, C3
	CLO 4	judge the superiority of a production method compared to other method	C1, C2,
	CLO 5	comment about the difference between different rows of transition metals	D1, D2
	CLO 6	explain the applications of elements in periodic table	A4, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Lee, J.D. Concise Inorganic Chemistry, 5th Edition, John Wiley and Sons, 2008. 2. Haider, S.Z. Introduction to Modern Inorganic Chemistry, 8th Edition, Noor Card Board Offset Press, Bangladesh, 2000. 3. Madan, R.D. Modern Inorganic Chemistry, S Chand & Co: India, 2013.
Supplementary Readings	1. Huheey, J.E. Keiter, E.A. Keiter, R.L. Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2006. 2. Earnshaw, A. Greenwood, N.N. Chemistry of Elements, Elsevier, 2012. 3. Douglas, B.E. McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970.

	4. Shriver, D.D. Atkins, P. Inorganic Chemistry, 2nd Edition, Oxford University Press, 1994.

Course No : 0531 18 Chem 2104	**Credit :** 1	**Year :** Second	**Term:** First
Course Title : Quantitative Inorganic Analysis Sessional		**Course Status :** Core	
Prerequisite	None		
Rationale	This course will provide ideas about qualitative as well as quantitative analysis of chemical species		

COURSE CONTENTS	**CLOs**
1. Determination of transition metal contents in samples using volumetric titration. 2. Determination of anion contents in various samples using volumetric titration (Cl^-, F^- etc.) 3. Determination of alkali and alkaline earth metals (Ca^{2+}, Mg^{2+}) using complex metric titration 4. Gravimetric determination of anions and cations (Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^- etc.) 5. Qualitative and quantitative measurement of metal ions using spectroscopic methods (Fe, Na, K, Ca etc.) 6. Potentiometric determination of anions (Cl^-, I., SO_4^{2-}) in drinking water 7. Paper chromatography separation and identification of metal ions.	1-5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	quantification of cations and anions using volumetric titration	A2, B1, C3, D1
	CLO 2	estimate the number of anions and cations gravimetrically and complex-ometrically	A2, B1, C3, D1
	CLO 3	quantify the amount of metal ions in water spectrophotometrically	A2, B1, C3, D1
	CLO 4	potentiometric determination of anions	A2, B1, C3, D1
	CLO 5	identify metal ions by paper chromatography	A2, B1, C3, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question Answer Session, & Experiment	Assignments, Oral and Written examinations and lab test
2	Lecture, Discussion, Question Answer Session, & Experiment	Assignments, Oral and Written examinations and lab test
3	Lecture, Discussion, Question Answer Session, & Experiment	Assignments, Oral and Written examinations and lab test

4	Lecture, Discussion, Question Answer Session, Experiment & Problem solving	Assignments, Oral and Written examinations and lab test
5	Lecture, Discussion, Question Answer Session, Experiment & Problem solving	Assignments, Oral and Written examinations and lab test

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Mendham, J. Denney, R.C. Barnes, J.D. Thomas, M. Vogel 's Text book of Quantitative Chemical analysis, Pearson education, 2000. 2. Harris, D.C. Quantitative Chemical Analysis, 7th Edition, W. H. Freeman and Company, 2006.
Supplementary Readings	1. Samnani, P.B. Teaching of Chemistry Practical, A.P.H. Publications Corporation, New Delhi, 2001. 2. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Pearson Education, Ltd., 2009.

Course No : 0531 18 Chem 2105	**Credit :** 3	**Year :** Second	**Term:** First
Course Title : Chemistry of Aliphatic and Aromatic Compounds		**Course Status :** Core	
Prerequisite	0531 18 Chem 1205		
Rationale	This course is designed to provide core concept of organic chemistry with aromatics and functional organic compounds.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Aromaticity and Aromatic Compounds:** Aromatic and aliphatic compounds; nomenclature of aromatic hydrocarbons; structure and bonding in bonding in benzene; aromatic character: the Huckel rule.	1, 2
2	**Reactions Involving Aromatic Compounds:** Reactivity of benzene; electrophilic aromatic substitution reactions: nitration, sulfonation, Friedel-Craft alkylation and halogenation; nucleophilic aromatic substitution of benzene and other aromatic compounds.	3, 4, 5
3	**Polynuclear Aromatic Compounds:** Aromaticity, reactivity, electrophilic and nucleophilic substitution reactions of naphthalene, anthracin, and phenanthrene.	3, 4, 5
4	**Phenol and Nitroso Compounds:** Preparation, resonance and reactions of phenol and aromatic and aliphatic nitroso compounds, acidity of phenol, identification of phenol and nitroso compounds, TNT, TNB, aromatic diazonium salt: preparation and reactions.	3, 4, 5, 6
Section B		**CLOs**
5	**Aldehydes and Ketones (Alphatic and aromatic):** Structure, nomenclature, general methods of preparations, physical properties, reactions: nucleophilic addition to carbonyl compounds, oxidation and reduction	2, 3, 4, 5
6	**Carboxylic Acids (Aliphatic & Aromatic) & its Derivatives:** Nomenclature, orbital picture, hydrogen bonding, acidity, resonance effect and inductive effect on acidity, general methods of preparation and	2, 3, 4, 5, 6

	reactions of carboxylic acids: hydroxy acids, unsaturated acids, keto acids, derivatives of carboxylic acids (esters, amides, acid halide and anhydrides) relative reactivity of carboxylic derivatives.	
7	**Amines (Aliphatic and Aromatic):** Nomenclature, preparation, physical properties, separation of amines, structure and basic nature, reactions: alkylation, conversion into amides, oxidation, ring substitution, ring substitution in aromatic amines: analysis of amines.	2, 3, 4, 5
8	**Cyan and active Methylene Compounds:** Introduction to cyan compounds, nomenclature, structure, physical properties, chemical properties, synthesis and applications; Introduction to active methylene compounds, synthesis, chemical properties: acidity of α-hydrogen, alkylation, ketonic hydrolysis, keto-enol tautomerism	2, 3, 4

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	learn about the structure and aromaticity of organic compounds	A1, C3
	CLO 2	conceptualize the properties and reactivity of aromatics and functional organic compounds	A1, C3, D2, D3
	CLO 3	narrate different methods of preparation of aromatics and functional organic compounds	A2, A3
	CLO 4	illustrate the reactions involves in aromatics and functional organic compounds and their application in real life	A2, A3, C1, D2, D3
	CLO 5	illustrate the reaction mechanisms involves in aromatics and some functional organic compounds	A3, C1, C2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Bahl, A. Bahl, B.S. Advanced Organic Chemistry, 3rd Edition, S. Chand & Company Ltd., New Delhi, 1987. 2. Solomons, T.W.G. Fryhle, C.B. Snyder, S.A. Solomons' Organic Chemistry, 12th Edition, John Wiley & Sons, Inc., 2017. 3. Bahl, A. Bahl, B.S. A Text Book of Organic Chemistry, 22nd Edition, S. Chand & Company Ltd., New Delhi, 2019.
Supplementary Readings	1. Morrison, R.T. and Boyd, R.N. Organic Chemistry, 7th Edition, Pearson Education India, 2010. 2. Finar, I.L. Organic Chemistry: Volume 1, 6th Edition, Pearson Education India, 2002. 3. Wade, L.G. Organic Chemistry, 8th Edition, Pearson Education, 2016. 4. Clayden, J. Greeves, N. Warren, S. Organic Chemistry, 2nd Edition, Oxford University Press, 2014.

Course No : 0531 18 Chem 2106	**Credit :** 3	**Year :** Second	**Term:** First
Course Title : Qualitative Analysis of Organic Compounds Sessional		**Course Status :** Core	
Prerequisite	0531 18 Chem 1206		
Rationale	This course is designed to provide the extended practical knowledge for the identification of unknown solid and liquid organic compounds.		

COURSE CONTENTS	CLOs
Identification an unknown organic compound (solid/liquid) and evaluate the plausible structure on the basis of the following step: 1. Visual observation, color, and odor of the unknown compounds 2. Perform the solubility/miscibility test of the unknown organic compounds and classify them 3. Separate individual compounds from the mixture (if applicable) 4. Determinations of melting point/boiling point of the unknown organic compounds. 5. Elementary analysis in the unknown organic compounds. 6. Analysis of functional groups depends on element present. 7. Propose a plausible structure of the unknown organic compounds 8. Preparation of derivatives of the identified organic compounds	1-6

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	determine the nature of an unknown organic compound and classify them on the basis of nature	A1
	CLO 2	separate an individual compounds from the mixture	A1
	CLO 3	explain the role of melting point and boiling point to identify an unknown organic compound	A1, A2, D2
	CLO 4	identify the elements and functional	A1, A3, D2

		groups present in an unknown organic compound	
	CLO 5	evaluate the plausible structure of an unknown organic compound	A3, C3
	CLO 6	Prepare the derivatives of the identified organic compounds	A3, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Laboratory work, Question & Answer Session	Assignments, Report writing, Term papers, Oral and Written examinations
2	Lecture, Discussion, Laboratory work, Question & Answer Session, Case Study	Assignments, Report writing, Term papers, Oral and Written examinations
3	Lecture, Discussion, Laboratory work, Question & Answer Session, Case Study	Assignments, Report writing, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Laboratory work, Case Study	Assignments, Report writing, Term papers, Oral and Written examinations
5	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Report writing, Term papers, Oral and Written examinations
6	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming	Assignments, Report writing, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	5. Shriner, R.L. Fuson, R.C. Curtin, D.Y. Morrill, T.C. Systematic Identification of Organic Compounds, 8th Edition, Wiley & Sons, 2004. 6. Skoog, D.A. West, D.M. Holler, F.J. Crouch, S.R. Fundamentals of Analytical Chemistry, 9th Edition, Thomson Books/Cole, 2014. 7. Lehman, J.W. Operational Organic Chemistry, 4th Edition, Pearson, 2008. 8. Agarwal, O.P. Advanced Practical Organic Chemistry, 1st Edition, Krishna Prakashan Media (P) Ltd. India, 2014.
Supplementary Readings	5. Morrison, R.T. Boyd, R.N. Organic Chemistry, 7th Edition, Pearson Education India, 2010. 6. Finar, I.L. Organic Chemistry: Volume 1, 6th Edition, Pearson Education India, 2002. 7. Bahl, A. Bahl, B.S. A Text Book of Organic Chemistry, 22nd Edition, S. Chand & Company Ltd., New Delhi, 2019. 8. Solomons, T.W.G. Fryhle, C.B. Snyder, S.A. Solomons' Organic Chemistry, 12th Edition, John Wiley & Sons, Inc., 2017.

Course No: 0541 18 Math 2151	Credit : 3	Year : Second	Term: First
Course Title: Differential Equation and Numerical Analysis		Course Status : Optional	
Prerequisite	None		
Rationale	This course will provide an understanding to convert real life problem into differential equation and their analytical and numerical solutions.		

COURSE CONTENTS		CLOs
Section A		
1	**Differential equation:** Definition and classification of differential equations, formulation of differential equation based on real problems related to chemistry, initial, boundary value problems and existence of solution.	1, 2
2	**Solution of first order differential equation:** Separation of variables, exact equation, homogeneous equation, nonlinear equation (Bernoulli's equation) and application in chemistry.	1, 2
3	**Second order differential equation:** Second order differential equation (homogeneous and non-homogeneous) with constant coefficients.	1, 2
4	**Laplace transforms:** Definition, basic properties and application in differential equation.	1, 2
Section B		**CLOs**
5	**Solution of equation of one variable:** Bisection method, Newton-Raphson method, Iteration method, and error analysis.	1
6	**Numerical differentiation and integration:** Quadrature formula, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, numerical differentiation using Newton's forward, Stirling's formula.	1, 3
7	**Solution of system of equation and interpolation:** Gauss-Jordan method, Gauss-Seidel method, interpolation (equal and unequal space).	1
8	**Numerical solution of differential equation:** Euler method, modified Euler method, Runge-Kutta method.	1, 3, 4

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	identify different types of differential equation and their solution procedure.	A1, D1, D2
	CLO 2	apply different differential equations in chemistry.	C3
	CLO 3	evaluate differentiation and integration numerically.	C1
	CLO 4	compare numerical solution with analytical solutions.	D1, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT

STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Raisinghania, M.D. Laplace & Fourier Transforms, S. Chand & Co. Ltd., New Delhi, 1995. 2. Epperson, J.F. An Introduction to Numerical Methods and Analysis, 1st Edition, John Wiley & Sons Inc. New Jersey, USA, 2007. 3. Rao, S. Numerical Analysis, 3rd Edition, New Age International Pvt. Ltd., New Delhi, India, 2006.
Supplementary Readings	1. Sastry. S.S. Introductory Methods of Numerical Analysis, 4th Edition, Prentice-Hall, India, 2005. 2. Rao, G.S. Reddy, E.K. Mathematical Methods, 3rd Edition, I. K. International Publishing House Pvt. Ltd., New Delhi, 2009. 3. Das, B.C. Mukherjee, B.N. Differential Calculus, 19th Edition, U.N. Dhur and Sons Pvt. Ltd., Kolkata, 1995. 4. Das, B.C. Mukherjee, B.N. Integral Calculus, U.N. Dhur and Sons Pvt. Ltd., Kolkata, 2012. 5. Spiegel, M.R. Advanced Calculus, McGraw-Hill Co. & Ltd., New York, 1974.

Course No : 0542 18 Stat 2161	**Credit :** 3	**Year :** Second	**Term:** First
Course Title : Introduction to Statistics		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental statistical concepts and some of their practical application of statistics in chemistry.		

COURSE CONTENTS		CLOs
	Section A	
1	**Introduction to Statistics:** Definition and scope of the study of statistics, nature of statistical data, attributes and variables, population and sample, frequency and frequency distribution, graphical representation of data.	1
2	**Statistical Data Analysis:** central tendency: mean, median, mode, dispersion: absolute measures and relative measures of dispersion. Distribution of random errors.	1, 2
3	**Correlation and Regression:** Bivariate data, scatter diagram, relationship between the variables, concept and uses of correlation and regression,	3

	estimation procedure of simple regression parameters, correlation and regression coefficients, rank correlation.	
Section B		**CLOs**
4	**The basis of sampling:** Sampling methods; basic concepts of simple random sampling, systematic random sampling, stratified random sampling and cluster sampling, their uses and practical applications in real life data, detail about non-probability sampling methods, sampling errors and non-sampling error.	3, 4
5	**Different Tests and Significances:** Basic idea about hypothesis testing, null hypothesis and alternative hypothesis, one tail and two tail test, acceptance region and rejection region, z-test, *F*-test, *t*-test and *Q* test and their application.	4, 5
6	**Analysis of Variance:** Assumptions and definition of analysis of variance, implementation in chemistry, basic concept of different analysis of variance with example.	4, 5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	decipher the background of statistics and its scopes as well as applications	A2, B3
	CLO 2	produce and interpret graphical summaries of data and assess which methods for summarizing a data set are most appropriate to highlight interesting features of the data	C1, C3, D3
	CLO 3	calculate and interpret numerical summary statistics as well as to have knowledge of important properties of different measurements	A3, C1, C3
	CLO 4	use a simple linear regression model to predict the value of one variable based on the value of an associated variable	C1, C3, D3
	CLO 5	describe the analysis of variance and its application	B2, D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Lind, A.D. Marchal, W. Wathen, S. Statistical Techniques in Business and Economics, 18th Edition, Mcgraw Hill Inc. 2021. 2. Newbold, P. Carlson, W.L. Throne, B.M. Statistics for Business and Economics, 9th Edition, Pearson Education Ltd. 2019. 3. Lane, D. Introduction to Statistics, David Lane, Rice University, 2003.
Supplementary Readings	1. Beirlant, J. Goegebeur, Y. Segers, J. Teugels, J. Waal, D. Ferro, C. Statistics of Extremes: Theory and Applications, 1st Edition, Wiley, 2004. 2. Eubank, L.R. Nonparametric Regression and Spline Smothing, 2nd Edition, Marcel Dekker, 1999. 3. Heumann, C. Schomaker, M. Shalabh. M. Introduction to Statistics and Data Analysis: With Exercises, Solutions and Applications, Spinger, 2016. 4. Cochran, W.G. Sampling Techniques, 3rd Edition, Wiley Eastern, New Delhi. 2019. 5. Mood, A.M. Graybill, F.A. Boes, D.C. Introduction to the Theory of Statistics, 3rd Edition, Tata Mcgraw-Hill, New Delhi, 2017.

Course No : 0542 18 Stat 2162	**Credit :** 2	**Year :** Second	**Term:** First
Course Title : Introduction to Statistics Sessional		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental statistical concepts and some of their practical application of statistics in chemistry.		

COURSE CONTENTS		CLOs
1	Construction of frequency distribution with graphs and charts.	1
2	Determination of statistical averages and percentiles and deviation from the mean and median, range, and quartile deviation.	2
3	Determination of univariate and bivariate analysis with contingency tables.	1, 2,3
4	Determination of sample size and the relative efficacy of different sampling Schemes.	1, 3
5	Determination of one-way ANOVA and covariance analysis	3, 4
6	Solving practical problems by using several statistical packages and software, such as SPSS.	4

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	learn basic statistics, data handling, manipulation, presentation, fitting, and modeling.	A2, B3
	CLO 2	predict the quality of data and derive a	C1, C3, D3

		mathematical model of chemical and physical processes.	
	CLO 3	learn sample drawing and data analysis estimation	A3, C1, C3
	CLO 4	constructing different effective data molding	C1, C3, D3
	CLO 5	running SPSS using production facility	B2, D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Landan, S. Everitt, S.B. A Handbook of Statistical Analyses using SPSS, Chapman and Hall/CRC, 2003. 2. Norusis, M.J. A Guide SPSS/PC for Data Analysis, SPSS Inc., USA, 1991. 3. Cochran, W.G. Sampling Techniques, 3rd Edition, Wiley Eastern, New Delhi, 1991. 4. Agresti, A. An Introduction to Categorical Data Analysis, 1st Edition, Wiley, 1996.
Supplementary Readings	1. Mood, A.M. Graybill, F.A. Boes, D.C. Introduction to the Theory of Statistics, 3rd Edition, Tata Mcgraw-Hill, New Delhi, 2017. 2. Marchette, J. D. Random Graphs for Statistical Pattern Recognition, 1st Edition, Willy-Intersccience, 2004. 3. Barlow, R.J. Statistics: A Guide to the Use of Statistical Methods, John Wiley & Sons. 1989.

Second Year Second Term

Course No : 0531 18 Chem 2201	Credit : 3	Year : Second	Term: II
Course Title : Chemical Kinetics and Photochemistry		Course Status : Core	
Prerequisite	None		
Rationale	This course is useful to the students in various fields of study, where reaction rates and mechanisms of both normal and photochemical reactions are important.		

	COURSE CONTENTS	CLOs
	Section A	
1	**Scope of the Study of Chemical Kinetics:** Reaction rate, order & molecularity of reactions, first order reaction and its mathematical formulation.	1
2	**Second Order Reaction and its Mathematical Formulation:** Pseudo-molecular reactions; reversible or opposing reactions; consecutive reaction; parallel reactions; chain reaction, effect of temperature on reaction rate.	1
3	**The collision Theory of Unimolecular and Bimolecular Reactions:** Kinetic theory of termolecular reactions; theory of absolute reaction rate; transition state theory for gas phase bimolecular reactions, eyring equation, thermodynamic formulation of reaction rate, application; activated complex theory & collision theories for reaction in solution, diffusion-controlled reaction, effect of dielectric constant & pressure on the rate of reaction in solution, primary salt effect, kinetic isotope effect, unimolecular reaction: Lindemann-Hinshelwood approach, steady state approximation method.	2
4	**Mechanism on the basis of Kinetic Studies:** Thermal decomposion of C_2H_6, CH_3CHO, CH_3COCH_3, O_3, $COCl_2$, hydrogen-bromine reaction and calculation of activation energy, solid state reaction: Tarnish reaction & Wagner theory, thermal decomposition: mechanism, solid-solid reaction.	3
	Section B	**CLOs**
5	**Catalysis:** Competitive adsorption and kinetics of surface reactions, Arrhenius & van't Hoff's intermediate, enzyme catalysis, Michaelis-Menten mechanism, specific & general acid base catalysis, heterogeneous catalysis: outline application, absorption isotherms & rate law, specific rotation.	3
6	**Laws of Photochemistry:** The Grotthus-Draper law; the Einstein law of photochemical equivalence, photochemical Vs thermal reaction.	4
7	**Consequence of Light Absorptions by Atoms:** Consequences of light absorption by molecules; photochemical kinetics; experimental study of photochemical reactions.	4
8	**Photochemical Gas Reaction:** Photolysis; photochemical reactions in the liquid phase; photochemical effects in solids; flash photolysis, effect of temperature on photochemical reactions; photochemical equilibrium, chemiluminescence.	4

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	distinguish between a first-order reaction and a second-order reaction	A1
	CLO 2	discuss the collision model of chemical reactions and how various factors such as temperature can affect reaction rate	A2, C1
	CLO 3	illustrate the Arrhenius and Van't Hoff's equation and apply them to solve problems identify, formulate, and solve problems of photochemistry in a multidisciplinary environment	A4, C3
	CLO 4	get acquainted with the techniques and tools of photochemistry	A3, B2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Laidler, J.K. Chemical Kinetics, 3rd Edition, Pearson Education, India, 1987. 2. Denisov, E.T. Denisov, E. Sarkisov, O. Likhtenshtein, G.I. Chemical Kinetics: Fundamentals and Recent Developments, 1st Edition, Elsevier, Netherlands, 2003.
Supplementary Readings	1. Atkins, P. and Paula, J. Physical Chemistry, 8th Edition, Oxford University Press, New York, 2006. 2. Soustelle, M. An Introduction to Chemical Kinetics, 1st Edition, John Wiley & Sons, UK, 2013.

Course No : 0531 18 Chem 2202	Credit : 1	Year : Second	Term: II
Course Title : Chemical Kinetics and Photochemistry Sessional		Course Status : Core	
Prerequisite	None		
Rationale	This course is designed to train the students in measuring of rate and order of chemical reactions.		

	COURSE CONTENTS	CLOs
1	Determination of the equilibrium constant for the reaction: $KI + I_2 = KI_3$.	1,2
2	Determination of the specific rotation of sucrose and the specific reaction rate of the inversion of sucrose in presence of acid. (polarimetric method.)	1,5
3	Determination of the specific reaction rate of the hydrolysis of an ester by NaOH solution	3, 5
4	Investigation of the kinetics of the reaction $S_2O_8^{2-}(aq.) + 2I^- (aq.) \longrightarrow SO_4^{2-} (aq.) + I_2 (aq.)$ and determination of the order of the reaction with respect to the persulfate.	1,2
5	Study of the adsorption of acetic acid on charcoal from aqueous solution	4
6	Determination of energy of activation for the reaction. $5KBr + KBrO_3 + 3H_2SO_4 \longrightarrow 3Br_2 + 3K_2SO_4 + 3H_2O$	1,2

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	calculate the equilibrium constant of different chemical reactions	A2, A3,
	CLO 2	construct an experiment to study kinetics of chemical reactions using polarimeter	A2, B3
	CLO 3	interpret kinetics of hydrolysis of ester	C2
	CLO 4	justify adsorption and absorption reactions through kinetics studies	B2, C1
	CLO 5	measure energy of activation of chemical reactions express rate equations of unimolecular and bimolecular chemical reactions	A2, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming,	Assignments, Term papers, Oral and

	Project Design	Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Laidler, J.K. Chemical Kinetics, 3rd Edition, Pearson Education, India, 1987. 2. Khosla, B.D. Garg, V.C. Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co, India, 2018. 3. Garland, C.W. Nibler, J.W. Shoemaker, D.P. Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York, 2009.
Supplementary Readings	1. Halpern, A.M. McBane, G.C. Experimental Physical Chemistry, 3rd Edition, W.H. Freeman & Co., 2006. 2. Sindhu, P.S. Practicals in Physical Chemistry, Macmillan Publishers India Limited, 2005. 3. Wilson, J.M. Newcombe, R.J. Denaro A.R. Experiments in Physical Chemistry, 2nd Edition, Elsevier Science, 2013 4. Viswanathan, B. Raghavan, P.S. Practical Physical Chemistry, 1st Edition, Viva Books Pvt. Ltd, New Delhi, 2009. 5. Athawale, V.D. Paul, M. Experimental Physical Chemistry, 1st Edition, New Age International Pvt. Ltd, New Delhi, 2001.

Course No : 0531 18 Chem 2203	**Credit :** 3	**Year :** Third	**Term:** First
Course Title : Coordination Chemistry		**Course Status :** Core	
Prerequisite	None		
Rationale	The course is primarily designed for depth introduction with vast subfield of the discipline dealing with coordination compounds.		

COURSE CONTENTS		CLOs
Section A		
1	**Introduction:** Introduction of coordination chemistry, double salts and coordination compounds, coordination number, nomenclature of coordination compounds, ligands and their types, Scope of coordination chemistry.	1,3
2	**Structural Theories of Complex Compounds:** Werner's theory and its limitations and applications, Sidgwick's electronic theory and its limitations and applications, valence bond theory and its limitations and applications.	1, 4
3	**Stereochemistry of the Coordination Compounds:** Structural isomerism; geometrical isomerism, optical isomerism, determination of configurations of *cis*-*trans*-isomer, stereochemistry of 4-coordinated complex, stereochemistry of 6-coordinated complex.	2,4
4	**Stability of Complexes:** Factors influencing the stability of complexes, stability constant, effect of ligand on the stability of complexes.	3
Section B		**CLOs**
5	**Crystal Field Theory:** Crystal field theory, crystal field splitting, crystal field stabilization energy (CFSE), high spin and low spin complexes.	2
6	**Non-octahedral symmetry:** Tetrahedral symmetry, tetragonal symmetry and square planner symmetry, pairing energies, factors influencing ligand field splitting, spectrochemical series, measurement of 10Dq.	2, 5

7	**Stereo-chemical Distortions of Complexes:** Jahn-Teller effects and limitations of Jahn-Teller theory, general effects of orbital splitting on the properties of complexes, Magnetism, limitations of CFT.	3,4, 5
8	**Molecular Orbital Theory:** Basic principles, σ-bonding and π-bonding in octahedral complexes, effects of π-bonding, MOT in tetrahedral and square planar complexes, limitations of MOT, comparison of different approaches to bonding in coordination compounds.	1,3, 5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	Discuss about the basic principles of coordination chemistry	A1, A2
	CLO 2	Explain the structural isomerism and different complexes of coordination compounds	A3, C2
	CLO 3	Predict the stability and distortions of complexes	A3, C3
	CLO 4	Predict the different theories of coordination chemistry and explain the applications and limitations of the theories.	A1, D2
	CLO 5	Deduce the comparison of different approaches to bonding in coordination compounds and splitting properties of d-orbital of central metals	A1, A3, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations, Home Work
2	Lecture, Group problem solving, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term Papers, Oral and Written Examinations
4	Lecture, Question & Answer Session, Team/Group Work, Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Lecture, Problem Solving, Brain Storming	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Cotton, A.F. Wilkinson G. Gaus, P.L. Basic Inorganic Chemistry, 3rd Edition, Wiley, 1994. 2. Lawrance, G.A. Introduction to Coordination Chemistry, 4th Edition, Wiley, 2010. 3. Kapoor, R. Chopra, R.S. Inorganic Chemistry, 3rd Edition, R. Chand & Co. Ltd., New Delhi, 2019.
Supplementary	1. Lee, J.D. Concise Inorganic Chemistry, 4th Edition, ELBS, 1991.

Readings	2. Bhatt, V. Essentials of Coordination Chemistry, 1st Edition, Elsevier: Academic Press, 2016. 3. Weller, M. Overton, T. Rourke, J. Inorganic Chemistry, 7th Edition, Oxford University Press, New York, 2018.

Course No : 0531 18 Chem 2204	**Credit : 0**1	**Year :** Third	**Term:** First
Course Title : Coordination Chemistry Sessional		**Course Status :** Core	
Prerequisite	None		
Rationale	This course will provide practical knowledge and skills in the synthesis and characterization of the corresponding simple and complex inorganic compounds.		

COURSE CONTENTS		**CLOs**
1	Synthesis of Cu(II) complex from Cu-salt and determination of the percentage of yield.	1,5
2	Preparation of Ni(II) complexes with o-amino benzoic acid from Ni(II) solution. Also, determination of percentage of yield and characterization the complex through spectroscopic method.	1, 5
3	Synthesis of nickeldimethylglyoxamate $[Ni(DMGH)_2]$ from Ni^{2+} solution and determination of percentage of yield and characterization the complex through spectroscopic method.	1,5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	demonstrate a competency and proficiency with experimental skills involved in chemical synthesis, instrumental methods, quantitative measurements and statistical data analysis	A1, A3
	CLO 2	explain key concepts of inorganic and coordination chemistry including those related to synthesis, reaction chemistry, and structure and bonding	C2, D2
	CLO 3	write and present formal laboratory reports on the results of chemical experiments	A1, C3
	CLO 4	explain the different theories of coordination chemistry	A1, D2
	CLO 5	Describe and explain the bonding in d-metal complexes	D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**

1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Sessional Work, Question & Answer Session, Case Study	Lab Report, Term papers, Oral and Written Examinations
4	Lecture, Group Work, Sessional Work	Lab Report, Term papers, Oral and Written Examinations
5	Lecture, Sessional Work, Mock Test	Lab Report, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Szfran, Z. Pike, R.M. Mono, M.S. Micro Scale Inorganic Chemistry: A Comprehensive Laboratory Experience, 1st Edition, Wiley & Sons, New York, 1991. 2. Nath, M. Inorganic Chemistry: A Laboratory Manual, Lab Manual Edition, Alpha Science International, 2016.
Supplementary Readings	1. Gilbert, G.L. Alyea, H.N. Dutton, F.B. Dersisbac, D. Tested Demonstration in Chemistry, 1-2, Division Chemical Education, American Chemical Society, 1983. 2. Girolami, G.S. Rauchfuss, T. Rauchfuss, T.B. Angelici, R.J. Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual, 1st Edition, University Science Books, 1999.

Course No : 0531 18 Chem 2205	**Credit :** 3	**Year :** Second	**Term:** Second
Course Title : Stereochemistry and Heterocyclic Compounds		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental concepts of stereochemistry and core concept of heterocyclic compounds.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Introduction to Isomerism:** Basic concept of isomerism, classifications, physical properties, chemical properties of various isomerisms of same compounds.	1
2	**Geometric Isomerism:** Conditions, Configurations of Geometrical Isomers: Cis-trans. E/Z system, syn-anti, physical properties and configurational and assignment of. geometrical isomers. geometrical isomerism of polyenes, carbon-nitrogen, nitrogen-nitrogen double bonds and cyclic compounds (cis –trans isomerism in disubstituted cyclohexane.	2
3	**Optical Isomerism:** Cause of optical activity. chirality (dissymmetry and asymmetry), prochirality, pseudo chirality, symmetry elements. asymmetric synthesis –Crame‘s rule. Optical isomers, diastereoisomers, enantiomers. epimers. anomers, meso and racemic compounds, racemic modification and their resolution, recemization, Walden inversion	3

4	**Configuration and Conformational Isomerism:** D& L, threo erythro, R & S configurations, absolute and relative configuration and their correlation; Conformation and conformers, conformation of propane, butane, ethanediol, dihydroxystyrene, dichlorostyrene, their physical properties and stability.	4
Section B		**CLOs**
5	**Atropisomerism:** Nomenclature, synthesis and stereochemistry of biphenyls, allenes and spiranes, molecular properllers and gears, helicencenes; molecules with planar chirality.	5
6	**Five membered heterocyclic compounds:** Aromaticity, synthesis, structure, physical, chemical properties: electrophilic substitution reaction of pyrrole, furan, thiophene, imidazole, oxazole, thiazole, pyrazole**,** and indole.	6
7	**Six membered heterocyclic compounds:** Aromaticity, structure, synthesis, physical, chemical properties: electrophilic substitution reaction, basicity of pyridine, pyrimidine, pypiridine, purine, quinolone, and isoquinoline.	6
8	**Drug synthesis:** Defination, classifications, **s**ynthesis, properties, functions, metabolim of sulfadiazine, sulfadimidine, sulfafurazole (sulfisoxazole), sulfisomidine (sulfaisodimidine), sulfamethoxazole, sulfamoxole, sulfadimethoxine, sulfamethoxypyridazine, sulfametoxydiazine, sulfadoxine, sulfametopyrazine, tolazamide, acetazolamide, methazolamide,	7

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	learn about the core concept of isomerism	A1
	CLO 2	identify the geometric isomerism of various organic compounds	C3, D2
	CLO 3	predict the optical activity of organic compounds	C3, D1
	CLO 4	model the conformational and configurational isomerism	C3, D3
	CLO 5	explain the basic idea about atropisomerim	C3, D1
	CLO 6	predict the synthesis mode and reactivity of heterocyclic compounds	C3,
	CLO 7	Narrate the preliminary concept of drug synthesis	A2, A3, B1, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question &	Assignments, Term papers, Oral and

	Answer Session, Case Study	Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1 Kalsi, P.S, Stereochemistry: Conformation and Mechanism, Wiley, 1990. 2 Eliel, E.L. Wilen, S.H. Stereochemistry of Organic Compounds, Wiley, London, 1994. 3 Finar, I.L. Organic Chemistry: Stereochemistry and The Chemistry of Natural Products, Longman Scientific & Technical, 1988. 4 Solomons, T.W.G. Fryhle, C.B. Snyder, S.A, Solomons' Organic Chemistry, 12th Edition, Wiley, 2016.
Supplementary Readings	1. Morrison, R.N. Boyd, R.N. Organic Chemistry, 6th Edition, Pearson Education, India, Ltd, 2008. 2. Finar, I.L. Organic Chemistry: Volume 1, 6th Edition, Pearson Education India, 2002. 3. Wade, L.G. Organic Chemistry, 8th Edition, Pearson Education, 2016. 4. Clayden, J. Greeves, N. Warren, S. Organic Chemistry, 2nd Edition, Oxford University Press, 2014.

Course No : 0531 18 Chem 2206	**Credit :** 1	**Year :** Second	**Term:** Second
Course Title : Organic Synthesis Sessional		**Course Status :** Core	
Prerequisite	None		
Rationale	This course is designed to provide fundamental concepts of synthesis of organic compounds		

COURSE CONTENTS	**CLOs**
1. Synthesis route of aspirin from various organic compounds 2. Synthesis of Paracetamol 3. Preparation of acetanilide 4. Preparation of p-nitroacetanilide 5. Alkaline and acidic hydrolysis of aspirin	1-5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	learn about the synthesis route of organic compounds	A1, A4, D1, D2, C3
	CLO 2	learn about the purification of synthesized organic compounds	A4, D1, D2, C3
	CLO 3	calculate the percentage of yield of the organic compounds	C1, C3, D1
	CLO 4	get an idea about the validation of the synthesis method	C1, C3, D1

	CLO 5	analysis the physical parameters of the compounds	A4, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Conduct Experiment	Assignments, Oral and Practical examinations
2	Lecture, Discussion, Conduct Experiment	Assignments, Oral and Practical examinations
3	Lecture, Discussion, Conduct Experiment	Assignments, Oral and Practical examinations
4	Lecture, Discussion, Conduct Experiment	Assignments, Oral and Practical examinations
5	Lecture, Discussion, Conduct Experiment	Assignments, Oral and Practical examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Fieser, L.F. Organic Experiments, D.C. Health Canada Ltd, 1935. 2. Addison, A. Techniques and Experiments for Organic Chemistry, Waveland Press, 1994. 3. Durst, D.H. Gokel, G.W. Experimental Organic Chemistry, 2nd Edition, McGraw-Hill Book Company, New York, 1987.
Supplementary Readings	1. Mann, F.G. Saunders, B.C. Practical Organic Chemistry, Pearson Education, 2009. 2. Ahluwalia, V.K. Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2004. 3. Furniss, B.S. Hannaford, A.J. Smith, P.W.G. Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, Pearson. 2012. 4. Leonard, J. Lygo, B. Procter, G. Advanced Practical Organic Chemistry, CRC Press, 2013. 5. Norris, J.F. Experimental Organic Chemistry, Hard Press, New York, 2001. 6. Furniss, B.S. Hannaford, A.J. Smith, P.W.G. Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, 4th Edition, Longman, 1986.

Course No : 0531 18 Chem 2207	**Credit :** 3	**Year :** Second	**Term:** Second
Course Title : Analytical Chemistry		**Course Status :** Core	
Prerequisite	None		
Rationale	This course will provide the practical demonstration of experimental techniques of determining physical parameters and analytical knowledge about separation.		

COURSE CONTENTS		CLOs
Section A		
1	**Introduction of Analytical Chemistry:** Definition and scope of analytical chemistry, chemical analysis, types of analysis, classification of basic instrumental methods of chemical analysis, requirements for the suitability of a reaction, completeness of a chemical reaction, micro chemical units used in analytical chemistry.	1,2
2	**Solvent Extraction:** Distribution coefficient, distribution ratio, factors favoring solvent extraction, quantitative treatment of solvent extraction equilibria, synergistic extraction; ion association complexes, extraction reagents, solvent extraction of metals.	1,2
3	**Ion Exchange:** Principles, types of resin, action of ion exchange resign, cross linkage, structure and properties, ion exchange chromatography, swelling, effect of pH, ion exchange in organic and aqueous-organic solvents; separation of amino acids, effect of complexing agent; separation of metal ions on anion exchange columns.	3,4
4	**Gravimetric analysis:** General principles of gravimetric analysis; steps in gravimetric analysis, the colloidal state; super saturation, precipitation method; types, properties and formation of precipitates, precipitating reagents, precipitation reactions and titrations; determination of end points in precipitation titration, the purity of the precipitate: co-precipitation, post precipitation, digestion, washing and drying of precipitate.	3,4
Section B		**CLOs**
5	**Principles of Chromatography:** Classifications of chromatographic techniques, thin-layer chromatography, the recovery of separated substances by elution techniques; techniques of column chromatography; column efficiency in chromatography.	4,5
6	**Liquid Chromatography:** Introduction, types of liquid chromatography, components for high performance liquid chromatography (HPLC), mobile phase, sample injection, column design, choosing a detector, chiral chromatography, derivatization, quantitative analysis	4,5
7	**Gas Chromatography (GC):** Principle, gas chromatography (GC): principle, programmed temperature gas chromatography, quantitative analysis by GC; elemental analysis by gas chromatography.	4,5
8	**Atomic Spectrometric Methods:** Emission spectroscopy, flame emission spectrometry, plasma emission spectrometry, distribution between ground and excited state, atomic absorption spectrophotometry; internal standard and standard addition calibration.	6

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	follow the proper procedures and regulations for safe handling and use of chemicals	A2, D2
	CLO 2	explain on the working principle of different analytical techniques and recognize their advantages and limitations	A1
	CLO 3	apply ion-exchange and gravimetric analysis procedure for separation of	A3, D1

		compounds	
	CLO 4	categorize and explain the chromatographic techniques	A1, C2
	CLO 5	integrate different analytical techniques to solve analytical problems	A3, C1, C3
	CLO 6	implement the basic principle of spectrophotometric techniques in metal detection and quantification	A2, C1, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Quiz and Class Test, Term papers
2	Problem-based Learning and Presentation, Discussion	Assignments, Term papers, and Written examinations
3	Lecture, Discussion, Question & Answer Session	Assignment and Final Examination
4	Discussion, Question & Answer Session, Team/Group Work	Quiz and Class Test, Term papers
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations
6	Problem-based Learning and Presentation	Class Test, Assignment and Final Examination

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Skoog, D.A. West, D.M. Holler, F.J. Fundamentals of Analytical Chemistry, 9th Edition, Brooks/Cole, USA, 2014. 2. Mendham, J. Denney, R.C. Barnes, J.D. Thomas, M. Vogel's Textbook of Quantitative Chemical analysis, 6th Edition, Pearson education, 2009. 3. Sharma, B.K. Instrumental Methods of Chemical Analysis, 5th Edition, Goel Publishing House, Merrut, 1993.
Supplementary Readings	1. Usharani, S. Analytical Chemistry: Techniques & Instrumentation, Trinity Press, India, 2019. 2. Harvey, D. Modern Analytical Chemistry, McGraw-Hill Companies, 2000. 3. Harris, D.C. Quantitative Chemical Analysis, W. H. Freeman and Company, 2010. 4. Trimble, H. Practical and Analytical Chemistry: A Complete Course in Chemical Analysis, Wentworth Press, 2019.

Course No : 0531 18 Chem 2208	Credit : 1	Year : 2nd	Term: II
Course Title : Analytical chemistry sessional		Course Status : Core	
Prerequisite	None		
Rationale	The course will provide the practical demonstration of experimental techniques and application of analytical concepts.		

COURSE CONTENTS		CLOs
Section A		
1	Determination of total alkalinity of soda ash.	1, 2, 5
2	Determination of water hardness with EDTA.	1, 2, 5
3	Determination of chloride in a soluble chloride: Fajann's method	2, 5
4	Analysis of commercial hypochlorite or peroxide solution by iodometric titration	1,2
5	Determination of the amount of Fe(II) and Fe(III) in a given sample using a standard dichromate solution.	3,5
6	Estimation of Cu(II) using sodium thiosulphate solution	3,5
7	Determination of heavy metals concentrations in environmental samples based on spectrophotometric methods	3,5
8	Determination of concentration of Na^+, K^+, Ca^{2+} and Mg^{2+} ions in drinking water samples based on flame-photometric methods	3,5
9	Separation of acidic, basic and neutral compounds based on the principle of solvent extraction	4,5
N.B. Experiments may be added to or removed from the above list if necessary.		

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	Identify the important analytical issues to be considered during analysis	A2, B3, C1
	CLO 2	Implement analytical concepts and techniques to solve practical analytical problems	B2, C3
	CLO 3	Determine the concentrations of minerals and heavy metals	A1
	CLO 4	Separate acidic, basic and neutral compounds	A2
	CLO 5	Perform writing to represent scientific information clearly and accurately, both in oral and in written forms	B1, B2, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1-CLO5	Class Lecture, Practical Experiments, and Team Work	Report writing, Final examination, and viva voice

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Mendham, J. Denney, R.C. Barnes, J.D. Thomas, M. Vogel's Textbook of Quantitative Chemical analysis, 6th Edition, Pearson education, 2009. 2. Verma R.M. Analytical Chemistry: Theory and Practice, 3rd Edition, CBS Publishers & Distributors, India, 2018. 3. Kitaw, S.L. Practical Analytical Chemistry, Lab Manual, LAP Lambert Academic Publishing, 2015.
Supplementary Readings	1. Usharani, S. Analytical Chemistry: Techniques & Instrumentation, Trinity Press, India, 2019. 2. Poppiti, J.A. Practical Techniques for Laboratory Analysis, Lewis publishers, CRC press, 1994. 3. Evans, E.H. Foulkes, M.E. Analytical Chemistry: A Practical Approach, Oxford University Press, 2019. 4. Trimble, H. Practical and Analytical Chemistry: A Complete Course in Chemical Analysis, Wentworth Press, 2019.

Course No: 0222 18 HC 2263	Credit : 3	Year : Second	Term: Second
Course Title: Emergence of Bangladesh		Course Status : Core	
Prerequisite	None		
Rationale	This course provides the students with an understanding of the historical roots of Bangladesh as an independent state.		

Course Contents		**CLOs**
Section A		
1	Partition of Bengal in 1947: Historical background, events, significance, and its impacts	2
2	Language Movement (1947-1952): Background, events, and significance	1,2
3	Constitutional development of Pakistan	3
4	Movement for autonomy: Emergence of Political Parties, United Front, the election of the Provincial Assembly of East Bengal, United Front ministries	3
5	Promulgation of Martial Law; Military rule 1958-1962: nature and reactions, System of Basic Democracies	3, 2
Section B		**CLOs**
1	Bengali nationalist movement: Movement of 1962-64, 6-point movement of the Awami League and its historical significance, Agartala case, Mass upsurge of 1969	3
2	Initial discriminations between East Bengal and West Pakistan; development of colonial economy in East Bengal	2
3	The military rule of 1969: legal framework order, the general election of 1970, Cyclone of 1970, Non-cooperation movement of 1971, 7th March speech	1, 3
4	Liberation War of Bangladesh: Mujibnagar Government and its activities, role of India and super powers, contributions of the immigrant Bangladeshis	1, 2

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	describe the major historical developments and trends that led to the emergence of Bangladesh as an independent country;	A1, A2, B3
	CLO 2	explain different aspects of events and movements that occurred during 1947-71;	A2, D1
	CLO 3	construct ideas that developed into the nationalist movement against West Pakistan;	A4, C1
	CLO 4	recognize the areas of exploitation and oppression during the Pakistan regime.	B2, C3, D2

Mapping CLOs With the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Presentation and Team Teaching	Assignments, Written examinations, Viva voce and Final Exam
2	Lecture, Discussion, Question & Answer Session, Case Study	Quiz and Class Test, Assignments, Written examinations, and Final Exam
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Presentations, Group Activities, Written examinations, Viva-voce and Final Exam
4	Discussion, Question & Answer Session, Team/Group Work, Case Study	Problem Solving, Brain Storming, Presentations, Group Activities, Viva-voce and Final Exam

Indicative Learning Materials	
Recommended Readings	1. Ghosh, S. The Awami League 1949-1971, Academic Publishers, Dhaka, 1990. 2. Kamal, A. State Against the Nation: The Decline of the Muslim League in Pre-independence Bangladesh, 1947-54, UPL, Dhaka, 2009. 3. Kashem, A. The Fiery Force: Student Politics and Making of Bangladesh, Kathaprokash, Dhaka, 2021. 4. O'Donnell, C.P. Bangladesh: Biography of a Muslim Nation, Boulder, Colo.: Westview, 1984. 5. Mustafa, G. Alliance Politics in Pakistan: A Study of the United Front, Pakistan Journal of History and Culture, Volume-XXXI, No. 1, Pakistan, Karachi, 2010. 6. Hayes, L.D. Politics in Pakistan: The Struggle for Legitimacy, Boulder: Westview, 1984. 7. Sen, R. Political Elites in Bangladesh, UPL, Dhaka, 1986. 8. Jahan, R. Pakistan: Failure in National Integration, UPL, Dhaka 2015. 9. Humayun, S. Sheikh Mujib's 6-Point Formula: An Analytical Study of the Breakup of Pakistan, Royal Book, Dhaka, 1995.

	10. †gvt gvneei ingvb, *evsjv‡`‡ki BwZnvm 1947-1971* (XvKv: mgq cKvkb, 2017)| 11. †gv. gKm`i ingvb m¤úv., *¯vaxb evsjv‡`‡ki Af¨`‡qi BwZnvm* (XvKv: Av‡jqv eK wW‡cv, 2017)| 12. Ave †gvt †`‡jvqvi †nv‡mb, *evsjv‡`‡ki BwZnvm 1905-1971* (XvKv: XvKv wek¦e`¨vjq cKvkbx, 2008)| 13. Avej Kv‡kg, *gw³i ci¤civ: evsjv‡`‡ki gw³msMv‡gi †c¶vcU I c¯wZce* (XvKv: K_v cKvk, 2020)| 14. gl`` Avng`, *evsjv‡`k: ¯vqËkvmb t_‡K ¯vaxbZv* (XvKv: BDwcGj, 1996)| 15. †gv. nwweejøvn evnvi, *cwiK¯Ív‡bi AvÂwjK ‰elg¨ 1947-1969: cvjv‡g‡›Ui fvl¨* (XvKv: evsjv GKv‡Wwg, 2017)| 16. †jwbb AvRv`, *EbmË‡ii MY Af¨Ìvb: ivó, mgvR I ivRbxwZ* (XvKv: BDwcGj1997)| 17. mvjvn DÏxb Avng`, †gvbv‡qg miKvi I biæj Bmjvg gÄi, *evsjv‡`‡ki gw³msMv‡gi BwZnvm (1947-1971)* (XvKv: AvMvgx cKvkbx, 1997)| 18. †gvnv¤§` dv‡qK D¾vgvb, *gwRe bMi miKvi I evsjv‡`‡ki gw³h×* (XvKv: Abvh cKvkbx, 2018)| 19. Avej dRj nK, *evsjv‡`‡ki kvmb e¨e¯v I ivRbxwZ* (XvKv: Abb¨v cKvkbx, 1998)|
Supplementary Readings	1. Umar, B. The Emergence of Bangladesh, Part-1&2, Bangala Gobeshona, Dhaka, 2015. 2. Ahmed, C.M. Government and Politics in Pakistan, Puthighar, Dacca, 1968. 3. Ahmed, M. Bangladesh: Constitutional Quest for Autonomy, 1950-71, UPL, Dhaka, 1976. *4.* Zaheer, H. The Separation of East Pakistan: The Rise and Realization of Bangali Muslim Nationalism, UPL, Dhaka, 1994. 5. ˆmq` Av‡bvqvi †nv‡mb, *evsjv‡`‡ki ¯vaxbZv h‡× enrkw³i fwgKv* (XvKv: RvZxq Mš cKvkb, 2005)|

Course No : 0411 18 BA 2265	**Credit :** 3	**Year :** Second	**Term:** First
Course Title : Marketing Principles		**Course Status :** Optional	
Prerequisite	None		
Rationale	This course is designed to provide the understanding of basics of Marketing concepts and to get introduced with major market operations and mechanisms of an organization. Marketing strategy becomes central to enterprise strategy. It is marketing that can make difference among the competing firms. To be successful, firms need to be creative in marketing with efficient operation of all other major value chain activities. In that case understanding basics of marketing is very important. This course focuses on some major fundamental operational areas of Marketing.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Introduction**: Definition and concept of market and marketing, nature and scope of marketing; evaluation of marketing, importance of marketing. Distinction of need, want, and demand; value and satisfaction; exchange and transaction.	1,2

2	**Analyzing the marketing environment**: Defining the marketing environment, elements of micro-environment: the company, suppliers, marketing intermediaries, competitors, publics, customers; elements of macro-environment: demographic environment, economic environment, natural environment, technological environment, political environment, social environment, the cultural environment.	3,5
3	**Product**: Product planning and development, product mix and product classification, product levels, brand, packaging, labeling, product life cycle, new product development, product line, product mix, services, unique features of services.	1,4
4	**Price**: Meaning of price; objectives of price, importance pricing, price determination, general pricing approaches, cost-based pricing, value-based pricing, competition-based pricing, mark-up pricing, break-even analysis; price strategies, new product pricing strategy, product mix pricing strategy, price adjustment strategy, price changes.	1,7
Section B		**CLOs**
4	**Customer driven marketing strategy**: market segmentation, market targeting, differentiation, positioning; target market strategy, bases of market segmentation, undifferentiated and differentiated marketing, concentrated marketing, micro marketing, differentiation and positioning strategy.	3,5
5	**Consumer market and business market buying behavior**: Consumer market, consumer buying behavior, characteristics affecting consumer behavior, types of buying decision behavior, the buyer decision process, the adoption process; Business market, business buyer behavior, types of buying situation, the business buying process, institutional and government markets.	3,5,6
6	**Marketing Channels of Distribution**: Channel of distribution, physical distribution, supply chain and value delivery network, nature and importance of marketing channel, channel design and management decision, marketing logistics and supply chain management.	5
7	**Promotion**: Purpose and nature of promotion, types of promotion, promotion mix, advertising, publicity, public relation, personal selling, social media marketing, internet marketing, direct marketing; promotion budget, steps in developing effective promotion.	1,8

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	conceptualize the basic idea of market and marketing	A1
	CLO 2	differentiate need, want and demand	A3
	CLO 3	explain bases of market segmentation	A3
	CLO 4	explain product planning and development	A3
	CLO 5	scan and address marketing environment.	A3
	CLO 6	analyze consumer and business buyer behavior	A3
	CLO 7	develop pricing policies and strategies.	B2
	CLO 8	explain steps in developing effective promotion	D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Kotler, P. Armstrong, G. Principles of Marketing, Illustrated Edition, Pearson, 2010. 2. Singh, H.K. Marketing Management, APH Publishing Corporation, New Delhi, India, 2016. 3. Singh, H.K. Introduction to Marketing Research, APH Publishing Corporation, New Delhi, India, 1996.
Supplementary Readings	1. Kotler, P. Keller, K.L. Marketing Management, 14th Edition, Prentice Hall, 2012. 2. Dibb, S. Simkin, L. Pride, W.M. Ferrell, O.C. Marketing Concepts and Strategy, Houghton Mifflin, USA, 1990. 3. Armstrong, G. Adam, S. Denize, S. Kotler, P. Principles of Marketing, Pearson Higher Education AU, 2011. 4. Parment, A. Armstrong, G. Kotler, P. Principles of Marketing Scandinavian Edition, 2nd Edition, Pearson Higher Ed., 2016.

Third Year First Term

Course No: 0531 18 Chem 3101	Credit: 3	Year: Third	Term: First
Course Title: Electrochemistry		Course Status: Core	
Prerequisite	None		
Rationale	This course will deal with the theoretical and experimental electrochemistry.		

COURSE CONTENTS		CLOs
Section A		
1	**Conductance:** Concept of weak and strong electrolytes, specific conductance (κ) and molar conductance (λ) and their measurements, variation of κ and λ with the concentration of weak and strong electrolytes, Kohlrausch's law of independent ion migration and its application, transport number and its determination, factors affecting transport number, applications of conductance in kinetic measurements.	1
2	**Theories of Electrolytes:** Theories of strong electrolytes: Debye Hückel limiting law and its test, determination of activity co-efficient, Debye-Hückel-Onsagar equation: limitations and applications.	1, 2
3	**Galvanic Cells:** Galvanic cells, half cells, electrode potentials, e.m.f. of cells, different types of electrodes: standard hydrogen electrode, secondary reference electrodes, concentration of cells, measurement of e.m.f. of a cell: compensation method, use of high impedance voltmeters, measurements of electrode potentials, cell reactions, half-cell reactions, thermodynamic functions from e.m.f. measurements: standard free energy changes, equilibrium constants, activities, quinohydrone and hydrogen ion selective electrodes.	5
4	**Industrial Application:** Chlor-alkali industry, water purification, electroplating, corrosion and its control, batteries and fuel cells.	2, 3
Section B		**CLOs**
5	**Electrode Potential and emf of a Cell:** Cell reaction and derivation of Nernst equation, measurement of emf of a cell, factors affecting electrode potential, rates of electrode potential, different parameters determined by potential measurements (pH, equilibrium constant, activity coefficient, transport number, oxidation state etc.), standard oxidation reduction potential, application of emf measurement.	4
6	**Cyclic Voltammetry:** Principle and application, striping voltammetry: basic principles and some fundamental features, amperometry: principle and application.	1
7	**Electrode Processes:** Polarization, concentration polarization, activation polarization and Ohmic polarization, Polarography and voltammetry.	1
8	**Electrochemical Sensors:** Electrochemical biosensor, Enzyme based electrode: Glucose sensor, Ethanol electrode, Urea electrode, Toxin (Enzyme Inhibition) biosensor. Affinity biosensor: Immunosensors, DNA hybridization biosensor, Gas sensors, Solid state device.	2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	provide basic concept of electrolytes, conductance in detail and conductance behavior of weak and strong electrolytes as well as electrochemical process using different method.	A1
	CLO 2	develop their logical and critical thinking through problem solving.	C3
	CLO 3	identify and solve problems on learned topics in related areas of electrochemistry and other fields as well as real-life cases.	D2
	CLO 4	state and apply the Nernst equation to calculate cell emf and ion activities.	A1
	CLO 5	distinguish between different types of cells.	A3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Brain Storming, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Atkins, P. Paula, J.D. Physical Chemistry, 10th Edition, Oxford University Press, 2013. 2. Bard, A.J. Faulkner, L.R. Electrochemical Methods, Fundamentals and Applications, Wiley, New York, 1980. 3. Castellan, G.W. Physical Chemistry, 4th Edition, Narosa, 2004. 4. Kapoor, K.L. A Textbook of Physical Chemistry, 3rd Edition, McGraw Hill Education, 2013.
Supplementary Readings	1. Barrow, G.M. Physical Chemistry, McGraw-Hill College, 1996. 2. Alberty, R.A. Physical Chemistry, John Wiley & Sons, 1979. 5. Kapoor, K.L. A Textbook of Physical Chemistry, Volume-5, 3rd Edition, McGraw Hill Education, 2015. 3. Glasstone, S. An Introduction to Electrochemistry, Maurice Press, 2008.

Course No: 0531 18 Chem 3102	Credit: 01	Year: Third	Term: First
Course Title: Electrochemistry Sessional		Course Status: Core	
Prerequisite	None		
Rationale	This course will provide knowledge of electro-analysis.		

COURSE CONTENTS	CLOs
1. Determine of metal ion using potentiometric titration 2. Construct galvanic cell with different electrode and determine the cell potential in various concentration of electrolyte 3. Determination of pH by direct potentiometry 4. Determination of conductivity of natural water 5. Determination of the half wave potential of various the metal ions 6. Determination of NH_3 in water sample by ion-selective electrode 7. Conductometric titration of a strong acid with a strong base	1-5

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	CLO 1	apply different electro-analytical techniques for quantitative analysis.	A1
	CLO 2	evaluate the suitable conditions to make analysis.	C3
	CLO 3	measure pH, conductivity of natural water and finally characterize water.	D2
	CLO 4	identify various metal by electro-analytical techniques.	A1
	CLO 5	collect and rationalize a wide range of chemical facts, concepts and principles.	A3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Sessional Work, Case Study, Question & Answer Session,	Lab Report, Term papers, Oral and Written Examinations
4	Lecture, Group Work & Sessional Work	Lab Report, Term papers, Oral and Written Examinations
5	Lecture, Sessional Work & Case Study	Lab Report, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Sawyer, D.T. Roberts, J.L. Experimental Electrochemistry for Chemists, Wiley, New York, 1974. 2. Christian, G.D. Analytical Chemistry, 6th Edition, John Wiley &

	Sons, Inc.: Hoboken, NJ, 2004. 3. Braun, R.D. Introduction to Chemical Analysis, McGraw Hill International, 1982.
Supplementary Readings	1. Delahay, P. New Instrumental Methods in Electrochemistry, Interscience, New York, 1954. 2. Jeffery, G.H. Bassett, J. Mendham, J. Denney, R.C. Vogel's Quantitative Chemical Analysis, 5th Edition, Longman Scientific & Technical, Great Britain, 1989. 3. Ewing, G.W. Instrumental Methods of Chemical Analysis, McGraw Hill International, 1969.

Course No: 0531 18 Chem 3103	**Credit:** 3	**Year:** Third	**Term:** First
Course Title: Solid State Chemistry and Chemical Crystallography		**Course Status:** Core	
Prerequisite	None		
Rationale	This course is to give students a broad view in material chemistry including solid state chemistry and crystallography.		

	COURSE CONTENTS	**CLOs**
	Section A	
1	**Classification of Solid:** Crystalline and amorphous solid, distinction between crystalline & amorphous solid, polycrystalline solid, polymorphism, isomorphism, allotropy, molecular crystal (Van der Waals crystal), covalent crystal, ionic crystals, metallic crystal, Born-Haber cycle, lattice energy of an ideal ionic crystal.	1
2	**Properties of Solid Surface:** Surface cleaning, techniques of characterization of solid surfaces, LEED, XPS, Auger spectroscopy.	2
3	**Electrical Properties of Solids:** Band theory, semiconductors and their types, doping, superconductors, photoconductivity, photocells for solar energy conversion.	3
4	**Reaction of Solids:** Film photography, kinetics of decomposition of solids, different types of corrosion and their prevention, tarnishing reactions.	4
	Section B	**CLOs**
5	**Structure and Symmetry Operations:** Structure of crystals, lattices and unit cells, lattice planes, crystal system, Bravais lattice, close packed systems, hexagonal and cubic close packing, radius ratio and coordination number, symmetry elements, point groups, space groups.	5
6	**X-ray Diffraction by Crystals:** Generation of X-rays, properties of X-rays, scattering of X-rays, Bragg's law, the powder method: theory, principle, and applications, single crystal X-ray diffraction: theory, principle, and applications, crystal structure of materials: NaCl, CsCl, CaF_2, TiO_2, $CdCl_2$, pervoskite and spinal structure.	6
7	**Crystal Defects:** Perfect and imperfect crystals, type of crystal defects, thermodynamic and equilibrium concentration of intrinsic defect, creation and color centers, influence of defects on physical properties of solids.	7
8	**Liquid Crystal and Alloy:** Liquid crystals: classifications, theory and their applications. Alloys and some typical inorganic solid.	1

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	explain the various form of solid and energy of the ionic crystal.	A1
	CLO 2	able to explain the surface of solid by using different spectroscopic method.	C3
	CLO 3	express of atomic structure of solid and the physical characteristics such as electronic structure and optical and transport properties and current-voltage characteristics.	A3
	CLO 4	describe the different mechanisms of solid-state reactions and their required modification.	A3
	CLO 5	explain the description of a crystal structure in terms of atom positions, unit cells, and crystal symmetry; and to relate the crystal symmetry to the symmetry observed in a diffraction experiment.	A1, C1
	CLO 6	explain the basics of X-ray diffraction theory in terms of X-rays, Diffraction and Bragg's law. Compare different crystal structure of different solid materials.	A1, A2
	CLO 7	explain the various crystal defect and their physical properties.	A1, A3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Team/Group Work, Problem Solving, Brain Storming, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving & Brain Storming	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Case study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
7	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. West, A.R. Solid State Chemistry and Its Applications, 2nd Edition, Wiley, 2014. 2. Rao, C.N.R. Gopalakrishnan, J. New Directions in Solid State Chemistry, Cambridge University Press, 1986. 3. Smart, L.E. Moore, E.A. Solid State Chemistry-An Introduction, 5th Edition, CRC Press, 2020. 4. Atkins, P. Paula, J. Physical Chemistry, 8th Edition, Oxford University Press, New York, 2006.
Supplementary Readings	1. Smart, L.E. Moore, E.A. Solid State Chemistry: An Introduction 4th Edition, CRC Press, 2012. 2. Dann, S.E. Reactions and Characterization of Solids, RSC Publishing, 2000. 3. Wells, A.F. Structural Inorganic Chemistry, 5th Edition, Oxford University Press, 1984. 4. Cheetham, Solid State Chemistry: Techniques, Clarendon Press, 1990. 5. Cox, P.A. The Electronic Structure and Chemistry of Solids, Oxford, 1987.

Course No: 0531 18 Chem 3104	**Credit:** 1	**Year:** Third	**Term:** Second
Course Title: Solid State Chemistry and Chemical Crystallography Sessional		**Course Status:** Core	
Prerequisite	None		
Rationale	This course aims to give a thorough introduction to Crystallography with focus on the molecular crystal growing data analysis as well as powder x-ray diffraction and solid surface analysis.		

COURSE CONTENTS	CLOs
1. Growing of single crystal for X-ray diffraction 2. Data analysis of powder X-ray diffraction, AF-SEM, TEM, etc. 3. Preparation of different crystal model	1-3

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	able to analyze structure of materials at atom and molecular level.	A1, C3, D3
	CLO 2	explain the materials morphology.	C3, D3
	CLO 3	build up the concept of various crystal shape such as cubic, hexagonal etc.	C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations

2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Sessional Work, Question & Answer Session, Case Study	Lab Report, Term papers, Oral and Written Examinations
4	Lecture, Group Work, Sessional Work	Lab Report, Term papers, Oral and Written Examinations
5	Lecture, Sessional Work, Mock Test	Lab Report, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Hammond, C. The Basics of Crystallography and Diffraction, Oxford Science Publications, 2001.
Supplementary Readings	1. West, A.R. Solid State Chemistry and Its Applications, 2nd Edition, Wiley, 2014. 2. Smart, L. E. Moore, E.A. Solid State Chemistry: An Introduction 4th Edition, CRC Press 2012 3. Dann, S.E. Reactions and Characterization of Solids, RSC Publishing 2000. 4. Wells, A.F. Structural Inorganic Chemistry, 5th Edition, Oxford University Press, 1984.

Course No: 0531 18 Chem 3105	**Credit:** 03	**Year:** Third	**Term:** First
Course Title: Chemistry of Biomolecules		**Course Status:** Core	
Prerequisite	None		
Rationale	This course is design to provide fundamental concepts of biomolecules and their functions and metabolism.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Carbohydrates and Polysacharides:** Definition, classification, constitution and configuration of monosaccharide and polysacharides, synthesis, structure, properties and reactions of monosacharides, di-sacharides, tri-sacharides and polysaccharides.	1, 2, 3
2	**Protein and Amino Acid:** Definition, sources, classification and importance of amino acids, buffer action in biological system, structure and configuration of amino acids, biosynthesis of amino acids, peptides, its occurrence.	1, 2, 3
3	**Lipids:** Definition, occurrence, classification and function, composition of fats and oils, hydrolysis of fats, saturated and unsaturated fatty acids, phosphoglycerides, phosphate esters; phospholipids and cell membranes, biosynthesis of lipids.	1, 2, 3
4	**Metabolism of Biomolecules:** Introduction to metabolism, types metabolic reactions, metabolism of carbohydrates, protein and lipids, TCA cycle, beta oxidation, urea cycle, disposal of urea, integration between urea cycle and TCA cycle.	4
Section B		**CLOs**

5	**Fe-S Protein and Cytochrome:** Iron-sulfur protein, long distance electron transfer, ferridoxins and rubredoxiens (structure and functions), cytochrome: classification and structure of cytochrome-C, function, physical properties, cytochrome P_{450} enzyme, oxygen saturation curve of myoglobin and hemoglobin.	1, 2, 3
6	**Nucleic acid:** Definition, sources and importance, structure of nucleic acids, nucleosides and nucleotides, DNA and RNA, replication, double helix model, genetic sequence.	1, 2, 3
7	**Metabolism of Minerals:** Biological classification of essential elements, trace elements and its classification, role of essential trace elements in human nutrition, biochemical functions and metabolism of minerals.	1, 2
8	**Enzyme, Vitamins and Antibiotics:** Occurrences, isolation and classification of enzyme, vitamins and antibiotics, biological functions, constitutions, coenzyme and prosthetic group, brief treatment on enzymatic reaction mechanism and its regulation.	1, 2, 3, 6

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	identify the sources and uses of biomolecules.	A1
	CLO 2	describe the function of biomolecules.	D1
	CLO 3	correlate the function of carbohydrates, protein, lipids, nucleic acid and enzyme.	C1, D3
	CLO 4	describe how biomolecules are metabolized, and explain how they can be used for energy.	A3, D2
	CLO 5	describe the metal containing biomolecules for the electron transfer reactions.	A1, D2
	CLO 6	describe how the antibiotics work against microorganisms.	D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Presentation, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Brain Storming, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Problem Solving, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Satyanarayana, J. Chakrapani, U. Biochemistry, 2nd Edition, Books and Allied Ltd, 2008. 2. Agrawal, O.P. Organic Chemistry Natural Products, Volume-I, GOEL Publishing House, India, 2013. 3. Agrawal, O.P. Organic Chemistry Natural Products, Volume-II, 38th Edition, GOEL Publishing House, India, 2010.
Supplementary Readings	1. Chatwal, G. Organic Chemistry of Natural Products, Volume-I, 4th Edition, Himalaya Publishing House, India, 2019. 2. Chatwal, G. Organic Chemistry of Natural Products, Volume-II, 5th Edition, Himalaya Publishing House, India, 2019. 3. Agrawal, O.P. Synthetic organic chemistry, Goel Publishing House, Meerut, 1977. 4. Bhat, S.V. Nagasampagi, B.A. Sivakumar, M. Chemistry of Natural Products, Narosa Publishing House, India, 2013.

Course No: 0531 18 Chem 3106	**Credit:** 1	**Year:** Third	**Term:** First
Course Title: Biomolecules Analysis Sessional		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide ideas about qualitative as well as quantitative analysis of biomolecules		

COURSE CONTENTS	CLOs
1. Chromatographic separation of pigments in plant samples 2. Analysis and separation of protein sample 3. Estimation of physicochemical parameters of lipids 4. Analysis of blood sugar and cholesterol 5. Estimation of vitamins and minerals using spectroscopically 6. Analysis of antioxidant properties of phytochemicals	1-5

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	chromatographic analysis of biomolecules.	B1, C3, C1, D1
	CLO 2	estimation of physicochemical parameters of lipid samples.	B1, C3, C1, D1
	CLO 3	analysis of blood sugar and cholesterol in biological samples.	B1, C3, C1, D1
	CLO 4	spectroscopic determination of vitamins and minerals.	B1, C3, C1, D1
	CLO 5	examine the antioxidant properties of various phytochemicals.	B1, C3, C1, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations

2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Sessional Work, Case Study, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
4	Lecture, Group Work & Sessional Work	Lab Report, Term papers, Oral and Written Examinations
5	Lecture & Sessional Work	Lab Report, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Satyanarayana, J. Chakrapani, U. Biochemistry, 2nd Edition, Books and Allied Ltd, 2008. 2. Christian, G.D. Analytical Chemistry, 6th Edition, Wiley, 2003.
Supplementary Readings	1. Verma, R.M. Analytical Chemistry: Theory and Practice, 3rd Edition, CBS Publishers & Distributors Pvt Ltd, India, 2007. 2. Jeffery, G.H. Bassett, J. Mendham, J. Denney, R.C. VOGEL'S Textbook of Quantitative Chemical Analysis. Longman Scientific & Technical, Great Britain, 1989.

Course No: 0531 18 Chem 3107	**Credit:** 3	**Year:** Third	**Term:** First
Course Title: Introduction to Chemical Spectroscopy		**Course Status:** Core	
Prerequisite	**None**		
Rationale	This course will provide the knowledge about the basic concept of spectroscopy and problem-solving ability.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Electromagnetic Radiation:** Interaction of electromagnetic radiation with atoms and molecules, characterization of electromagnetic radiation, region of spectrum, emission and absorption spectra, representation of spectra, special peaks and intensities, width and resolution, signal to noise ratio and signal averaging.	1
2	**Ultra-violet and Visible Spectroscopy:** Basic principle, absorption law, types of electronic transition, transition probability, the chromophore and auxochrome, absorption and intensity shifts, types of absorption bands.	1, 2, 3
3	**Solvent Effect on Absorption Bands:** Absorption for conjugated dienes and α, β-unsaturated carbonyl compounds, benzene and its derivatives, Woodward-Fieser rules for calculating absorption maximum in dienes, α,β-unsaturated carbonyl compounds and benzene and its derivatives; electronic transitions for charge-transfer complexes; applications of ultra-violet spectroscopy.	2, 3
4	**Infrared Spectroscopy:** Basic principle, molecular vibration, vibrational frequency, number of fundamental vibrations, harmonic and inharmonic vibration in diatomic molecules, scanning of infrared spectrum.	4
5	**Factors Influencing Vibrational Frequencies:** Finger print region, sampling techniques, applications of infrared spectroscopy.	4
Section B		**CLOs**

6	**Magnetic Resonance Spectroscopy:** Nuclear spin and resonance, the energies of nuclei in magnetic fields, common nuclei with spin (^{1}H, ^{13}C, ^{15}N, ^{19}F, ^{31}P), interaction of magnetic field with nuclear spin, resonance absorption of radiation, the spectrometer: NMR spectrum.	5, 6
7	**Chemical Shifts:** Shielding and deshielding of nuclei, factors affecting the chemical shift.	6
8	**Splitting of the Signals:** Spin-spin coupling, coupling constant, intensity of NMR signals and integration, calculating the ratio in the heights of the signals, chemical exchange.	6
9	**Correlation NMR Spectroscopy:** Double resonance; nuclear overhauser effect, NMR absorption by other nuclei, NMR spectrum at more than one radiofrequency, ^{13}C-NMR spectroscopy; COSY and NOESY, application of NMR in the investigation of chemical reactions.	6

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	compare and contrast atomic and molecular spectra.	A1
	CLO 2	draw an energy level diagram and identify the transitions.	A3
	CLO 3	evaluate the utility of UV/Vis spectroscopy as a qualitative and quantitative method.	B2
	CLO 4	determine the vibrations for a triatomic molecule and identify whether they are infrared-active.	C2
	CLO 5	interpret atomic absorption spectroscopy.	D3
	CLO 6	explain working principles, taking spectrum and outline of NMR spectroscopy device.	D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session,	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work & Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Pavia, D.L. Lampman, G.M. Kriz, G.S. Vyvyyan, J.R. Introduction to Spectroscopy, 4th Edition. Brooks/Cole, Cengage Learning, 2009. 2. Banwell, C.N. Fundamentals of Molecular Spectroscopy, 3rd Edition, McGraw-Hill, 1983.
Supplementary Readings	1. Barone, V. Computational Strategies for Spectroscopy, 1st Edition, Wiley, 2011. 2. Ball, D.W. The Basics of spectroscopy. SPIE Press, 2003. 3. Kuzmany, H. Solid-State Spectroscopy: An Introduction, 2nd Edition. Springer-Verlag Berlin Heidelberg, 2009.

Course No: 0531 18 Chem 3108	**Credit:** 1	**Year:** Third	**Term:** First
Course Title: Chemical Spectroscopy Sessional-I		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide a demonstration on making standard solution, calibration curve, handling instruments and structure elucidation.		

COURSE CONTENTS	CLOs
1. Preparation of solution, calibration curve and interpretation of UV-Visible spectra 2. Instrument preparation, calibration and interpretation of IR-Spectra 3. Instrument preparation, calibration and interpretation of NMR-Spectra	1-5

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	demonstrate instrumentation.	A3
	CLO 2	prepare standard solution and calibration curve.	B3
	CLO 3	evaluate different types of spectra.	D1
	CLO 4	hypothesize an experiment using spectroscopy.	B1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Sessional Work, Case Study, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
4	Lecture, Group Work & Sessional Work	Lab Report, Term Papers, Oral and Written Examinations
5	Lecture, Sessional Work & Problem Solving	Lab Report, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Christian, G.D. Dasgupta, P.K. Schug, K.A. Analytical Chemistry, 4th Edition, John Wiley & Sons, 2009. 2. Ewing, G.W. Instrumental Methods of Chemical Analysis, McGraw Hill International, 1954.
Supplementary Readings	1. Robert, L.P. Shields, L.D. Modern Methods in Chemical Analysis, 2nd Edition, John Wiley & Sons, Inc, 1968. 2. Williams, D.H. Fleming, I. Spectroscopic Methods in Organic Chemistry, 6th Edition, McGraw-Hill, 1995.

Course No: 0531 18 Chem 3109	**Credit:** 3	**Year:** Third	**Term:** First
Course Title: Environmental Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide a vast knowledge about chemistry of environment.		

COURSE CONTENTS		CLOs
Section A		
1	**Chemistry of Water:** Properties and chemical composition of natural water, uses of water, water resources: hydrological cycle, physical chemistry of sea water, complexation in natural water and waste water, aquatic biochemical process, water conservation.	2
2	**Water Pollution:** Characterization of waste water, nature and sources of water pollutants**,** classification of water pollutants, trace elements in water, chemical speciation, eutrophication, effects of water pollution.	1, 2, 3
3	**Water Treatment:** Municipal **w**ater treatment, sewage treatment, industrial wastewater treatment, removal of solids**,** removal of metals, removal of dissolved organic, removal of inorganic pollutants, water disinfection, desalination of marine water, natural water purification processes, green water.	4
4	**Soil Pollution:** Composition and importance of soil, soil indicator plants, sources of soil pollution, effects of soil pollution: effects of modern agricultural practices, synthetic fertilizers, pesticides, industrial effluents and urban wastes, control of soil pollution.	1, 2, 3
Section B		**CLOs**
5	**Air Pollution:** Composition of air, classification of air pollutants and their sources, chemical and photochemical reactions of air pollutants and their consequent effects, acid rain, photo chemical smog, greenhouse effect, ozone layer depletion, air quality standards, air monitoring, atmospheric sampling and analysis, analytical and industrial techniques used in the estimation of atmospheric pollutants, air pollution control.	1, 2, 3
6	**Industrial Waste and Chemical Toxicology:** Characterizations and classification of industrial wastes, utilization of industrial wastes, classification of toxicants, LC_{50} & $LC3_0$, concept of threshold limit value, biochemical effect of heavy metals, carcinogens, bio-warfare agents.	1, 5
7	**Resources and Energy:** Sources of energy, renewable and nonrenewable energy, solar energy, hydro power, wind power, biomass energy, photosynthesis, photo electrochemistry, geothermal energy, tidal	6

	power, air energy, world energy resources: composition and conservation.	
8	**Importance of Analytical Methods in Environmental Chemistry**: Uses of analytical methods in analyzing environmental samples, choice of analytical methods for selective environmental analysis, validation of analytical procedures, quality assurance and quality control practices in chemical analysis, interpretation of result.	4

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	define the human activities and industrial process contributing to environmental pollution.	C1, D2
	CLO 2	classify different segments of environment and describe their composition along with pollution status.	A2, D1, D2
	CLO 3	recognize the sources and effect of environmental pollution including water, soil and air pollution.	C1, D2
	CLO 4	demonstrate the treatment methods of different wastes.	A2, C1, C3
	CLO 5	comment about toxicity, types and effect of toxic substance on human health.	D2
	CLO 6	Identify the energy sources and their conversion.	A4, D2, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question, Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question, Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question Answer, Session, & problem Solving,	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Srivastava, M.M. Chemistry of Environment, 1st Edition, Narosa Publishing House, New Delhi, 2005. 2. Manahan, S.E. Environmental Chemistry, 9th Edition, CRC Press, Taylor & Francis group, New York, 2010. 3. Verma, R.M. Analytical Chemistry: Theory and Practice, 3rd

	Edtion, CBS Publishers and Distributors, New Delhi, 2000.
Supplementary Readings	1. De, A.K. Environmental Chemistry, 7th Edition, New Age International (P) Ltd, New Delhi, 2010. 2. Cunningham, W.P. Environmental Science: A Global Concern, 1st Edition, McGraw-Hill, New York, 1990. 3. Dara, S.S. A Textbook of Environmental Chemistry and Pollution Control, 11th Edition, S. Chand & Company Ltd, New Delhi, 2006. 4. Sodhi, G.S. Fundamental Concepts of Environmental Chemistry, 2nd Edition, Narosa Publishing House, New Delhi, 2005. 5. Kaur, H. Environmental Chemistry, 7th Edition, Progati Prakashan, New Delhi, 2012.

Course No: 0531 18 Chem 3110	**Credit: 01**	**Year:** Third	**Term:** First
Course Title: Environmental Chemistry Sessional		**Course Status:** Core	
Prerequisite	None		
Rationale	This course is designed to provide the knowledge about environmental sample collection, preparation, analysis and quality identification.		

COURSE CONTENTS	**CLOs**
1. Determination of water quality parameters 2. Determination of sediment and soil quality parameters 3. Determination of air quality parameters	1-3

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain about the environmental sample collection, preparation and preservation.	D2, D3
	CLO 2	apply different analytical techniques to determine the basic parameters for assessing the quality of water, air, sediments and soil.	C1, D2, D3
	CLO 3	perform accurate laboratory work in a range of basic analytical chemistry applications.	B1, C1, D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Laboratory experiment, Discussion, Question & Answer Session	Report writing, Laboratory Practical Examinations and Oral Examinations
2	Laboratory experiment, Discussion, Question & Answer Session	Report writing, Laboratory Practical Examinations and Oral Examinations
3	Laboratory experiment, Discussion, Question & Answer Session	Report writing, Laboratory Practical Examinations and Oral Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Pani, B. Textbook of Environmental Chemistry, 2nd Edition, International Publishing House, 2017. 2. Christian, G.D. Analytical Chemistry, 6th Edition, Wiley, 2003. 3. Verma, R.M. Analytical Chemistry: Theory and Practice, 3rd Edition, CBS Publishers & Distributors Pvt Ltd., India, 2007.
Supplementary Readings	1. Moore, J.W. Moore, E.M. Environmental Chemistry, Academic Press, New York, 2004. 2. Manahan, S.E. Environmental Chemistry, Brooks, California, 2005. 3. Neil, P.O. Environmental Chemistry, Chapmann, London, 2004. 4. Baird, C. Environmental Chemistry, Freeman, New York, 2003. 5. Kumar, A. Environmental Chemistry, Wiley Eastern, New Delhi, 2005. 6. Andrews, J.E. Brimblecombe, P. Jickells, T.D. Liss, P.S. Reid, B.J. An Introduction to Environmental Chemistry, 2nd Edition, Blackwell Publishers, 2003. 7. Banerji, S.K. Environmental Chemistry, Tata Publisher, Delhi, 2006. 8. Baird, C. Environmental Chemistry, W.H. Freeman and Company, 1998.

Course No: 0421 18 Law 3167	**Credit:** 3	**Year:** Third	**Term:** First
Course Title: Environmental Laws in Bangladesh		**Course Status:** Optional	
Prerequisite	None		
Rationale	This course is designed to introduce various domestic laws and international instruments for protecting environment.		

COURSE CONTENTS		CLOs
Section A		
1	**History and Evolution of Environmental Laws in Bangladesh:** Sources of environmental law, Features of the domestic regulatory regimes for the protection of environment, Environmental law and policy-making process.	1, 2, 3
2	**International Conventions:** Evaluation of international regulations on environment, international conventions and principles of international environmental law and its impact on national policies of Bangladesh;	3,4
3	**National Laws and Policies:** The Environmental Conservation Act 1995 and Rules 1997, The Environmental Court Act 2010: Composition, Powers, Functions and procedures of the environmental court, public interest litigation;	1,3,5
Section B		**CLOs**
5	**Sector Based Laws and Policies in Bangladesh:** Pollution (air, water, sound), Waste disposal, Conservation of forest and biodiversity, Ship breaking sectors.	3
6	**Evaluation the Role of Governmental and Non-governmental Organisations:** Ministry of Environment and Forest (MoFF), Department of Environment (DoE), Department of Forest (DoF), NGOs and INGOs in	3,4

	protecting environmental rights.	
7	**Challenges Regarding Environmental Situation:** Implication of environmental laws, National and international climate change response legislation.	5,6
8	**Sector based laws and policies:** pollution (air, water, sound), waste disposal, conservation of forest and biodiversity, ship breaking yards sectors.	3

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain historical evolution of Environmental Laws in Bangladesh.	A2
	CLO 2	realize the basic principles of environmental law.	A2, C2
	CLO 3	analyse domestic laws and policies regulating conservation of environment.	C3, B2, D2
	CLO 4	evaluate the implication process of environmental laws in Bangladesh.	C1, D1
	CLO 5	critical assessment of the challenges and relevant legal provisions in order to protecting environment for a better future.	C1, D1
	CLO 6	identify possible pathways to protect the environment and generate plans to engage themselves in the progress.	C1, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session,	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question, Answer Session, & Team/Group Work	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Sands, P. Principles of International Environmental Law, Cambridge University Press, 2018. 2. Birnie, P. International Law and the Environment, Oxford University Press, 2009. 3. Faruque, A.A. Environmental Law: Bangladesh and Global Perspective, New Warsi Book Corporation, 2017. 4. Hassan, S.R. Islam, T. Judicial Decisions on Environment in South Asia, Bangladesh Lawyers Association, 2005.

	5. Zona, R. Public Interest Environmental Litigation in India, Pakistan and Bangladesh, Kluwer Law International, 2004.
Supplementary Readings	1. Hossain, M.I. International Environmental Law: Bangladesh Perspective, Dhaka International University Press, 2004. 2. Farooque, M. Hassan, R. Law Relating Environment in Bangladesh, Bangladesh Environmental Lawyers' Association, 2004. 3. Leelakrishnan, P. Environmental Law Case Book, LexisNexis, India, 2006. 4. Divan, S. Rosencranz, A. Environmental Law and Policy in India: Cases, Materials and Statutes, Oxford University Press, 2002. 5. Diwan, P. Diwan, P. Environmental Administration Law and Judicial Attitude, Deep & Deep Publications, India, 2002.

Course No: 0811 18 AT 3169	**Credit:** 3	**Year:** Third	**Term:** Second
Course Title: Agricultural Technology		**Course Status:** Optional	
Prerequisite	None		
Rationale	This course will provide basic concepts about agrochemicals and their functions in agricultural purposes.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Pesticides and its Classification**: Properties of standard pesticides, classification of pesticides according to various ways.	1
2	**Toxicity of Pesticides:** Acute effect, chronic effect, systemic effects, various diseases for toxicity of pesticides.	2
3	**Formulation of Pesticides:** Granular, wettable powder, emulsion, soluble, soluble dust, soluble powder, EC etc.	2
4	**Mode of Action of Pesticides:** Metabolism of some organochlorine, organophosphorus and carbamic acid derivatives pesticides in biological system and in environment.	2
Section B		**CLOs**
5	**Agrochemicals:** Agrochemicals, classification, uses of agrochemical e.g. insecticide, fungicide, herbicide, fertilizers, their advantages and disadvantages, preparation of some commercially available herbicide, fungicide and insecticide, analysis of agrochemicals in biological samples and in environments.	1
6	**Mode of Action of Fertilizer in Soil:** Definition, classification, sources, essential requirement, chemical action of nitrogenous, phosphate and potassium fertilizer, their deficiency and mode of action, nitrogen fixation, nutritional status in plants, agronomic efficiency, nanofertilizers and their importance, fertilizer recommendation guideline for various crops.	2, 3, 4
7	**Pest Control by Natural Products**: Pest control by pyrethrum and the pyrethrins, nicotine, rotenone, sabadilla, ryania, neem, limonene and linalool, their advantages and disadvantages.	5
8	**Pest control by pheromones:** Mechanism of pest control by sex pheromones, pheromone trap, advantage of using pheromones over	5

	synthetic pesticides, synthesis route of some pheromones.	

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	relate chemical concepts to agriculture including fertilization, pesticide use, and environmental fate of compounds.	A1, C3, D2
	CLO 2	apply the toxicity, formulation, and mode of action of pesticides.	A2, D2
	CLO 3	explain the mode of action and synthesis route of agrochemicals.	A3, D2
	CLO 4	develop knowledge, understanding and skills about fertilizer for the production of crops.	D1, D2
	CLO 5	investigate the method of pest control by natural products and pheromones.	C2, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Team/Group Work, Problem Solving & Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Chopra, L.S. Kanwar, J.S. Analytical Agricultural Chemistry, Kalyani Publishers, Ludhiana, New Delhi, India, 1980. 2. Manahan, S.E. Environmental Chemistry, 9th Edition, CRC Press LLC, Boca Raton, Florida, USA, 2010. 3. Ramulu, U.S.S. Chemistry of Insecticides and Fungicides, Oxford and IBH Publication, New Delhi, India, 1995.
Supplementary Readings	1. Baird, C. Environmental Chemistry, Freeman, New York, 2003. 2. Kumar, A. Environmental Chemistry, Wiley Eastern, New Delhi, 2005. 3. Andrews, J.E. Brimblecombe, P. Jickells, T.D. Liss, P.S. Reid, B.J. An Introduction to Environmental Chemistry, 2nd Edition, Blackwell Publishers, 2003. 4. Tomlin, C.D.S. The Pesticide Manual, 13th Edition, British Crop Protection Council, Hampshire, UK, 2003. 5. Tandon, H.L.S. Methods of Analysis of Soils, Plants, Waters, Fertilizers and Organic Manures, Fertilizer Development and Consultation Organization, New Delhi, India, 2013.

Third Year Second Term

Course No: 0531 18 Chem 3201	**Credit:** 3	**Year:** Third	**Term:** Second
Course Title: Organometallic Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	This course aims to give a thorough introduction to organometallic chemistry with focus on the transition metals with fundamental molecular properties and gradually develops this into practical applied catalysis.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Introduction to Organometallic Chemistry:** Historical background, classification of organometallic compounds by bond type, difference between main groups and transition metal organometallics, the stability of organic compounds.	1
2	**Preparation of Organometallic Compounds:** The direct reaction: mechanistic consideration, reactions of organometallic reagents with metal halides, free metals, organic halides, and unsaturated compounds, electrochemical methods.	2
3	**Structure and Bonding:** Structure and bonding of metal carbonyl, metal nitrosyls and metal phosphines, synthesis and reactions, metal alkyl complexes: structure, stability, synthesis and reactivity.	3
4	**Transition Metal Organometallics:** Classification of organic ligands, 18-electron rule & its basis, applications and exceptions, catalytic reactions and the 16/18 VE rule.	2
Section B		**CLOs**
5	**Chemistry of Iron Group Metallocenes:** Preparation, structure and bonding, properties, reactions, comparative reactivities of ferrocene, mechanism of electrophilic substitution, mechanism of the arylation reaction.	3
6	**Stoichiometric Reactions of Transition Metal Organometallics:** Oxidative addition (reaction with hydrogens and protons), reductive elimination (reaction forming carbon-carbon bonds and carbon-hydrogen bonds) and insertion reactions.	2
7	**Catalytic Reactions of Transition Metal Organometalics:** Water gas shift reaction, arylation /vinylation of olefins (Heck Reaction), alkene metathesis, oligomerization and polymerization of ethylene and propylene, olefin oxidation (Waker process), hydrogenation of alkenes, hydroformylation (oxo reaction), Fisher-Tropch synthesis.	2, 3
8	**Metal -Metal Bonds and Cluster :** Formation and criteria of metal-metal bond cluster, synthesis, structure and reactivity of osmium, ruthenium and iron cluster, electron count, structure and isolobal analogies, di-nuclear clusters, tri-nuclear clusters and higher nuclear clusters.	4

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	have a good overview of the fundamental principles of organotransition-metal chemistry and explain how to chemical properties are affected by metals and ligands.	A1
	CLO 2	explain fundamental reaction types and mechanism and how to combine these to explain efficient catalytic processes.	A3, D1
	CLO 3	demonstrate knowledge and understanding in bonding, structure and reactivities of main group and transition metal organometallics, especially in transition metal clusters, metal alkyls.	C3
	CLO 4	illustrate the characteristic properties of metal complexes in terms of their structures and explain the basic concepts on metal cluster.	A3, C1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Team/Group Work, Problem Solving & Case Study	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Alexander, D.G. Boris, I.K. Synthetic, Coordination and Organometallic Chemistry, Marcel Dekker Inc., New York, 2003. 2. Chandrasekhar, V. Inorganic and Organometallic Polymers, Springer, Germany, 2007. 3. Coates, G.E. Green, M.L. Powel, P. Wade, K. Principle of Organometallic Chemistry, Springer, 1968. 4. Manfred, B. Organometallics 1: Complexes with Transition Metal-Carbon Sigma-Bonds, 1st Edition, Oxford Science Publications, 1994. 5. Manfred, B. Organometallics 2: Complexes with Transition Metal-Carbon Pi-Bonds, Oxford Science Publications, 1994.
Supplementary Readings	1. Crabtree, R.H. The Organometallic Chemistry of the Transition Metals, John Wiley, 2000. 2. Archer, R.D. Inorganic and Organometallic Polymers, 1st Edition, Wiley-VCH, 2007.

	3. Cotton, F.A. Wilkinson, G. Gaus, P.L. Basic Inorganic Chemistry, 3rd Edition, Wiley, India, 1998. 4. Greenwood, N.N. Earnshaw, A. Chemistry of the Elements, 2nd Edition, Elsevier, 1997. 5. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.

Course No: 0531 18 Chem 3202	**Credit:** 1	**Year:** Third	**Term:** Second
Course Title: Organometallic Chemistry Sessional		**Course Status:** Core	
Prerequisite	None		
Rationale	This course aims to give a thorough introduction to organometallic chemistry with focus on the transition metals with fundamental molecular properties and gradually develops this into practical applied catalysis.		

COURSE CONTENTS	**CLOs**
1. Preparation of cis- and trans- compounds and characterization using various spectroscopic method 2. Synthesis and characterization of metal complexes using various spectroscopic method 3. Separate and estimation of various metal ion using gravimetrical method. 4. Determine the metal ion by direct titrimetric method	1-5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	demonstrate a competency and proficiency with experimental skills involved in chemical synthesis, instrumental methods, quantitative measurements and statistical data analysis.	A3, A4
	CLO 2	concept of gravimetric analysis including experimental aspects of this type of analysis and the use of gravimetric factor in calculations.	C3
	CLO 3	explain advanced laboratory procedures used in inorganic synthesis including spectroscopic and analytical techniques for identification and characterization of small molecules.	C1
	CLO 4	demonstrate practical knowledge and skills in the synthesis and characterization of the corresponding simple and complex inorganic compounds.	C1

	CLO 5	write and present formal laboratory reports on the results of chemical experiments.	D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written examinations
2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Sessional Work, Question & Answer Session	Lab Report, Term papers, Oral and Written Examinations
4	Lecture, Group Work & Sessional Work	Lab Report, Term papers, Oral and Written Examinations
5	Lecture, Sessional Work & Problem Solving	Lab Report, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Szfran, Z. Pike, R.M. Mono, M.S. Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience, John Wiley & Sons, 1991. 2. Jeffery, G.H. Bassett, J. Mendham, J. Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
Supplementary Readings	1. Alyea, H.N. Tested Demonstration in Chemistry, 6th Edition, Division of Chemical Education of the American Chemical Society, Easton, 1965. 2. Marr, G. Rockett, B.W. Practical Inorganic Chemistry, Van Nostrand Reinhold, 1972. 3. Svehla, G. Vogel's Qualitative Inorganic Analysis, Prentice Hall, 1996.

Course No: 0531 18 Chem 3203	**Credit:** 3	**Year:** Third	**Term:** Second
Course Title: Advanced Organic Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	The course is designed to provide students with the knowledge required for careers & higher education about periodic table and bonding in inorganic chemistry.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Molecular Orbital Theory:** Phase of an orbital and its role in bonding and antibonding, Huckel molecular orbital theory, LCAO's theory and M.O.'s theory- their shapes and energy states, Pi Systems and conjugated systems, illustration with 1,3-butadiene allyl system and 1,3,5-hexatriene, cyclic pi systems.	1
2	**Orbital Symmetry Controlled Reactions:** Analysis of pericyclic and	1, 2

	electrocyclic reactions, stereoisomer rotation, ring closing and opening, analysis of cyclo-addition reactions and sigmatropic rearrangements, rules for cycloaddition, Humo-Lumo interactions, anionic oxy-cope reactions, cope and claisen rearrangements.	
3	**Fundamental Aspects of Chirality:** Factors leading to chirality, elements of symmetry, molecular symmetry and group theory, molecular dissymmetry, atomic asymmetry and conformational asymmetry.	3
4	**Chiroptical Properties:** Circular bifringence and circular dichroism (CD), optical rotatory dispersion (ORD), Cotton effect, description of ORD curve, haloketone rule and octant rule, application of these in determining the structure, conformation and configuration of different compounds.	
Section B		**CLOs**
5	**Basic Knowledge of Organic Reaction and Retrosynthesis:** Introduction of retrosynthesis, restrosynthesis involves disconnection, restrosynthesis step, disconnection approach of some well-known reaction, synthons, target molecule, functional group interconversion (FGI), role of FGI in organic synthesis, aspects of strategy and planning for useful disconnections.	3, 4
6	**Restrosynthetic Analysis at Different Systematic Approach:** One group C-X disconnection, two group C-X disconnection, target molecules with the involvement of two functional groups, C-C disconnection, synthesis of the saturated and unsaturated heterocyclic compound.	4, 5
7	**Selectivity and Specificity.** Protection of functional group, alcohol, aldehyde, ketone and carboxylic acids, introduction to regioselectivity and stereochemistry, regioselective reaction, chemoselectivity, asymmetric synthesis.	4, 5
8	**Synthesis of Some Typical Organic Molecules.** Oxanamide, Z-jasmone, retronecine, abscisic acid and longifolene.	3, 4, 5

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain different theory of bonding.	A1, B1
	CLO 2	demonstrate the importance of the configuration of chiral organic compounds, including those with no chiral centre, in relation to chemical and physical properties.	B2
	CLO 3	explain symmetry element and its effect on chirality.	A1, B1, D2
	CLO 4	analyze and interpret the structure and reactivity relationship of organic molecules.	A1, A3, B1
	CLO 5	interpret stereochemical data that informs a mechanistic hypothesis.	A2, A3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Team/Group Work, Problem Solving & Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	4. Morrison, R.T. Boyd, R.N. Organic Chemistry, 7th Edition, Pearson Education India, 2010. 5. Bahl, A. Bahl, B.S. Advanced Organic Chemistry, 3rd Edition, S. Chand & Company Ltd., New Delhi, 1987. 6. Solomons, T.W.G. Fryhle, C.B. Snyder, S.A. Solomons' Organic Chemistry, 12th Edition, John Wiley & Sons, Inc., 2017. 7. Bahl, A. Bahl, B.S. A Text Book of Organic Chemistry, 22nd Edition, S. Chand & Company Ltd., New Delhi, 2019.
Supplementary Readings	5. Finar, I.L. Organic Chemistry: Volume-1, 6th Edition, Pearson Education India, 2002. 6. Wade, L.G. Organic Chemistry, 8th Edition, Pearson Education, 2016. 7. Clayden, J. Greeves, N. Warren, S. Organic Chemistry, 2nd Edition, Oxford University Press, 2014.

Course No: 0531 18 Chem 3204	**Credit:** 1	**Year:** Third	**Term:** Second
Course Title: Advanced Organic Chemistry Sessional		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide the practical knowledge about paper chromatography, thin layer chromatography and column chromatography as well as the use of these techniques to separate, identify and monitor organic reaction.		

COURSE CONTENTS	CLOs
1. Studies of some organic reactions 2. Separation of organic compounds by chromatographic methods: a) Preparation of thin layer plates b) Separation of mixture of colored compounds by TLC c) Separation of colored compounds by column chromatography d) Identification of free sugars by paper chromatography	1-4

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	prepare thin layer plates.	A1, C3
	CLO 2	identify the biomolecules by paper chromatography.	A2, B2
	CLO 3	separate the mixture by thin layer and column chromatography.	C1, C2
	CLO 4	monitor the progress of organic reaction.	D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
2	Lecture, Sessional Work, Question & Answer Session	Lab Report, Term Papers, Oral and Written Examinations
3	Lecture, Sessional Work, Question & Answer Session, Case Study	Lab Report, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	9. Shriner, R.L. Fuson, R.C. Curtin, D.Y. Morrill, T.C. Systematic Identification of Organic Compounds, 8th Edition, Wiley & Sons, 2004. 10. Skoog, D.A. West, D.M. Holler, F.J. Crouch, S.R. Fundamentals of Analytical Chemistry, 9th Edition, Thomson Books/Cole, 2014. 11. Lehman, J.W. Operational Organic Chemistry, 4th Edition, Pearson, 2008. 12. Agarwal, O.P. Advanced Practical Organic Chemistry, 1st Edition, Krishna Prakashan Media (P) Ltd. India, 2014.
Supplementary Readings	9. Morrison, R.T. Boyd, R.N. Organic Chemistry, 7th Edition, Pearson Education India, 2010. 10. Finar, I.L. Organic Chemistry: Volume-1, 6th Edition, Pearson Education India, 2002. 11. Bahl, A. Bahl, B.S. A Text Book of Organic Chemistry, 22nd Edition, S. Chand & Company Ltd., New Delhi, 2019. 12. Solomons, T.W.G. Fryhle, C.B. Snyder, S.A. Solomons' Organic Chemistry, 12th Edition, John Wiley & Sons, Inc., 2017.

Course No: 0531 18 Chem 3205	**Credit:** 3	**Year:** Third	**Term:** Second
Course Title: Advanced Chemical Spectroscopy		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide students great understanding on spectroscopy and its applications.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Microwave Spectroscopy:** Rotation of molecules and their classification, interaction of rotating molecules with radiation, microwave spectrometer,	1, 3

	rotational energies of linear rotors, distribution of molecules and rotational spectra, centrifugal distortion; effect, of isotropic substitution, stark effect and its use in microwave spectrometers, determination of molecular geometry from microwave spectra.	
2	**Raman Spectroscopy:** Raman effect, classical theory of Raman scattering, criterion of Raman activity, Raman spectrometers, use of laser in Raman spectroscopy, vibrational and rotation Raman spectra, use of Polarized light, applications of Raman spectroscopy.	1, 2, 3
3	**ESR Spectroscopy:** The G- factor, hyperfine splitting, determination of electron density from ESR spectroscopic studies, applications of ESR spectroscopy.	4
4	**Mossbauer Spectroscopy:** Nuclear energy levels, Doppler effect, resonance adsorption of radiation by nuclei, Mossbauer spectrometer, chemical shift, the quadrupole effects, Zeeman splitting, applications in chemistry.	5
Section B		**CLOs**
5	**Mass Spectroscopy:** Techniques of ionization, electron impact, fast atom bombardment, field desorption, photo ionization, multiphoton ionization, thermal methods; principles of moss separation, sector magnet technique, quadrupole mass separator, time flight mass spectrometer, ion optics, sampling for mass spectroscopic measurements, molecular beam sampling, ionizations potentials and measurements, fragmentation of ions, rearrangement of ions, base peak, mass spectra of various classes of compounds, correlation.	6
6	**NMR Spectroscopy:** COSY, HETCOR, HMQC, HMBC, TOCSY, ROESY.	7
7	**Structure Elucidation:** Structure elucidation of compounds by joint application of UV, IR, NMR, and mass spectroscopy.	7

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain molecular rotation and their classification.	A1
	CLO 2	express the interaction of rotating molecules with radiation.	A2
	CLO 3	evaluate the molecular geometry from microwave spectra.	A3, B2
	CLO 4	measure electron density from ESR spectroscopic studies.	C1
	CLO 5	conceptualize the Mossbauer spectroscopy.	C1
	CLO 6	generalize different types of ionization techniques in mass spectroscopy and mass spectra of various classes of compounds.	D3
	CLO7	elucidate the chemical structure of unknown compound interpreting spectroscopic data.	C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Question Session, Team/Group Work & Brain Storming	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Pavia, D.L. Lampman, G.M. Kriz, G.S. Vyvyyan, J.R. Introduction to spectroscopy, 4th Edition, Brooks/Cole, Cengage Learning, 2009. 2. Banwell, C.N. Fundamentals of Molecular Spectroscopy, 3rd Edition, McGraw-Hill, 1983.
Supplementary Readings	1. Barone, V. Computational Strategies for Spectroscopy, 1st Edition, Wiley, 2011. 2. Ball, D.W. The Basics of spectroscopy. SPIE Press, 2003. 3. Kuzmany, H. Solid-State Spectroscopy: An Introduction, 2nd Edition, Springer-Verlag Berlin Heidelberg, 2009.

Course No: 0531 18 Chem 3206	**Credit:** 01	**Year:** Third	**Term:** Second
Course Title: Chemical Spectroscopy Sessional-II		**Course Status:** Core	
Prerequisite	**None**		
Rationale	This course will provide a demonstration on making standard solution, calibration curve, handling instruments and structure elucidation.		

COURSE CONTENTS	CLOs
1. Preparation of solution, calibration curve and interpretation of UV-Spectra, determination of unknown concentration of solution. 2. Instrument preparation, sample preparation, calibration and interpretation of IR-Spectra. 3. Instrument preparation, calibration and interpretation of NMR-Spectra. 4. Spectroscopic techniques for the structure elucidation of compounds.	1-5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	demonstrate instrumentation.	A3
	CLO 2	prepare standard solution and calibration curve.	B3
	CLO 3	evaluate different types of spectra.	D1
	CLO 4	hypothesize an experiment using spectroscopy.	B1

	CLO 5	recommend structure of unknown compounds using spectroscopy.	D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
2	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
3	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
4	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
5	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Christian, G.D. Dasgupta, P.K. Schug, K.A. Analytical Chemistry, 4th Edition, John Wiley & Sons, 2009. 2. Ewing, G.W. Instrumental Methods of Chemical Analysis, McGraw Hill International, 1954.
Supplementary Readings	1. Pecsok, R.L. Shields, L.D. Modern Methods in Chemical Analysis, 2nd Edition, John Wiley & Sons, Inc, 1968. 2. Williams, D.H. Fleming, I. Spectroscopic Methods in Organic Chemistry, 6th Edition. McGraw-Hill, 1995.

Course No: 0531 18 Chem 3207	**Credit: 3**	**Year:** Third	**Term:** Second
Course Title: Industrial and Pharmaceutical Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide a demonstration on making standard solution, calibration curve, handling instruments and structure elucidation.		

COURSE CONTENTS		**CLOs**
Section A		
1	**General Considerations in the Development of Industry:** Fundamental considerations in the development of an industry, site and technology selection criteria, raw materials, process design, unit operations and unit processes, construction and safety measurement, manufacturing plant, future prospect of different types of industries in Bangladesh.	1
2	**Sugar Industry:** Composition of sugar cane, manufacturing process of sugar from sugar cane, refining of raw sugar, by-products of sugar industries and their utilization.	1, 2
3	**Soaps, Detergents and Fertilizers Industries:** Definition, raw materials, manufacture of different types of soaps and detergents, recovery of glycerin from spent lye, phenomena involved in the improvement of soapy character, production of detergents and quality comparison with soaps, classification of	3

	fertilizers, manufacture of urea, superphosphate, SSP, TSP, NPK fertilizers.	
4	**Glass and Cement Industries:** Definition of glass and ceramics, classification and properties of glass, raw materials, manufacturing methods of glass, some special glass and their properties, composition, properties and classification of cements, manufacture of cement by different methods, setting and hardening of cement, testing of cement.	3
Section B		**CLOs**
5	**Pharmaceutical and Drug Analysis:** Significance of qualitative and quantitative analysis in pharmaceutical quality assurance and quality control, Basic concepts of GMP, ISO 9000, ISO 9001, TQM, application of UV, IR, HPLC in drug analysis, microbiological assay, application, sterility and pyrogen test.	4
6	**Tablet and Capsule:** Definition, formulation and compounding, wet and dry granulation methods, slugging and capping of tablets, coating of tablets, disintegration test for compressed tablets, essential qualities of good tablets, materials for production of hard gelatin capsules, methods of capsule filling, importance evaluation of capsules.	4,5
7	**Parenteral Products:** Definition and types of parenteral products, vehicles for parenteral products, cleaning equipments and preparation of parenteral products including clarification, filling, sterilization, sealing and capping, control requirements for parenteral products, pyrogen tests, sterility test, foreign particles, inspection for leakage, identity, labeling, storage, administration of parenteral products.	5
8	**Ointments and Emulsions:** Definition and classification of ointments, factors affecting skin absorption, ointments bases, preparation of ointments including dermatological preparation, emulsifications and types of emulsifying agents, sedimentation testing, preparing equipment, internal and external liquid, preparations of different types of syrups and elixirs, compounding of internal and external liquids.	5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	describe the industrial operation system of chemical industry.	A1
	CLO 2	categorize various raw materials for individual chemical industry and design raw material for good products.	A1, A3, C1
	CLO 3	recognize and implement good production knowledge on sugar, soaps, glass cement, fertilizer industries.	A1, A3,C1
	CLO 4	conceptualize the basic concepts of GMP, ISO 9000, ISO 9001 and TQM, and demonstrate the uses of UV, IR, HPLC in drug analysis.	C3, C1
	CLO 5	conceptualize the preparation of medicines.	A1, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Team/Group Work, Problem Solving, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Presentation	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Sharma, B.K. Industrial Chemistry, GOEL Publishing House, 2000. 2. Gareth, T. Fundamentals of Medicinal Chemistry, 1st Edition, Wiley-Blackwell, 2003. 3. Gupta, A.K. Bajaj, S.S. Introduction to Pharmaceutics, Volume-1 & II, CBS Publication, 2013.
Supplementary Readings	1. Ali, M. Bassam A. Handbook of Industrial Chemistry: Organic Chemicals, 1st Edition, McGraw-Hill Professional, 2004. 2. Trimm, H.H. Hunter, W. Industrial Chemistry: New Applications, Processes and Systems, Apple Academic Press, 2011. 3. Xiao, T.L. Wei, S.F. Medicinal Chemistry of Bioactive Natural Products, 1st Edition, Wiley-Interscience/John Wiley, 2006. 4. Donald, C. Essentials of Pharmaceutical Chemistry, 3rd Edition, Pharmaceutical Press, 2008. 5. Graham, L.P. An Introduction to Medicinal Chemistry, 5th Edition, Oxford University Press, 2013. 6. Thomas, L. David, A.W. Foye's Principles of Medicinal Chemistry, 7th Edition, Lippincott Williams & Wilkins, 2012.

Course No: 0531 18 Chem 3208	**Credit:** 1	**Year:** Third	**Term:** Second
Course Title: Industrial and Pharmaceutical Chemistry Sessional and Field Visit		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide a practical knowledge about industrial and pharmaceutical production.		

COURSE CONTENTS	CLOs
1. Analysis of different raw materials and products in various industries and pharmaceutical companies 2. Industrial or pharmaceutical tour or field visit 3. Submission of tour report	1-3

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the importance and roles of route selection, process economics and process optimization in chemical processing.	A1, D2
	CLO 2	explain the preparation of industrial as well as pharmaceutical products.	A3, C3, C1
	CLO 3	overview the manufacturing and final products of the industries.	D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion & Sessional Tour	Assignments, Oral, Written Examinations and Presentation
2	Lecture, Discussion & Sessional Tour	Assignments, Oral, Written Examinations and Presentation
3	Lecture, Discussion & Sessional Tour	Assignments, Oral, Written Examinations and Presentation

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Sharma, B.K. Industrial Chemistry, GOEL Publishing House, 2000. 2. Gareth, T. Fundamentals of Medicinal Chemistry, 1st Edition, Wiley-Blackwell, 2003. 3. Gupta, A.K. Bajaj, S.S. Introduction to Pharmaceutics, Volume-I & II, CBS Publication, 2013.
Supplementary Readings	1. Mark, A.B. Industrial Chemistry For Advanced Students, De Gruyter, 2019. 2. Ali, M. Bassam A. Handbook of Industrial Chemistry: Organic Chemicals, 1st Edition, McGraw-Hill Professional, 2004. 3. Trimm, H.H. Hunter, W. Industrial Chemistry: New Applications, Processes and Systems, Apple Academic Press, 2011. 4. Xiao-Tian, L. Wei-Shuo, F. Medicinal Chemistry of Bioactive Natural Products, 1st Edition, Wiley-Interscience/John Wiley, 2006. 5. Donald, C. Essentials of Pharmaceutical Chemistry, 3rd Edition, Pharmaceutical Press, 2008. 6. Graham, L.P. An Introduction to Medicinal Chemistry, 5th Edition, Oxford University Press, 2013. 7. Thomas, L. David, A.W. Foye's Principles of Medicinal Chemistry, 7th edition, Lippincott Williams & Wilkins, 2012.

Course No: 0531 18 Chem 3209	**Credit:** 03	**Year:** Third	**Term:** Second
Course Title: Colloid and Adsorption Chemistry		**Course Status:** Optional	
Prerequisite	None		
Rationale	This course will provide an understanding of colloidal systems and interfacial phenomena.		

COURSE CONTENTS		CLOs
Section A		
1	**Adsorption:** Different types of adsorption isotherm: Langmuir, Freundlich, BET and other adsorption isotherm for gas-solid system.	1, 2, 3
2	**Adsorption at Surface of Solution:** Gibbs adsorption equation, surfactants, surface films, adsorption by solids from solution, surface films, electro capillary phenomenon.	1, 2
3	**Kinetics of Adsorption:** Elovich equation, Lagergren equation, Tempkin equation, mobility of absorbed species on surface, role of adsorption in heterogeneous catalysis.	2, 3
4	**Liquefactions of Gas:** Avogadro's theory, diffusion and effusion of gases, Graham's law, thermal conductivity of gases, principles of liquefaction, Andrew's experiment & critical phenomena.	2
Section B		**CLOs**
5	**Colloidal Dispersions:** Sols and their preparation, optical properties of sols, kinetic properties of sols, electrical properties of sols, general methods of classification, preparation, and uses of colloids, properties of gels, colloidal electrolytes, preparation, types, specific properties and stability of emulsions microemulsion.	1, 4
6	**Electro Kinetic Phenomena:** Double layer structure, zeta potential, electrophoresis and electro osmosis, diffusion and activation controlled reactions, the Bronested relation, linear free energy relation.	4, 5
7	**Micelles:** Micelle formation and critical micelle concentration, uses of colloids and emulsions.	4
8	**Applications of Colloidal Concept:** Applications of colloid in different environmental problems.	2, 4, 5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	identify the interfacial phenomena in different interfacial systems.	A1, A2
	CLO 2	determine the factors that affect their properties, interactions and stability and state precisely their importance in chemical industries.	A2, B1, C1
	CLO 3	analyze adsorption isotherm of materials	A1, D1
	CLO 4	describe precisely the effect of surface tension, contact angle, micellization and surfactant on certain application of interfacial phenomena.	B2
	CLO 5	explain the fundamentals in emulsion formulation and stability.	A1, B2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study,	Assignments, Term Papers, Oral and

	Question & Answer Session	Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session,	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Problem Solving, Brain Storming & Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Alexander, A.E. Johnson, P. Colloid Science, Oxford Clarendon Press, 1949. 2. Shaw, Duncan, J. Introduction to Colloid and Surface Chemistry, Butterworth and Co Publishers Ltd., 1970. 3. Atkins, P. Paula, J. Physical Chemistry, 8th Edition, Oxford University Press, New Delhi, 2009. 4. Jirgensons, B. Straumains, M.E. A Short Textbook of Colloid Chemistry, Pergamon, 1954.
Supplementary Readings	1. Somorjai, G.A. Yimin, L. Introduction to Surface Chemistry and Catalysis, 2nd Edition, Wiley Publishers Ltd., 2010. 2. Chakrabarty, D.K. Viswanathan, B. Heterogeneous Catalysis, 1st Edition, New Age International Publishers, 2011. 3. Chakrabarty, D.K. Adsorption and Catalysis by Solids, 1st Edition, New Age International Publishers, 2007. 4. Birdi, K.S. Handbook of Surface and Colloid Chemistry, 3rd Edition, CRC Press, 2009.

Course No: 0531 18 Chem 3210	**Credit:** 1	**Year:** Third	**Term:** Second
Course Title: Colloid and Adsorption Chemistry Sessional		**Course Status:** Optional	
Prerequisite	None		
Rationale	This course will provide the practical demonstration of experimental techniques in physical and colloid chemistry expose the fundamental principles that are applicable to physicochemical systems.		

COURSE CONTENTS	**CLOs**
1. Characterization and study the adsorption isotherm of the natural adsorbent 2. Adsorption from a solution on a solid-mass-sorbent 3. Preparation of hydrophobic colloidal system 4. Preparation of colloidal systems by condensation	1-3

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning	**CLO 1**	gain skills of work with the equipment is set, to learn the main ways of processing of experimental data and assessment of errors of the obtained results.	A3

Outcomes (CLOs)	**CLO 2**	identification of gas adsorption on solid surfaces.	B3, C1
	CLO 3	identify the various types of colloidal systems.	C1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
2	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations
3	Lecture, Discussion & Conduct Experiment	Assignments, Oral and Practical Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Harry N.H. Laboratory Manual Colloid Chemistry, John Wiley & Sons, Inc., London: Chapman and Hall, Ltd., 1922. 2. Bucak, S. Rende, D. Colloid and Surface Chemistry: A Laboratory Guide for Exploration of the Nano World, Boca Raton: CRC Press, Taylor & Francis Group, 2014.
Supplementary Readings	1. Birdi, K.S. Handbook of Surface and Colloid Chemistry, 3rd Edition, CRC Press, 2009. 2. Richard, M.P. Marilyn, E.K. Applied Colloid and Surface Chemistry, John Wiley & Sons, 2005. 3. Abe, M. Measurement Techniques and Practices of Colloid and Interface Phenomena, Springer Singapore, 2019. 4. Gabor A.S. Yimin, L. Introduction to Surface Chemistry and Catalysis, 2nd Edition, Wiley Publishers Ltd., 2010.

Course No : 0531 18 Chem 3211	**Credit:** 3	**Year:** Third	**Term:** Second
Course Title: Microbiology		**Course Status:** Optional	
Prerequisite	None		
Rationale	This course will provide students a profound understanding on microorganism, their functions and way of preventions.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Introduction:** Overview of microorganism, germ theory of disease, major areas/branches of microbiology, microscopic observation of microbes and their detection criteria.	1
2	**Characterization of Microorganism:** Types of microorganism, morphological and physiological properties, classwise identification, economic importance of bacteria, cyanobacteria, fungi, algae, protozoa and archea, prions, viroids, mycoplasma, actinomycetes.	1
3	**Culture of Bacteria, Virus and Others:** Reproductive characteristics of bacteria and virus, culture of microbes, types of media and preparation,	2

	isolation, maintenance and preservation of pure culture.	
4	**Control of Microorganism:** Principle of microbial control, control measures by physical and chemical means, factors affecting microbial control.	2
Section B		**CLOs**
5	**Hygiene and Sanitation:** Concept of hygiene and sanitation, medical hygiene, home and everyday life hygiene; waste water, health impact on sanitation, ecological sanitation; participatory hygiene and sanitation transformation.	3
6	**Food Microbiology:** General aspects of food, sources of microbial contaminants on food, food-borne diseases; factor affecting microbial growth in food, causes and types of microbial food spoilage, general principles of food preservation, physical methods, chemical preservatives and natural antimicrobial compounds, biological control of food-borne microorganisms.	4
7	**Industrial Microbiology:** Application of microbiology in commertial production, characteristics of commercially important microorganism, single cell protein; microbial biomass protein, yeast biomass, treatment of industrial wastes.	5
8	**Environmental Microbiology:** Introduction to indicator organisms, isolation and identification of indicator bacteria, water-borne pathogens, water treatment system in rural and urban areas, microbiological treatment: an aspect of wastewater treatment.	5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	illustrate the nature and function of different types of microorganism.	A1
	CLO 2	explain preparation and maintenance of pure culture and different prevention methods for the control of microorganism.	A1, D2
	CLO 3	interpret the concept of hygiene and sanitation in food and health care.	A1, D2
	CLO 4	analyze the source of pathogenic bacteria for food contamination and prevention method.	C1
	CLO 5	describe an aspect of waste water management for industrial and environmental microbiology.	A4

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Case Study,	Assignments, Term Papers, Oral and

	Question & Answer Session	Written Examinations
3	Lecture, Discussion, Case Study, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Team/Group Work, Problem Solving & Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Madigan, M.T. Martinko, J.M. Dunlap, P.V. Clark, D.P. 14th Edition, Brock Biology of Microorganisms, Pearson Prentice Hall, 2014. 2. Pelczer, M.J. Chan, E.C.S. Krieg, N.R. Microbiology, 5th Edition, Tata McGraw-Hill, 2002. 3. Tortora, G.J. Funke, B.R. Case, C.L. Microbiology: An Introduction, 12th Edition, Pearson, Boston, 2016. 4. Pelczer, M.J. Chan, E.C.S. Krieg, N.R. Microbiology: Concepts and Applications, McGraw Hill College, 1993.
Supplementary Readings	1. Waites, M.J. Morgan, N.L. Rockey, J.S. Higton, G. Industrial Microbiology: An introduction, 1st Edition, Blackwell Science, Oxford, 2001. 2. Hu, L. Food Safety: Rapid Detection and Effective Prevention of Food-borne Hazards, 1st Edition, Apple CRC Press, 2017. 3. Maier, R.M. Pepper, I.L. Gerba, C.P. Environmental Microbiology, 2nd Edition, Academic Press, 2009.

Fourth Year First Term

Course No: 0531 18 Chem 4100	Credit: 3	Year: Fourth	Term: First
Course Title: Project Design Sessional		Course Status: Core	
Prerequisite	None		
Rationale	This course will provide idea about project design and proposal submission.		

COURSE CONTENTS	CLOs
1. Brief conceptualization about research 2. Generation of research idea 3. Finalization of research proposal	1-3

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	develop the cognitive thinking about the research.	A1, A2
	CLO 2	evaluate the noble research idea.	A2
	CLO 3	write a good and scientific research proposal.	B1, C1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question, Literature Review & Presentation	Assignments, Term papers and Oral Presentation
2	Lecture, Discussion, Question, Literature Review & Presentation	Assignments, Term papers and Oral Presentation
3	Lecture, Discussion, Question, Literature Review & Presentation	Assignments, Term papers and Oral Presentation

INDICATIVE LEARNING MATERIALS	
Recommended Readings	4. Davis, H.B. Tyson, J.F. Pechenik, J.A. A Short Guide to Writing About Chemistry, Addison-Wesley, Boston, MA, 2010. 5. Boudah, D.J. Conducting Educational Research: Guide to Completing a Thesis, Dissertation, or Action Research Project, 2nd Edition, Thousand Oaks, CA: Sage, 2020. 6. Pan, M.L. Preparing Literature Reviews: Qualitative and Quantitative Approaches, Pyrczak Publishing, 2013.
Supplementary Readings	6. Islam, M.N. An Introduction to Research Methods, 4th Edition, Mullick and Brothers, Dhaka, 2018. 7. Creswell, J.W. Research Design: Qualitative, Quantitative and Mixed Methods Approach, 5th Edition, Thousand Oaks, CA: Sage, 2018. 8. Heppner, P.P. Heppner, M.J. Writing and Publishing Your Thesis, Dissertation, and Research: A Guide for Students in the Helping Professions. Belmont, CA: Brooks/Cole-Thomson Learning, 2004.

Course No: 0531 18 Chem 4101	Credit: 1	Year: Fourth	Term: First
Course Title: Chemical Weapons Convention and Basics of Chemical Hazards and Safety		Course Status: Core	
Prerequisite	None		
Rationale	This course is designed to gather idea about chemical weapons and safety measures from chemical hazards as well as chemical accidents.		

COURSE CONTENTS		CLOs
Section A		
1	**Chemical Weapons:** Definition, classifications of weapons, classes of chemical weapon agents, schedule chemicals and their effects, harmful effects of CW, chemical weapons in international politics, categories of weaponizable chemical agents.	1, 3
2	**Organization for the Prohibition of Chemical Weapons (OPCW):** Brief history of chemical weapons, background for the formation of OPCW, organizations for the prohibition of chemical weapons, functions and role of OPCW, chronology of chemical weapon (CW) international control efforts, control over of developed countries on OPCW.	2
3	**Bangladesh National Authority for Chemical Weapons Convention (BNACWC):** History of BNACWC formation, mission, vision, and motto of BNACWC**,** organogram of BNACWC**,** role of BNACWC in national and international level, national legislation on CWC in Bangladesh, chemical weapons (Prohibition) Act-2006.	2, 7
4	**Dual Use of Chemicals and Chemical Threat**: Definition, example of some duel use of chemicals, duel use of some chemicals derived from laboratory and natural sources, initiatives for chemical threat control, world war-1: harmful use of chemicals.	3
Section B		**CLOs**
5	**Introduction to Chemical Safety and Hazard Communication:** Loss prevention, hazard, risks, occupation and process safety, safety program, chemical safety and security, hazard communication standard (HCS), relation between chemical safety and security practices, modern agreements.	1, 4
6	**Exposure, Evaluation and Health Risks of Chemical Exposure in Workplace:** Methods of identifications of chemicals in work place, ways for the exposure of chemicals, methods of control for chemical weapons in workplace, health risks, effects, carcinogenic and non-carcinogenic risks in human body, long term effects.	5
7	**Chemical Accidents and Major Hazardous Control:** Chemical accidents, causes of chemical accidents, prevention of chemical accidents and hazardous control; methods for the immediate action of chemical accidents, disposal of chemical agents, causes of chemical accidents in Bangladesh.	6
8	**Chemical Safety Standards and Regulations:** Definition of chemical safety, measureable steps, rules and regulations for chemical safety in national and international level, government's initiatives.	2, 7

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the general concepts of chemical weapons and weaponizable chemical.	A1, D2
	CLO 2	get an idea about the role of various organizations for the prohibition of chemical weapons in national and international level.	B2, D2
	CLO 3	discuss the use chemicals in welfare and destruction of mankind.	D2, D3
	CLO 4	explain the basic idea about chemical safety.	A2
	CLO 5	learn about the exposure and risks of chemicals in workplace.	D2
	CLO 6	overview about the chemical accidents in workplace.	A2, C3
	CLO 7	explain the rules and regulations about chemical safety.	D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Presentation	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion & Question	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
4	Lecture, Discussion, Video Presentation & Team/Group Work	Assignments, Term papers, Oral and Written Examinations
5	Lecture, Discussion, Question & Poster Presentation	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Question, Answer Session & Video Presentation	Assignments, Term papers, Oral and Written Examinations
7	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Walters, D.B. Ho, P. Hardesty, J. Safety, Security and Dual-Use Chemicals, *J. Chem. Health Safety*, 2015; 1-14. 2. Gilbert, S. Chemical Weapons, *Toxipedia,* 2014; 1-13.
Supplementary Readings	1. Chemical Weapons (Prohibition) Act-2006, Bangladesh National Authority for Chemical Weapons Convention (BNACWC), 2006.

Course No: 0531 18 Chem 4103	Credit: 3	Year: Fourth	Term: First
Course Title: Reactions Mechanism		Course Status: Core	
Prerequisite	None		
Rationale	This course will provide knowledge about reaction mechanism and novel synthesis pathways of organic and inorganic reactions.		

COURSE CONTENTS		CLOs
	Section A	
1	**Substitution Reactions**: Mechanism of S_N2 & S_N1 reaction, kinetics, thermodynamics and stereochemistry, effect of structure, solvent, leaving grouop, attracting and neighboring group participation in substitution reactions, electrophilic substitution in benzene, formation of sigma and pi complexes, electrophilic substitution in monosubstituted benzene, nucleophile substitution in substituted benzene through benzyne intermediates.	1
2	**Elimination Reaction:** E1 and E2 mechanism, stereoselectivity of E2 mechanism, mechanism of E1CB reaction, orientation in E2 reaction, elimination vs substitution reaction, Saytzef vs Hofmann products in elimination reactions.	1, 3, 5
3	**Addition Reaction:** 1,2 and 1,4-additions, their stereochemistry, kinetics and thermodynamics, addition to conjugated system like conjugated dienes and conjugated unsaturated carbonyl compounds, effect of structure on reactivity.	1, 3
4	**Named Reactions:** Aldol condensation of organic and metal complexes, Benjoin condensation, Cannizzaro reaction, Perkin reaction, Diels-Alder reaction, Michael and Mannich reactions, Reimer-Tinmann reaction, Meerwein-Pronndrof, Clemmenson and Wolf-Kshiner reduction, Wittig reaction and Oppenauer oxidation reaction.	2
	Section B	**CLOs**
5	**Molecular Rearrangement of Inorganic Reaction:** Molecular rearrangement, four coordinate complexes, six coordinate complexes, Reaction at coordinated ligands, reaction due to metal ion polarization,	1
6	**Inorganic Electron Transfer Reaction Mechanism:** Outer sphere electron transfer reactions, inner sphere electron transfer reaction, formation of precursor complexes, rearrangement of precursor complexes and electron transfer, factor affecting the rate of electron transfer reaction, two electron transfer, one equivalent-one equivalent reaction, two equivalent-one equivalent reaction, complementary and non-complementary reaction mechanism.	5
7	**Inorganic Substitution Reaction Mechanism:** Trans effect, substitution reaction of octahedral complexes, square planar complexes, acid hydrolysis, base hydrolysis, ligand substitution reaction, metal substitution reaction, dissociation SN1 mechanism, displacement SN2 mechanism, SN1 CB dissociation mechanism, substitution reaction without M-L bond, cis-trans isomerism in planar complexes, conjugate base mechanism, substitution in trans and cis-complexes.	5
8	**Reactions of Solid Surfaces:** Film photography, kinetics of decomposition of solids, different types of corrosion and their prevention, tarnishing reactions, adsorption at high surface coverage, surface reactions with rate controlling steps, decline of surface activity-catalysts deactivation, electronic excitations and surface chemistry.	6

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:	**Mapping with PLO**
	CLO 1 describe mechanism of organic and inorganic substitution, elimination, addition reaction.	A1, B1
	CLO 2 compare between the different reaction mechanisms.	B2,C2
	CLO 3 apply various techniques in studying organic and inorganic reaction mechanisms, and principles in multi-step organic syntheses.	A1, B1, D2
	CLO 4 compare and contrast conformational, steric, and stereoelectronic effects of organic molecules and coordinate complexes.	A1, A3, B1
	CLO 5 explain various factors affecting substitution, elimination, addition reaction, electron transfer reaction.	A2, A3
	CLO 6 gain knowledge about solid surface reactions and surface chemistry.	A1, A2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question, Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question, Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question, Problem Solving, Brain Storming & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Sykes, P.A. Guidebook to Mechanism in Organic Chemistry, 6th Edition, Pearson, India, 2003. 2. Morrison, T.M. Boyd, R.N. Bhattacharjee, S.K. Organic Chemistry, 7th Edition, Pearson, 1999. 3. Purcell, K.F. Kotz, J.C. Inorganic Chemistry, Cengage, 1980. 4. Malik, W.U. Tuli, G.D. Madan, R.D. Selected Topics in Inorganic Chemistry, S. Chand and Company Ltd, India, 1993. 5. Raj, G. Advanced Inorganic Chemistry, Volume-1, GOEL

	Publishing House, India, 1992. 6. Huheey, J.E. Keiter, E.A. Inorganic Chemistry Principles of Structure and Reactivity, 16th Edition, Pearson Noida, 2013.
Supplementary Readings	1. Solomons, T.W.G. Fryhle, C.B. Organic Chemistry, 12th Edition, Wiley, 2016. 2. Raj. K.B. Organic Reaction Mechanism, Tata McGraw Hill, New Delhi, 1990. 3. Mukherji, S.M. Singh, S.P. Reaction Mechanism in Organic Chemistry, Trinity Press, 2017. 4. Carey, F.A. Sundberg, R.J. Advanced Organic Chemistry: Part B: Reaction and Synthesis, Springer, 2007. 5. Cotton, F.A. Wilkinson, G. Murillo, C.A. Bochmann, M. Advanced Inorganic Chemistry, 6th Edition, Wiley, 2007. 6. Huheey, J.E. Keiter E.A. Keiter, R.L. Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, Pearson Education Inc., 2000.

Course No: 0531 18 Chem 4105	**Credit:** 3	**Year:** Fourth	**Term:** First
Course Title: Statistical and Quantum Mechanics		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will provide an introduction to the microscopic formulation of thermal physics, generally known as statistical mechanics, quantum chemical principles and the necessary mathematical techniques for atomic molecular modeling.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Development of Quantum Mechanics:** Black body radiation, photoelectric effect, eigen values and eigen functions, normalization of wave function, orthogonality and completeness of the wave function, operators**.**	1, 2
2	**Application of Quantum Mechanics:** Particle in one dimensional box, electron in a ring, wave function of harmonic oscillator, significance of Φ(φ), Θ(θ) and R(r) equation, quantum numbers and total energy of an orbital, spaces wave function and radial distribution curves.	2
3	**Quantum Mechanics for Many Electron Systems:** Approximation method, variation and perturbation method, Born-Oppenhemer approximation, antisymetry principle, Hartree-Fock equation, one electron integral, two electron integral, interpretation of determinantal energies, Coulomb and exchange operators, Fock operators, introduction to basis of the Roothan equations, SCF procedure.	3, 4
Section B		**CLOs**
4	**Introduction to Statistical Mechanics:** Probability and thermodynamic probability, probability distribution of particles in energy states, most probable distribution, entropy and number of eigen states, derivation of Maxwell- Boltzman distribution.	5, 6
5	**Partition Function:** Definition and physical significance of partition function, separation of partition function, translational, rotational,	7

	vibrational, electronic and total partition functions, molar partition functions, the entropy of mixing.	
6	**Application of Partition Functions:** Monoatomic and diatomic molecules, relationship between partition functions and thermodynamic functions, statistical expression for equilibrium constant, equipartition of energy.	6, 7
7	**Quantum Statistics:** Maxwell-Boltzmann statistics, Bose-Einstein statistic, Fermi-Dirac statistics, electron gas theory in metals, specific heat of solids, Einstein and Debye theory of specific heat.	8

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain the basic principle of blackbody radiation, photoelectric effect.	A1, B1
	CLO 2	explain the origin of quantum mechanics and significance of wave function.	A2
	CLO 3	construct the electronic and total Hamiltonian operators for any molecule and explain the meaning of each part.	C1
	CLO 4	judge the applicability of the Hartree-Fock methods for calculations on atomic and molecular systems.	C1
	CLO 5	explain the concepts of microstate and microstate of a model system, probability distribution.	A1
	CLO 6	apply the Boltzmann distribution and the role of the partition function in different types of microstates.	A2
	CLO 7	discuss about the partition function and its relation with different thermodynamic parameters.	B3
	CLO 8	use the Fermi-Dirac distribution for the calculation of thermal properties of electrons in metals.	B3, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Quiz and Class Test
2	Lecture & Group Discussion	Assignments and Term papers
3	Lecture & Problem-based Learning	Assignments, Term papers, Oral and Written Examinations
4	Group Discussion, Question & Answer Session	Quiz and Class Test
5	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
6	Lecture & Team Teaching	Final Examination

7	Lecture & Problem-Based Learning	Assignments, Term papers, Oral and Written Examinations
8	Group Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. McQuarrie, D.A. Quantum Chemistry, 2nd Edition, University Science Books, 2007. 2. Swendsen, R.H. An Introduction to Statistical Mechanics and Thermodynamics, 2nd Edition, Oxford University Press, UK, 2020. 3. Szabo, A. Ostlund, N.S. Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Publications, 1996.
Supplementary Readings	1. Prasad, R.K. Quantum Chemistry. New Age International Limited Publishers, India, 2022. 2. Levine, I. Quantum Chemistry, 7th Edition, Pearson, 2013. 3. Gupta, M.C. Statistical Thermodynamics, New Age International Limited, India, 2021. 4. Stowe, K. An Introduction to Thermodynamics and Statistical Mechanics, 2nd Edition, Cambridge University Press, 2007.

Course No: 0531 18 Chem 4108	**Credit:** 1	**Year:** Fourth	**Term:** First
Course Title: Instrumental Analysis and Research Methodology Sessional		**Course Status:** Core	
Prerequisite	None		
Rationale	The course will design for how to operate chemical analysis instrument as well as data analysis and research methodology.		

COURSE CONTENTS	**CLOs**
1. Characterization of compounds using various analytical techniques 2. Article review, literature survey, and oral presentation 3. Writing of scientific research proposal 4. Misconduct of research	1-4

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain basic principle of various spectroscopic methods and interpretation of spectroscopic data.	A1, C3
	CLO 2	explain the most recent research outcomes and carry out a critical literature review, using well developed analytical and synthesis skills.	A2, B2
	CLO 3	present good research proposal, using high level written and verbal communication skills.	B1, C1, C2
	CLO 4	explain the ideas of values, ethics, and	D2

		morality in a multicultural context.	

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question, Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question, Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question, Problem Solving, Brain Storming & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Usharani, S. Analytical Chemistry: Techniques and Instrumentation, 1st Edition, Laxmi Publications Pvt Ltd, 2019. 2. Harvey, D. Modern Analytical Chemistry, McGraw-Hill Companies, Massachusetts, 2000. 3. Cochran, W.G. Cox, G.M. Experimental Design, 2nd Edition, John Wiley and Sons, 1992. 4. Willard, H.H. Instrumental Methods of Analysis, 7th Edition, Wardsworth Publishing Company, 1988.
Supplementary Readings	1. Khandpur, R.S. Handbook of Analytical Instruments, 5th Edition, Tata McGraw Hill publishing Co. Ltd., 2018. 2. Ewing, G.W. Instrumental Methods of Analysis, Mc Graw Hill, 2004. 3. Liptak, B.G. Process Measurement and Analysis, 5th Edition, CRC Press, 2016. 4. Braun, R.D. Introduction to Instrumental Analysis, McGraw-Hill, Singapore, 2006. 5. Skoog, D.A. Holler F.J. Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd, 2005.

Course No: 0531 18 Chem 4109	Credit: 2	Year: Fourth	Term: First
Course Title: Introduction to Material Science		Course Status: Optional	
Prerequisite	None		
Rationale	This course is designed to provide fundamental concepts of material science, synthesis approaches, characterizations, and different applications.		

COURSE CONTENTS		CLOs
Section A		
1	**Materials:** Classification of materials, materials of the future, modern materials needs.	1
2	**Physical properties:** Mechanical properties, concept of stress and strain, tensile properties, compressive, shear and torsional deformation, elastic deformation, slip, creep, plasticity and viscoelasticity, strengthening mechanism, brittle and ductile fracture, thermal and optical properties of metals and non-metals, application of optical phenomena: luminescence, photoconductivity, LASER, electrical properties**,** electrical and ionic conduction, energy band structures in solid, electron mobility, intrinsic semiconductor, extrinsic semiconductor, conduction in polymeric material, magnetic properties, basic concepts of magnetism, diamagnetism, paramagnetism, ferromagnetism, anti-ferromagnetism, influence of temperature on magnetic behavior, domains and hysteresis, soft magnetic materials, hard magnetic materials.	2
3	**Phase Diagrams and Microstructure in Materials:** Equilibrium phase diagrams, binary isomorphous systems, development of microstructure in isomorphous alloy, mechanical properties of isomorphous alloy, binary eutectic systems, development of microstructure in eutectic alloy, equilibrium diagrams having intermediate phases or compounds, eutective and peritectic reactions, congruent phase transformation, iron-iron carbide phase diagram, development of microstructure in iron-carbon alloys, super alloys.	2
4	**Composite Materials**: Particle-reinforced composites: large-particle composites, dispersion strengthened composites, fiber-reinforced composites: influence of fiber length, influence of fiber length, influence of fiber orientation and concentration, fiber phase, matrix phase, polymer- matrix composites, metal-matrix composites, ceramic- matrix composites, carbon-carbon composites, hybrid composites, structural composites: laminar composites, sandwich panels.	3, 4
Section B		**CLOs**
5	**Introduction to Nanomaterials**: History and scope of nanomaterial, properties, classifications, quantum dots, nanowires, nanorods, nanoshells, nanotubes, nanofluids, nanofantasies, applications of nanomaterials, challenges and future prospects, inorganic nanotubes: iron oxide, zinc oxide and titanium oxide nanoparticles, synthesis, properties and applications of gold, silver, zinc oxide and titanium oxide nanorodes and nanowires.	1, 2
6	**Synthesis and Characterizations:** Bottom–up approaches: physical vapor disposition (PVD), chemical vapor deposition (CVD), sprays conversion processing, sol-gel process, wet chemical synthesis, self-assembly, top-down approaches: mechanical alloying and nanolithography, biological synthesis of nanoparticles using bacteria, fungi, algea, virus and plant extract.	3, 4
7	**Applications of Nanomaterials:** Nano electronics, micro and nano-	5

	electromechanical systems, functionalization of nanomaterial, nanosensor, nanocatalysts, application of nanomaterial in food, agriculture, cosmetics, consumer goods, structure and engineering, water treatment, environmental purposes, medical applications, textiles, paints, energy, defense and space applications, dye sensative solar cell, photo and electrochemistry of nanoparticles.	
8	**Advanced Materials**: Fullerenes, carbon nanotube, optical fibers in communications, polymer electrolytes and polymeric hydrogels.	6

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	learn about basic knowledge about material science and nanomaterial.	A1
	CLO 2	explain about physical and chemical properties of materials.	A1
	CLO 3	predict the synthesis rout of nanoparticles.	A2, A4
	CLO 4	characterize the materials using advanced techniques.	C3,
	CLO 5	get an idea about the applications of nanomaterial.	D2, C3
	CLO 6	evaluate the advanced materials.	A1, B1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question Answer Session, Team/Group Work, Problem Solving & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations
6	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1 Callister, W.D. Rethwisch, D.G. Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th Edition, John Wiley & Sons, UK, 2012. 2 Askeland, D.R. Wright, W.J. Essentials of Materials Science and Engineering, 4th Edition, Cengage Learning, USA, 2018. 3 Klabunde, K.J. Sergeev, G.B. Nanochemistry, 2nd Edition, Elsevier Science, UK, 2013.

Supplementary Readings	1 Poole, J.R. Charles, P.O. Frank, J. Introduction to Nanotechnology, John Wiley and Sons, 2003. 2 Rao, C.N.R. Muller, A. Cheetham, A.K. The Chemistry of Nanomaterials: Synthesis, Properties, Wiley VCH, 2004. 3 Rosoff, M. Nano-Surface Chemistry, CRC Press, 2019.

Course No: 0531 18 Chem 4111	**Credit:** 3	**Year:** Fourth	**Term:** First
Course Title: Advanced Inorganic Chemistry		**Course Status:** Optional	
Prerequisite	None		
Rationale	This course deals with theoretical knowledge of important inorganic compounds, their structure design and preparation.		

	COURSE CONTENTS	**CLOs**
	Section A	
1	**Group Theory:** Symmetry analysis and its application, matrix representations of symmetry operations, construction of molecular orbitals, symmetries of molecular vibration.	1
2	**Bonding in Metals and Alloys:** Theory of metals, valence bond approach, the band theory of metals, super structure and inter metallic compounds, nonstoichiometric compounds.	2
3	**Bonding in Coordination Compounds:** Basic principles, σ-bonding and π- bonding complexes, effects of π-bonding, MOT in tetrahedral and square planar complexes, limitations of MOT.	2
4	**Electronic Spectra of Metal Complexes:** Term symbols, selection rules, Hund's rule and ground state term, splitting of electronic energy levels and spectroscopic states, spectra of d^1 , d^2 , d^5 , d^8, and d^9 complexes, charge transfer spectra.	3
	Section B	**CLOs**
5	**Inorganic macromolecules:** Chain and network polymers, silicon polymers, boron nitrogen polymers.	4
6	**Phosphonitrilic Compounds:** Fluorocarbons: preparation, structure and uses, chemistry of fullerenes.	4
7	**Metal Carbonyls, Nitrosyls and Hydrides:** Preparations, abundance, applications and their important compounds.	4
8	**Non-Aqueous Solvent Systems:** Classification of solvents, properties of ionizing solvents; solubility criteria in ionizing solvents, acid-base phenomenon in non-aqueous systems, studies of some typical non-aqueous ionizing solvents such as liquid ammonia.	5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain the molecular symmetry.	A1, A3
	CLO 2	analyze bond formation in metals, alloys, and complex compounds.	A3, C1
	CLO 3	Get an idea about electronic spectra of metal complexes.	B2, C2, C3, D1
	CLO 4	synthesize and characterize of phosphonitrilic, inorganic polymers,	A3, C3, D2

		metal carbonyl, and metal nitrosyl compounds.	
	CLO 5	classify non aqueous solution and evaluate ionized mechanism in non-aqueous solvent system.	A1, C1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written examinations
2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Purcell, K.F. Kotz, J.C. Inorganic Chemistry, 1st Edition, W. B. Saunders Company, 1977. 2. Malik, W.U. Tuli, G. D. Madan, R.D. Selected Topics in Inorganic Chemistry, 1st Edition, S. Chand & Company Ltd., New Delhi, 1976. 3. Lee, J.D. Concise Inorganic Chemistry, 4th Edition, Chapman & Hall, New York, 1991.
Supplementary Readings	1. Cotton, F.A. Wilkinson, G. Advanced Inorganic Chemistry. A Comprehensive Text, 3rd Edition, Interscience Publisher, New York, 1972. 2. Haider, S.Z. Introduction to Modern Inorganic Chemistry, 6th edition, Noor Card Board Offset Press, Bangladesh, 2004. 3. Madan, R.D. Modern Inorganic Chemistry, 3rd Edition, S Chand & Co Ltd, India, 1990. 4. Huheey, J.E. Keiter, E.A. Keiter, R.L. Inorganic Chemistry, 4th Edition, HerperCollins College Publishers, 1993.

Course No: 0531 18 Chem 4113	Credit: 3	Year: Fourth	Term: First
Course Title: Computational Chemistry		Course Status: Optional	
Prerequisite	None		
Rationale	This course has opened the door for experimental researchers to apply computational chemistry methods to solve problems and to make predictions.		

COURSE CONTENTS		CLOs
Section A		
1	**Introduction:** The subject of computational chemistry and its tools, Scope of computational chemistry.	1
2	**Molecular Mechanics/Force Field Methods**: Introduction to molecular mechanics; comparison of popular force fields; performance of molecular mechanics.	1
3	The Born-Oppenheimer approximation, potential energy surfaces, local and global minima, transition states, and Hessian indices.	2
4	**Hartree-Fock molecular orbital theory:** Slater determinants, anti-symmetry principle, deriving the Hartree-Fock equations, Hartree-Fock energy expressions for arbitrary spin-orbital configurations, spin integration, restricted and unrestricted references, self-consistent-field (SCF) procedure.	3
Section B		CLOs
5	**Conformational analysis by molecular mechanics:** Dynamical and structural studies of molecules using molecular dynamics simulations; Monte Carlo simulations of molecules.	3
6	**Vibrational frequency analysis:** Symmetry analysis, harmonic vs. fundamental frequencies, zero-point vibrational energies (ZPVE's), Hessian index, distinguishing minima from transition states.	4
7	**Electrostatics:** Atomic charges, dipole moment, polarizability, hyperpolarizability. Transition state theory, statistical mechanics, and thermodynamic properties.	4

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	CLO 1	explain when, which and how to use computational tools to gain insights into chemical systems.	A2, C1, D3
	CLO 2	explain general contents and critically evaluate quality and applicability of computational chemistry methods.	A2, C1
	CLO 3	perform standard computational chemistry tasks such as, for instance, geometry optimizations or free energy calculations including solvation.	A3, C3, D1
	CLO 4	explain model building and molecular mechanics	A2, D1
	CLO 4	discuss molecular orbitals and electronic structure	A2, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question, & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question, Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question, Answer Session, Team/Group Work, Problem Solving, Brain Storming, & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Cramer, C.J. Essentials of Computational Chemistry, 2nd Edition, Wiley, 2004. 2. Foresman, J.B. Frisch, A.E. Exploring Chemistry with Electronic Structure Methods, 3rd Edition, Gaussian, Inc., Wallingford, CT, 2015.
Supplementary Readings	1. Andrew, R.L. Molecular Modelling: Principle and Application, 2nd Edition, Addison-Wesley Longman Ltd., 2001. 2. McQuarrie, D.A. Quantum Chemistry, University Science Books, Mill Valley, CA, 1983. 3. Levine, I.N. Quantum Chemistry, 4th Edition, Prentice Hall, Englewood Cliffs, NJ, 1991. 4. Cotton, F.A. Chemical Applications of Group Theory, 3rd Edition, Wiley, New York, 1990. 5. Wilson, E.B. Decius, J.C. Cross, P.C. Molecular Vibrations: The Theory of Infrared and Raman Vibrational Spectra, Dover, New York, 1980.

Fourth Year Second Term

Course No: 0531 18 Chem 4200	Credit: 3	Year: Fourth	Term: Second
Course Title: Thesis		Course Status: Core	
Prerequisite	None		
Rationale	This course will provide idea about the selection of convenient methods and preparation of dissertation of possible outcomes.		

COURSE CONTENTS	CLOs
1. Method validation for proposed research 2. Expected outcomes and critical discussion 3. Preparation of dissertation and presentation	1-4

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	CLO 1	select the suitable method for the research.	A4, D1
	CLO 2	discuss about the findings.	B1, D1
	CLO 3	write a good and scientific dissertation.	C3, D1
	CLO 4	present the findings or results.	D1, C3, D3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, Discussion, Question, Literature Review & Presentation	Literature Review and Oral Presentation
2	Lecture, Discussion, Question, Literature Review & Presentation	Oral Preparation and Document Submission
3	Lecture, Discussion, Question & Presentation	Dissertation Preparation
4	Lecture, Discussion, Question & Presentation	Poster Presentation and Oral Presentation

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Anderson, J. Dursten B.H. Poole, M. Thesis and Assignment Writing, Wiley Eastern, 1977. 2. Rajamal, P. Devadoss, P. A Hand Book of Methodology of Research, R.M.M. Vidya Press, 1976.
Supplementary Readings	1. Davis, H.B. Tyson, J.F. Pechenik, J.A. A Short Guide to Writing about Chemistry, Addison-Wesley, Boston, MA, 2010. 2. Boudah, D.J. Conducting Educational Research: Guide to Completing a Thesis, Dissertation, or Action Research Project, 2nd Edition, Thousand Oaks, CA: Sage, 2020. 3. Pan, M.L. Preparing Literature Reviews: Qualitative and Quantitative Approaches, Pyrczak Publishing, 2013. 4. Islam, M.N. An Introduction to Research Methods, 4th Edition, Mullick and Brothers, Dhaka, 2018. 5. Creswell, J.W. Research design: Qualitative, Quantitative and Mixed

	Methods Approach, 5th Edition, Thousand Oaks, CA: Sage, 2018. 6. Heppner, P.P. Heppner, M.J. Writing and Publishing Your Thesis, Dissertation, and Research: A guide for Students in the Helping Professions. Belmont, CA: Brooks/Cole-Thomson Learning, 2004.

Course No: 0531 18 Chem 4201	**Credit:** 3	**Year:** Fourth	**Term:** Second
Course Title: Polymer Chemistry		**Course Status:** Core	
Prerequisite	None		
Rationale	This course will give enormous idea about polymer, polymerization and characterizations as well as the applications of polymers in real life.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Introduction to Polymer and Polymer Composite:** Definition and types of organic and inorganic polymer, basic structure of polymers, nomenclature and tacticity, molecular forces and chemical bonding in polymers, flow behavior of polymers, physical and chemical properties of polymers: crystallinity, melting point, glass transition temperature, general concept of polymer composite.	1
2	**Polymerization Reactions:** Mechanism and kinetics of polymerization: initiator, initiation, propagation and termination, polymerization techniques, co-polymerization, mechanism and kinetics of co-polymerization, craft and co-polymers, synthesis of some important inorganic polymers.	2
3	**Characterization of Polymer:** Number average molecular weight, weight average molecular weight, viscosity average molecular weight, thermo gravimetric analysis, instrumental techniques, glass transition temperature (T_g), physical testing of polymers.	3
4	**Polymer Solution:** Criteria for polymer solubility, size and shapes of polymer in solution, thermodynamics of polymer solutions, Flory-Huggins theory, fractionation of polymers by solubility, viscosity.	4
Section B		**CLOs**
5	**Kinetics of Polymerization:** Kinetics of chain polymerizations (free radical, ionic, and coordination), step polymerization, poly-condensation, poly-addition and ring opening, kinetics of free radical polymerization.	2, 4
6	**Polymer Processing:** Polymer processing techniques, molding, extrusion, thermoforming, phenol formaldehyde resin, urea formaldehyde resin, melamine formaldehyde resin etc. epoxy resin, polyester, polyethylene, PVC etc.	2
7	**Chemical Transformation of Polymers:** Polymers degradation, Introduction, types of degradation, thermal degradation, factors affecting thermal degradation, mechanical degradation, degradation by ultrasonic waved, photodegradation, oxidative degradation, degradation by high energy and bacteria, hydrolytic degradation, impacts of polymer degradation on environment, cross linking, intra molecular rearrangements, plasticization, vulcanization of rubber, curing of plastics, stabilization.	5
8	**Natural Polymers:** A brief outline of cotton, jute, silk, wool and	1, 6

	neoprene rubber, sources and structure of cellulose, allomorphs and their inter conversion.	

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	get an idea about organic, inorganic and polymer composite.	A1
	CLO 2	create a new route for synthesis of polymer.	A3, C1
	CLO 3	evaluate the molecular weight, size of polymer, functional groups, and morphology.	C1, C3
	CLO 4	explain the behavior of polymer in solution and the reaction kinetics.	C2, C3
	CLO 5	explain the transformation of polymer molecules in various states.	A4, D2
	CLO 6	get an idea about natural polymers and their applications.	A2, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question, Answer Session, Problem Solving & Brain Storming	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations
6	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Odian, G. Principles of polymerization, 4th Edition, John Wiley & Sons, UK, 2004. 2. Stevens, M.P. Polymer Chemistry: An Introduction, 3rd Edition, Oxford University Press, New York, 1999.
Supplementary Readings	1. Flory, P.J. Principles of Polymer Chemistry, 1st Edition, Cornell University Press, UK, 1953. 2. Allcock, H.R. Lampe, F.W. Mark, J.E. Contemporary Polymer Chemistry, 3rd Edition, Prentice-Hall, 2003. 3. Billmeyer, F.W. Textbook of Polymer Science, 3rd Edition, Wiley-Interscience, 1984. 4. Fried, J.R. Polymer Science and Technology, 2nd Edition, Prentice-

	Hall, 2003. 5. Sperling, L.H. Introduction to Physical Polymer Science, 4th Edition, John Wiley & Sons, 2005.

Course No: 0531 18 Chem 4203	**Credit:** 3	**Year:** Fourth	**Term:** Second
Course Title: Chemistry of Natural Products		**Course Status:** Core	
Prerequisite	None		
Rationale	This course is design to promote understanding of the significance of natural products in terms of their biosynthesis, biological activity and chemical synthesis, combining organic chemistry and biological chemistry.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Natural Products:** General methods of isolation, purification and determination of structure of natural products by chemical and spectroscopic methods with reference to alkaloid, terpenes, steroids and hormones, primary and secondary metabolites.	1, 2
2	**Alkaloids**: Definition, isolation of alkaloids from plant sources, test of alkaloids, characterization of alkaloids by chemical spectroscopic and synthetic methods with reference to ephedrine, adrenaline, nicotine, atropine, quinine and papaverin, morphine, strychnine.	2, 3, 4, 5, 6
3	**Terpenoids:** Terpenes and terpenoids, classification of terpenoids, isoprene rule; essential terpenoids; determination of structure of citral, menthol, cadenine and synthetic methods; biogenesis of terpenoids.	2, 3, 4, 6
Section B		**CLOs**
5	**Steroids and Hormones:** Introduction of steroids and hormones, nomenclature and functions of steroids and hormones, cholesterol and its effects in biological systems, steroidal hormones and glycoisides, natural and synthetic hormones.	1, 2, 3, 4, 5
6	**Organic Colouring Materials**: A relationship between colour and constitution, anthocyanidines, flavones, xanthenes and other materials, naturally occurring coloured compounds, chlorophyll.	1, 2, 3, 4, 6
7	**Purines and Pyrimidines:** Chemistry of purines, synthesis of purine, classification of purine, purine derivatives, purine derivatives and xanthine derivatives, uric acid, theine, theobromine, theophylline, hypoxanthine.	2, 3, 4, 5
8	**Lignin and Pectine:** Sources, production and chemical structure of lignin and pectin, properties, similarities and dissimilarities of lignin and pectin, gel formation properties of pectin, pharmaceutical used of pectin, constitution of lignin, pectin or pectic substances, structure of pectic acid.	2, 3, 4, 6

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain about the natural sources of organic compounds	A1, B2
	CLO 2	classify, identify, purify, and estimate the natural sources-based compounds.	A2, C1
	CLO 3	clarify the properties, chemical and	A1, B2, D2

		biological function of natural sources-based compounds	
	CLO 4	elucidate the constitution and structure of natural sources-based compounds	A2, C3
	CLO 5	Modify the natural sources-based compounds to prepare a new compounds	C3
	CLO 6	utilize the natural sources-based compounds in different applications	B2, D2, C3

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question, Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question Answer Session, & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question, Answer Session, Team/Group Work, Problem Solving, Brain Storming, & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, & Project Design	Assignments, Term papers, Oral and Written Examinations
6	Problem Solving, Brain Storming, & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Agrawal, O.P. Organic Chemistry Natural Products: Volume-I, 43rd Edition, GOEL Publishing House, New Delhi, 2014. 2. Agrawal, O.P. Organic Chemistry Natural Products: Volume-II, 41st Edition, GOEL Publishing House, New Delhi, 2014. 3. Chatwal, G. Organic Chemistry of Natural Products: Volume-I, 1st Edition, Himalaya Publishing House, New Delhi, 2010. 4. Chatwal, G. Organic Chemistry of Natural Products: Volume-II, 5th Edition, Himalaya Publishing House, New Delhi, 2019. 5. Finar, I.L. Organic Chemistry: Volume 2, 5th Edition, Longman Group Ltd., 1988.
Supplementary Readings	1. Bhat, S.V. Nagasampagi, B.A. Sivakumar, M. Chemistry of Natural Products, Revised Edition, Narosa Publishing House, New Delhi, 2013. 2. Singh, J. Ali, S.M. Singh, J. Natural Products Chemistry, 1st Edition, Pragati Prakashan, India, 2010. 3. Xu, R. Ye, Y. Zhao, W. Introduction to Natural Products Chemistry, 1st Edition, CRC Press, 2011. 4. Nakanishi, K. Goto, T. Ito, S. Natori, S. Nozoe, S. Natural Products Chemistry, Volume-3, 1st Edition, Kodansha Ltd., Tokyo, 1983.

Course No: 0531 18 Chem 4205	Credit: 3	Year: Fourth	Term: Second
Course Title: Nuclear Chemistry		Course Status: Core	
Prerequisite	None		
Rationale	This course will provide students to summarize the background knowledge about nuclear chemistry.		

COURSE CONTENTS		CLOs
Section A		
1	**The Atomic Nucleus and Its Properties:** Atomic nucleus and its composition, nuclear radius and nuclear density, nuclear force, mass defect, packing fraction, binding energy, nuclear spin and moments, nuclear potential, concepts of nuclear structure - shell model, nuclear statistics, nuclear stability, nuclidic mass and atomic mass, nuclear mass and energy correlation, classification of nuclides.	1
2	**Radioactivity and Radioactive Decay Laws:** Radioactivity, units of radioactivity, natural and artificial radioactivity, radioactive decay, radioactive decay constant, kinetics of radioactive decay, half-life and average life, radioactive decay series, radioactive equilibria, comparison between radioactive equilibrium and chemical equilibrium.	2
3	**Nuclear Reactions:** Nuclear reactions and their comparison with chemical reactions, types of nuclear reactions, conservation laws, energetics of nuclear reactions, nuclear reaction cross-section, excitation function, nuclear reactions mechanisms, liquid drop model of nuclear fission and fissionability parameters, general features of mass, charge and kinetic energy distributions in thermal neutron induced fission of ^{235}U and ^{239}Pu.	2
4	**Radioisotopes:** General principles of production of radioisotopes, radiochemical separation and purification of isotopes, uses of radioisotopes in chemical, physical, and biological sciences, medicine, agriculture and industry citing illustrations of current interests.	1
Section B		**CLOs**
5	**Techniques in Nuclear Chemistry:** Target Preparation, Target Chemistry, Preparation of Samples for Activity Measurements, Determination of Half Lives, Decay Scheme Studies, In-Beam Nuclear-Reaction Studies, Determination of Absolute Disintegration rates.	3
6	**Radiation Detector:** Introduction of nuclear detector, Types of Nuclear detector, Gas filled detector: Ionization chamber detector, Proportional counter, Geiger Mueller counter, Scintillation detector: Inorganic scintillators (NaI), Semiconductor detector: Silicon-based semiconductor detectors, Neutron detectors: Self-Powered Neutron detector (SPND), Dead time, Recovery time, Quenching effect.	3
7	**Nuclear Reactor and Accelerators:** Nuclear reactors – working principles, major components of reactors, classification of reactors, application of reactors; the natural uranium reactor; the four factor formula; rector power; critical size of thermal rector; the Breeder reactor: Thorium cycle, Uranium cycle; working principles, basic components and utilization of Van de graaff, tandem Van de graaff and cyclotron accelerators.	4
8	**Safety:** Radiation exposure, radiation dose, dose equivalent, quality factor, simple calculation of radiation exposure and radiation dose for γ-rays and β-rays, radiation hazards, radioactive wastes and their management.	5

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	explain the characteristics of nuclear forces, different models of nuclear structure and uses of radioisotopes in chemistry.	A1
	CLO 2	explain the decay of unstable nuclei and can differentiate between the different types of nuclear reactions.	A1, C3
	CLO 3	interpret and rationalize the radiochemical techniques and explain the operational principles of different radiation detectors.	A3, C3
	CLO 4	explain operation of nuclear reactor and the basic functionality of particle accelerators.	A1
	CLO 5	illustrate the safety recommendation and regulations of external and internal radiation.	B1, D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term Papers, Oral and Written Examinations
3	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question Answer Session, Problem Solving, Brain Storming & Case Study	Assignments, Term Papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Ehmann, W.D. Vance, D.E. Radiochemistry and Nuclear Methods of Analysis, John Wiley and Sons Inc., New York, 1991. 2. Friedlander, G. Kennedy, J.W. Macias, E.S. Miller, J.M. Nuclear and Radiochemistry, 3rd Edition, Wiley, 1981. 3. Harvey, B.G. Introduction to Nuclear Physics and Chemistry, Literary Licensing, LLC, 2012.
Supplementary Readings	1. Arnikar, H.J. Essentials of Nuclear Chemistry, 4th Edition, New Age International Publisher, 2011. 2. Choppin, G.R. Rydberg, J. Nuclear Chemistry, Theory and Applications, Pergamon Press, New York, 1980. 3. Glasstone, S. Source Book on Atomic Energy, 3rd Edition, Krieger Pub Co., 1979.

Course No: 0531 18 Chem 4207	Credit: 3	Year: Fourth	Term: Second
Course Title: Green Chemistry		Course Status: Optional	
Prerequisite	None		
Rationale	To articulate how sustainability ethics applies to chemistry, especially sustainable chemistry to overcome issues harmful to health and environment for a better future.		

COURSE CONTENTS		CLOs
Section A		
1	**Introduction to Green Chemistry:** Theory and practice, green chemistry: meeting the global challenge.	1
2	**Atom Economy:** A measure of the efficiency of a reaction, less hazardous chemical syntheses, designing safer chemicals.	1, 2
3	**Safer Solvents and Auxiliaries:** Design for energy efficiency, use of renewable feedstocks, reduces derivatives, catalysis.	3
4	**Real Time Analysis for Pollution Prevention:** Inherently safer chemistry for accident prevention.	2, 3
Section B		**CLOs**
5	**Greening up the Suzuki Reaction:** A green, guided inquiry based electrophilic aromatic substitution for organic chemistry.	3, 4
6	**Household Fenton's Reagent:** A green homogeneous catalysis demo, A greener bromination of stilbene: TAML oxidant activators, green bleaching agents for paper manufacturing.	2, 4
7	**Combinatorial Chemistry:** Antibiotic drug discovery, a greener approach for the measuring of colligative properties.	4
8	**Biosynthesis of Ethanol from Molasses:** Recent applications of biocatalysis in developing green chemistry for chemical synthesis at the industrial scale.	1, 4

	Upon completion of this course, the students will be able to:		Mapping with PLO
Course Learning Outcomes (CLOs)	**CLO 1**	short out grand challenges of green chemistry and consider what it will take to resolve them.	A1, B3
	CLO 2	identify reagents, reactions and technologies that should be and realistically could be replaced by green alternatives.	A3, C1
	CLO 3	find a greener approach for the measuring of colligative properties.	A2, C1
	CLO 4	implement biocatalysis to synthesize substance at industrial scale in a greener way.	D2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term Papers, Oral and Written Examinations
2	Lecture, Discussion, Question	Assignments, Term Papers, Oral and

	Answer Session & Case Study	Written Examinations
3	Lecture, Discussion, Question, Answer Session & Case Study	Assignments, Term Papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Problem Solving, Brain Storming & Case Study	Assignments, Term Papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Anastas, P.T. Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press New York, 1998. 2. Lancaster, M. Green Chemistry: An Introductory Text, 3rd Edition, RSC Publishing, 2016. 3. Ahluwalia, V.K. Kidwai, M. New Trends in Green Chemistry, 1st Edition, Kluwer Academic Publishers, New Delhi, 2004.
Supplementary Readings	1. Ahluwalia, V.K. Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers, 2005. 2. Cann, M.C. Connely, M.E. Real-World Cases in Green Chemistry, American Chemical Society, Washington, 2000. 3. Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker, 2001. 4. Anne, E.M.P. Martin, A.A. Green Chemistry and Engineering: A Pathway to Sustainability, Wiley, 2009. 5. Ryan, M.A. Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington, 2002.

Course No: 0531 18 Chem 4209	**Credit:** 3	**Year:** Fourth	**Term:** Second
Course Title: Supramolecular Chemistry		**Course Status:** Optional	
Prerequisite	None		
Rationale	The course deals with the basic principles of supramolecular chemistry, preparation of supramolecule and their application.		

COURSE CONTENTS		**CLOs**
Section A		
1	**Conceptual Foundation of Supramolecular Chemistry:** Natural and artificial molecular recognition.	1
2	**Synthesis and Design of Supramolecular Framework**: Synthesis and design of organic and inorganic supramolecular frame-work: cryptands and catenands.	2, 4
3	**Host-Guest Interactions**: Host-gust interaction in calthrate inclusions.	4, 5
4	**Bio-inorganic Chemistry**: Synthesis of template, metal ion and marco molecular recognition.	2, 3
Section B		**CLOs**
5	**Bio-organic Molecules and Liquid Crystal:** Functions of some bio-organic molecules and liquid crystals.	3, 4
6	**Enzyme:** Recognition behavior of enzymes, lynthetic enzymes, drug design and recognition.	4, 5
7	**Surfactants:** Surfactants, micelles, vesicles, pre-organidtion of interface active compounds, self-organization.	4, 5
8	**Some Inorganic Supramolecular Systems:** (a) silicates (b) molybdenum and vandium phosphates (c) clays (d) inorganic host-guest chemistry,	3, 4, 5

	nano-structures.	

Course Learning Outcomes (CLOs)	Upon completion of this course, the students will be able to:		**Mapping with PLO**
	CLO 1	describe the major types of supramolecular interactions and apply relevant chemical concepts to explain the nature and origins of these interactions.	A1, B1, C1
	CLO 2	identify and compare the nature, synthesis, supramolecular interactions and applications of host molecules and receptors.	A2, B2
	CLO 3	modify the based on the nature and chemical features of a supramolecular species.	B2, C1, D1
	CLO 4	analyze a series of host molecules, identify and hypothesize the trends in reactivity and binding of guests.	A2, C1
	CLO 5	explain host-guest interaction.	A1, D1

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations
2	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question Answer Session & Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work & Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming & Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	1. Steed, J.W. Atwood, J.L. Supramolecular Chemistry, 2nd Edition, John Wiley and sons, 2009. 2. Lehn, J.M. Supramolecular Chemistry- Concepts and Perspective, 1st Edition, John Wiley and sons, 1995.
Supplementary Readings	1. Dodziuk, H. Introduction to Supramolecular Chemistry, Springer, 2002. 2. Vogtle, F. Supramolecular Chemistry: An Introduction, 1st Edition, John Wiley and sons, 1993. 3. Ariga, K. Kunitake, T. Supramolecular Chemistry: Fundamentals and Applications, Springer, 2006.

Course No : 0531 18 Chem 4211	Credit: 3	Year: Fourth	Term: Second
Course Title: Advanced Physical Chemistry		Course Status: Core	
Prerequisite	None		
Rationale	The course deals with important principles and phenomena related to surface chemistry. Furthermore, to understand the principles of reaction kinetics, mechanisms and effect of catalysts on surface reactions.		

COURSE CONTENTS		CLOs
	Section A	
1	**Nature of Solid Surfaces:** Steps, terraces, kinks, dislocations, and defects, contamination, cleaning of surfaces.	1
2	**Adsorption Energetic:** Isotherms, isobers and enthalpy changes, adsorption measurements, studies on physical properties of absorbents, surface area, pore structure of polycrystalline absorbent.	2
3	**Kinetics of Adsorption:** Elovich equation, Lagergren equation, Tempkin equation, mobility of absorbed species on surfaces.	3
4	**Chemisorptions Processes on Solid Surfaces:** The Langmuir-Hind-Shelwood mechanism, general considerations in the determination of heterogeneous reaction mechanism, catalysis by transition metals.	2,3
	Section B	**CLOs**
5	**Binding of Ligands and Metal ions to Macromolecule:** Equilibrium dialysis, bioenergetics, ATP-the currency of energy, glycolysis, some limitations of thermodynamics.	4
6	**Biological Oxidation**: Chemiosmotic theory of oxidative phosphorylation, amino acid: dissociation of amino acids, isoelectric point, effect of ionic strength and temperature on buffer solution.	4
7	**Enzyme Catalysis:** Equation of enzyme kinetics, Michaeles - Menten kinetics, steady state kinetics, enzyme inhibition: reversible and irreversible inhibition, allosteric interaction, membrane and surfaces in biological system.	5

	Upon completion of this course, the students will be able to:		**Mapping with PLO**
Course Learning Outcomes (CLOs)	**CLO 1**	explain the properties and cleaning procedure of a surface.	A1, A2
	CLO 2	describe the most important and fundamental theories in surface chemistry.	A1, B2
	CLO 3	judge the limitations of thermodynamics.	A3, C1
	CLO 4	identify mechanisms for adhesion between surfaces and materials and use different methods to estimate this.	A2, A3, C2
	CLO 5	explain the kinetics of enzyme catalysis reaction.	A2, B2, C2

MAPPING CLOs WITH THE TEACHING-LEARNING AND ASSESSMENT STRATEGY		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
1	Lecture, Discussion, Question & Answer Session	Assignments, Term papers, Oral and Written Examinations

2	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
3	Lecture, Discussion, Question & Answer Session, Case Study	Assignments, Term papers, Oral and Written Examinations
4	Discussion, Question & Answer Session, Team/Group Work, Problem Solving, Brain Storming, Case Study	Assignments, Term papers, Oral and Written Examinations
5	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written Examinations

INDICATIVE LEARNING MATERIALS	
Recommended Readings	3. Chang, R. Physical Chemistry: for the Chemical and Biological Sciences, Viva Books Private Limited, 2015. 4. Raj, G. Advanced Physical chemistry, GOEL Publishing House, India, 2020. 5. Laidler, K.J. Chemical Kinetics, 2nd Edition, McGraw-Hill, New Delhi, 1973. 6. Bergethon, P.R. Simons, F.R. Biophysical Chemistry, Springer Verlag, 1998.
Supplementary Readings	6. Atkins, P. Paula, J.D. Elements of Physical Chemistry, 6th Edition, Oxford University Press, USA, 2013. 7. Mahan, B.H. Elementary Chemical Thermodynamics, 2nd Edition, Courier Corporation, New York, 2013. 8. Stolen, S. Grande, T. Chemical Thermodynamics of Materials: Macroscopic and Microscopic Aspects, John Wiley & Sons, UK, 2004. 9. Levain, I.R. Physical Chemistry, 6th Edition, McGraw-Hill Education, USA, 2009.

PART D

20. GRADING AND EVALUATION

20.1 Grading Scale

a) Letter Grades and corresponding Grade Points will be awarded following provisions shown below:

Numerical Grade	Letter Grade	Grade Point
80% or above	A+ (A plus)	4.00
75 to less than 80%	A (A regular)	3.75
70 to less than 75%	A- (A minus)	3.50
65 to less than 70%	B+ (B plus)	3.25
60 to less than 65%	B (B regular)	3.00
55 to less than 60%	B- (B minus)	2.75
50 to less than 55%	C+ (C plus)	2.50
45 to less than 50%	C (regular)	2.25
40 to less than 45%	D	2.00
Less than 40%	F	00
Incomplete	I	
Withdrawn	W	
Continuation (for the project, thesis design, etc. course)	X	

20.1.1 Evaluation of Theory Courses

a. All theory courses will be evaluated out of 100 marks, the distribution of which is given below:

Sl. No.	Items	Marks
1	Attendance and Class Participation	10
2	Continuous Assessments	30
3	Term Final Examination	60
-	**Total**	**100**

b. The basis for awarding marks for class attendance and participation will be as follows:

Attendance & Participation	Marks
90% or above	10
85 to below 90%	9
80 to below 85%	8
75 to below 80%	7
70 to below 75%	6
65 to below 70%	5
60 to below 65%	4
Below 60%	0

c. The continuous assessments of the theory courses may be conducted in the form of class tests, assignments, homework, presentation, quiz, viva voce, etc. The course teacher(s) will evaluate every continuous assessment and share the result with the students within 2(two) weeks of conducting that continuous assessment.

d. The duration of a class test may be 20-45 minutes, and it will preferably be given during class hours.

e. If a student does not attend the class test for reasons satisfactory enough to the course teacher, the course teacher may allow the student one more chance for such assessment during the term; however, it must be held before the term final examinations. A student who has been absent for a short period, up to a maximum of three weeks due to illness, should approach the course teacher(s) or Coordinator(s) for make-up of quizzes/class tests or assignments, etc., immediately on returning to the classes. Such request should be supported by a medical certificate endorsed by the Chief Medical Officer of the University. The medical certificate issued by a registered medical practitioner (with the registration number shown explicitly on the certificate) and endorsed by the Chief Medical Officer of the University will also be acceptable only when the student has valid reasons for his/her absence from the University.

f. The number of Continuous Assessments (CAs) in each course will be as follows:

No. of credit(s)	Total no. of CA required	CAs to be considered for grading
3 - 4	4 (2 in each section)	Section best assessments shall be averaged for grading
1.5 - 2	3 (at least one in each section)	

g. If two teachers teach a course, both the teachers will conduct continuous assessments individually.

h. Answer scripts of the continuous assessment may be shown to the students to identify their strengths and weaknesses, but those would not be returned to them. The concerned teacher would submit the evaluated continuous assessment answer scripts and attendance register to the Head of the Discipline/Program Offering Entity (POE). The final score of attendance and class participation (out of 10) and continuous assessment (out of 30) should be displayed on the Discipline's notice board/ Discipline website/ Course web page before starting the term final examination.

i. The course teachers must submit the continuous assessment mark sheets to the Chair of the Examination Committee before the starting of the term final examination.

j. The Term Final Examination will carry 60 marks. There will be two separate answer scripts for Section A and Section B in the Term Final Examination.

k. When a student repeats a course in which he/she previously obtained an F grade, he/she will be given just an immediate lower grade that he/she obtained in the repeated course. However, in case he/she obtains a D grade, that will be maintained, and this grade will be shown in the transcript. If a student has to repeat a course due to punishment on him/her, the grade obtained will be maintained. If a student obtains a grade other than an F in a course, he/she will not be allowed to repeat the course for grade improvement.

l. If a student obtains an 'F' grade in any Core course in any term, this 'F' grade will not be counted for Grade Point Average (GPA) but will be shown on the grade sheet, and in such case, he/she will have to retake the course for grade improvement.

m. While registering for a retake/re-retake theoretical course, a student must be given an option to decide whether s/he intends to sit for continuous assessment of the course. If s/he opts to sit for continuous assessments, his/her fresh mark will be counted to prepare the result. However, the class attendance and participation marks will be taken from the previous record.

n. A student has to register for the backlog/retake/re-retake core courses first followed by the fresh courses offered by the Discipline for the term s/he is going to enroll subject to the compliance with: **(i)** completion of prerequisite courses (if any) and **(ii)** maximum registration limit of 25 credits per term. However, s/he may not choose to register the optional backlog/retake/re-retake courses first.

o. In addition, a student may be allowed to register for advance course(s) in a term subject to: **(i)** his/her all backlog/retake/re-retake and offered core courses are either clear or registered, **(ii)** his/her current terms' offered all core courses are registered, **(iii)** completion of corresponding prerequisite courses (if any), **(iv)** compliance with a maximum registration limit of 25 credits per term, and **(v)** the desired advance courses are offered by the Discipline/POE in the current term. However, such advance course registration option will not be applicable for capstone courses like Thesis/ Project/ Internship/ Research study/ Monograph/ Portfolio, and so on.

p. A Special Term may be offered for the final year students who have retake/re-retake course(s). In this case, the maximum credit limit for a student will be 15 credits. This will be a Non-Taught Term. The Examination of Special Term will start 4 (four) weeks after publishing 4th-year 2nd Term results and will continue not more than 2 (two) weeks. The continuous assessment marks (40%) will be carried over from previously registered theory course(s), and Special Term Final Examination will carry the remaining (60%) marks. Final Year Term Thesis/Dissertation/Design or Core Sessional(s) supervisor(s)/course teacher(s) in consultation with the Head may allow the student(s) to re-submit the Thesis/Dissertation Design or Core Sessional(s) within the Special Term schedule. However, it must be within the allowed limits of the Special Term credits.

20.1.2 Evaluation of Sessional Courses

a. All sessional courses will be evaluated out of 100 marks, the distribution of which is given below:

Sl. No.	Items	Marks
1	Attendance/Class Participation/Contact with teachers	10
2	Sessional Evaluation/Internal criticism/Observation	60
3	Viva Voce/ Final Jury	30
Total		**100**

b. Sessional evaluation would be done through a laboratory test, class test, quiz, assignment, assigned project, report, oral test, performance/behavior of the students, etc. The course teacher(s) will complete every sessional evaluation and share the result with the students within 2(two) weeks of conducting that item. Attendance and sessional evaluation mark sheets (out of 10+60=70) will be displayed on the

Discipline's notice board/Discipline website/Course web page before starting the term final examination.

c. Viva Voce of each sessional course will usually be conducted by the course teacher(s). The senior most among the course teachers (if any) will be the Chair of the viva board. However, such viva voce/final assessment of a sessional course can also be done through jury board in applicable cases. The jury board will be headed by the Head of the Discipline or any other senior teacher of the Discipline/POE not below the rank of Assistant Professor. The Chairman of the viva/jury board may appoint other teacher(s) as a board member if necessary. A student must attend a sessional evaluation and viva voce. In case of absence in any component, he/she will get an F grade in that course.

d. The course teachers must submit the continuous assessment mark sheets to the Chair of the Examination Committee before the starting of the term final examination.

e. A student may register sessional courses as retake/re-retake (if applicable) on the Discipline Head's written approval. For retake/re-retake sessional courses, no previous records/marks will be counted.

20.1.3 Evaluation of Capstone Courses

a. The distribution of marks for a Capstone (Thesis/ Monograph/ project paper/ etc.) course will be as follows:

No.	Description	Marks
i)	Contact/Discussion/Communication with the Supervisor	10
ii)	Evaluation	60
iii)	Oral presentation and/or Viva voce	30
	Total	**100**

b. There will be two examiners (including the Supervisor) to examine the Thesis. Each examiner will evaluate the Thesis separately, and the average marks will be considered for grading. However, if the marks given by the First and Second Examiners vary 20% or more, a Third Examiner to be appointed by the concerned Examination Committee from the outside the University will evaluate the Thesis Monograph/Project paper. Among these numbers, the average of the closest two numbers will be considered for grading. However, if the marks given by the Third Examiner happen to stand at the middle of the marks given by the first two Examiners, the average of the three marks will be considered for grading.

c. For the thesis/dissertation/final project/other projects like the thesis of the final year students, there will be a presentation and defense session before the board (Jury/ other board). If deemed necessary to the concerned Examination Committee, these sessions might be arranged online. The chairman of the board normally will be the Discipline Head or any other senior teacher of the Discipline/POE not below the rank of an Assistant Professor. All supervisors of the thesis/ project/ internship/ research study/ monograph/ portfolio courses will be the concerned board members. The chairman may appoint other teacher(s) as member(s). Every member of the board will evaluate

individually and the final marks will be calculated by averaging all the marks given by the members.

d. A Discipline might allow some students to register for an Internship program/ Project paper/ Monograph/ Research study according to the course curriculum of the respective Discipline. Such an internship program/ Project paper/ Research study course might be considered as the substitute of Thesis for those students. The evaluation and related activities of such Internship program/ Project paper/ Research study courses will be similar to Thesis. Usually, a Thesis will carry double weight in terms of credit compared to other alternatives like Project/ Internship/ Research study/ Monograph/ Portfolio and so on.

e. A Discipline might allow splitting the thesis/similar course into more than one term. 'X' grade may be assigned for continuing the same course in multiple terms to assign a complete grade in the last term. Alternatively, multiple courses under thesis/similar course might be assessed by providing complete grades at the end of each term. The curriculum of the concerned Discipline/Entity will clarify all such issues.

20.1.4 Evaluation of Viva Voce

There might be a grand viva voce in each term. A student will not usually be allowed to register for more than one course of this type bearing 01 (one) credit in a term. The concerned Examination Committee of that Term will conduct the viva and assess the students. The distribution of marks for viva voce will be as follows:

Description	Marks
Viva voce	100

20.2 Grades

Grade related issues are reported in section 20.1.

20.3 Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA)

a. Grade Point Average (GPA) is the weighted average of Grade Points obtained in all the courses passed/completed by a student. For example, if a student has passed/completed five courses in a term having credits of C1, C2, C3, C4, and C5 and his/her points in these courses are G1, G2, G3, G4, and G5, respectively, then,

$GPA = \sum CiGi/\sum Ci$

b. A Numerical Example: Suppose a student has completed five courses in a term and obtained the following grades:

COURSE	CREDIT	GRADE	
A	3	A+	4.00
B	3	C+	3.00
C	3	A	3.75
D	2	B	3.25
E	1	B+	3.50

Then his/her GPA for the term will be computed as follows:
GPA= 3(4.0) + 3(3.0) + 3(3.75) + 2(3.25) + 1(3.5) / (3 + 3 + 3 + 2 + 1) = 3.52

c. A student's performance will be evaluated in terms of three indices- Term Grade Point Average (TGPA), Yearly Grade Point Average (YGPA), and Cumulative Grade Point Average (CGPA). The TGPA is computed by dividing the total points earned in a Term by the number of credits taken in the Term. The YGPA is computed by dividing the total grade points earned in two Terms in a year by dividing the number of credits taken in that year. The CGPA is computed by dividing the total grade points accumulated till date by the total completed credits. Thus a student who has earned 275 grad points in attempting 100 credits of courses would have an overall CGPA of 2.75.

20.4 Course Withdrawal

a. 'W' is the corresponding grade for withdrawn of a course, as mentioned in section 20.1.

b. If any student cannot complete the Term Final Examination due to severe illness or serious accident, he/she may apply to the Dean through the Head of the concerned Discipline for total withdrawal from the Term within eight working days after the Term Final Examination. However, he/she may choose not to withdraw from any sessional course if the grade obtained in such a course is C or better. A medical certificate endorsed by the Chief Medical Officer of the University must support the application. The Dean of the concerned School will decide on such an application and inform the Academic Council. If a student is allowed to withdraw from a Term, he/she will have to register as fresh from the Term he/she has withdrawn. However, he/she may be allowed to register for backlog courses, if offered.

20.5 Incomplete (I) Courses

'I' is the corresponding grade for an incomplete course, as mentioned in section 20.1.

20.6 Retake

Retake related issues are reported in sections 20.1.1 and 20.1.2.

20.7 Grade Improvement

Grade improvement related issues are reported in section 20.1.1.

20.8 Dropout/Cancellation of Studentship

a. A first-year first term student's admission will stand cancelled if he/she fails to complete course registration by ten working days from the beginning of the classes.

b. A first-year first term student's admission will stand cancelled if he/she fails to attend at least 50 percent of classes during ten working days from the beginning of the classes. However, in case of severe illness/accident this provision may be relaxed subject to submission of a medical certificate issued by a registered medical

practitioner (with the registration number shown explicitly on the certificate) and endorsed by the Chief Medical Officer of the University.

c. A student's studentship will stand cancelled if he/she fails to comply with registration of minimum credit requirements under article 12.2 of the latest (July 2022) 'Ordinance for Undergraduate Program' of Khulna University. According to that article, a student must register for at least 15 credits per term and may be allowed to register for up to a maximum of 25 credits if recommended by his/her Discipline Head. The Discipline/POE might offer less than, greater than or equal to 25 credits per term as per the approved curriculum. The student will enjoy the option of choosing backlog, re-take, re-retake, advance courses (subject to compliance with applicable requirements/restrictions, as reported in other articles of the Ordinance) in addition to fresh courses to comply with the restriction of maximum 25 credits per term. If any student fails to register, in any way, for minimum credits (15 credits), his/her studentship at the University will stand canceled. This minimum 15-credit registration limit may be relaxed if: (i) the student requires less than 15-credit to complete his/her graduation, or (ii) the sum of applicable (for the student) credits offered by the Discipline is less than 15-credit in the corresponding term for any valid reason.

d. A student's studentship will stand cancelled if he/she fails to earn minimum credits under article 12.5.2 of the latest (July 2022) 'Ordinance for Undergraduate Program' of Khulna University. According to that article, when a student is going to register for his/her courses in the 3rd year 2nd term, his/her earned credits up to 2nd year 2nd term must be at least 36. Otherwise, his/her studentship at the University will stand canceled.

11. APPROVAL RECORDS	
Approving Authority	Date of Approval
Curriculum Committee of the Discipline	
Executive Committee of the School	
BOAS (if applicable)	
Academic Council	
Syndicate (if applicable)	

12. REFERENCE POINTS

1. BAC (2021a), Bangladesh Accreditation Council (BAC) Standards for Accreditation of Academic Program, BAC, Dhaka.
2. BAC (2021b), Bangladesh National Qualifications Framework (BNQF) Part B: Higher Education,
3. UGC (2020), Template of Outcome Based Education (OBE) Curriculum (Revised).
4. IQAC (2022), Template of Outcome-based Curriculum, Institutional Quality Assurance Cell (IQAC), Khulna University.
5. KU (2022a), Ordinance for Undergraduate Examination, Khulna University.
6. KU (2022b), Ordinance for Undergraduate Program, Khulna University.

Acknowledgement

Concerned Committee of the Discipline/POE (if applicable)			
Serial No.	**Name and Address**	**Designation in Committee**	**Remarks**
1.	Prof. Dr. Md. Rezaul Haque Head, Chemistry Discipline, Khulna University	Member	
2.	Prof. Dr. Mosummath Hosna Ara Chemistry Discipline, Khulna University & Pro-Vice chancellor, Khulna University	Member	
3.	Dr. Kaykobad Md. Rezaul Karim Associate Professor, Chemistry Discipline, Khulna University	Convener	
4.	Dr. Md. Mahiuddin Associate Professor, Chemistry Discipline, Khulna University	Member	
5.	Dr. Jamil Ahmed Chemistry Discipline, Khulna University	Member	
6.	Dr. Muhammad Shamim Al Mamun Associate Professor, Chemistry Discipline, Khulna University	Member	
7.	Palash Kumar Dhar Assistant Professor, Chemistry Discipline, Khulna University	Member	
8.	Sumon Chakrabarty Assistant Professor, Chemistry Discipline, Khulna University	Member Secretary	
9.	Shishir Kumar Dey Assistant Professor, Chemistry Discipline, Khulna University	Member	
10.	Rumpa Kundu Assistant Professor, Chemistry Discipline, Khulna University	Member	
11.	Jannatul Naime Assistant Professor, Chemistry Discipline, Khulna University	Member	
12.	Prianka Saha Assistant Professor, Chemistry Discipline, Khulna University	Member	
13.	Dr. Md. Ahsan Habib Assistant Professor, Chemistry Discipline, Khulna University	Member	
14.	Sagar Kumar Dutta Assistant Professor Chemistry Discipline, Khulna University	Member	
15.	Md. Abu Rayhan Khan Assistant Professor, Chemistry Discipline, Khulna University	Member	
16.	Professor Dr. Md. Ahsan Habib Department of Chemistry, Dhaka University	Expert Member	
17.	Professor M. Nazrul Islam Department of Chemistry, University of Rajshahi	Expert Member	

List of the concerned stakeholders		
Serial No.	**Name**	**Designation**
1.	Prof. Dr. Mahmood Hossain	Vice chancellor
2.	Prof. Dr. Mosummath Hosna Ara	Pro-Vice chancellor
3.	Prof. Dr. Afroza Parvin	Dean, Science, Engineering and Technology School
4.	Professor Mohammed Ziaul Haider, Ph.D	Director, IQAC
5.	Professor Dr. Md. Matiul Islam	Additional Director, IQAC
6.	Professor Dr. Jagadish Chandra Joardar	Additional Director, IQAC
7.	Md. Mostafizur Rahman	Additional Director, IQAC
8.	Prof. Dr. Md. Rezaul Haque	Member Discipline Curriculum Committee
9.	Dr. Kaykobad Md. Rezaul Karim	Convener, Discipline Curriculum Committee
10.	Dr. Md. Mahiuddin	Member, Discipline Curriculum Committee
11.	Dr. Jamil Ahmed	Member, Discipline Curriculum Committee
12.	Dr. Muhammad Shamim Al Mamun	Member, Discipline Curriculum Committee
13.	Palash Kumar Dhar	Member, Discipline Curriculum Committee
14.	Sumon Chakrabarty	Member Secretary, Discipline Curriculum Committee
15.	Shishir Kumar Dey	Member, Discipline Curriculum Committee
16.	Rumpa Kundu	Member, Discipline Curriculum Committee
17.	Jannatul Naime	Member, Discipline Curriculum Committee
18.	Prianka Saha	Member, Discipline Curriculum Committee
19.	Dr. Md. Ahsan Habib	Member, Discipline Curriculum Committee
20.	Sagar Kumar Dutta	Member, Discipline Curriculum Committee
21.	Md. Abu Rayhan Khan	Member, Discipline Curriculum Committee
22.	Professor Dr. Md. Ahsan Habib	Expert Member, Discipline Curriculum Committee
23.	Professor M. Nazrul Islam	Expert Member, Discipline Curriculum Committee
24.	Md. Habibur Rahman	Employer Office, QC, Essential drugs Company Limited, Gopalganj
25.	Md. Noman Hossain	Employer Vice-Principal, Imperial College of Engineering, Khulna
26.	Md. Mahabubur Rahman	Alumni and craft Instructor, Civil Department, Khulna Polytechnic institute.
27.	Md. Saiful Islam	Alumni and craft Instructor, CMI Department, Khulna Polytechnic institute.
28.	Rokeya Khatun	Alumni and craft Instructor, Civil Department, Khulna Polytechnic institute.
29.	Md. Shakil Anwar	Alumni

30.	Pronoy Gosh	Alumni
31.	Yeasin Arafat Tarek	Alumni and Research Fellow, BCSIR, Dhaka
32.	Uttam Kumar	Alumni
33.	Md. Mahadi Hasan	Alumni
34.	Hasan Md. Ashekul Islam	Alumni and craft Instructor, CST Department, Khulna Polytechnic institute.