Curriculum

Undergraduate
Session: 2024-2025

Department of Chemistry

Shahjalal University of Science and Technology
Sylhet, Bangladesh

Published by:

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Department of Chemistry

Shahjalal University of Science & Technology

Sylhet-3114, Bangladesh

Curriculum of B. Sc. (Honours) Program for Outcome Based Education (OBE)

Session: 2024-2025

1. **Title of the Academic Program: B. Sc. (Honours) in Chemistry**
2. **Name of the University: Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh**
3. **Vision of the University:** To be a leading university of excellence in Science and Technology with a strong national commitment and significant international impact.
4. **Mission of the University:**

- To advance learning and knowledge through teaching and research in science and technology.
- To serve as a center for knowledge creation, technological innovation and transfer among academia, industry, and society.
- To assist in transferring Bangladesh a country with sustainable economic growth and equitable social development.

5. **Name of the Program offering Entity: Department of Chemistry, SUST**
6. **Vision of the Program offering Entity:**

The Department of Chemistry, SUST endeavors to be a nationally recognized model for producing chemistry graduates to compete in and contribute to the needs of time-demanding and technology-centered chemistry world.

7. **Mission of the Program offering Entity:**

M1. To provide the highest possible standards of teaching and research in chemistry and allied subjects by providing a high quality of education that will allow graduates to be active, productive, engaged members of society on local, national and international levels.

M2. To prepare students as successful professionals for employment in any of the vast array of chemistry-related industries including: Chemical, Pharmaceuticals, Biotechnology, Environmental, and Quality Control-Quality Assurance sectors.

M3. To develop the students as effective researchers on fundamental and applied problems and promoting the development of innovative interdisciplinary research programs.

M4. To equip students for developing academic attitudes by use of modern educational technology in secondary and tertiary level, exercising independent thought, collegial exchange of ideas and practicing high ethical standards.

Objectives of the program offering entity:

Providing high-quality education: Chemistry departments aim to provide students with a strong foundation in the principles and practices of chemistry, and to equip them with the skills and knowledge needed to pursue careers in various fields related to chemistry.

Conducting research: Chemistry departments conduct research to advance our understanding of chemical reactions, properties, and structures. They aim to develop new technologies, materials, and medicines that can benefit society.

Promoting scientific discovery: Chemistry departments aim to promote scientific discovery by developing new theories and hypotheses, and testing them through experimentation and analysis. They also strive to disseminate their findings through publications, conferences, and other forms of communication.

Fostering interdisciplinary collaboration: Chemistry departments often work closely with other departments and disciplines, such as biology, physics, and engineering, to solve complex scientific problems that require a multidisciplinary approach.

Engaging with the community: Chemistry departments aim to engage with the broader community through outreach programs, public lectures, and other educational activities. They aim to promote a greater understanding and appreciation of chemistry, and to inspire the next generation of scientists.

8. **Name of the Degree**: Bachelor of Science (Honours) in Chemistry
9. **Description of the Program:**

The B.Sc. (Hons.) program in Chemistry, SUST is a four years program. This program requires students to complete a set of core courses of all mail branches of Chemistry, as well as additional courses in related subjects such as

mathematics, physics, statistics, management, industrial chemistry, programing language, etc. Students are required to complete a research project or thesis in their final year of study (the alternative is in-plan training at some chemical industries for the student who is not qualified for the research project), which allows them to apply the knowledge and skills they have learned throughout the program to a real-world research problem.

Overall, the program is designed to provide students with a strong foundation in Chemistry, as well as the skills and knowledge needed to pursue a career in research or related industries. Graduates of the program are well-equipped to pursue advanced studies in their field or to enter the workforce in a variety of roles**.**

10. **Graduate Attributes (GA):**

Graduate attributes refer to the skills, knowledge, and qualities that students are expected to have acquired upon completing their degree program. For a chemistry graduate, some of the key graduate attributes would include:

GA1. Subject Specific Knowledge: In-depth knowledge of all major areas of Chemistry

GA2. Analytical and critical thinking: Have the ability to analyze data and information, evaluate arguments and evidence, and draw logical conclusions. They should be able to think critically to solve chemistry problems.

GA3. Scientific literacy: Deep understanding of the scientific method, including design experiments, collect and analyze sample, interpret results.

GA4. Communication skills: Able to communicate effectively with different audiences, including scientific peers, policymakers, and the general public. They should be able to write and speak clearly and use appropriate scientific language and terminology.

GA5. Teamwork and collaboration: Able to work effectively as part of a team, collaborating with other scientists and professionals to achieve common goals. They should be able to contribute their own ideas, listen to others, and work towards consensus.

GA6. Ethics and professionalism: Understand the ethical principles and standards of their profession, and be able to demonstrate professionalism.

GA7. Adaptability and lifelong learning: Able to adapt to new situations and technologies, and be willing to learn and acquire new knowledge and skills throughout their career. They should have a growth mindset and be able to embrace change and uncertainty.

11. **Program Educational Objectives (PEO):**

Program Educational Objectives (PEO) of the B.Sc. (Hons.) in Chemistry

PEOs are the expected achievements of graduates, in there, carrier and professional life a few year after graduation. It is given that all students obtaining a certified degree in chemistry should be well trained in chemical concepts and laboratory practices. However, to be effective and productive scientists, students need to master a variety of skills that go beyond course content alone. The objectives or learning targets of the curriculum are categorized in the following dimensions:

- *Knowledge and Understanding*
- *Skills and Processes, and*
- *Values and Attitudes*

To meet these goals, the following are the program objectives:

PEO1. Help the students to conceptualize the basic knowledge, theories, principles, processes and procedures of the main four areas of chemistry: physical, inorganic, organic, analytical and environmental.

PEO2. Make the students able to demonstrate high level analytical and critical thinking skills to solve conceptual and quantitative problems in chemistry through the application of fundamental chemical principles in all four major fields of chemistry.

PEO3. Develop skill to demonstrate safe and acceptable skills in laboratory procedure, experimental design.

PEO4. Help the students to acquire the basic tools needed to carry out chemistry research independently and in team.

PEO5. To produce skilled graduate on communicating scientific results effectively in written, oral and in interactive presentation.

PEO6. Help students develop curiosity and interest in making scientific investigation, personal integrity and to realize the roles of chemist on industrial, environmental social and economic aspects nationally and globally.

PEO7. Acquaint students with moral and ethical values to handle the research findings, maintaining secrecy of IP and development of patriotism.

12. Program Learning Outcome (POs)

POs	Learning Attribute	PO statement *After successful completion of the program, graduate will be able to-*	BNQF Domain
PO1	*Knowledge of Chemistry and Allied Subjects*	Explain and apply the fundamentals of chemical concepts and theories and principles and will demonstrate mastery in the four major fields of Chemistry, Physical, Inorganic, Organic, Analytical and Environmental Chemistries, and allied subjects.	Fundamental
PO2	*Laboratory and Instrumental Skills*	Demonstrate safe handling and use of chemicals, apply theoretical concepts of instruments that are commonly used lab instrument; design and carry out qualitative and quantitative chemistry experiments, synthesis, isolation and characterize the materials; record experimental result accurately, analyze the results using statistical and computational methods.	Fundamental
PO3	*Critical Thinking and Problem-Solving Skills*	Demonstrate excellent critical thinking and problem solving abilities to integrate concepts and ideas and skills learned to perform qualitative and quantitative analysis and analytical reasoning.	Thinking and Problem-solving
PO4	*Research Skills*	Search and explore the chemistry literature and related scientific resources to design and perform research works as individual and collaboratively to explore new knowledge in chemistry and allied fields.	Fundamental and Thinking
PO5	*Communication, ICT, and digital Fluency*	Communicate the results of scientific work in oral, written and electronic visual formats and be able to prepare logical, organized and concise written article or reports; able to use modern devices and platforms for general, social and professional communication	Social
PO6	*Employability and Entrepreneurships*	Plan and manage activities required for professional development in chemical and related industries; have the skills to work in interdisciplinary research/industries; be competence in keeping up with global innovations and developments in chemistry and in related fields; find gainful employment in academics, industry and government organizations and develop entrepreneurships and professional career.	Personal
PO7	*Professional Integrity and Leadership*	Act professional integrity, safety, and environmental stewardship and display effective cooperation with others on projects in various learning and work environments. Able to lead the in research and in profession.	Personal
PO8	*Environment and sustainability*	Realize the environmental protection and work/laboratory safety and integrate the rules of chemist and impact of chemical solutions in societal and environmental contexts and realize the needs for sustainable development of society and country.	Social
PO9	*Ethics and morality*	Demonstrate the moral and professional ethical values to handle the research findings, data manipulation and maintaining secrecy of intellectual Property. (IP) and development of patriotism.	Personal
PO10	*Life-long Learning*	Recognize the needs and engage in independent and life-long learning by themselves in the broadest context of change in the chemistry world and develop entrepreneurships and professional career.	Personal

13. Mapping of the Mission Statement of the Department with PEO

Mission/ PEO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO16	PEO7
M1	**x**	**x**	**x**	**x**	**x**	**x**	**x**
M2	**x**	**x**	**x**		**x**	**x**	
M3	**x**	**x**	**x**	**x**	**x**	**x**	**x**
M4	**x**	**x**	**x**			**x**	**x**

14. Program Education Objectives (PEO) to Program Learning Outcome (PO) Mapping:

PO/PEO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO16	PEO7
PO1	x						
PO2		x					
PO3			x				
PO4				x			
PO5					x		
PO6						x	x
PO7						x	x
PO8	x	x	x	x	x	x	x
PO9							x
PO10						x	

15. Mapping of Courses with Program Learning Outcomes (POs)

Course No	Course Name	Program Learning Outcomes (PO)									
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
	Theory Course	***3: highly, 2: Moderately and 2: weakly aligned***									
CHE 0531 1121	States of matter	3									
CHE 0531 1131	Fundamental of Inorganic Chemistry	3									
CHE 0531 1141	Fundamental Organic Chemistry I	3		2							
CHE 0531 1222	Chemical energetics	3	3	2					1		1
CHE 0531 1235	General Principles of Inorganic Chemistry	3		2							
CHE 0531 1243	Fundamental Organic Chemistry II	3	1								
CHE 0531 1291	Seminar and Oral	1				3					
CHE 0531 2121	Thermodynamics	3		1							
CHE 0531 2134	Chemistry of s and p block elements	2	1								
CHE 0531 2135	Chemistry of transition metals	3	1								
CHE 0531 2141	Stereochemistry and Heterocyclic Chemistry	3		3							
CHE 0531 2223	Phase Equilibria, Colloids and Surface Chemistry	3					3				
CHE 0531 2224	Electrochemistry	3		3					3		
CHE 0531 2236	Molecular Structure and Chemical Bonding	2		3							

CHE 0531 2243	Organic Reaction Mechanism	3		3							
CHE 0531 2251	Industrial Chemistry I	3		3							
CHE 0531 2291	Seminar and Oral	2		2		2				3	
CHE 0531 3121	Chemical Kinetics & Photochemistry	3		3							
CHE 0531 3131	Coordination Chemistry	3		3							
CHE 0531 3132	Nuclear Chemistry	3	3						2		2
CHE 0531 3143	Chemistry of Natural Products	3	1		1						
CHE 0531 3151	Analytical Chemistry										
CHE 0531 3222	Chemical Spectroscopy	3		2							
CHE 0531 3233	Organometallic Chemistry	2		1	2						
CHE 0531 3241	Polymer Chemistry	3		1	2		1				
CHE 0531 3252	Environmental Chemistry	3		3							
CHE 0531 3251	Industrial Chemistry II	3							2		
CHE 0531 3291	Seminar and Oral	2		1		2				3	
CHE 0531 4121	Quantum Chemistry and Statistical Mechanics	3		3							
CHE 0531 4131	Electronic spectra and reaction mechanism	3									
CHE 0531 4141	Advanced Organic Chemistry	3		3							1
CHE 0531 4147	Spectroscopic Methods in Structural Analysis	3		2							
CHE 0531 4151	Chromatographic Methods	3		3			3	3			
CHE 0531 4152	Analytical Chemistry Practical		3								
SPS 1015 4153	Industrial Tour			2			2				
CHE 0531 4222	Solid state Chemistry and Crystallography	3		3							
CHE 0531 4232	Bioinorganic Chemistry	3		3							
CHE 0531 4242	Selected Topics on Biological and Medicinal Chemistry	3		3							
CHE 0531 4243	Organic Reagents and Syntheses	3		2	2						
CHE 0531 4253	Electroanalytical Techniques	3		3							
CHE 0531 4271	Research Project			3		3		1		3	3
CHE 0531 4273	Advanced Practical *										
CHE 0531 4291	Academic and Scientific Presentation	2		3		2					1
	Practical										
CHE 0531 1132	General Inorganic Chemistry Practical		3								3
CHE 0531 1142	Laboratory Techniques for Organic Chemistry		3	2							
CHE 0531 1223	Introductory Physical Chemistry Practical		3	1	1						
CHE 0531 1234	Qualitative Inorganic Chemistry Practical		3	2					2	2	
CHE 0531 2122	Progressive Physical Chemistry Practical		2		1						
CHE 0531 2132	Inorganic Chemistry Practical (Quantitative)	3	2			3					
CHE 0531 2242	Preparation of Organic Compounds		3	3							
CHE 0531 3223	Essential Physical Chemistry Practical	3		3							
CHE 0531 3234	Inorganic Chemistry Practical		2		2						
CHE 0531 3142	Qualitative Identification of Organic Compounds		3	2							
CHE 0531 3253	Industrial Chemistry Practical	1	3								
	GEd Courses										
MAT 0541 1102K	Vector Analysis and Geometry										
MAT 0541 1203K	Calculus and Differential Equations										
MAT 0541 2202K	Mathematical Methods										
PHY 0533 1204K	Mechanics, Waves and Optics	3									
PHY 0533 2102K	Basic Physics Laboratory	1	3								
PHY 0533 2107K	Electricity, Magnetism and Modern Physics	3	1								
ENG 0231 1101K	Effective Communication in English					3					2
STA 0542 1109K	Statistics for Chemistry	3		3	3						
FET 0721 2101K	Food processing and preservation	3	3	3							
CSE 0613 2216K	Python Programming Lab	3		3							
STA 0542 3109K	Statistical tools for data analysis in chemistry		3	2	2						
SPS 0613 3170	Computational Methods for Chemistry		2	2		2					
SPS 1015 4153	Industrial Tour	3		3		3	3				3
SPS 0223 4281	Personal Behavior and Professional Ethics									2	2
SPS 0031 4272	Industrial Assignment						3	2			2
IPE 0413 3219K	Industrial Management							2			2
BUS 0413 4101K	Business Management and Entrepreneurship						3	2			2

16. Structure of Curriculum:

a. **Program duration: 4 Years; Number of Semesters: 8**

b. **Admission Requirements:**

c. **Graduating Credits: 140.0 (Offered 145 Credits)**

d. **Duration of each semester will be as follows:**

Classes:	**14 weeks**
Recess before final examination:	**02 weeks**
Final Examination:	**04 weeks**
Semester break (Result processing and publication):	**02 weeks**
Total:	**22 weeks**

e. **Minimum CGPA requirements for graduation: 2.00**

f. **Maximum academic years of completion: 6 (Six) Year**

g. **Category of Courses:**

Theory Courses

Course No	Course Name	Hours/Week Theory + Lab	Credits	Courses Type
CHE 0531 1121	States of matter	2 + 0	2.0	Theory
CHE 0531 1131	Fundamental of Inorganic Chemistry	2 + 0	2.0	Theory
CHE 0531 1141	Fundamental Organic Chemistry I	3 + 0	3.0	Theory
CHE 0531 1222	Chemical energetics	2 + 0	2.0	Theory
CHE 0531 1235	General Principles of Inorganic Chemistry	2 + 0	2.0	Theory
CHE 0531 1243	Fundamental Organic Chemistry II	3 + 0	3.0	Theory
CHE 0531 2121	Thermodynamics	3 + 0	3.0	Theory
CHE 0531 2134	Chemistry of s and p block elements	2 + 0	2.0	Theory
CHE 0531 2135	Chemistry of transition metals	2 + 0	2.0	Theory

CHE 0531 2141	Stereochemistry and Heterocyclic Chemistry	2 + 0	2.0	Theory
CHE 0531 2223	Phase Equilibria, Colloids and Surface Chemistry	2 + 0	2.0	Theory
CHE 0531 2224	Electrochemistry	2 + 0	2.0	Theory
CHE 0531 2236	Molecular Structure and Chemical Bonding	2 + 0	2.0	Theory
CHE 0531 2243	Organic Reaction Mechanism	3 + 0	3.0	Theory
CHE 0531 2251	Industrial Chemistry I	2 + 0	2.0	Theory
CHE 0531 3121	Chemical Kinetics & Photochemistry	2 + 0	2.0	Theory
CHE 0531 3131	Coordination Chemistry	3 + 0	3.0	Theory
CHE 0531 3132	Nuclear Chemistry	2 + 0	2.0	Theory
CHE 0531 3143	Chemistry of Natural Products	3 + 0	3.0	Theory
CHE 0531 3151	Analytical Chemistry	3 + 0	3.0	Theory
CHE 0531 3222	Chemical Spectroscopy	3 + 0	3.0	Theory
CHE 0531 3233	Organometallic Chemistry	2 + 0	2.0	Theory
CHE 0531 3241	Polymer Chemistry	2 + 0	2.0	Theory
CHE 0531 3252	Environmental Chemistry	2 + 0	2.0	Theory
CHE 0531 3251	Industrial Chemistry II	2 + 0	2.0	Theory
CHE 0531 4121	Quantum Chemistry and Statistical Mechanics	3 + 0	3.0	Theory
CHE 0531 4131	Electronic spectra and reaction mechanism	3 + 0	3.0	Theory
CHE 0531 4141	Advanced Organic Chemistry	3 + 0	3.0	Theory
CHE 0531 4147	Spectroscopic Methods in Structural Analysis	3 + 0	3.0	Theory
CHE 0531 4151	Chromatographic Methods	2 + 0	2.0	Theory
CHE 0531 4222	Solid state Chemistry and Crystallography	3 + 0	3.0	Theory
CHE 0531 4232	Bioinorganic Chemistry	2 + 0	2.0	Theory
CHE 0531 4242	Selected Topics on Biological and Medicinal Chemistry	2 + 0	2.0	Theory
CHE 0531 4243	Organic Reagents and Syntheses	2 + 0	2.0	Theory
CHE 0531 4253	Electroanalytical Techniques	2 + 0	2.0	Theory
		Total Credit:	**83.0**	

Practical Courses

Course No	Course Name	Hours/Week Theory + Lab	Credits	Courses Type
CHE 0531 1132	General Inorganic Chemistry Practical	0 + 4	1.5	Practical
CHE 0531 1142	Laboratory Techniques for Organic Chemistry	0 + 4	1.5	Practical
CHE 0531 1223	Introductory Physical Chemistry Practical	0 + 4	1.5	Practical
CHE 0531 1234	Qualitative Inorganic Chemistry Practical	0 + 4	1.5	Practical
CHE 0531 2122	Progressive Physical Chemistry Practical	0 + 5	2.0	Practical
CHE 0531 2232	Inorganic Chemistry Practical (Quantitative)	0 + 4	1.5	Practical
CHE 0531 2242	Preparation of Organic Compounds	0 + 5	2.0	Practical
CHE 0531 3142	Qualitative Identification of Organic Compounds	0 + 5	2.0	Practical
CHE 0531 3223	Essential Physical Chemistry Practical	0 + 5	2.0	Practical
CHE 0531 3234	Inorganic Chemistry Practical	0 + 4	1.5	Practical
CHE 0531 3253	Industrial Chemistry Practical	0 + 4	1.5	Practical
CHE 0531 4152	Analytical Chemistry Practical	0 + 4	1.5	Practical
CHE 0531 4273	Advanced Practical *	0 + 5	*2.0	Practical
		Total Credit:	**20.0 (or 22.0)**	

Other courses

Course No	Course Name	Hours/Week Theory + Lab	Credits	Courses Type
CHE 0531 1291	Seminar and Oral	-	1.0	Viva
CHE 0531 2291	Seminar and Oral	-	1.0	Viva
CHE 0531 3291	Seminar and Oral	-	1.0	Viva
CHE 0531 4291	Academic and Scientific Presentation	-	1.0	Capstone
CHE 0531 4271	Research Project*	2 week	*2.0	Capstone
	Total:		**4.0 (or 6.0)**	

GEd Courses

Course No	Course Name	Hours/Week Theory + Lab	Credits	Courses Type
MAT 0541 1102K	Vector Analysis and Geometry	2 + 0	2.0	Theory (GEd)
MAT 0541 1203K	Calculus and Differential Equations	3 + 0	3.0	Theory (GEd)
MAT 0541 2202K	Mathematical Methods	2 + 0	2.0	Theory (GEd)
PHY 0533 1204K	Mechanics, Waves and Optics	3 + 0	3.0	Theory (GEd)
PHY 0533 2107K	Electricity, Magnetism and Modern Physics	3 + 0	3.0	Theory (GEd)
PHY 0533 2102K	Basic Physics Laboratory	0 + 4	2.0	Practical (GEd)
ENG 0231 1101K	Effective Communication in English	2 + 0	2.0	Theory (GEd)
STA 0542 1109K	Statistics for Chemistry	2 + 0	2.0	Theory (GEd)
FET 0721 2101K	Food Processing and Preservation	3 + 0	3.0	Theory (GEd)
CSE 0613 2216K	Python Programming Lab	0 + 6	3.0	Practical (GEd)
STA 0542 3109K	Statistical tools for data analysis in chemistry	0 + 3	1.5	Practical (GEd)
SPS 0613 3170	Computational Methods for Chemistry	0 + 4	1.5	Practical (GEd)
SPS 1015 4153	Industrial Tour	-	1.0	Exposer (GEd)
SPS 0223 4281	Personal Behavior and Professional Ethics	2 + 0	2.0	Theory (GEd)
SPS 0031 4272	Industrial Assignment*	2 Weeks	*2.0	Exposer (GEd)
IPE 0413 3219K	Industrial Management	3 + 0	3.0	Theory (GEd)
BUS 0413 4101K	Business Management and Entrepreneurship	2 + 0	2.0	Theory (GEd)
	Total Credit = 36.0 (or 38)			**(25-26%)**

17. Semester wise distribution of courses

18. First Year: *Semester I*

Course No	Course Name	Hours/Week Theory + Lab	Credits	Course Type	Prerequisite courses
CHE 0531 1121	States of matter	2 + 0	2.0	Theory	
CHE 0531 1131	Fundamental of Inorganic Chemistry	2 + 0	2.0	Theory	
CHE 0531 1132	General Inorganic Chemistry Practical	0 + 4	1.5	Practical	
CHE 0531 1141	Fundamental Organic Chemistry I	3 + 0	3.0	Theory	
CHE 0531 1142	Laboratory Techniques for Organic Chemistry	0 + 4	1.5	Practical	
MAT 0541 1102K	Vector Analysis and Geometry	2 + 0	2.0	Theory (GEd)	
STA 0542 1109K	Statistics for Chemistry	2 + 0	2.0	Theory (GEd)	
ENG 0231 1101K	Effective Communication in English	2 + 0	2.0	Theory (GEd)	
	Total	**13 + 08 = 21**	**16.0**		

First Year: *Semester II*

Course No.	Course Name	Hours/Week Theory + Lab	Credit	Course Category	Prerequisite courses

CHE 0531 1222	Chemical energetics	2 + 0	2.0	Theory	
CHE 0531 1223	Introductory Physical Chemistry Practical	0 + 4	1.5	Practical	
CHE 0531 1234	Qualitative Inorganic Chemistry Practical	0 + 4	1.5	Practical	
CHE 0531 1235	General Principles of Inorganic Chemistry	2 + 0	2.0	Theory	CHE 0531 1131
CHE 0531 1243	Fundamental Organic Chemistry II	3 + 0	3.0	Theory	
MAT 0541 1203K	Calculus and Differential Equations	3 + 0	3.0	Theory (GEd)	
PHY 0533 1204K	Mechanics, Waves and Optics	3 + 0	3.0	Theory (GEd)	
CHE 0531 1291	Seminar and Oral	-	1.0	Viva	
	Total	**13 + 8= 21**	**17.0**		
Second Year: *Semester I*					
Course No.	Course Name	Hours/Week Theory + Lab.	Credit	Course Category	Prerequisite courses
CHE 0531 2121	Thermodynamics	3 + 0	3.0	Theory	CHE 0531 1222
CHE 0531 2122	Progressive Physical Chemistry Practical	0 + 5	2.0	Practical	
CHE 0531 2132	Inorganic Chemistry Practical (Quantitative)	0 + 4	1.5	Practical	CHE 0531 1131
CHE 0531 2134	Chemistry of s and p block elements	2 + 0	2.0	Theory	CHE 0531 1235
CHE 0531 2135	Chemistry of transition metals	2 + 0	2.0	Theory	
CHE 0531 2141	Stereochemistry and Heterocyclic Chemistry	2 + 0	2.0	Theory	
PHY 0533 2107K	Electricity, Magnetism and Modern Physics	3 + 0	3.0	Theory (GEd)	
PHY 0531 2102K	Basic Physics Laboratory	0 + 4	2.0	GEd Practical	
FET 0721 2101K	Food Processing and Preservation	3 + 0	3.0	Theory (GEd)	
	Total	**15 + 13 = 28**	**20.5**		
Second Year: *Semester II*					
Course No.	Course Name	Hours/Week Theory + Lab.	Credit	Course Category	Prerequisite courses
CHE 0531 2223	Phase Equilibria, Colloids and Surface Chemistry	2 + 0	2.0	Theory	
CHE 0531 2224	Electrochemistry	2 + 0	2.0	Theory	
CHE 0531 2236	Molecular Structure and Chemical Bonding	2 + 0	2.0	Theory	
CHE 0531 2242	Preparation of Organic Compounds	0 + 5	2.0	Practical	
CHE 0531 2243	Organic Reaction Mechanism	3 + 0	3.0	Theory	CHE0531 1141
CHE 0531 2251	Industrial Chemistry I	2 + 0	2.0	Theory	
MAT 0541 2202K	Mathematical Methods	2 + 0	2.0	Theory (GEd)	MAT 0541 1203K
CSE 0613 2216K	Python Programming Lab	0 + 6	3.0	GEd Practical	
CHE 0531 2291	Seminar and Oral	-	1.0	Viva	
	Total	**13 + 11 = 24**	**19**		
Third Year: *Semester I*					
Course No.	Course Name	Hours/Week Theory + Lab.	Credit	Course Category	Prerequisite courses
CHE 0531 3121	Chemical Kinetics & Photochemistry	2 + 0	2.0	Theory	

CHE 0531 3131	Coordination Chemistry	3 + 0	3.0	Theory	CHE 0531 2235, CHE 0531 2236
CHE 0531 3132	Nuclear Chemistry	2 + 0	2.0	Theory	CHE 0531 1121
CHE 0531 3142	Qualitative Identification of Organic Compounds	0 + 5	2.0	Practical	
CHE 0531 3143	Chemistry of Natural Products	3 + 0	3.0	Theory	
CHE 0531 3151	Analytical Chemistry	3 + 0	3.0	Theory	
STA 0542 3109K	Statistical tools for data analysis in Chemistry	0 + 3	1.5	Lab (GEd)	
SPS 0613 3170	Computational Methods for Chemistry	0 + 4	1.5	GEd Practical	
	Total	**13 + 12 = 25**	**18.0**		
Third Year: *Semester II*					
Course No.	Course Name	Hours/Week Theory + Lab.	Credit	Course Category	Prerequisite courses
CHE 0531 3222	Chemical Spectroscopy	3 + 0	3.0	Theory	
CHE 0531 3223	Essential Physical Chemistry Practical	0 + 5	2.0	Practical	
CHE 0531 3233	Organometallic Chemistry	2 + 0	2.0	Theory	CHE 0531 3131
CHE 0531 3234	Inorganic Chemistry Practical	0 + 4	1.5	Practical	
CHE 0531 3241	Polymer Chemistry	2 + 0	2.0	Theory	
CHE 0531 3252	Environmental Chemistry	2 + 0	2.0	Theory	CHE 0531 3151
CHE 0531 3251	Industrial Chemistry II	2 + 0	2.0	Theory	
CHE 0531 3253	Industrial Chemistry Practical	0 + 4	1.5	Practical	
CHE 0531 3291	Seminar and Oral	-	1.0	Viva	
IPE 0413 3219K	Industrial Management	3 + 0	3.0	Theory (GEd)	
	Total	**14 + 13 = 27**	**20.0**		
Fourth Year: *Semester I*					
Course No.	Course Name	Hours/Week Theory + Lab.	Credit	Course Category	Prerequisite courses
CHE 0531 4121	Quantum Chemistry and Statistical Mechanics	3 + 0	3.0	Theory	MAT 0541 2202K
CHE 0531 4131	Electronic spectra and reaction mechanism	3 + 0	3.0	Theory	CHE 0531 3131
CHE 0531 4141	Advanced Organic Chemistry	3 + 0	3.0	Theory	CHE 0531 2141 CHE 0531 2243
CHE 0531 4147	Spectroscopic Methods in Structural Analysis	3 + 0	3.0	Theory	CHE 0531 3132
CHE 0531 4151	Chromatographic Methods	2 + 0	2.0	Theory	
CHE 0531 4152	Analytical Chemistry Practical	0 + 4	1.5	Practical	CHE 0531 3151
BUS 0413 4101K	Business Management and Entrepreneurship	2 + 0	2.0	Theory (GEd)	
SPS 1015 4153	Industrial Tour	-	1.0	Exposer (GEd)	
	Total	**16 + 4 =20**	**18.5**		

Fourth Year: *Semester II*					
Course No.	Course Name	Hours/Week Theory + Lab.	Credit	Course Category	Prerequisite courses
CHE 0531 4222	Solid state Chemistry and Crystallography	3 + 0	3.0	Theory	
CHE 0531 4232	Bioinorganic Chemistry	2 + 0	2.0	Theory	
CHE 0531 4242	Selected Topics on	2 + 0	2.0	Theory	

	Biological and Medicinal Chemistry				
CHE 0531 4243	Organic Reagents and Syntheses	2 + 0	2.0	Theory	CHE 0531 2243
CHE 0531 4253	Electroanalytical Techniques	2 + 0	2.0	Theory	CHE 0531 3151
SPS 0223 4281	Personal Behavior and Professional Ethics	2 + 0	2.0	Theory (GEd)	
CHE 0531 4271*	Research Project	0 + 12	2.0	Capstone	
SPS 0031 4272*	Industrial Assignment	2 Weeks	2.0	Practical	
CHE 0531 4273*	Advanced Practical		2.0	Lab	
SPS 1015 4280	Study Tour		0.0	Exposer (GEd)	
CHE 0531 4291	Academic and Scientific Presentation		1.0	Capstone	
	Total	**13 + 12 = 25**	**16.0**		

*****Student will choose either CHE 0531 4271 or SPS 0031 4272 or CHE 0531 4273

Semester wise and grand total hours/week (Theory + Lab) and credits

Semester	1st	2nd	3rd	4th	5th	6th	7th	8th	Total
Hours/week (Theory +Lab)	13+8 = 21	13+8 = 21	15+13 = 28	13+11 = 24	13+12 = 25	14+13 = 27	16+4 = 20	13+12 = 25	110+81 = 191
Credits	16.0	17.0	20.5	19.0	18.0	20.0	18.5	16.0	145.0

List of Core Courses

Course No.	Course Title
CHE 0531 1131	Fundamental of Inorganic Chemistry
CHE 0531 1235	General Principles of Inorganic Chemistry
CHE 0531 2121	Thermodynamics
CHE 0531 2134	Chemistry of s and p block elements
CHE 0531 2135	Chemistry of transition metals
CHE 0531 2141	Stereochemistry and Heterocyclic Chemistry
CHE 0531 2224	Electrochemistry
CHE 0531 2236	Molecular Structure and Chemical Bonding
CHE 0531 2243	Organic Reaction Mechanism
CHE 0531 2251	Industrial Chemistry I
CHE 0531 3131	Coordination Chemistry
CHE 0531 3143	Chemistry of Natural Products
CHE 0531 3151	Analytical Chemistry
CHE 0531 3222	Chemical Spectroscopy
CHE 0531 3233	Organometallic Chemistry
CHE 0531 3241	Polymer Chemistry
CHE 0531 3252	Environmental Chemistry
CHE 0531 4121	Quantum Chemistry and Statistical Mechanics
CHE 0531 4131	Electronic spectra and reaction mechanism
CHE 0531 4141	Advanced Organic Chemistry
CHE 0531 4147	Spectroscopic Methods in Structural Analysis
CHE 0531 4151	Chromatographic Methods
CHE 0531 4222	Solid state Chemistry and Crystallography
CHE 0531 4253	Electroanalytical Techniques

All Core courses, Practical Courses, Seminar and Oral Courses, Course CHE 0531 4271 / SPS 0031 4272 / CHE 0531 4273 are mandatory and must be completed for the award of Bachelor Degree. Completed GEd course must be 25% of total completed credits for the award of Bachelor Degree

19. Evaluation:

The marks distribution of a given course will be as follows:

Class Attendance	10%
Assignments and Mid-Semester Examinations	20%
Quiz, Assignment, etc.	10%
Final Examination	60%

Class Participation:

The marks for class participation will be as follows:

Attendance (Percentage)	Marks	Attendance (Percentage)	Marks	Attendance (Percentage)	Marks
95 and above	10	80 to 84	7	65 to 69	4
90 to 94	9	75 to 79	6	60 to 64	3
85 to 89	8	70 to 74	5	Less than 60	0

A student will not be allowed to appear at the examination of a course if his/her class attendance in that course is less than 50%.

Assignments, Mid-Semester Examinations:

There should be at least two mid-semester examinations for every course. The course teacher may decide the relative

marks distribution between the assignments, tutorial, and mid-semester examinations, however at least 50% of contribution should come from the mid-semester examinations. **The course teacher of each course will design the distribution of COs for the Class test, mid-semester, and final exam in the course plan that will be submitted to the department prior to the start of class. A copy of this course plan will also be provided to the chairman of the examination committee so that it can be used during the moderation of the questions so that the attainment of all the COs will be confirmed throughout all the assessments.** The answer script should be returned to the students as it is valuable to their learning process.

Final Examination:

The final examination will be conducted as per the Semester Examination Ordinance.

(a) Duration of the Final Examination: There will be a 3-hour final examination for every course of 3 credits or more after the 14th week from the beginning of the semester. Courses less than 3 credits will have final examination of duration of 2 hours.

(b) Evaluation of Answer Script: The students of the School of Applied Science and Technology and the School of Agriculture and Mineral Sciences will have two answer scripts to answer separate questions during the final examination. Two separate examiners will grade the two scripts separately and the marks will be added together to get the final mark. For the students of the other schools, there will be a single answer script that will be evaluated by two examiners. The two marks will be averaged and if the marks by the two examiners differ by 20% or more the concerned answer scripts will be examined by a third examiner and the two closest marks among the three will be averaged to get the final mark. If the marks of the first and second examiners differ by 15% of 50% or more scripts then all script will be sent to a third examiner.

Grading System

Letter Grade and Grade Point:

Letter Grade and corresponding Grade-Point for a course will be awarded from the roundup marks of individual courses as follows:

Numerical Grade	Letter Grade	Grade Point
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	C-	2.00
Less than 40%	F	0.00

Calculation of Grades

GPA:

Grade Point Average (GPA) is the weighted average of the grade points obtained in all the courses completed by a student in a semester.

CGPA:

Cumulative Grade Point Average (CGPA) of only major and both major and second major degree will be calculated by the weighted average of every course of previous semesters along with the present semester. For clearing graduates if the roundup value of the third digit after decimal is nonzero the second digit will be incremented by one. A student will also receive a separate CGPA for his second major courses.

F Grades:

A student is given an 'F' grade if he fails or is absent in the final examination of a course. If a student obtains an 'F' grade his grade will not be counted for GPA and s/he has to repeat the course. An 'F' grade will be in his/her record and s/he will not be eligible for Distinction.

Distinction

Candidates for four-year Bachelor degree will be awarded the degree with Distinction if his/her overall CGPA is 3.75 or above. However, a student will not be considered for Distinction if (a) s/he is not a regular student (has semester drop, incomplete courses in any semester or break of study) (b) has 'F' grade in one or more courses.

Description of all courses of the program (Course Profile):

Course No: **CHE 0531 1121**	Credit: 2.0	Year: First	Semester: First
Course Title: **States of matter**		Course Type: Theory	

Course Rationale:

This course has been designed to give the preliminary concept of different terminology in physical chemistry, preliminary ideas and laws of states of matters, and equilibrium state.

Course Objectives:

The objectives of this course are:

- to know basic terminologies of physical chemistry
- to familiarize the students with states of matter
- to understand different states of matter and their properties
- to acquire preliminary ideas of chemical equilibrium state
- to make students able to analyze and calculate physico-chemical parameters using standard equations

Course Content:

Introduction: States of aggregation: Solid, liquid, gaseous state; State variables, Standard state & reference state, Fundamental and compounded units; Calculations based on Empirical and Molecular formula, Composition, balanced chemical equation.

Gaseous state: Ideal gas & gas laws, Equation of state, Dalton's law of partial pressure, Avogadro's theory, kinetic theory of gases, kinetic energy calculation, distribution of molecular velocities, collision frequency, density & cross-section, Mean free path, Maxwell-Boltzmann distribution of molecular velocities, average velocity, most probable velocity, Molecular interpretation of perfect and real gases, Compression factor and Amagat's curve; Van der Waal's & Virial equations for real gases; Theory of corresponding states; Principle of Liquefaction, Andrew's Experiment & critical phenomena.

Liquid state: Molecular interpretation, Measurement of vapor pressure and it's variation with temperature; Vaporization, Evaporation & boiling temperature of a liquid & liquid mixture; Surface tension and viscosity, polarity & dielectric constant, dipole moment; Concepts of ppm, ppb, molarity, molality & mole fraction.

Solid state: Molecular interpretation, Crystalline and amorphous solids, Crystal lattice and lattice energy, Unit cell, Elementary idea on Crystal Systems, Solubility of ionic solids and solvation energy.

Equilibrium state: Concept of equilibrium, Equilibrium law and equilibrium constant, Relation between K_p, K_c and K_x, Le Chaltelier principle, effect of temperature, pressure, concentration and inert gas on *K*, application of *K*. Nernst distribution law

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe and explain basic concepts, laws and effects on state of matter

CO2. Explain and describe the modification of laws for the ideal gas and real gas with their application

CO3. Discuss the preliminary ideas of vaporization, surface tension, viscosity and different concentration units.

CO4. Explain the concept of solid materials in terms of crystal structure

CO5. Understand applications of various parameters for shifting the position of equilibrium states

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	2									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture demonstration	Short Q and MCQ
CO2	Lecture demonstration, Discussion	Derivation, Quiz, assignment
CO3	Lecture demonstration, group discussion, problems analysis	Short Q and MCQ, problem solving
CO4	Lecture, Group discussion, ppt presentation, video clip	Broad question, problem solving, drawing structures
CO5	Lecture demonstration	Short and broad question

Books Recommended:

1. Ramsden, *A-Le vel Chemistry*
2. Raymond Chang, *General Chemistry*
3. P. W. Atkins, *Elements of Physical Chemistry*
4. P. W. Atkins, *Physical Chemistry*
5. Moore, *Physical Chemistry*

Course No: **CHE 0531 1131**	Credit: 2.0	Year: First	Semester: First
Course Title: Fundamental of Inorganic Chemistry		Course Type: Theory (Core)	

Course Rationale:

This course aims to gain knowledge of atom models, electronic configuration, periodic classification, and numerous properties of atoms and molecules.

Course Objectives:

The objectives of this course are:

- To provide a bridge in knowledge between college chemistry and the start of university chemistry and to bring students of different backgrounds to the same point
- To provide a clear understanding of basic concepts of inorganic chemistry to enter into the field of inorganic chemistry at the graduate level.
- To achieve the elementary concepts of atomic structure, chemical bonding, and geometry of molecules and chemistry of elements in the periodic table

Course Content:

Atomic Structure: Historical development of atomic theory, Discovery of subatomic particles Fundamental particles of an atom, atomic number, mass number and isotopes, Spectroscopic information, Quantum effects and photons, Planck's quantization of energy, Photoelectric effect, Bohr theory and atomic spectrum of hydrogen atom.

Atomic orbitals: Quantum numbers, electron spin, orbital and orbital energies, size and shape of atomic orbitals, spin quantum number and the magnetic spin quantum number.

Periodic Table and periodic properties of atoms: Periodic Law, format of the periodic table, classification of the elements, Properties of s and p block elements, and transition metals and their ions, building-up principle; Aufbau principle, Exceptions to the Building-Up Principle**,** orbital diagrams; Hund's rule, Pauli exclusion principle, penetration and shielding, Effective nuclear charge, electron configurations of atom, atomic and ionic radii, electropositive, electronegativity, **ionization energies,** electron affinities, polarizability, magnetic properties of atom and ions.

Chemical bonding: Ionic bond, covalent bonds, coordination bond, metallic bond, hydrogen bond, properties and examples associated with different bonds, octet rule, Lewis structure and formal charge, resonance, dipole moments, polar and nonpolar molecules, effect of chemical bonding in molecular properties, lattice energy, and application of lattice energies.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the brief history of inorganic chemistry, correlate atomic models, orbit & orbitals, electron distribution & energy level, hydrogen spectral series, etc.

CO2. Apply different principles to determine the configuration for any atom or ion, relate electron configurations to elements' classifications in the periodic table

CO3. Explain the development of the periodic table of elements

CO4. Analyze and compare periodic trends in physical and chemical properties (Electronegativity, bond character, material properties) of elements in the periodic table

CO5. Explain the ionic bonds, covalent bonds, valance bond theory, and molecular orbital theory; describe the nature of the bonding in ionic and molecular compounds

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT, *Whiteboards*, and demonstration of practical data	Assignment
CO2	Lecture using PPT, *Whiteboards*, and demonstration	Short Q and MCQ
CO3	Lecture using PPT, *Whiteboards*, and demonstration of practical data	Short Q, MCQ, Quiz, Explanation
CO4	Lecture using PPT, *model demonstration*, and Group discussion	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and model demonstration and Group discussion	Short Q, MCQ, Quiz, Explanation

Books Recommended:

1. S. Z. Haider, Introduction to Modern Inorganic Chemistry, Friends International, 1994
2. J. D. Lee, Concise Inorganic Chemistry (5th Edition), Blackwell Science Ltd., 2014
3. Cotton, Wilkinson and Gaus, Basic Inorganic Chemistry (3rd Edition), John Wiley & Sons, 1995
4. Raymond, Chang General Chemistry, (10th Edition), 2020
5. D. Ebbing, General Chemistry, (5th Edition), A.I.T.B.S Publisher, 2005
6. Shriver, Atkins and Langford, *Inorganic Chemistry (4th edition)*
7. Huheey, Keitler and Keitler, *Inorganic Chemistry (4th edition)*
8. Gary L. Miessler and Donald A. Tarr, *Inorganic Chemistry (3rd edition)*
9. Catherine E. Housecroft, A. G. Sharpe, *Inorganic Chemistry (2nd edition)*
10. Douglas. McDaniels and Alexander, *Concepts and Models of Inorganic Chemistry (3rd edition)*

Course No: **CHE 0531 1132**	Credit: 1.5	Year: First	Semester: First

Course Title: **General Inorganic Chemistry Practical**	Course Type: Practical

Course Rationale:
This course is designed primarily to gain knowledge about safety precautions and to make the student practically skilled in the techniques involved in the preparation, purification, and examination of various inorganic compounds.

Course Objectives:
The objectives of this course are:
- To impart knowledge in understanding different colors originate from various cations
- To demonstrate the practical techniques employed for the preparation, separation, and analysis of important inorganic compounds

Course Content:
(a) Safety rules in the chemistry laboratory, glass blowing techniques, detection of cations by flame test.
(b) Preparation of tetramminecopper(II) sulphate $[Cu(NH_3)_4]SO_4$ and identification of its constituents.
(c) Preparation of aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ and identification of its constituents.
(d) Preparation and identification of copper oxalate complex $K_2[Cu(C_2O_4)_2].2H_2O$

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Prepare and use the aqueous solution of various ingredients of inorganic compounds accurately for selected inorganic compounds' synthesis using necessary reagents
CO2. Prepare, separate, and analyze inorganic compounds
CO3. Explain the origin of different colors
CO4. Develop an informed interest in inorganic compounds that may lead to further study

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		3								
CO3		3								
CO4										3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures and experiment demonstration	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. Vogel, *Qualitative Inorganic Analysis* (7^{th} Edition). 2012
2. Z. Vasilyeva, A. Granovskaya, A. Taperova, Laboratory Manual for General and Inorganic Chemistry

Course No: **CHE 0531 1141**	Credit: 3.0	Year: First	Semester: First
Course Title: **Fundamental Organic Chemistry I**		Course Type: Theory	

Course Rationale:
This course aims to give a preliminary understanding of Organic Chemistry that will be needed for the further study of higher courses. This is also to make a bridge with their previous knowledge of this.

Course Objectives:
The objectives of this course are:

- To acquaint students with the fundamentals of Organic Chemistry
- To make the students familiar with the structure, synthesis, physical and chemical properties, and uses of aliphatic and aromatic hydrocarbons
- To acquire the concept of electrophilic aromatic substitution
- To understand the aromaticity of benzene and fused ring systems and make them able to predict the properties of other aromatics
- To provide knowledge of the use of alkyl halides in organic synthesis
- To conceptualize the basics of the S_N1 and S_N2 mechanisms
- To make them familiar with general and industrial methods of preparation, physical and chemical properties, and applications of alcohol and phenol

Course Content:
Introduction to Organic Chemistry: Review of chemical bonding, atomic and molecular orbitals, hybridization, and shapes of molecules with special reference to carbon compounds, polar covalent bonds, dipole moment, polar and nonpolar compounds, rules for resonance forms, formal charge calculations, acid–base behavior of molecules resonance, inductive effect, electrophiles, and nucleophiles.
Aliphatic Hydrocarbons: Alkanes: Nomenclature, general methods of preparation, physical and chemical properties, and uses of alkanes. Conformations of simple alkanes, e.g., ethane, propane, n-butane, etc.
Alkenes: Structure, nomenclature, general methods of preparation, physical and chemical properties, geometrical isomerism, and uses of alkenes.
Dienes: Alkadienes and polyunsaturated hydrocarbons. 1,3-Butadiene: Electron delocalization, stability of conjugated dienes. Electrophilic attack on conjugated dienes: 1,2- and 1,4-addition. 1,4-Cycloaddition (The Diels-Alder Reaction).
Alkynes: Structure, nomenclature, general methods of preparation, physical and chemical properties, and uses of alkynes. The acidity of alkynes. Analysis of alkynes.
Aromatic Hydrocarbons: Introduction to aromatic hydrocarbons, the structure of benzene, preparation, properties, and uses. Electrophilic aromatic substitutions, the orientation of substitution in benzene derivatives, determination of orientation, Friedel-Crafts alkylation and acylation, nitration, sulphonation, and halogenation of benzene and benzene derivatives. Substitute effect on a benzene ring can impact reactivity and the ability to undergo additional substitutions. Reactions that can convert a given substituent into new functional groups.
Polycyclic Aromatic Hydrocarbons: Synthesis, physical and chemical properties of naphthalene, phenanthrene and anthracene.
Alkyl and Aryl Halides: Nomenclature, general methods of preparation, physical and chemical properties and uses of alkyl and aryl halides. Preparation and uses of Grignard reagent. Introduction to S_N1 and S_N2 mechanisms.
Alcohol and Phenols: Nomenclature, general and industrial methods of preparation of alcohol and phenol, physical and chemical properties and uses. The reactivity of alcohols, ethers, and a special group of ethers known as epoxides.
Ether and Epoxides: Nomenclature, industrial sources of ethers (dehydration of alcohols), Williamson synthesis, physical and chemical properties and uses. Preparation of epoxides, ring-opening reactions, and uses.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Describe and explain the bonding in carbon compounds, hybridization of orbitals, shapes of molecules, inductive effect, polar and non-polar molecules, electrophiles, and nucleophiles
CO2. Formulate the proper structure, name the molecule, outline the synthesis, and predict the physical and chemical properties of alkanes, alkenes, dienes, and alkynes and their derivatives
CO3. Explain the aromaticity and predict the relative reactivity and the orientation of substitution reaction on aromatic rings towards electrophilic aromatic substitution
CO4. Apply the concepts of Grignard Reagent to use alkyl halides in organic synthesis and outline the S_N1 and S_N2 mechanisms
CO5. Illustrate the general and industrial methods of preparation, physical and chemical properties, and application of common aliphatic and aromatic hydrocarbons, alcohols & phenols, and ethers & epoxides

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	2		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with the model, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay-type test, problem-solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis	Essay-type test, problem-solving

Books recommended:

1. R. T. Morrison & R. N. Boyd, *Organic Chemistry* (6th edition)
2. G. Solomon, *Organic Chemistry* (11th edition)
3. I. L. Finar, *Organic Chemistry* vol-1 (6th edition)
4. F. Carey, *Organic Chemistry*

Course No: **CHE 0531 1142**	Credit: 1.5	Year: First	Semester: First
Course Title: **Laboratory Techniques for Organic Chemistry**		Course Type: Practical	

Course Rationale:

This course is aimed at make the student introduce the commonly used laboratory apparatus, their uses, and laboratory safety measures. This course is also aimed to make the students skilled in simple physical tests and separation techniques.

Course Objectives:

The objective of this course is:

- To facilitate necessary knowledge about the use of basic laboratory equipment and awareness of laboratory safety
- To acquaint the students with the basic tools and techniques of organic compound purification
- To make them able to prepare the simple organic compounds in the laboratory
- To develop skills to measure the purity of organic compounds by determining the melting and boiling points

Course Content:

Introduction to basic laboratory equipment and the safety and hygiene in the chemistry lab

Melting points and boiling points of Organic compounds: Discussion on melting point and boiling point, Determination of melting points of solids, Mixed melting points, Determination of boiling points of liquids.

General purification technique: Purification of solid organic compounds by recrystallization, use of miscible solvents, use of drying agent and their properties, purification of liquids, experimental techniques of distillation, simple distillation, fractional distillation, steam distillation. Extraction, use of immiscible solvents, solvent extraction. **Synthesis of some simple compounds:** Preparation of acetanilide and *tert*-butyl chloride.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Make use of basic laboratory equipments and aware of laboratory safety.

CO2. Check the purity of organic compounds by determining the melting points and boiling points

CO3. Purify organic solids by recrystallization and organic liquids by distillation and to separate them by extraction and fractional distillation.

CO4. Select the appropriate chemicals required for the synthesis of simple organic compounds and to arrange the necessary set up for their synthesis.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3								
CO2		3								
CO3		3								
CO4		2	2							
CO5		3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration	Lab Performance (group), lab Report
CO2	Lecture, Demonstration	Lab Performance (group), lab Report, Viva
CO3	Lecture, Demonstration	Individual Lab Performance, Lab Report, Quiz
CO4	Lecture, Demonstration	Individual Lab Performance, lab Report, Viva
CO5	Lecture, Demonstration	Lab Performance (group), lab Report, Viva

Books Recommended:

1. Clark, *Experimental Organic Chemistry*
2. A. I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A. I. Vogel, *Elementary Practical Organic Chemistry*-Part 1

Course No: **MAT 0541 1102K**	Credit: 2.0	Year: First	Semester: First
Course Title: **Vector Analysis and Geometry**		Course Status: Theory (Ged)	

Rationales: Concepts of vector algebra and geometry are basic requirements for science and engineering.

Course Objectives:

The objectives of this course are:

- To introduce the fundamental concepts of vector algebra, including scalars, vectors, and operations such as addition, subtraction, and multiplication, with applications in chemical systems.
- To develop the ability to work with null and unit vectors, resolve vectors into components, and apply scalar and vector products in solving problems related to molecular structures and reactions.
- To understand the products of three and four vectors and apply these concepts in the analysis of chemical bonding and molecular interactions.
- To outline the methods of line, surface, and volume integration, and highlight their relevance in chemical thermodynamics and transport phenomena.
- To develop a foundational understanding of coordinate geometry, including transformation of axes, and the study of straight lines and planes in three-dimensional space, supporting visualization of molecular geometry and crystallography.

Course Content

Vector Algebra: Scalars and vectors; algebraic operations on vectors; null and unit vectors; components of vectors; scalar and vector products of two vectors; product of three and four vectors – their applications. **Vector Calculus**: Derivative of vectors with respect to scalar variable; vector operator DEL; gradient, divergence and curl – their physical significance; outlines of line, volume and surface integration. **Geometry:** Transformation of axes; pair of straight lines; direction cosines of a straight line in space; equations for plane and straight line in space.

Course Learning Outcomes:

On completion of this course, students will be able to

CO1. explain various algebraic operations on vectors, vector products in different co-ordinate systems.

CO2. determine derivatives, gradient, divergent and curl of vectors.

CO3. evaluate line surface and volume integrals.

CO4. solve the problems of two-dimensional geometry

CO5.solve the problems of three-dimensional geometry.

Mapping of COs with the POs: 3: Strong, 2: Moderate, 1: Weak

	Fundamental Skill			Social Skill		Thinking Skill		Personal Skill	
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3								
CO2	3								
CO3	3								
CO4	3								
CO5	3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lectures using board	Continuous assessment and mid-term exam
CO2	Lectures using board	Continuous assessment and quiz test
CO3	Lectures using board	Continuous assessment and mid-term exam 1
CO4	Lectures using board	Continuous assessment and Assignment
CO5	Lectures using board	Mid-term exam 2 and semester end exam

Recommended Reference Books:

1. Sarder and Others: *Higher Trigonometry.*
2. Speigel M R.: *Vector analysis.*
3. Smith C.: *An elementary treatise on coordinate geometry of three dimension.*
4. Rahman and Bhattacharjee: *A Text Book on coordinate geometry.*
5. Harun Ar Rashid: *A Text Book on coordinate geometry.*

Course No: **STA 0542 1109K**	Credit: 2.0	Year: First	Semester: First
Course Title: **Statistics for Chemistry**		Course Type: Theory (GEd)	

Rationale of the Course:

Apply statistical expertise by gathering data to analyze the needs of users before managing development and testing. This course is assigned to acquire knowledge for analyzing the data.

Course Objectives:

The objectives of this course are:

- Provide basic knowledge of statistical tools.
- Equip the students for analyzing the data in descriptive way as well as provide the basic concepts of probability and probabilit distributions.
- Facilitate necessary knowledge about bivariate data analysis including correlation and regression analysis.

Course Content:

Introductory concepts: Meaning of statistics, subject matters, population and sample, different types of variables etc. **Summarization of data:** Frequency distribution, Graphical representation and tabulation of statistical data. **Central tendency and dispersion:** Mean, median, mode, standard deviation, mean deviation, coefficient of variation and quartiles, deciles and percentiles. **Correlation and regression:** Coefficient of correlation, Linear regression, Curve fitting. **Probability:** Concepts of probability, Laws of probability. **Probability distribution:** Binomial distribution, Normal distribution.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the basic concepts of statistics and describe various statistical tools.
CO2. Apply the descriptive statistical tools for the collected data.
CO3. Analyze the bivariate data and interpret the results.
CO4. Explain and apply the basic concepts of probability and probability distribution.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3									
CO4			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lecture using board/ projectors, reference books, online materials	Quiz/ assignment/presentation (individual/group), class test
CO2	Lecture using board/ projectors, reference books, online materials	Quiz/ assignment/presentation (individual/group)
CO3	Lecture using board/ projectors, reference books, online materials	Quiz/ assignment/presentation (individual/group)
CO4	Lecture using board/ projectors, reference books, online materials	Quiz/ assignment/presentation (individual/group)

Books Recommended:

1. Wonnacott & Wonnacott- Introductory Statistics, Wiley
2. Mostafa M Gf, Methods of Statistics, Bangladesh
3. Jhonston, J- Econometric Methods
4. G.D. Christian, Analytical Chemistry, John Wiley & Sons, 4th Ed.

Course No: **ENG 0231 1101K**	Credit: 2.0	Year: First	Semester: First
Course Title: **Effective Communication in English**		Course Type: Theory (GEd)	

Course Rationale:

This course is expected to develop two basic skills i.e. reading and writing. A variety of reading strategies and texts will be used to effectively develop first year students' academic reading skills thereby facilitating their future study. Also, the course focuses on developing the writing skills of students by familiarizing them with grammar rules, providing them with practice and enabling them to demonstrate the accurate use of grammar in their writing.

Course Objectives:

The objectives of this course are:

- To enable students to write with accuracy;
- To facilitate effective and comprehensible writing;
- To raise awareness of common errors that occur in writing;
- To develop students' ability to understand write-ups on issues of general concern;
- To improve the vocabulary of learners for effective communication.

Course Content:

Reading: Different Reading Strategies, Guessing Meaning from the Context, Critical Reading (Analyze), Critical Reading (Synthesize), Critical Reading (Evaluate), Annotation, Summary Writing
A selection of other materials may be supplied as handouts by the instructor as necessary
Writing: Forms and functions of different word categories (noun, verb, adjective, etc.), Aspects and uses of tense, Subject-verb agreement, Use of infinitive, gerund, present participle, past participle, modals, causatives, conditionals, subjunctives, modals, Use of sentence connectors/ cohesion markers/ punctuation, Effective combination of sentences (simple, complex, compound), Developing a paragraph

Learning Materials:

- A selection of 08-10 editorials and reports from newspapers/ magazines/journals, etc.
- Reading texts in New Headway Upper Intermediate Student's Book (Current edition)

- Selected passages from recommended books

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Apply grammar rules

CO2. Express oneself correctly by using appropriate words, phrases, sentences or ideas

CO3. Critically reflect on a text (grasp abstract ideas and interpret them effectively, arrive at well-reasoned conclusions and solutions)

CO4. Create using earned knowledge both independently and in collaboration with peer groups

CO5. Demonstrate a comprehension of subject knowledge and its subsequent use

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1					3					
CO2					3					
CO3					3					
CO4					2					1
CO5										3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture using board/LCD projectors/OHP projectors Self-learning using reference books/research articles/case study/other online materials	Quiz, Assignment
CO2	Lecture using board/LCD projectors/OHP projectors Self-learning using reference books/research articles/case study/other online materials	Quiz, Assignment, Presentation (Individual/group) /Viva voce
CO3	Self-learning using reference books/research articles/case study/other online materials	Assignment, Presentation (Individual/group) /Viva voce
CO4	Lecture using board/LCD projectors/OHP projectors Self-learning using reference books/research articles/case study/other online materials	Presentation (Individual/group) /Viva voce
CO5	Lecture using board/LCD projectors/OHP projectors Self-learning using reference books/research articles/case study/other online materials	Quiz, Assignment

Evaluation

- IELTS, TOEFL and other standardized testing formats for assessing the level of reading skill will be followed. Test items may be as follows: fill in blanks, true/false, multiple choice/ matching word meanings/ information transfer/matching titles with relevant paragraphs in the text, etc.
- Reading skill will be tested on two reading texts. One reading text will be taken from one of the selections students have already read during the semester. The other reading text will be similar in terms of contents and difficulty but will not have been previously discussed.

Books Recommended

Tibbits, E. E., editor. *Exercises in Reading Comprehension*. Longman, 2013.

Liz and John Soars. *New Headway Upper Intermediate Student's Book*. Oxford University Press, 2014.

Payle, Michael. *Cliff's TOEFL Preparation Guide.* 12th ed., Cliffs Notes Inc., 2019.

Other resources recommended by course instructors

Course No: **CHE 0531 1222**	Credit: 2.0	Year: First	Semester: Second

Course Title: Chemical energetics	Course Type: Theory

Course Rationale:

This course is designed to give learners the preliminary concepts of basic thermodynamics, thermochemistry, basic electrochemistry, ionic equilibria and salt hydrolysis.

Course Objectives:

The objectives of this course are:

- To familiarize the students with basic concepts of thermodynamics and thermochemistry
- To understand laws of thermochemistry and various enthalpies of physical and chemical processes
- To facilitate the necessary knowledge on common phenomena of Electrochemistry
- To understand the different types of conductivity and the applications of conductance measurements
- To understand the basic concept of chemical dynamics

Course Content:

Basic Thermodynamics: Definition, scope & limitations of thermodynamics, State function, System, surroundings, intensive and extensive properties, thermodynamic variables, exact and inexact differentials, work, heat, energy, internal energy, enthalpy, thermodynamic processes: isothermal, adiabatic, isobaric, reversible, irreversible processes, molar heat capacities for gases and condensed phases. First law of thermodynamics, its importance and limitation

Thermochemistry: Reaction enthalpies: standard enthalpy of formation, combustion, hydrogenation, neutralization, hydration, heats of solution, thermochemical laws, calorimetry, Kirchoff's equation, bond energies.

Fundamental of Electrochemistry: (i) **Basic terminologies**: Definition of Electrochemistry & its scope, Electrolytes, Conductor, Insulator, Semiconductor, Oxidation, Reduction, Types of electrochemical processes. (ii) **Conductance of Electrolytes:** Relation between resistance and conductance, cell constant. Types of conductance: Equivalent conductance, Molar conductance, Specific Conductance, Influence of temperature & viscosity on conductance, Relationship between conductance and diffusion. (iii) **Applications of conductance:** Conductometric titration (strong acid vs. strong base, weak acid vs. strong base, mixture of acid vs. strong base), solubility product, degree of dissociation of a weak electrolyte, Kohlrausch's law, Ostwald dilution law. (iv) **Ionic equilibria and salt hydrolysis**: Solubility & Solubility product, Common ion effect, pH and pOH, Neutralization curves different acid-base titrations, Principle of buffer action and buffer capacity, buffer range, Calculation of pH of poly basic acid, weak acid and acid-base mixtures, Salt hydrolysis, relationship between pH, pKa/pKb and pKw, calculation of pH of various types of electrolytes (HCl, H_2CO_4, H_3PO_4, NaCl, NaCN, CH_3COOH) Theories of indicator and Selection of Indicator.

Reaction dynamics: Rate of reaction and measurement, rate constant and order of a reaction, Differential rate equation, Half-life of a reaction, Temperature effect on reaction rate.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe and explain basic concepts of thermodynamics and thermochemistry

CO2. Calculate thermodynamic and thermochemical parameters of chemical and physical processes.

CO3. Recognize different types of electrochemical cell, their constructions

CO4. Determine the solubility of sparingly soluble salts and demonstrate the phenomenon of pH of solutions, buffer action and select the suitable indicator for a particular titration

CO5. Understand the basic concepts of reaction dynamics

Mapping of Course Learning Outcomes (COs) with Pos 3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

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

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture demonstration	Class test (Short Q and MCQ)
CO2	Lecture demonstration	Short Q and problem solving
CO3	Lecture demonstration, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ),quiz
CO4	Lecture demonstration, Group discussion	Essay test, problem solving
CO5	Lecture demonstration Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. P. W. Atkins, *Elements of Physical Chemistry*
2. S. Glasstone, *Physical Chemistry*
3. Maron and Pruton, *Principles of Physical Chemistry*
4. Raymond Chang, *General Chemistry.*
5. RL Madan, *Physical Chemistry*

Course No: **CHE 0531 1223**	Credit: 1.5	Year: First	Semester: Second
Course Title: Introductory Physical Chemistry Practical		Course Type: Practical	

Course Rationale:

This course is aimed to make the student practically skilled to determine the strength of different solutions, study the kinetics of different real reactions, and study the thermodynamics.

Course Objectives:

The objectives of this course are:

- To make the students able to prepare a solution/ sample of desired concentration and to standardize them
- To develop the skill for relate viscous flow of liquid and its relation with the solution concentration
- To develop the skill to apply color and turbidity change to calculate/ determine kinetics parameter
- To make the students able to study reaction kinetics using color change of solution
- To apply the knowledge of Nernst's distribution law for determining the equilibrium constant
- To apply the common ion effect on solubility
- Make the student able to observe the enthalpy changes in physical/chemical processes

Course Content (8-10 experiments to be done)

Acid base titration:

1. a) Preparation of acid, base and salt solutions of specified amount and concentration
b) Standardization of base solution (NaOH) against primary standard (oxalic) acid solution and further standardization of other acid (HCl, CH_3COOH etc.) solutions
2. Determination of percentage of acetic acid in commercial vinegar sample

Viscosity:

1. Determination of viscosity coefficient of a known sample using Ostwald's viscometer and
2. Determination of its unknown concentration
3. Determination of radius of glycerin by measuring viscosity at room temperature
4. Determination of activation energy of viscous flow of a liquid sample or solution

Kinetics:

1. Determination of order and rate constant of the reaction of MnO_4^- with oxalic acid by visual color disappearance method
2. Determination of order and rate constant of formation of colloidal sulfur by the reaction of $S_2O_3^{2-}$ with H^+

Distribution:

1. Determination of distribution coefficient of I_2 in water and CCl_4 mixture at room temperature
2 . Determination of equilibrium constant of the reaction $I_2 + I^- \leftrightarrow I_3^-$ using Nernst distribution law

Ionic Equilibria:

Determination of solubility and solubility product constant of $Ca(OH)_2$ in aqueous solution in absence and presence of common ion (OH^-)

Thermodynamics:

1. Determination of enthalpy of dissolution of $CuSO_4$ in water calorimetrically
2. Determination of enthalpy of neutralization of strong acid against a strong base
3. Determination of enthalpy of dilution of H_2SO_4 acid in aqueous solution

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Prepare sample and solution of desired concentration and standardize them
CO2. Determine the viscosity of a sample and calculate the concentration of it
CO3. Determine the kinetic parameters using physical changes observation
CO4. Apply common ion effect on solubility and solvent extraction technique practically
CO5. Determine the equilibrium constant and apply the thermodynamics principles towards laboratory and real life

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		3								
CO3		3								
CO4		3	1							
CO5		3		1						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration, Video Demo	Lab Performance (group), lab Report, Individual Lab Performance/Exam, Viva (Individual)
CO2	Lecture, Demonstration, Video Demo	Lab Performance (group), lab Report, Individual Lab Performance/Exam, Viva (Individual)
CO3	Lecture, Demonstration, Video Demo	Lab Performance (group), lab Report, Individual Lab Performance/Exam, Viva (Individual)
CO4	Lecture, Demonstration, Video Demo	Lab Performance (group), lab Report, Individual Lab Performance/Exam, Viva (Individual)
CO5	Lecture, Demonstration, Video Demo	Lab Performance (group), lab Report, Individual Lab Performance/Exam, Viva (Individual)

Books Recommended:

1. Physical Chemistry by P. W. Atkins,
2. Physical Chemistry by Gilbert W. Castellan,
3. Principle of Physical Chemistry by Samuel H. Maron and Carl F. Prutton,
4. Physical Chemistry by S. K Jain,
5. Advance Physical Chemistry by Gurdeep Raj

Course No: **CHE 0531 1234**	Credit: 1.5	Year: First	Semester: Second
Course Title: **Qualitative Inorganic Chemistry Practical**		Course Type: Practical	

Course Rationale:

This course is aimed to make the student practically skilled in handling inorganic compounds and focus on detecting ions in an aqueous solution which are essential for the study of Chemistry.

Course Objectives:

The objectives of this course are:

- To acquire knowledge and develop practical skills for the identification of various ions in inorganic compounds by qualitative analysis.

Course Content:

1. Identification of acid and basic radicals by semi-micro qualitative analysis.

a) Basic cations: Silver, lead, mercury, bismuth, copper, cadmium, tin, antimony, iron, aluminum, chromium, zinc, cobalt, nickel, calcium, barium, strontium, potassium, sodium, and ammonium.

b) Acidic cations: Carbonate, sulfate, nitrate, chloride, bromide, iodide.

2. Precipitation reaction and oxidation-reduction reaction, solubility, molar solubility, solubility product, ion product, and the common ion effect.
3. The alkali metals, the alkaline earth metals, and the transition metals.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Prepare and use the aqueous solution of inorganic compounds accurately for the identification of cations and anions using necessary reagents.

CO2. Identify acidic and basic cations in solutions using various chemical reactions and safe scientific practices.

CO3. Analyze metal and nonmetal ions and develop an informed interest in inorganic compounds that may lead to further study.

CO4. Recognize the impact of the identified ions and reagents in living systems and environments.

CO5. Identify basic radicals by flame test using conc. HCl

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		3								
CO3		2	2							
CO4								2	2	
CO5		3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures and experiment demonstration	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. Vogel's Qualitative Inorganic Analysis (7th Edition), Edited by G. Svehla, Pearson, 2011
2. General Chemistry, Raymond Chang, New York (5th edition)

Course No: **CHE 0531 1235**	Credit: 2.0	Year: First	Semester: Second
Course Title: **General Principles of Inorganic Chemistry**		Course Type: Theory (Core)	

Course Rationale:

This course helps students to gain knowledge on various rules, geometries, and structure-related properties of chemical compounds.

Course Objectives:

The objectives of this course are:

To acquire knowledge of acid-base concepts and apply them to identify different acids and bases

- To understand electronic concepts of oxidation-reduction, redox potentials, and electrochemical cells and apply them to predict the course of redox reactions
- To understand symmetry elements and symmetry operations and apply them identifying point groups of molecules

- To provide clear knowledge of the structure and morphology and energetics of ionic solids
- To understand the solvent properties to use in various chemical reactions.

Course Content:

Acids and Bases: Modern concepts of acids and bases, the strength of acids and bases, super acids, hard and soft acids, and bases, and thermodynamic acidity parameters. Periodic trends in aqua acid strength, Chemistry of oxide, hydroxides, and superoxides.

Oxidation and Reduction Reaction: Electronic concept, oxidation state and oxidation numbers, assignment of oxidation numbers, oxidizing reducing agents, balancing of redox reactions, oxidation-reduction (redox) potentials. Lattimer diagram, and Frost diagram.

Molecular Symmetry: Symmetry operations and elements, symmetry point group, assigning of molecules to point groups, Symmetry of orbitals.

Structure and Energetics of Inorganic Solids: Close packing of spheres, Non-close-packing, Lattices, unit cell, Metallic and ionic radii, radius ratio rules, Born-Lande expression, Crystal Structures of NaCl, CsCl, zinc blende, wurtzite, fluorite, rutile, perovskite ($CaTiO_3$) lattice.

Solvents and Solutions: Solvent properties, donor and acceptor properties, protic and aprotic solvents, the chemistry of some non-aqueous solvents: liquid NH_3, hydrogen fluoride, liquid N_2O_4, BrF_3, anhydrous sulphuric acid.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Interpret various concepts for defining acids-bases, oxidizing-reducing substances, and various solvents including corresponding chemical reactions.

CO2. Explain qualitatively and quantitatively various behavior of acids-bases and oxidizing-reducing substances based on fundamental parameters; such as pH, pOH, pK_a, pK_b, and redox potentials.

CO3. Analyze and predict the appropriate point groups for molecules through symmetry operations by applying different symmetry elements to understand their nature.

CO4. Determine geometries and structures of solid-state materials and explain their structure-related properties.

CO5. Illustrate the physical and chemical characteristics of various solvents and their uses in different applied fields.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	**Program Learning Outcomes**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2		2							
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture using PPT and demonstration of practical data	assignment
CO2	Lecture using PPT and demonstration of practical data	Class test (Short Q and MCQ)
CO3	Lecture using PPT and model demonstration	Short Q, MCQ, Quiz, Explanation
CO4	Lecture using PPT and model demonstration	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and Group discussion	Short Q, MCQ, Quiz, Explanation

Books Recommended:

1. Inorganic Chemistry, Atkins, Overton, Rourke, Weller, Armstrong and Hagerman, (5th Edition), Oxford University

Press, 2010
2. Basic Inorganic Chemistry, F. A.Cotton, G.Wilkinson, P. L. Gaus, (3rd Edition), John Wiley & Sons, 1995
3. Concise Inorganic Chemistry, J. D. Lee, (5th Edition), Blackwell Science Ltd., 2014
4. Inorganic Chemistry, A. J. Sharpe, (3rd Edition), Darling Kindersley Pvt. Ltd. 2012
5. Inorganic Chemistry (4th Edition), J. E. Huheey, Addision-Wesley Publishing Company, 1993
6. Inorganic Chemistry, Catherine E. Housecroft
7. Inorganic Chemistry, Gary L. Miessler
8. Concepts and Models of Inorganic Chemistry, Bodie E. Douglas
9. General Chemistry, Darrel D. Ebbing
10. Non-aqueous Solvents, John R. Chipperfield

Course No: **CHE 0531 1243**	Credit: 3.0	Year: First	Semester: Second
Course Title: **Fundamental Organic Chemistry II**		Course Type: Theory	

Course Rationale:
The goal of the study of this course is to develop an in-depth understanding and knowledge of the chemistry of carbonyl compounds, carboxylic acids, and the relative reactivity of carboxylic acid derivatives. This course will also cover the chemistry of alicyclic compounds, their formation, conformation on stability, and reactions.

Course Objectives:
The objectives of this course are:
- To teach the students the nomenclature of organic compounds based on functional groups
- To facilitate necessary knowledge for the preparation of different functional group-containing organic compounds
- To provide adequate knowledge of the properties of organic compounds based on functional groups
- To acquire sufficient knowledge of the chemical reactions of common functional groups
- To make the students able to formulate a reaction plan for the synthesis of organic compounds

Course Content:
Aldehydes and Ketones: Structure and Nomenclature, General methods of preparation including some important industrial methods, Physical and Chemical Properties of carbonyl compounds. Nucleophilic addition reactions. Oxidation and reduction reactions with different reagents, Reactions at the α-carbon of carbonyl compounds, Canizzaro reaction, Aldol condensation, Wittig, and Haloform reactions.
Carboxylic acids and their functional derivatives: Structure, nomenclature, the general method of preparation, physical and chemical properties, Nucleophilic acyl substitution reactions, and the synthetic applications of carboxylic acids and their functional derivatives, e.g., acyl halides, esters, amides, anhydrides, etc.
Amines: Nomenclature, preparations, physical and chemical properties, structure and basicity, and the uses of alkyl- and aryl-amines.
Arene diazonium salts and azo-dyes: Synthesis, physical and chemical properties, and the uses of arene diazonium salts and azo dyes.
Organosulphur compounds: Nomenclature, physical properties, preparation, reactions, and uses of mercaptans, thioethers, thioaldehydes, thioketones, thioacids, and sulphonic acids.
Organo-phosphorus compounds: Basic Structural features; synthesis, general properties and reactions of phosphines; Phosphorous ylides: preparation and applications.
Alicyclic Compounds: Cycloalkanes: Nomenclatures, Industrial sources, Preparation, Reactions of small ring compounds e.g., cyclopropane and cyclobutane. Brayer strain theory. Conformation: Meaning and physical properties. Factors affecting the stability of conformations, the conformation of cyclohexane, and monosubstituted cyclohexane.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Explain the synthesis, reaction, and properties of carbonyl compounds, chemical analysis, and their uses in organic chemistry. Identify and solve organic chemical problems.

CO2. Relate the relative acidity, outline the synthesis and uses of carboxylic acids (especially for the preparation of their functional derivatives), and the reactivity of functional derivatives
CO3. Discuss the structure, physical properties, basicity, preparation, reactions, and uses of amines. Explain the preparation of diazonium salts and their application in the azo-dyes synthesis
CO4. Explain and describe the reactions, preparation and properties, and applications of organosulphur, and organo-phosphorous compounds; explain and apply the relative reactivities and reaction mechanism involved with aldehydes, ketones, and their functional derivatives. Analyze and compare the reactivity of various functional groups
CO5. Describe the preparation, and properties and explain the stability, and reactivity of small ring compounds and correlate between conformation and stability of cyclohexane, and monosubstituted cyclohexane.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3		1							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT demonstration	Class test, (Short Q and MCQ), Quiz
CO2	Lecture, Demonstration with the model, Discussion	Quiz, Assignment,
CO3	Lecture, animated VDO clips, Question-Answer session	Assignment
CO4	Lecture, Group discussion	Problem-solving, Assignment
CO5	Lecture, PPT presentation, group discussion for problem analysis	Problem-solving, Final Assessment

Books Recommended:
1. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
2. T. W. Graham Solomons, Craig Fryhle, Scott Snyder, *Organic Chemistry* (11th edition), Wiley
3. I. L. Finar, *Organic Chemistry* Vol. 1 (6th edition)
4. F. A. Carey, *Organic Chemistry*(3rd edition), McGraw-Hill Comp. Inc.

Course No: **MAT 0541 1203K**	Credit: 3.0	Year: First	Semester: Second
Course Title: **Calculus and differential Equations**		Course Status: Theory (Ged)	

Rationale
The focus and themes of the Calculus course address the most important foundations for applications of mathematics in science, engineering and commerce. The course will provide various technics with applications to solve engineering problems.
Course Objectives:
The objectives of this course are
- Develop a strong understanding of functions of real variables, their graphs, limits, continuity, and derivatives, with applications to physical problems in chemistry.
- To explain the physical significance of derivatives and to apply differentiation techniques, including successive differentiation, using Leibnitz's theorem, Rolle's theorem, mean value theorem, and Taylor's theorem.
- To determine the maximum and minimum values of functions, including those of two or three variables, through the use of partial and total derivatives.
- To introduce the concept of integration, its physical interpretation, and its application as an inverse process of differentiation, particularly in calculating areas and volumes relevant to chemical systems.
- To solve definite and improper integrals, use reduction formulas, and perform double integrations to evaluate areas and volumes in chemical contexts.

- To employ methods such as undetermined coefficients and variation of parameters for solving second-order differential equations and to apply solutions to initial value problems commonly encountered in chemistry.

Course content:

Differential Calculus: Function of a real variable and their graphs; limit, continuity and derivatives; physical meaning of derivative of a function; successive derivatives; Leibnitz's theorem; Rolle's theorem; mean value theorem and Taylor's theorem (statement only); Taylor's and Maclaurin's series and expansion of function; maximum and minimum values of functions; functions of two and three variables; partial and total derivatives.

Integral Calculus: Physical meaning of integration; integration as an inverse process of differentiation; definite integral as the limit of a sum and as an area definite integral as the limit of a sum and as an area; reduction formula; improper integrals; double integration; evaluation of areas and volumes by integration.

Differential Equations: Definition and solution of ordinary differential equations; first order ordinary differential equations; second order ordinary linear differential equations with constant coefficients; solutions by the method of undetermined coefficient and variation of parameter; initial value problems.

Course Learning Outcomes:

On completion of the course, the student will be able to-

CO1: Analyze the graphs of various functions and evaluate their limit, continuity and derivatives.

CO2: Acquire knowledge about Leibnitz's theorem, Rolle's theorem, Mean-value theorem and expand functions using Taylor's and Maclaurine's theorem.

CO3: Determine maxima and minima of a function.

CO4: Evaluate definite and indefinite integrals through different methods.

CO5: Acquire knowledge about differential equations and solve ordinary differential equations using different methods.

Mapping of Cos with the Pos: 3: Strong, 2: Moderate, 1: Weak

	Fundamental Skill			**Social Skill**		**Thinking Skill**		**Personal Skill**	
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3								
CO2	3								
CO3	3								
CO4	3								
CO5	3								

Mapping Course Learning Outcomes (Cos) with the Teaching-Learning and Assessment Strategy

Cos	**Teaching-Learning Strategy**	**Assessment Strategy**
CO1	Lectures white board	Continuous assessment and mid-term exam
CO2	Lectures white board	Continuous assessment and quiz test
CO3	Lectures white board	Continuous assessment and mid-term exam 1
CO4	Lectures white board	Continuous assessment and Assignment
CO5	Lectures white board	Mid-term exam 2 and semester end exam

Recommended Reference Books:

1. Thomas and Finney: *Calculus and analytic geometry*
2. Swokowski, E W: *Calculus with analytic geometry*
3. Mohammed and Bhattacharjee: *Differential Calculus*
4. Das and Mucharjee: *Differential Calculus*
5. Mohammed and Bhattacharjee: *Integral Calculus*
6. Das and Mucharjee: *Integral Calculus*
7. Ayres, F.: *Differential equations*

Course Code: **PHY 0533 1204K**	Credit: 3.0	Year: First	Semester: Second

Course Title: **Mechanics, Waves and Optics**	Course Type: Theory (GEd)

Course Rationale:

This course will prepare students to understand laws and principles of physics involved in Mechanics, Waves and Optics areas and to develop skills in problem-solving.

Course Objectives:

The objectives of this course are:

- to provide a basic understanding of Newtonian mechanics.
- to explore the nature of vibrating systems and wave motion.
- To make students familiar with the wave phenomenon of light.

Course Content:

Mechanics: Kinematics in one and two dimensions, projectile motion, circular motion; Newton's laws of motion; work, conservative force fields, potential energy, conservation of mechanical energy; dynamics of systems of particles, conservation of linear momentum, collisions; rotational dynamics of rigid bodies, conservation of angular momentum; central forces and gravitation, Kepler's laws.

Waves: Simple harmonic motion, damped and forced vibrations; waves in elastic media; sound waves, Doppler Effect; Fourier's theorem and its applications.

Optics: Nature and propagation of light, interference of light, Young's experiment, Newton's ring, Michelson interferometer, Fraunhofer and Fresnel diffraction, diffraction grating, polarization of light, optical activity, polarimetry.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. State projectile motion, force, work, energy, center of mass, momentum, collisions, gravitation, harmonic motion and sound, interference, diffraction and propagation of light.

CO2. Explain the concepts of classical mechanics, oscillatory systems, wave motion, Doppler Effect of sound and nature of light.

CO3. Organize laws of motion, energy and momentum conservation, particle dynamics, work-energy theorem, laws of gravitation, harmonic motion, Doppler Effect, Fourier's theorem.

CO4. Develop problem solving-skills related to the mechanics, waves and optical phenomena.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	**Program Learning Outcomes**								
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	3								
CO2	3								
CO3	3								
CO4	3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning**	**Assessment Strategy**
CO1	Lecture Using Board/ LCD projector/OHP Projector Self Learning using reference books/ research articles/ case study/ other	Mid Term Examination 1, Quiz
CO2	Lecture Using Board/ LCD projector/OHP Projector, Self Learning using reference books/ research articles/ case study/ other	Mid Term Examination 2, Quiz
CO3	Lecture Using Board/ LCD projector/OHP Projector Self Learning using reference books/ research articles/ case study/ other	problem solving, Quiz
CO4	Lecture Using Board/ LCD projector/OHP Projector Self Learning using reference books/ research articles/ case study/ other	Essay type test, problem solving

Books Recommended:

1. Mathur: Elements of Properties of Matter, S. Chand Limited, 2008
2. F. H. Newman and V. H. L. Searle: General Properties of Matter, 2nd ed., 1933
3. D. Halliday, R. Resnick, J. Walker: Halliday, *Fundamentals of Physics, 10th ed., 2013*

Course No: **CHE 0531 1291**	Credit: 1.0	Year: First	Semester: Second
Course Title: **Seminar and Oral Presentation**		Course Type: Oral	

Course Rationale:
Communication skill is now a day is very vital for professionalism. For academic, industrial and research purposes communication of scientific results and view as well as social communication is very important. This course aims to make the students capable of making proper communication, particularly in their subject matters.

Course Objectives:
The objectives of this course are:
- To familiarize the students with preparing an assignment on specific topics studied at the previous semester
- To familiarize the students with the experiences of oral presentation
- Acquaint students with the basics of academic viva-voce

Course Content:
Students will be assigned specific topics based on the curriculum of two semesters of 2nd year. Students will prepare a detailed assignment based on their assigned topics and give an oral presentation before the exam committee.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Prepare an assignment on specific topics to present orally
CO2. Present the selected topic in front of an examination committee
CO3. Explain the topics verbally in front of the examination committee

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	1				3					
CO2					3					
CO3	1				3					

Teaching- Learning and Assessment Strategies:
There will be no formal face-to-face instruction for the course. Students will learn throughout the semester from the related class lecture and discussions with teachers and among themselves. There will also be tutorial session where students will get the opportunity to discuss any related topics. The duration of the tutorial/ discussion class will be a total of 15 hours in a semester. The respective course teachers will provide the topics to each individual student for their presentation before the final presentation. Students will be evaluated and grades will be given on the basis of the marks given by the members of the examination committee individually or combinedly.

Assessment Rubric:

	Excellent (33p)	**Proficient (25p)**	**Satisfactory (20p)**	**Poor (15p)**
Content	-Students discuss the subject in great details -Student describes in detail about their topic	-Students discuss the subject with some details -Student outlines their topic	-Student discuss the subject with a few details -Student do not outline their topic	-Students discuss the subject with very minimal details -Students do not outline what they have learnt
Delivery	-Good posture -Eye contact with the audience most of the time	-Good posture -Frequent eye contact with the audience	-Intermittent good posture –Occasional eye contact with the audience	-Poor posture -Seldom eye contact with the audience
Answering to the Question	-Answers All the questions asked properly	-Answers All the questions asked properly	-Answers All the questions asked properly	-Answers All the questions asked properly

Course No: **CHE 0531 2121**	Credit: 3.0	Year: Second	Semester: First
Course Title: **Thermodynamics**		Course Type: Theory	

Course Rationale: This course is designed to provide the students with a comprehensive knowledge on laws of thermodynamics that govern the change of various physical and chemical processes. Some modern technologies that stem out from the laws are also focus of interest of this course.

Learning Objectives:
The objectives of this course are:
- To provide students with a clear understanding of thermodynamic laws and equations relating thermodynamic parameters.
- To introduce with essential uses of technology, that utilize laws of thermodynamics, in everyday life.
- To explain occurrences of natural and artificial phenomena with thermodynamic point of views.
- To estimate the amount of energy transferred during occurrence of a thermodynamic process.

Course Content:
Joule-Thomson effect: Joule-Thomson effect, Joule-Thomson coefficient, Change of Joule-Thomson coefficient for ideal and real gases, inversion temperature and its significant, compressibility and expansion coefficient.
Second law and third law of thermodynamics: Limitation of first law of thermodynamics and the necessity of second law, Spontaneity & Statement of Second law, Maxwell relationships, Carnot cycle, Heat engine and refrigeration, enthalpy, entropy & free energy, non-expansion work, Gibbs-Helmholtz equation, relation between heat capacity and entropy, Nernst heat theorem, Statement of 3rd law and its necessity, absolute entropy, Entropy & probability, statistical approach to entropy, residual entropy.
Physical Transformation of Pure Substances: Involvement of chemical potential in phase transformation, phase diagram and phase boundaries, phase diagrams of few substances, location of phase boundaries; Clapeyron equation, Clausius-Clapeyron equation.
Thermodynamic Treatment of mixtures: Partial molar quantities & their determinations, Gibb's energy, entropy and enthalpy of mixing, real gas and fugacity, Chemical potential and its application in derivation of various thermodynamics relations.
Thermodynamics of dilute Solutions Ideal & non-ideal solutions, Vapour pressure and its measurement, Raoult's law, Ideal-dilute solution and Henry's law, colligative properties: Elevation of boiling point, Depression of freezing point, Osmotic pressure, Lowering of vapour pressure, thermodynamic treatments of colligative properties.
Thermodynamics of Chemical Equilibria: Gibb's free energy and chemical equilibrium, Reaction Gibb's free energy and equilibrium constant (K_p, K_c &K_x), reaction isochore, reaction isotherm, reaction quotient and its significance, Homogeneous and heterogeneous equilibria, response of equilibria to pressure, concentration and temperature (van't Hoff equation), principle of mobile equilibrium and applications to reactions in industries likes alcohol, acid, ammonia etc. Coupling reactions and its importance in biological and industrial process.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1.	Explain thermodynamic relationships associated with various physical and chemical processes
CO2.	Explain various spontaneous and non-spontaneous phenomena happening both naturally and artificially
CO3.	Elucidate the working principles of technologies related to energy transfer processes, like heat engine, refrigerator, heat pump etc.
CO4.	Explain and understand properties of dilute solutions, mixture of ideal gases and applications of mobile equilibrium for chemical reaction in induries.
CO5	Solve problems and calculate various thermodynamic parameters

Mapping of Course Learning Outcomes (COs) with Pos 3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes (POs)									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3		1							
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture Demonstration (PPT), Question-Answer session, Group discussion for problem analysis, Video clips	Class test, assignment
CO2	Lecture Demonstration (PPT), Question-Answer session, Group discussion for problem analysis, Video clips	Assignment
CO3	Lecture Demonstration (PPT), Question-Answer session	Class test, assignment
CO4	Lecture Demonstration (PPT), Group discussion	Short and Broad Question
CO5	Lecture Demonstration (PPT)	Short and Broad Question

Recommended Text Books:

1. Atkins, *Physical Chemistry*
2. Robert A. Alberty, *Physical Chemistry*

Course No: **CHE 0531 2122**	Credit: 2.0	Year: Second	Semester: First
Course Title: **Progressive Physical Chemistry Practical**		Course Type: Practical	

Course Rationale:

This course is designed to give learners laboratory practical experience with a strong focus on developing skills on electrochemistry based experiments.

Course Objectives:

The objectives of this course are:

- To make the understand and demonstrate thermochemical properties of reactions
- To help the students to learn about drive a non-spontaneous electrochemical reaction
- To make them able to construct electrochemical (Galvanic) cell
- To m ake them able to construct pH curve to select perfect indicator
- To make them skilled to determine some thermochemical and electrochemical quantities using the corresponding equation and physical techniques. E.C. (I-S, composition of water, pK)
- To develop the skill to determine the pKa of acid base reaction

Course Content:

Determination of heat of neutralization of a strong acid and strong base
Determination of enthalpy of solution of a sparingly soluble electrolyte (succinic acid) in water.
Determination of partial molar quantities of a binary system (e.g. ethanol in water or NaCl in water)

Determination of enthalpy of formation of MgO
Determination of composition of water
Determination of number of electron transfer and E^{o}_{cell} of an electrochemically reversible reaction
Determination of ionic strength of a strong acid by conductometric titration
Construction of pH curve of a weak acid and strong base and determination of pKa value

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain and interpretate the effect of temperature on solubility and enthalpy
CO2. Demonstrate the application of Hess's law, partial molar quantities
CO3. Determine the heat of reaction

Mapping of Course Learning Outcomes (COs) with Pos 3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes (POs)									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		2		1						
CO2		2		1						
CO3		2		1						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO2	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO3	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment

Books Recommended:

1. An Introduction to Electrochemistry, S. Glasstone, Litton Educational Publishing Inc., New York
2. Text Book of Physical Chemistry (2nd Edition), S. Glasstone, Macmillan Press Ltd., 1974
3. Physical Chemistry (7th Edition), P.W. Atkins, Oxford University Press Inc., New York, 2002
4. Electrochemical Methods: Fundamentals and Applications 2nd Edition, Allen J. Bard & Larry R. Faulkner

Course No: **CHE 0531 2132**	Credit: 1.5	Year: Second	Semester: First
Course Title: **Inorganic Chemistry Practical (Quantitative)**		Course Type: Practical	

Course Rationale:

Students are expected to understand how to correctly set up the experiments to carry out the quantitative analysis.

Learning Objectives:

The objectives of this course are:

- To acquire knowledge for the preparation of standard or non-standard solutions for various substances.
- To measure volume for solutions, the calculation of concentration for solutions, and mass of solid substances.
- To gain knowledge on the oxidation-reduction state of the oxidizing-reducing substances.
- To estimate and describe the properties of metal and metal compounds.

Course Content:

Acid-Base Titration: Standardization of Appx. 0.1M NaOH by standard 0.1M oxalic acid solution and determination of the strength of approximate 0.1 M HCl solution**.**
Oxidation-Reduction Titration: Standardization of the given $KMnO_4$ solution (approximate 0.1M) with the standard oxalic acid solution (0.1M) and determination of Ferrous ion by standard potassium permanganate solution.
Iodometric Titration: Standardization of sodium thiosulphate solution with standard potassium dichromate solution and iodometric determination of copper with sodium thiosulphate solution.
Gravimetric Estimation: (i) Estimation of Ni as $Ni(DMG)_2$, (ii) Estimation of Sulphate as barium sulfate.
Separation of Mixtures and Estimation of Different Species: Separation and Quantitative determination of nickel

from a mixture.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1 Follow instructions and handle mixing various reagents and record data for an observation to occur.

CO2 Demonstrate and analyze the recorded data precisely, and draw appropriate conclusions from laboratory practice that carries out quantitative determinations.

CO3 Recognize and classify both acidic-basic and oxidizing-reducing substances, and gain knowledge on functions of various indicators.

CO4 Explain the changing of properties for compounds with changing both mass and temperature.

CO5 Separate and estimate a particular metal from a mixture

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		2			3					
CO3	3	2								
CO4	3	2								
CO5	3	2								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures for characterizations	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. Vogel, Textbook of Quantitative Analysis
2. Analytical chemistry, G. D. Christian, John Wiley & Sons, (4th ed.)
3. Introduction to chemical analysis, Braun, McGraw Hill International

Course No: **CHE 0531 2134**	Credit: 2.0	Year: Second	Semester: First
Course Title: Chemistry of s and p block elements		Course Type: Theory (Core)	

Course Rationale:

This course aims to give detailed knowledge of the periodic table, mainly the chemistry of main group elements. Why all these elements are arranged in a particular sequence, and what information can be easily extrapolated about these elements from the periodic table is the main topic of discussion in this course.

Course Objectives:

The objectives of this course are:

- To impart knowledge on the elementary idea about the chemistry of main group elements
- Understanding of the properties, bonding, and structure of the main group elements
- To develop skills to extrapolate ideas about the characteristics of any main group elements
- To be familiar with the periodic trend, chemical behavior, and bonding similarities of the elements in a group and along a column.

Course Content:

Group 1 elements: Electronic structure, physical properties: the size of the atoms and ions, ionization energies, electronegativity, and bond type, hardness and cohesive energies, flame coloration, and spectra; chemical properties: Reactions of group 1 metals with water, oxygen, hydrogen, and halide; oxides, hydroxides, peroxides and superoxides, hydrides, solubility and hydration, solution of metal in liquid ammonia.

Group 2 elements: Electronic structure, physical properties: the size of the atoms and ions, ionization energies, electronegativity, Hydration energies, anomalous behavior of Be, solubility and lattice energy; chemical properties: reactivity of Group 2 metals, hardness of water, hydride: polymeric structure of BeH_2; Halides: structure and bonding of $BeCl_2$ in the solid and gaseous state.

Group 13 elements: Electronic structure, Preparation of boron from BCl_3 and B_2H_6, Oxidation states and types of bonds: The (+III) oxidation state, The (+I) oxidation state- the inert pair effect, amphoteric behavior of the oxides and hydroxides of Al and Ga; Trihalides of boron: Preparation, electron-deficient compound, Lewis acidity trend, Structure and bonding of Al_2Cl_6; Diborane: preparation (from BF_3, etherate complexes of the boron halides, $Na[BH_4]$), structure and bonding, reaction with NH_3, synthesis and reactivity of borazine.

Group 14 elements: Electronic structure, Catenation, structure and allotropic forms of carbon, the difference in density and electrical conductivity between diamond and graphite, the toxicity of CO, preparation and bonding of metal carbonyls; preparation and detection of CO_2; Structure and bonding of $(CH_3)_3N$ and $(SiH_3)_3N$; Reaction of CCl_4 and $SiCl_4$ with H_2O, the reaction mechanism of hydrolysis.

Group 15 elements: Electronic structure and oxidation state, occurrence and abundance, Element hydride: bond angle and donor properties; trihalide, pentahalide: geometry of PCl_5; oxides of nitrogen: preparation, application, and reactivity, oxoacids of nitrogen; oxides and oxoacids of phosphorus.

Group 16 elements: Electronic structure, allotropic forms of sulfur, general properties of oxides: normal oxides, peroxides, suboxides, basic, amphoteric, and acidic oxide; oxides and oxoacids of sulfur, comparison of bond angles and boiling points of H_2O, H_2S, H_2Se, and H_2Te.

Group 17 elements: Electronic structure, Halogen oxides: difference in bond angle among OF_2, Cl_2O, and Br_2O; Oxoacids of halogens: Structure and strength; Interhalogen compounds: Preparation and structure, polyhalides.

Group 18 elements: Electronic structure, general properties, compounds, and structures.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Express the general physical and chemical trends of the main group elements.

CO2. Explain the physical and chemical properties, reactions, trend of solubility, magnetic behavior of superoxide and peroxide ion, various structures of $BeCl_2$, 3c-2e bonds in BeH_2, bonding of Al_2Cl_6, and the reactivity of borazine.

CO3. Explain the preparation, application, and reactivity of Oxides of nitrogen and phosphorus.

CO4. Distinguish the difference in density and electrical conductivity between diamond and graphite, pπ-dπ bond, donor properties of $(CH_3)_3N$ and $(SiH_3)_3N$, the trend in bond angles and boiling points of H_2O, H_2S, H_2Se, and H_2Te.

CO5. Explain the strength of oxoacids, the structure of interhalogen compounds and formulate the structure of XeF_2, XeF_4, XeF_6

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	**Program Learning Outcomes**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2		1							
CO2	2		1							
CO3	2		1							
CO4	1		2							
CO5	1		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with the model, Discussion	Quiz, assignment

CO3	Lecture, demonstration, and discussion	Class Test
CO4	Lecture, demonstration, and discussion	Class Test
CO5	Lecture, PPT presentation, Group discussion for problem analysis	Class Tests, problem-solving

Books Recommended:

1. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson, and P. Gauss, Wiley, John Wiley & Sons (3rd edition)
2. Concise Inorganic Chemistry, J. D. Lee, (5th edition)
3. Periodicity of s- and p-block elements, N. C. Norman, (OCP)

Course No: **CHE 0531 2135**	Credit: 2.0	Year: Second	Semester: First
Course Title: Chemistry of transition metals		Course Type: Theory (Core)	

Course Rationale:

This course aims to give an understanding of the chemistry of the transition metals, lanthanides, and actinides which will be needed for the further study of higher courses. This is also to make a bridge with their previous knowledge of this.

Course Objectives:

The objectives of this course are:

- To acquaint students with the principles of the chemistry of the transition metals, lanthanides, and actinides
- To make the students understand the trends in properties and reactivity of the d-block elements
- To recognize the electronic and magnetic qualities of these compounds and their colors
- To make the students familiar with redox potential, Lattimer and Frost diagram

Course Content:

Chemistry for the elements of groups: Group IIIB (3), group IVB (4), Group VB (5), group VIB (6), group VIIB (7), group VIIIB (8,9,10), group IB (11) and group IIB (12) elements.

Chemistry of Lanthanides: General features, lanthanide contraction, variable valency, magnetic and spectral properties, separation of lanthanides, common lanthanide compounds, comparison of lanthanide ions and transition metal ions**.**

Chemistry of Actinides: General features, actinide contraction, occurrence and properties of the elements, general chemistry of actinides, separation of the actinides, superactinides.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the properties and reactivity of transition metals.

CO2. Study the structures and properties of various compounds formed by transition metals

CO3. Explain the effects of different parameters such as temperature, pressure, and light for transition metals And their compounds.

CO3. Describe the chemistry of the lanthanide and actinide elements in order of increasing atomic number

CO4. Explain the importance of the 4f and 5f valence orbitals in determining the chemistry of the lanthanide and actinide elements

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3		1							
CO3	3									
CO4	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, PPT Demonstration, Discussion	Quiz, assignment
CO3	Lecture, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, PPT presentation	problem-solving

Books Recommended:

1. J. D. Lee, Concise Inorganic Chemistry, Fifth edition, Wiley Publishing
2. Cotton, Wilkison and Gaus, Basic Inorganic Chemistry, Third edition, John Wiley and Sons publishing
3. Cotton and Wilkison, Advanced Inorganic Chemistry, Third edition, Wiley Eastern Limited publishing
4. Shriver, Atkins and Langford, Inorganic Chemistry, Fourth edition, Oxford university press
5. Douglas, McDaniel and Langford, Concept and Models of Inorganic Chemistry, Third edition, 1994. John Wiley and Sons Inc. publishing
6. J. E. Huheey, Inorganic Chemistry, Fourth edition, Wesley publishing

Course No: **CHE 0531 2141**	Credit: 2.0	Year: Second	Semester: First
Course Title: **Stereochemistry and Heterocyclic Chemistry**		Course Type: Theory	

Course Rationale:

Stereochemistry aims at the study of the relative spatial arrangement of atoms or groups of atoms in molecules and their manipulation, and heterocyclic chemistry aims at the study of synthesis, physical and chemical properties of heterocyclic compounds and their applications. Stereochemistry finds its importance in biology and medicine. Heterocyclic chemistry finds its importance in chemical, biomedical, and industrial sectors.

Course Objectives:

The objectives of this course are:

- To make the students understand the optical and geometrical isomerism, configuration, and relation between chirality and optical activity,
- To give them an idea of the conformations of alicyclic compounds concerning their stability,
- To make them familiar with optical isomerism with compounds lacking a chiral center, and
- To provide knowledge on the synthesis, basicity, physical and chemical properties of five- and six-membered heterocyclic compounds with one heteroatom.

Course Content:

Introductory Stereochemistry: Stereoisomerism: definition and classification. Optical isomerism: optical activity, plane polarized light, polarimeter, specific rotation, enantiomerism, and optical activity. Molecular dissymmetry. Prediction of enantiomerism: chirality. Chiral center. Diastereoisomerism, Meso compounds, racemic modification: nature, formation, properties, and resolution of racemic modifications, Configurations, and their notations. Geometrical isomerism: geometrical isomerism in olefinic compounds and cyclic compounds. Conformations of alicyclic compounds, Factor affecting conformations, conformations of cyclohexane, e.g., chair and boat forms, and their relative stability. Conformations, relative stability, and optical activity of disubstituted cyclohexanes, e.g., 1,2-, 1,3-, and 1, 4-dimethylcyclohexanes.

Stereochemistry of Fused Ring Systems: Stereoisomerism in the bicyclic fused ring system e.g. decalin.

Optical isomerism is devoid of chiral centers: Atropisomerism, biphenyls, allenes, and determination of their configurations.

Chemistry of heterocyclic compounds with one hetero atom: Introduction to heterocyclic compounds, structure, aromaticity, source, synthesis, physical and chemical properties of five-membered heterocyclic compounds e.g., pyrrole, furan, and thiophene and six-membered heterocyclic compound e.g., pyridine. Relative basicity of pyrrole, pyridine, and their saturated analogs. Introduction to bicyclic ring systems containing one hetero atom.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the optical and geometrical isomerisms, configuration and conformation, assigning configurational

notation, the relation between chirality and optical activity, racemic modifications and their resolution
CO2. Interpret the relationship among the conformations, stability of alicyclic compounds like substituted cyclohexanes.
CO3. Explain the optical isomerism of compounds devoid of the chiral center like biphenyls and allenes
CO4. Delineate the synthesis, basicity, physical and chemical properties of five-membered heterocyclic compounds with one heteroatom like pyrrole, furan, and thiophene and their saturated analogs.
CO5. Explain the synthesis, physical and chemical properties of six-membered heterocyclic compounds with one heteroatom like pyridine and its saturated analog.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2			3							
CO3	3									
CO4	2		2							
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration, Discussion	Term Test
CO2	Lecture, molecular model, and PPT Demonstration	Quiz
CO3	Lecture, molecular model, and PPT Demonstration	Assignment
CO4	Lecture, PPT Demonstration	Term Test
CO5	Lecture, Discussion	Problem-solving

Books Recommended:

1. R. T. Morrison & R. N. Boyd, *Organic Chemistry* (6th edition)
2. I. L. Finar, *Organic Chemistry* vol-2 (5th edition)
3. E. L. Eliel, *Stereochemistry of Carbon Compounds* (Tata McGraw Hill Edition)
4. I. L. Finar, *Organic Chemistry* vol-1 (6th edition)
5. P.S.Kalsi, Stereochemistry, conformation and mechanism (New Age International Pvt Ltd Publishers,6th edition)

Course No: **PHY 0533 2107K**	Credit: 3.0	Year: Second	Semester: First
Course Title: **Electricity, Magnetism and Modern Physics**		Course Type: Theory (GEd)	

Course Rationale:
The applications of the general knowledge of electromagnetism and modern physics are common in different branches of pure and applied sciences and engineering. This course is aimed to give a preliminary theoretical understanding of elementary concepts of electromagnetic theory and physics of atoms and nuclei that are needed for the practical and research work.
Learning Objectives:
The objectives of this course are:
- to introduce the students with fundamental laws of electricity and magnetism.
- to prepare students for making applications of fundamental electromagnetic theory in their respective field.
- to familiarize students with atomic models, atomic spectra, nuclear chemistry, laser and other elementary topics on modern physics.

Course Content:

Electrostatics: Quantization and conservation of electric charges, **e**lectric field, Coulomb's law, a dipole in an electric field, Gauss's law and its applications, electric potential and potential energy, capacitance, dielectrics, three electric vectors, energy storage in an electric field.
Electric Current and Circuits: Electron theory of conductivity, conductors, semiconductors and insulators, superconductors, current and current density, Kirchhoff's law and its applications, DC/AC circuits with LR, RC, LC, LCR in series.
Magnetism: Magnetic field, magnetic forces on a current, torque on a current loop, Hall effect, Ampére's law, Biot-Savart law and their applications, Faraday's law of induction, Lenz's law, energy in magnetic field.
Modern Physics: Bohr's atomic model and hydrogen spectra, photoelectric effect, de-Broglie matter waves, Bragg' law of X-ray diffraction, uncertainty principle, LASER, radioactivity and radioactive decay law, alpha, beta and gamma emission, nuclear energy, thermonuclear reactions in stars, quantum dots and quantum tunneling.
Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. State and analyze electric field strength, potential, capacitance, current, atomic models and nuclear force.
CO2. Explain capacitance and dielectrics, different types of conducting materials and DC/AC circuits.
CO3. Apply laws of electricity and magnetism, Bohr model and spectra, Brag's law, radioactivity.
CO4. Develop problem solving skills related to electromagnetism, electric current and circuits, atomic and nuclear aspects.

Mapping of Course Learning Outcomes (COs) with POs:
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

	Program Learning Outcomes								
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	3								
CO2	2	1							
CO3	2	1							
CO4	3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy:

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture and Discussion	Class test (Short Q and MCQ)
CO2	Lecture and Discussion	Essay type test, problem solving
CO3	Lecture and Question-Answer session	Class test (Short Q and MCQ) Quiz
CO4	Lecture, PPT presentation, and Group discussion	Essay type test, problem solving

Books Recommended:

1. David Halliday, Robert Resnick, and Jearl Walker: *Fundamentals of Physics* (Vol. II)
2. David Griffiths: *Introduction to Electrodynamics*
3. Arther Beiser: *Concepts of Modern Physics*
4. John Brehm and William Mullin: *Concepts of Modern Physics*

Course No: **PHY 0533 2102K**	Credit: 2.0	Year: Second	Semester: First
Course Title: **Basic Physics Laboratory**		Course Type: Practical (GEd)	

Course Rationale:
This course is introduced so that students gather experience in the experiment of mechanics and optics and practice scientific report writing.

Course Objectives:
The objectives of the course are:
- Help the students gather experience in physics laboratory practices
- Facilitate to receive training in how to use apparatus, do measurements, analyze and interpret experimental data

- Make them familiar to write a complete report on an experiment
- To introduce with the precautionary measures to take before doing an experiment, safety, cleaning and as a whole laboratory management.

Course Content:
Students will perform the following experiments in groups or individual

Name of the experiment

1. Investigation of the angular momentum.
2. Determination of the electrochemical equivalent of copper by a copper voltameter
3. Determination of the refractive index of a liquid by pin method
4. Determination of the refractive index of the material of a thick prism using a spectrometer
5. Determination of the thickness of paper by means of interference fringes in an air wedge
6. Determination of the radius of curvature of a lens using Newton's ring method
7. Determination of specific rotation of sugar solution by a polarimeter

Course Learning Outcomes (COs):
After completion of the course, students will be able to-
CO1. Explain the concept of linear momentum, angular momentum, electrochemical equivalent, mechanical equivalent of heat, refractive index, polarization and interference of light having practical intuition.
CO2. Collect experimental data with necessary precautions.
CO3. Analyze experimental data to conclude about the different physical observable quantities.
CO4. Propagate systematic uncertainty of experimental measurements in the measured observable quantities. **CO5.** Report scientific findings in both written and verbal form.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	1	3								
CO2	1	3								
CO3		3								
CO4		3								
CO5		3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO1	Lecture, Demonstration	Lab Performance (group), lab Report, Viva
CO2	Lecture, Demonstration	Lab Performance (group), lab Report, Viva
CO3	Lecture, Demonstration	Lab Performance (group), lab Report, Viva
CO4	Lecture, Demonstration	Lab Performance (group), lab Report, Viva
CO5	Lecture, Demonstration	Lab Performance (group), lab Report, Viva

Recommended Books

1. Worsnop, B.L. and Flint, H.T.: Advanced Practical Physics
2. Chowdhury, S. A. and Basak, A. K.,: Byaboharik PadarthaBidya
3. Ahmed, G. and Uddin, M.S.: Practical Physics

Course No: **FET 0721 2101K**	Credit: 3.0	Year: Second	Semester: First
Course Title: **Food Processing and Preservation**		Course Type: Theory (Ged)	

Course Rationale:
This course is aimed to introduce the principles of manufacturing and processes and technologies used in the production of food products and their preservation.

Course Objectives:
- To provide knowledge on the causes of food spoilage and methods of processing and preserving foods
- To facilitate knowledge about processing equipment and preservation methods appropriate for specific foods
- To enhance skill on the effects of preservation methods on the quality of food

Course Contents:
1. Introduction: Scope and importance of food processing. Natural and artificial food preservatives. Principles and methods of food preservation.

2. Food processing and preservation using heat and energy: Blanching of fruits and vegetables, Pasteurization, canning and sterilization, cooking and frying of foods, smoking, baking and roasting, extrusion cooking, freezing-melting process in liquid food concentration. Irradiation and preservation of foods.

3. Food processing and preservation by controlling water, structure and atmosphere: Food processing and preservation by membranes, sticking and caking in food preservations, water activity, relationship between water activity and food stability, glass transition and stage diagram of foods, drying and osmotic dehydration in food processing, surface treatments and edible coating in food preservation.

4. Food additives and food preservation: Definition, classification, functional characteristics and functions of food additives. General principle of food deterioration and preservation. Natural antimicrobials and antioxidants for food preservation. pH in food preservation.

5. Novel food processing technology: High-pressure processing, Ohmic heating/pulsed electric fields, ultrasound, super-critical fluid extraction CO_2, nanotechnology, plasma technology (hot and cold), electron beams, infrared processing.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Summarize the principles and application of food processing and preservation technologies
CO2. Interpret the technologies using heat and energy to process and preserve the foods
CO3. Explain the mechanism of processing and preservation by controlling water, structure and atmosphere of the foods
CO4. Describe the implications of chemical, microbiological and non-thermal novel technologies to preserve foods
CO5. Choose appropriate processing and preservation technologies for the application in food industry to process safe foods

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3					2				1
CO2	3					1				
CO3	3					1				
CO4	3					2				1
CO5	3					1				1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture and problem-based learning	Class test, Assignment/MCQ and Semester Final Exam
CO2	Lecture and problem-based learning	Class test, Assignment/MCQ and Semester Final Exam
CO3	Lecture and problem-based learning	Class test, Assignment/MCQ and Semester Final Exam
CO4	Lecture and problem-based learning	Class test, Assignment/MCQ and Semester Final Exam
CO5	Lecture and problem-based learning	Class test, Assignment/MCQ and Semester Final Exam

Books Recommended:

11. M. Shafiur Rahman, Handbook of Food preservation, 3rd Edition, 2020, CRC Press
12. P. J. Fellows, food Processing Technology: Principles and Practice, 4th Edition, 2017, Elsevier Ltd.
13. N. N. Potter and J. H. Hotchkiss, Food Science, 5th Edition, 1998, Springer Science
14. H. -D. Belitz, W. Grosch, and P. Schieberle, Food Chemistry, 4th Edition, 2009, Springer-Verlag

Course No: **CHE 0531 2223**	Credit: 2.0	Year: Second	Semester: Second
Course Title: **Phase Equilibria, Colloid and Surface Chemistry**		Course Type: Theory	

Course Rationale:

This course is aim to understand the fundamental concepts of nonchemical behavior of particles, a correlation with physical outlook, degrees of gradation and their physical existence.

Course Objectives

The objectives of this course are:

- To familiarize the students with surface phenomenon in terms of different forms of Isotherms
- To provide the knowledge of Phase equilibria and phase transition
- To make the students able to understand and relate the colloidal stage of particles and their various applications
- To acquire the knowledge about the kinetics related with colloidal solutions

Course Content:

Phase equilibria: Phase Rule and its applications: one component systems like water, sulfur, phosphorus and carbon dioxide. Two component system: miscible solid-liquid systems of two components with and without compound formation. Binary liquid systems: Duhem-Mergules equation. Distillation of completely miscible liquid mixtures, fractional distillation, Azeotropic mixtures. Phase diagrams for partially miscible liquid systems, salt and water system. Solid-liquid-vapour equilibria in systems such as salt and water; efflorescence and deliquescence, vapor pressure of saturated solutions. Principle of the phase diagram for three component system.

Surface Chemistry: Adsorption: adhesive and cohesive force, Different types of adsorption isotherms. Theories of Langmuir and other adsorption isotherm for gas-solid system. Adsorption at surface of solution: Gibbs adsorption equation, Surfactants, surface films. Adsorption by solids from solution.

Colloids: General methods of preparation, classification and general properties of colloids. Electrokinetic phenomena: Double layer structure, Zeta potential, electrophoresis and electroosmosis. Properties of gels, Colloidal electrolytes. Emulsions: Preparation, types, specific properties and stability. Microemulsion. Micelles formation and critical micelle concentration, Uses of colloids and emulsions.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the basic concepts of phases and the phase transition of one, two and three component systems
CO2. Apply the knowledge on surface phenomenon and factors affecting the surface, thermodynamic relations
CO3. Relate the interrelation between thermodynamics and surface processes
CO4. Illustrate the properties and kinetics of colloids and an application of the knowledge of colloids and surface on sol, gel, emulsion etc.
CO5. Understand the micelles formation, critical micelle concentration and its impotance.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2						3				
CO3	3									
CO4	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Group discussion, Question-Answer session	Class test (Short Q and MCQ)
CO2	Lecture, Group Discussion, Question-Answer session	Quiz, Assignment
CO3	Lecture, Group Discussion, Question-Answer session	Essay type test
CO4	Lecture, Group Discussion, Question-Answer session	Class test (Short Q and MCQ)

Books Recommended:

1. P. W. Atkins, *Physical Chemistry*
2. G. M. Barrow, *Physical Chemistry*
3. Maron and Lando, *Fundamentals of Physical Chemistry*
4. Glasstone and Lewis, *Text book of Physical Chemistry*
5. Jirgensen and Stranmens, *Colloid Chemistry*
6. A. Findlay, *Phase rule*
7. S. Glasstone, *Physical Chemistry*
8. Adamson, *Physical Chemistry of Surfaces*
9. Alberty, *Physical chemistry*

Course No: **CHE 0531 2224**	Credit: 2.0	Year: Second	Semester: Second
Course Title: **Electrochemistry**		Course Type: Theory	

Course Rationale:

This course is aim to understand the fundamental concepts of energy-matter relation, the effective and efficient operations to design, re-design, and development of sustainable processes and materials for particular energy conversions and storages.

Course Objectives:

The objectives of this course are:

- To facilitate necessary knowledge about heterogeneous process
- To acquire insights of Mass transfer and conductivity
- To make them able to understand and correlation between chemical energy and electronic energy
- To provide the knowledge of storing energy with modern cells, Lithium battery, Fuel Cell, Solar cell, etc.
- To facilitate necessary knowledge about understand the process of how metal corrosion and its prevention

Course Content:

Preview of electrochemistry: General definitions: Electrochemistry, Current, Potential, Electrode, Redox reaction, Electrolytes, Electrolysis and Faraday's laws, Steps of electrochemical processes**,** Dependency of conductivity on solubility of electrolytes.

Mass transference: Relation between ionic mobility and drift velocity**,** relationship between ionic mobility and molar conductivity, Debye-Huckel-Onsagar equation, Transport number: Definition, measurements, Influence of temperature, Walden product. Interionic attraction theory: Asymmetric and Electrophoretic effects & its limitation. Modes of mass transfer, Relationship between diffusion and mass transference, Einstein- Nernst equation, Fick's diffusion law.

Ideal and nonideal solutions: Hydration sphere and Hydrodynamic radius of ions, Salting in effect, Concept of activity and activity coefficient, Ionic strength of poly electrolytes and mixtures, Dependency of activity coefficient on ionic charge/radius and concentration, Debye-Huckel limiting law and Extended Debye-Huckel limiting law for strong electrolytes, mean activity coefficient, molarity, molality.

Electrochemical Cells: Electrode, types of electrodes (Reversible), cells, types of cells: chemical cells, reversible and irreversible cells, origin of emf, standard electrode potential, Principle of measuring E.M.F. of reversible cells, standard potential and formal potential, standard cells, ΔG, ΔH in a reversible cells; Concentration cells, their types & application, liquid junction potential, Nernst equation, H_2-scale of potential, application of potentiometry, Reference electrodes(Hydrogen, Calomel, Ag/AgCl), glass electrode & its application. Polarization and overpotential**,** Liquid junction potential and its elimination

Energy and Corrosion: Dry cell, Lead storage battery, Lithium battery, Fuel Cell, Solar cell, electrochemical principle of corrosion and its protection

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe the ways of mass transfer and the properties of electrolytes in solution

CO2. Explain the views of electrode processes and apply the concept of energy generation and protection of metallic substances from corrosion

CO3. Illustrate the concept of effect of strong and weak electrolytes on solubility

CO4. Explain the electrochemical energy generation

CO5. Interpret the feasibility of reaction from emf measurement

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2								3		
CO3	3									
CO4	3									
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Group discussion, Question-Answer session	Class test (Short Q and MCQ)
CO2	Lecture, Group Discussion, Question-Answer session	Quiz, Assignment
CO3	Lecture, Group Discussion, Question-Answer session	Essay type test
CO4	Lecture, Group Discussion, Question-Answer session	Class test (Short Q and MCQ)
CO5	Lecture, Group Discussion, Question-Answer session	Essay type test

Books Recommended:

1. An Introduction to Electrochemistry, S. Glasstone, Litton Educational Publishing Inc., New York
2. Text Book of Physical Chemistry (2nd Edition), S. Glasstone, Macmillan Press Ltd., 1974
3. Physical Chemistry (7th Edition), P.W. Atkins, Oxford University Press Inc., New York, 2002
4. Electrochemical Methods: Fundamentals and Applications 2nd edition, Allen J. Bard & Larry R. Faulkner

Course No: **CHE 0531 2236**	Credit: 2.0	Year: Second	Semester: Second
Course Title: **Molecular Structure and Chemical Bonding**		Course Type: Theory (Core)	

Course Rationale:

Acquiring knowledge regarding the location and properties of electrons in atoms and examining the development of models of molecular structure and chemical bonding in terms of the various theories and structure-related properties of chemical compounds.

Course Objectives:

The objectives of this course are:

- To provide the necessary concept on atomic and molecular structures
- To facilitate necessary knowledge about MOT and VBT using H_2^+ ions and H_2 molecules, and apply them to illustrate and explain the bonding in homo- and heteronuclear molecules
- Acquaint students with the basic tools of bond order, bond length, bond energy, and magnetism of molecules qualitatively using the bonding principles

Course Content:

Valence shell electron pair repulsion theory (VSEPR): Overview of VSEPR, Isoelectronic molecules, basic and modification shapes and geometries of molecules and ions based on VSEPR theory, various factor effect on molecular geometries, Limitations of VSEPR theory, prediction shape of various molecules and ions.

Hybridization: Concept of hybridization, various types of hybridization, formation of various types of hybrid orbitals through linear combinations of atomic orbitals.

Valence bond theory (VBT): Concept of VBT, formation of σ, π and δ bonds, application of VB approaches to homonuclear diatomic molecules, hetero-nuclear diatomic molecules and Polyatomic molecules.

Molecular orbital theory (MOT): Approximation of MOT, MO through the linear combination of atomic orbitals (LCAO). Bonding, anti-bonding and non-bonding orbitals, building-up principle for molecules, Orbital mixing and σ-Π cross over, molecular orbital diagrams of homonuclear diatomic molecules, hetero-nuclear diatomic molecules, polyatomic molecules.

Bonding properties: bond order, bond correlations, bond strength, bond length, magnetic and electronic properties of molecules. Application of bonding principles (VBT and MOT) to various molecules and ions to describe molecular bonding such as $BeCl_2$, BeF_4^{2-}, Be_2Cl_4, BCl_3, B_2H_6, Al_2Cl_6, CH_4, C_6H_6, CO_2, CO_3^{2-}, NH_3, NF_3, NO_3^- and N_2O.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Use the VSEPR theory to predict the shapes of molecules and polyatomic ions are determined

CO2. Determination of the hybridization for atoms in the molecules.

CO3. Explain VBT and determine the structure of molecules/ions based on VBT

CO4. Discuss the electronic structures of molecules/ions by using MO theory, to predict bond properties and magnetic behavior of molecules

CO5. Explain the bonding of species mentioned above using VBT and MOT

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	**Program Learning Outcomes**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3		1							
CO2	3									
CO3	1		3							
CO4	1		3							
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration	Quiz test
CO2	Lecture, PPT Demonstration	Essay-type test, problem-solving
CO3	Lecture PPT Demonstration, Group discussion for solving problems, Question-Answer session	Short questions, based on problem-solving
CO4	Lecture PPT Demonstration, Question-Answer session, Group discussion	Class tests based on problem-solving

Books Recommended:

1. Shriver and Atkins, *Inorganic Chemistry (4th edition)*
2. Cotton, Wilkinson and Gaus, *Basic Inorganic Chemistry (3rd edition)*
3. Raymond Chang, *Chemistry (5th edition)*

4. N.C. Norman, *Periodicity and the s- and p-Block Elements (OCP) (1st Indian edition 2005)*
5. Cartmell and Fowles, *Valency and Molecular Structure (4th edition)*
6. J. D. Lee, Concise Inorganic Chemistry (5th Edition), Blackwell Science Ltd., 2014
7. Huheey, Keitler and Keitler, *Inorganic Chemistry (4th edition)*
8. Gary L. Miessler and Donald A. Tarr, *Inorganic Chemistry (3rd edition)*
9. Catherine E. Housecroft, A. G. Sharpe, *Inorganic Chemistry (2nd edition)*
10. Douglas. McDaniels and Alexander, *Concepts and Models of Inorganic Chemistry (3rd edition)*

Course No: **CHE 0531 2242**	Credit: 1.5	Year: Second	Semester: Second
Course Title: **Preparation of Organic Compounds**		Course Type: Practical	

Course Rationale:
This course is designed to give learners laboratory practical experience with a strong focus on preparation of simple organic molecules in the laboratory.

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

Course Content:
Preparation of organic compounds: Preparation of aspirin (*O*-acetylation (esterification) of salicylic acid), *p*-nitroacetanilide (nitration through electrophilic aromatic substitution of acetanilide), cyclohexanone (oxidation of cyclohexanol), Preparation of benzoic acid and benzyl alcohol from benzaldehyde, dibenzalacetone (condensation between benzaldehyde and acetone), and 3-aminoacetophenone (reduction of 3-nitroacetophenone)**.**
Hydrolysis of organic compounds: Alkaline hydrolysis of aspirin, Acidic hydrolysis of *p*-nitroacetanilide.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Design the experimental set up for the common single and two steps preparation
CO2. Carry out reaction and work-up procedure, separation and purification of organic compounds and to check the purity of the products prepared in the Lab
CO3. Prepare aspirin, *p*-nitoacetanilide, cyclohexanone, dibenzalacetone, 3-aminoacetophenone successfully in the laboratory as the sample compounds
CO4. Carryout the hydrolysis and characterize the products prepared

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1			3							
CO2		3								
CO3		3								
CO4		3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration, Animated VDO clips, Group Discussion	Class test (Short Q and MCQ), Quiz
CO2	Lecture, PPT Demonstration, Animated VDO clips, Group Discussion	Class test (Short Q and MCQ), Quiz
CO3	Lecture, PPT Demonstration, Animated VDO clips, Group Discussion	Class test (Short Q and MCQ),
CO4	Lecture, PPT Demonstration, Open Discussion	Assignment, Test

Books Recommended:

1. Vogel, *A Text book of Practical Organic Chemistry*
2. Clark F. Most, *Experimental Organic Chemistry*
3. Louis F. Fieser, Kenneth L. Williamson, *Organic Experiments*, D. C. Health & Company Lexington, Massachusetts, Toronto (4th edition)
4. Vogel, *Elementary Practical Organic Chemistry* (Part 2)
5. Vogels's *Text book of practical organic chemistry*, (ELBS with Longman, 5th edition)

Course No: **CHE 0531 2243**	Credit: 3.0	Year: Second	Semester: Second
Course Title: **Organic Reaction Mechanism**		Course Type: Theory	

Course Rationale:
For chemistry students, it is very important to have clear concepts of common types of organic reactions and knowledge of how they happen. This course is aimed to give detailed knowledge of the common classes of organic reaction mechanisms and their application in designing and manipulating organic synthesis.

Course Objectives:
The objectives of this course are:
- To acquaint students with the electrophiles, nucleophiles, reaction energetics, and various methods of determining reaction mechanism
- To acquire the concept of uni- and bi-molecular nucleophilic substitution, aromatic electrophilic and nucleophilic substitution reactions with detailed mechanism and stereochemical implications
- To understand the mechanistic concepts of addition reactions of carbon-carbon and carbon-oxygen double bonds, conjugated systems, and the relation between structure and reactivity
- To make the students familiar with the elimination reactions, their stereoselectivity, and competition with substitution reactions
- To provide knowledge of carbanion chemistry, specifically its application in organic synthesis

Course Content:
Introduction to Reaction mechanism: Definition of reaction mechanism, electrophiles, and nucleophiles, classes of reaction mechanism, substrates and reagents, electron movement. Reaction energetics: concerted reactions, the transition state, the energy profile-activation energy. Reaction kinetics: reaction rate, the rate-limiting step, kinetic versus thermodynamic control. Methods of determining reaction mechanism: identification of products, kinetic data, isotopic labeling, the study of intermediates, and stereochemical studies.
Broad concepts of the mechanism of substitution reactions: Nucleophilic substitution at saturated carbon: S_N1 and S_N2 reactions with energy profile diagram. Factors affecting the mechanism of substitution reactions: effect of solvent, the effect of structure, the effect of entering and leaving groups. The stereochemical implication of mechanism: S_N2 mechanism- inversion of configuration, S_N1 mechanism- racemization. Dual nature of S_N1 and S_N2 reactions. S_Ni mechanism- retention of configuration, neighboring group participation. Aromatic electrophilic substitution reactions: mechanism of nitration and primary kinetic isotope effect, Aromatic nucleophilic substitution reactions of atoms other than hydrogen, substitution *via* aryne intermediates, etc.
Broad concepts of the mechanism of Addition reactions: Electrophilic addition to C=C: addition of halogen, the effect of substitution on the rate of addition, the orientation of addition, hydroxylation, 1,3-dipolar addition. Electrophilic addition to conjugated diene, Diels Alder reaction. Nucleophilic addition to C=C, cyanoethylation, addition to C=C−C=O. Nucleophilic addition to C=O: structure and reactivity, hydration, the addition of alcohol and thiol. Hydride transfer to C=O: complex metal hydride ions, Cannizzaro reaction, and effect of D_2O. Addition of carbon nucleophile to C=O: Grignard reagents, Aldol reactions, and D_2O effect.
Broad concepts of the mechanism of Elimination reactions: *E*1, *E*2, and *E*1cB mechanisms, stereoselectivity in *E*2 reactions, orientation in *E*2- Saytzev vs Hofmann, competition between elimination and substitution, the effect of activating groups, pyrolytic *SYN* elimination. Effect of conformation on reactivity in cyclic system: reactivity of disubstituted cyclohexanes, e.g., 2-aminocyclohexanol, menthyl and neo menthyl chlorides.

Carbanions and enolizations: Formation, stabilization, and configuration of carbanions. Carbanions and tautomerism, the position of equilibrium and structure of tautomers. Carbanion reactions: α-halogenation of ketones and kinetic isotope effect, carbanion from active hydrogen compounds (Knoevenagel reaction), carbanion from an anhydride (Perkin reaction), enol to an iminium ion (Mannich reaction), carbanion from aromatic aldehyde (Benzoin condensation).

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain reaction energetics, reaction kinetics, reactions, and their mechanistic differences, and the mechanism and stereochemical implication of the mechanisms of S_N1, S_N2, S_Ni, aromatic electrophilic, and nucleophilic substitution reaction

CO2. Describe the mechanisms of electrophilic and nucleophilic additions to C=C and conjugated systems, nucleophilic addition to C=O, and express the mechanism and stereoselectivity in elimination reactions in a systematic way

CO3. Discuss the concepts of the formation of carbanions, their generation, stabilization, configurations, and their mechanisms in different types of reactions

CO4. Interpret the factors like solvent polarity, steric effect, isotope effect, etc. that affect S_N1, S_N2, S_Ni, aromatic electrophilic, and nucleophilic substitution reaction; illustrate the detailed mechanistic implication of electrophilic and nucleophilic additions to C=C and conjugated systems, nucleophilic addition to C=O, and elimination reaction; predict the competition between elimination and substitution reactions

CO5. Apply the concepts of carbanions and enolisations in designing and manipulating the synthesis of different types of organic compounds

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3									
CO4			3							
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration, Animated VDO clips, Group Discussion	Class test (Short Q and MCQ), Quiz
CO2	Lecture, PPT Demonstration, Animated VDO clips, Group Discussion	Class test (Short Q and MCQ), Quiz
CO3	Lecture, PPT Demonstration, Animated VDO clips, Group Discussion	semester end exam
CO4	Lecture, PPT Demonstration, Open Discussion	Assignment, Test
CO5	Lecture, PPT Demonstration, Open Discussion	Semester end exam

Books Recommended:

1. Peter Sykes, *A Guidebook to Mechanism in Organic Chemistry*, 6th Ed., 1985, John Wiley & Sons, Inc, New York, USA
2. R. T. Morrison, R. N. Boyd, and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011, Dorling Kindersley (India) Pvt. Ltd.
3. T. W. G. Solomons, C. B. Fryhle, and S. C. Snyder, *Organic Chemistry*, 12th Ed., 2016, John Wiley & Sons, Inc, New Jersy, USA
4. P. Vogel and K. N. Houk, *Organic Chemistry-Theory, Reactivity and Mechanisms in Modern Synthesis*, 2019, Wiley-VCH, Weinheim, Germany
5. R. J. Ouellette and J. D. Rawn, Organic Chemistry-Structure, Mechanism, and Synthesis, 2nd Ed., 2018, Academic Press (El Sevier), Oxford, UK

Course No: **MAT 0541 2202K**	Credit: 2.0	Year: Second	Semester: Second
Course Title: **Mathematical Methods**		Course Status: Theory (Ged)	

Rationales: Vector algebra have become a basic part of fundamental mathematical background in engineering and allied discipline. This course also provide the students a sound knowledge of Fourier transforms along with Fourier integrals, Laplace Transformation and complex variables.

Course Objectives:

The objectives of this course are

- To introduce students to different types of matrices, perform algebraic operations, and calculate determinants, focusing on applications in solving chemical problems.
- To develop an understanding of complex variables and analytic functions, and apply the Cauchy-Riemann equations in relevant chemical contexts.
- To enable students to represent periodic functions using Fourier series, with a focus on the Fourier expansion of odd and even functions in chemical analysis.
- To familiarize students with special functions, including Hermite, Bessel, Legendre, and associated Legendre functions, and their applications in physical chemistry and spectroscopy.
- To introduce the concept of Laplace transforms, including their computation for elementary functions, derivatives, and integrals, and to apply these techniques to solve chemical kinetics and system modeling problems.

Course Content

Matrices: Type of matrices; algebraic operations on matrices; determinant of square matrices; matrix equivalence; inverse of matrices; system of linear equations. **Complex Variables**: Analytic functions; Cauchy-Riemann equations. **Fourier Series**: Periodic functions; Fourier series of odd and even functions. **Special Functions**: Hermite and Bessel equations; Legendre and associated Legendre equations. **Laplace Transforms**: Definition; Laplace transforms of some elementary functions; Laplace transforms of derivatives and integrals; inverse Laplace transforms.

Course Learning Outcomes:

After the successful completion of the course, the student will be able to-

CO1: Recognize the algebra of matrices and solve a system of linear equation with the help of matrix.

CO2: Discuss about analytic function and how to check analyticity based on Cauchy – Riemann equation

CO3: Obtain the Fourier series of periodical and non-periodical functions.

CO4: Familiar with some special functions such as Hermite, Bessel and Legendre equations.

CO5: Compute Laplace transforms and solve differential equations using Laplace transforms methods

Mapping of COs with the POs:

	Fundamental Skill			**Social Skill**		**Thinking Skill**		**Personal Skill**	
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3								
CO2	3								
CO3	3								
CO4	3								
CO5	3								

3: Strong, 2: Moderate, 1: Weak

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy

Note: If required add/delete rows

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO1	Lectures using board	Continuous assessment and mid-term exam
CO2	Lectures using board	Continuous assessment and quiz test
CO3	Lectures using board	Continuous assessment and mid-term exam 1
CO4	Lectures using board	Continuous assessment and Assignment
CO5	Lectures using board	Mid-term exam 2 and semester end exam

Books Recommended:

1. Stephenson: *Mathematical Methods*
2. Spiegel, M.R.: *Laplace Transform*
3. Khanna, M.L.: *Laplace Transforms*
4. Churchill: *Introduction to Complex Variable and Applications*
5. Kodaira, K. K.: *Introduction to Complex analysis*
6. Ayres, F.: *Matrices*
7. Kolman, B.: *Elementary Linear Algebra*
8. Lipschutz, S.: *Linear Algebra*
9. Rahman , M.A.: *College Linear Algebra*

Course No: CSE 0613 2216K	Credit: 3.0	Year: Second	Semester: Second
Course Title: **Python Programming Lab**		Course Type: Practical (GEd)	

Course Rationale:

In this current world, most of the research works require computational data analysis of corresponding fields. This requirement has emphasized the necessity of a knowledge of computer programming for all the researchers. For research-related purposes, computer programming using Python is one of the best choices. This course is designed with the purpose to make students acquainted with programming using python and make them comfortable to deal with computational data analysis.

Course Objectives:

The objectives of this course are to:

- help students conceptualize basic theories of computer programming
- make the students understand fundamental components of python programming
- develop skills for writing computer programs using all necessary branches of Python
- accumulate basic ideas about data structures and data manipulations

Course Content:

Computer Basics: Concept on Computer Hardware, Software and its classification, Compiler vs Interpreter. **Using the Python Interpreter:** Invoking the Interpreter, Argument Passing, Interactive Mode, The Interpreter, and Its Environment, Source Code Encoding; **An Informal Introduction to Python:** Using Python as a Calculator- Numbers, Strings, Lists. First Steps Towards Programming; **More Control Flow Tools:** if Statements, for Statements, The range() Function, break and continue Statements, and else Clauses on Loops, pass Statements, Defining Functions; **More on Defining Functions:** Default Argument Values, Keyword Arguments, Arbitrary Argument Lists, Unpacking Argument Lists, Lambda Expressions, Documentation Strings, Function Annotations, **Intermezzo:** Coding Style; **Data Structures:** More on Lists- Using Lists as Stacks, Using Lists as Queues, List Comprehensions, Nested List Comprehensions, The del statement, Tuples and Sequences, Sets, Dictionaries, Looping Techniques, More on Conditions, Comparing Sequences and Other Types; **Modules:** More on Modules- Executing modules as scripts, The Module Search Path, Compiled" Python files, Standard Modules, The dir() Function, Packages- Importing * From a Package, Intra-package References, Packages in Multiple Directories, matplotlib, numpy, other common necessary packages; **Input and Output:** Fancier Output Formatting, Old string formatting, **Reading and Writing Files**: Methods of File Objects, Saving structured data with JSON; **Errors and Exceptions:** Syntax Errors, Exceptions, Handling Exceptions, Raising Exceptions, User-defined Exceptions, Defining Clean-up Actions, Predefined Clean-up Actions. **Classes:** A Word About Names and Objects, Python Scopes and Namespaces, Scopes and Namespaces Example, A First Look at Classes, Class Definition Syntax, Class Objects, Instance Objects, Method Objects, Class and Instance Variables, Random Remarks, Inheritance, Multiple Inheritance, Private Variables, Odds and Ends, Iterators, Generators, Generator Expressions.

Course Learning Outcomes (COs)

After the successful completion of the course, students will be able to:

CO1. apply knowledge of Python for writing computer programs
CO2. design solutions to real-life problems using necessary components of Python
CO3. identify errors from a program and use exception handlers to handle errors and exception
CO4. design basic data structures to solve efficient data storage issues;
CO5. utilize object oriented programming and modular concepts, etc., in data analysis and manipulation

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2			3							
CO3			3							
CO4			3							
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO1	Lecture using board/projectors/Lab work using Python	Viva, Programming language tests and Semester-end Exam
CO2	Lecture using board/projectors/Lab work using Python	Viva, Programming language tests and Semester-end Exam
CO3	Lecture using board/projectors/Lab work using Python	Viva, Programming language tests and Semester-end Exam
CO4	Lecture using board/projectors/Lab work using Python	Viva, Programming language tests and Semester-end Exam
CO5	Lecture using board/projectors/Lab work using Python	Viva, Programming language tests and Semester-end Exam

Books Recommended:

1. Learning Python, By Mark Lutz
2. Think Python, By Allen B. Downey
3. The Python Tutorial, Official documentation of Python

Course No: **CHE 0531 2251**	Credit: 2.0	Year: Second	Semester: Second
Course Title: **Industrial Chemistry I**		Course Type: Theory	

Course Rationale: This course is aim to provide an outline along with providing basic principles, processes of Industrial Chemistry that will be needed for professional life after graduation.

Learning Objectives:

The objectives of this course are:

- To impart knowledge in understanding different basic concept of industrial technology and chemical processes
- To provide the knowledge on sources, classification, composition, industrial manufacture and applications of cements, ceramics, glass, fertilizers and iron and steel
- To impart the skills to identify and describe basic concept for the establishment of chemical industries and prospect of various types of industries in Bangladesh in terms of Chemistry

Course Content

Introduction: Fundamental considerations in the development of a chemical industry, unit operations and unit processes.

Cement Industry: Definition, types, and raw materials of Portland cement, Portland cement manufacture, (clinker compounds and reaction during clinker formation), theory of setting and hardening of cement, plaster of Paris, importance of fly ash, slag and other ingredients for cement manufacturing, cement factories in Bangladesh and related pollution phenomena, preventive measures for that.

Ceramic Industry: Definition, differences with metals, general properties of ceramic, basic raw materials, white wares, chemical conversion including basic ceramic industry, definition and properties of refractories, manufacture of refractory, enamels, advanced ceramic materials manufacturing and application.

Glass industry: Glass transition and its impacts in glass manufacturing, properties and classification of different types of glasses, raw materials,and chemical reactions involve in the formation of glass, methods of manufacture, special glasses.
Fertilizer industries: Definition, plant nutrients and their functions, essential requirements of fertilizer, fertility and pH value of the soil, manufacture of ammonium nitrate, ammonium sulfate, ammonium phosphate, normal super phosphate (NSP), triple super phosphate (TSP), manufacture of urea from natural gas, fertilizer industries in Bangladesh.
Iron and Steel: Iron ores, cast iron, rought iron and steel. Construction and operation of blast furnace, fuel economy and uses of by-products. Different processes of steel production. Impact of impurities (S, P, Mn *etc.)* on steel.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Express the idea about the raw materials, composition, properties and uses of different types of cement; demonstrate different chemical reactions during manufacturing of cement
CO2. Explain the concept of ceramics; describe the uses of ceramic wares; illustrate the production of ceramics with basic raw materials
CO3. Illustrate the physical & chemical properties of glass; demonstrate industrial manufacturing process of glass; describe the composition and use of special glasses
CO4. Explain the concept, classification and importance of fertilizer; describe how fertilizers are manufactured; illustrate the function of ammonia, urea, single super phosphate (SSP) and Triple super phosphate (TSP)
CO5. Analyze the construction and operation of blast furnace with chemical reaction in the furnace; comparison study of different processes (Bessemer, open-hearth, & electrical) of steel production; illustrate effect of impurities (S, P, Mn *etc*.) on steel

Mapping of COs with POs

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

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. Shreve, *Chemical Process Industries*
2. B. K Sharma, *Industrial Chemistry*
3. Roger's, *Manual for Industrial Chemistry*
4. J. A. Kent, *Regels' Hand Book of Industrial Chemistry*
5. Liegue, *Engineering materials*
6. Martins, *Industrial Chemistry* (Vol. I, II & III)
7. R. K. Das, *Industrial Chemistry* (Part I & II)
8. Othmer and Klerk, *Encyclopedia of Chemical Technology*
9. B. K Sharma, *Industrial Chemistry*

Course No: **CHE 0531 2291**	Credit: 1.0	Year: Second	Semester: Second
Course Title: **Seminar and Oral Presentation**		Course Type: Oral	

Course Rationale
Communication skill is now a day is very vital for professionalism. For academic, industrial and research purposes communication of scientific results and view as well as social communication is very important. This course aims to make the students capable of making proper communication, particularly in their subject matters.

Course Objectives:
The objectives of this course are:
- To train the students to better prepare assignment
- To familiarize the students for oral presentation
- Acquaint students with the academic viva-voce

Course Content:
Students will be assigned specific topics based on the curriculum of two semesters 2nd year. Students will prepare a detailed assignment based on their assigned topics and give an oral presentation before the exam committee.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Prepare an assignment on a specific topic
CO2. Prepare for oral presentations
CO3. Practices the norms of academic presentation and viva-voce
CO4. Make the logical argument on the topic defended

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2				2					
CO2	1				3					
CO3					1				3	
CO4			2		2					

Teaching- Learning and Assessment Strategies:
There will be no formal face-to-face instruction for the course. Students will learn throughout the semester from the respective related class lecture and discussions with teachers and among themselves. There will also be tutorial session where students will get the opportunity to discuss any related topics. The duration of the tutorial/ discussion class will be a total of 15 hours in a semester. Respective course teachers will provide the topics to each individual student for their presentation before the final presentation. Students will be evaluated and grades will be given on the basis of the marks given by the members of the examination committee individually or combinedly.

Assessment Rubric:

	Excellent (33p)	Proficient (25p)	Satisfactory (20p)	Poor (15p)
Content	-Students discuss the subject in great details -Student describes in detail about their topic	-Students discuss the subject with some details -Student outlines their topic	-Student discuss the subject with a few details -Student do not outline their topic	-Students discuss the subject with very minimal details -Students do not outline what they have learnt

Delivery	-Good posture -Eye contact with the audience most of the time -Appropriate gesture and expression	-Good posture -Frequent eye contact with the audience	-Intermittent good posture –Occasional eye contact with the audience	-Poor posture -Seldom eye contact with the audience
Answering to the Question	-Answers All the questions asked properly	-Answers All the questions asked properly	-Answers All the questions asked properly	-Answers All the questions asked properly

Course No: **CHE 0531 3121**	Credit: 2.0	Year: Third	Semester: First
Course Title: **Chemical Kinetics and Photochemistry**		Course Type: Theory	

Course Rationale:
The aim of this course is to acquire and consolidate the fundamental concepts of photochemistry as well as the homogeneous and heterogeneous reaction kinetics and their reaction mechanisms. These concepts will be needed for the advanced theoretical and practical courses.

Course Objectives
The objectives of this course are:
- To acquaint students with the fundamentals of chemical kinetics, rate laws, and photochemistry
- To understand the kinetics of complex reactions
- To conceptualize the basics of reaction rates theories to explain the occurrence of reactions at the molecular level
- To provide the knowledge of determining reaction mechanisms from kinetic studies
- To facilitate necessary knowledge of experimental techniques for kinetic measurements
- To understand the interaction between light and molecules, the basics of radiative emission processes, and the methods of determining quantum efficiency

Course Content:
Elementary reaction and Kinetics: Rate, rate constant, zero order, 1st order, 2nd order, nth order reaction, determination of the order of reaction, activation energy.
Complex reactions: Elementary reaction and molecularity, complex reaction: consecutive reaction, parallel reaction, opposing reaction, steady state and rate-determining step, chain reaction.
Theories of reaction rate: Collision theory. Statistical approach to reaction dynamics. Transition state theory for bimolecular reactions and its application. Activated complex theory and 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.
Mechanism on the basis of kinetic studies: Thermal decomposition of C_2H_6, CH_3CHO, CH_3COCH_3, O_3, $COCl_2$, hydrogen-bromine reaction and calculation of activation energy.
Catalysis: Competitive adsorption and kinetics of surface reactions**,** Arrhenius and van't Hoff's intermediate, Enzyme catalysis: Michaelis-Menten mechanism, Specific & general acid base catalysis, Heterogeneous catalysis: Outline, application.
Elements of Photochemistry: Laws of photochemistry, quantum yield and its significance, Photolysis, Photosensitization, Photo-oxidation, Photoreduction, Photochemistry of molecular O_2, anthracene and carbonyl compounds. Chemiluminescence, Fluorescence, and Phosphorescence, Chemical actinometer; construction and application, Solar energy and its application, some storage system fuel: hydrogen, application. Photovoltaic cell and photocurrent.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Explain the concept of the rate of reaction associated with the chemical changes in simple and complex reactions and by what method it can be measured

CO2. Interpret a reaction coordinate diagram and determine if such a diagram supports a given single or multistep mechanism, including the concept and depiction of any transition states and reaction intermediates
CO3. Apply the concepts of basic theories related to the reaction rate and catalysis in solution and gaseous (surface reaction) medium
CO4. Describe the interaction between light and molecules, the basics of radiative emission processes, and methods of determining quantum efficiency
CO5: Explain fluorescence, and phosphorescence, Chemical actinometer; Solar energy, storage system of fuel.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3			3							
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Group discussion, Question-Answer session	Class test (Short Q and MCQ)
CO2	Lecture, Group Discussion, Question-Answer session	Quiz, Assignment
CO3	Lecture, Group Discussion, Question-Answer session	Essay type test
CO4	Lecture, Group Discussion, Question-Answer session	Class test (Short Q and MCQ)
CO5	Lecture, Group Discussion, Question-Answer session	Semester end test, Problem solving

Books Recommended:

1. S. Glasstone, Text book of Physical Chemistry
2. P. W. Atkins, Physical Chemistry
3. K.J. Laidler, Reaction Kinetics
4. Steinfeld, Francisco &Huse, Chemical Kinetics and Dynamics
5. Rajaram & Kuriacore, Kinetics and Mechanism of Chemical Transformation.
6. Wayne, Photochemistry: Techniques and application.
7. J. W. Moore & Ralph. G. Pearson, Kinetics & Mechanism: A study of homogeneous chemical reactions.
8. Henry Eyring, Modern Chemical Kinetics

Course No: **CHE 0531 3131**	Credit: 3.0	Year: Third	Semester: First
Course Title: **Coordination Chemistry**		Course Type: Theory (Core)	

Course Rationale:
To promote knowledge of the nature of ligand-metal bonding of coordination compounds in terms of VBT, CFT, and MOT for their structure determination.
Course Objectives:
The objectives of this course are:
- Promote knowledge about valence bonds, crystal field, and molecular orbital theories of coordination compounds
- Impart knowledge of structural and magnetic properties of coordination compounds

Course Content:
Introduction of coordination chemistry: Definition: Coordination compound, double salt, different types ligands, template effect, and nomenclature of coordination compounds.
Stereochemistry of the coordination compounds: Structure and examples of different coordination numbers, stereochemistry, nonrigid and fluxional molecules. Isomerism in coordination compounds, Constitutional isomerism: linkage isomerism, coordination isomerism, ionization isomerism, hydrate isomerism, Stereoisomerism: Geometrical isomerism, optical isomerism; identification of *cis-trans* isomers.

Bonding of coordination compounds: Werner's theory, Sidgwick's theory, valence bond theory, limitations of these theories.

Crystal field theory: Basic principle, splitting of *d*-orbital in octahedral, tetrahedral, tetragonal, and square planar symmetries, crystal field stabilization energy, high spin, and low spin complexes, pairing energies, factors affecting ligand field splitting, spectrochemical series, measurement of 1ODq, Jahn-Teller effects, limitations of Jahn-Teller theory, magnetic properties, thermodynamic effects, absorption spectra, limitations of CFT.

Molecular orbital theory for coordination compounds: Basic principle, 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.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Identify the types of ligands and nomenclature of complexes

CO2. Explain the Lewis model of bonding, structural features, and the isomerism of coordination compounds

CO3. Explain the nature of ligand-metal bonding in terms of CFT and MOT, the origins of Δ_o.

CO4. Apply CFT to octahedral, tetrahedral, and square planar complexes to recognize the high-spin and low-spin electron configuration, and electronic, thermodynamic, and magnetic properties of complex compounds

Mapping of Course Learning Outcomes (COs) with Pos 3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	1		3							
CO3			3							
CO4	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration	Quiz test
CO2	Lecture, PPT Demonstration	Quiz test, orally based on problem-solving
CO3	Lecture, PPT Demonstration, Group discussion for solving problems, Question-Answer session	Short question, problem-solving
CO4	Lecture, PPT Demonstration, Question-Answer session, Group discussion	Short questions, orally based on problem-solving

Books Recommended:

1. Shriver, Atkins and Langford, *Inorganic Chemistry (4th edition)*
2. Cotton, Wilkinson and Gaus, *Basic Inorganic Chemistry (3rd edition)*
3. Mark. J. Winter, *d-Block Chemistry (OCP) (1st edition 1994)*
4. Huheey, Keitler and Keitler, *Inorganic Chemistry (4th edition)*
5. Douglas. McDaniels and Alexander, *Concepts and Models of Inorganic Chemistry (3rd edition)*
6. Miessler and Tarr, *Inorganic Chemistry (3rd edition)*

Course No: **CHE 0531 3132**	Credit: 2.0	Year: Third	Semester: First
Course Title: **Nuclear Chemistry**		Course Type: Theory	

Course Rationale:

Developing nuclear power plants safe and efficient sources of nuclear power is important to overcome the energy crises. So, nuclear Chemistry enables students to create safe and efficient nuclear power sources.

Course Objectives:

The objectives of this course are:

- To explore the fundamental aspects of nuclear and radiochemistry.
- To discuss the determination of radioactive species and the application of nuclear processes, radioactive materials, and radiochemical techniques in chemical analysis.
- To gain knowledge about nuclear fuels and reprocessing of the fuels, and proper disposal of nuclear waste.

Course Content:

Introduction: Discovery of radioactivity, the statistical approach of radioactivity, radioactive decay and growth, naturally occurring radioactive substance, type of radioactive decay, average and half-life of radioactive elements, nuclear structure, mass and energy, nuclear binding energy.

Nuclear Shell Model, Nuclear reaction: Nature of nuclear reaction, the energy of nuclear reaction, cross-section, theory of nuclear reaction, types of reactions, fission & fusion reaction.

Radio isotopes and their uses: Production and separation of radioisotopes, the Szilard - Chalmers reaction, isotope dilution analysis, activation analysis, and tracer technique for reaction kinetics and industrial, agricultural, and medical uses.

Nuclear energy: Nuclear fuels outline different types of nuclear reactors, and fuel reprocessing.

Radiation hazard and safety measures: Introduction to radiation hazards and safety measures.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Define the origins of nuclear instability, fundamental aspects of radioactive decay, and modes of interaction of radiation with matter

CO2. Describe various types of nuclear reactions and methods for radiation detection and measurement.

CO3. Identify nuclear wastes and determine their proper management

CO4. Recognize the society awareness and protect the environment from the impact of nuclear hazards.

CO5. Apply the acquired knowledge in the analytical applications of nuclear reactions and nuclear materials, and designing of nuclear reactors to generate nuclear fuels.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	2	2								
CO4								2	2	
CO5		3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT and discussion	Assignment
CO2	Lecture using PPT and demonstration reported data	Class test (Short Q and MCQ)
CO3	Lecture using PPT and demonstration of various VIDEO clips	Short Q, MCQ, Quiz, Explanation
CO4	Lecture using PPT	Class test (Short Q and MCQ, presentation
CO5	Lecture using PPT and Group discussion	Short Q, MCQ, Quiz, Explanation

Books Recommended:

1. Nuclear Chemistry, Navratil, O, etal
2. Nuclear and Radiochemistry, Friedlander and Kennedy,
3. Nuclear and Radioactivity, Choppin
4. Principles of Nuclear Chemistry, Williams
5. Nuclear Chemistry Vol. I & II, L. Yaffe,
6. Introduction to Nuclear Physics and Chemistry, Harvey
7. General Chemistry; Raymond Chang
8. Inorganic Chemistry, Catherine E. Housecroft

Course No: **CHE 0531 3143**	Credit: 3.0	Year: Third	Semester: First

Course Title: **Chemistry of Natural Products**	Course Type: Theory

Course Rationale:
This course provided a sound knowledge of natural products and contribute to the advancement of the physical and biological sciences.

Course Objectives:
The objectives of this course are:

- To acquaint the students with the basics of natural products like their definitions, sources, identification and classification into primary and secondary metabolites
- To outline the methods of extraction, isolation and purification of natural products
- To Make sense of general methods of determining the structures of natural products through detecting the functional groups, double bonds and their numbers, conjugation, aromatization, presence *O*-methyl, *N*-methyl, methylenedioxyl groups, etc.
- To learn the degradation methodologies to convert a natural product into smaller fragments and then reunion of the fragments to give the structure
- To design the synthesis of natural products in the laboratory from simple organic compounds

Course Content:
Introduction to Natural Products: Primary and secondary metabolites.
Alkaloids: Definition, occurrence, classification, extraction, and purification of alkaloids, general methods of determining structure, detailed degradative and synthetic study of atropine, nicotine, and papaverine.
Terpenoids: The essential oils. Classification of terpenoids, isoprene rule, special isoprene rule, isolation, and purification, general methods of determining the structure of terpenoids. Detailed study of some terpenoids: Myrcene, ocimene, citral, farnesol.
Steroids: Introduction to steroids e.g., cholesterol (detailed structural elucidation is not included).
Carbohydrates: Definition, classification, the D-family of aldoses, ketoses. Monosaccharide: reactions of monosaccharides, e.g. glucose. Cyclic structure:
anomers, glycosides, epimers, mutarotation, determination of ring size of glucose and fructose, Haworth projections, and conformational structures configuration of D (+)-glucose. Introduction to disaccharides e.g. Maltose, lactose, and sucrose.Introductory knowledge of other sugars: deoxysugar and amino sugar, uronic acids.
Amino acids and Proteins: Classification, synthesis, physicochemical properties and analysis of amino acids. Peptide synthesis: determination of their primary structures, end group analysis. Introduction to protein and structures of proteins.
Purines and Nucleic acids: Introduction to purines: classification, pyrimidine structures, and their derivatives. Occurrence, isolation, and purification of purines. Structure elucidation of Uric acid and its synthesis.
Nucleic acids: pyrimidine & purine bases, nucleosides and nucleotides, classification and their structures.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Define and identify the natural products and to classify them as primary and secondary metabolites.
CO2. Outline the methods of extraction, isolation and purification of natural products like terpenoids, alkaloids, purine, etc.
CO3. Make sense of general methods of determining the structures of natural products, e.g., terpenoids, alkaloids, carbohydrates (especially ring structure of glucose) and purines.
CO4. Learn the degradation methodologies for elucidation of the structures of natural products like terpenoids, alkaloids, purines, carbohydrates and peptides.
CO5. Design the synthesis of natural products (alkaloids, terpenoids, purines and peptides) in the laboratory from simple organic compounds and interconversion sugars like a pentose to hexose or a hexose to pentose and one epimer to other.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3	1								
CO4	3			1						
CO5	3			1						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Classwork, PowerPoint presentation	Class test (Short Q and MCQ)
CO2	Lecture, Classwork, PowerPoint presentation	Quiz, assignment
CO3	Lecture, Question-Answer session, PowerPoint presentation	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion, PowerPoint presentation	Semester end exam, problem-solving
CO5	Lecture, Group discussion, PowerPoint presentation	Semester end exam, problem-solving

Books recommended:

1. Organic Chemistry (Vol. 2: Stereochemistry and the Chemistry of Natural Products) (5th Edition, Longman Group Ltd., 1995 (Reprint)), *I. L. Finar*
2. Natural Products Chemistry, *P.S. Kalsi*
3. Chemistry of Organic Natural Products (Vol. 1 & 2) (29 th Edition, Goel Publishing House, 2003), *O.P.Agarwal*

Course No: **CHE 0531 3151**	Credit: 3.0	Year: Third	Semester: First
Course Title: **Analytical Chemistry**		Course Type: Theory	

Course Rationale:
This course is aim to give a preliminary theoretical understanding of various analytical methods/techniques that will be needed for the practical and research work.

Learning Objectives:
The objectives of this course are:

- To help the students conceptualize the practice of analytical chemistry
- Acquaint students with the proper use of analytical instruments
- Give them an idea about the importance of measurement statistics
- Give the basic understanding of common analytical techniques
- To facilitate necessary knowledge about the safety in the laboratory, hazards associated with chemicals

Course Content:

Introduction: The scope of analytical chemistry. Analytical methods and their classification. Trends in development of analytical methods. Different ways of expression of concentration. Safety in the laboratory and hazards associated with chemicals.

Error in the chemical analysis and sampling: Determinate and indeterminate error, normal distribution of error, data treatment, potential sources of error, precision, accuracy, standard deviation, F-test, sampling, sample size, collecting the sample.

Instrumental quantitative analysis: Working curve, blank solution, standard-addition technique, curve fitting.

Titrimetric methods of analysis: Definition, classification.

(a) Complexometric titration: Chelating agents, stability of metal chelates, metal indicators, effect of pH, masking agents and their roles, EDTA, method of titration, titration curve and application. (b) Precipitation titration: Effects of acidity on the solubility of precipitates, effect of complexation on solubility, titration curve, titration

process, indicators, application. (c) Redox titration: Principle, process, titration curve indicators, application.

Gravimetry and thermogravimetry: Precipitation equilibria, unit operation in gravimetric analysis and calculation. TGA, DTA, DSC, & DTG analysis of a typical sample.

Solvent extraction: Distribution coefficient, distribution ratio, percent of extraction, solvent extraction of metal and metal chelates, successive extraction.

Analytical spectroscopy: Introduction to **a**nalytical Spectroscopic methods using IR, NMR spectroscopy; and Mass Spectrometry.

Emission and Atomic absorption spectrometry, AAS lectures: Flame emission and plasma emission spectrometry, Principle, Instrumentation, Hollow cathode lamp, Interference, Sample preparation, Electrothermal atomizer. Flameless mercury determination.

UV-Visible spectrophotometry: Principle, Beer-lambert law and its application in UV-Visible spectroscopy**,** instrumentation, qualitative and quantitative analysis by UV, simultaneous determination in a mixture by UV.

Flurometry: Principle, instrumentation and application

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the working principle of analytical methods and safety related to these techniques, and also will be able to express results in different units as per ISO requirements.

CO2. Explain the principle and application of various titrimetric, gravimetric methods for chemical analysis and also will be to apply it in professional life.

CO3. Explain the basic principles and applications of separation by solvent extraction methods.

CO4. Explain the basic principles of absorption and emission spectroscopy, various application of AAS

CO5. Explain the principles of spectroscopic methods and will also be able to compare and contrast among different spectroscopic techniques for sample analysis.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1			3							
CO2	2	1								
CO3	2	2								
CO4	2									
CO5				3						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture and PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture and Discussion	Essay type test, problem solving
CO3	Lecture, PPT presentation, Video Clip and Group discussion	Essay type test, problem solving
CO4	Lecture and problem solving and assigning topics to students.	Semester end exam, problem-solving
CO5	Lecture, Group discussion for problem analysis	Semester end exam, problem-solving

Books Recommended:

1. G. D. Christian, John Wiley & Sons, *Analytical chemistry* (4th Edn.)
2. Braun, *Introduction to chemical analysis*, McGraw Hill International
3. Ewing, *Instrumental methods of chemical analysis*, McGraw Hill International
4. Vogel, *Inorganic quantitative analysis* (4th Edn.)
5. Pecsok and Shields, *Modern methods of chemical analysis*, John Wiley & Sons, (2nd Edn.)
6. Willard, Muritt, Dean and Settle, *Instrumental methods of analysis*, (6th Edn.)
7. Skoog and West, *Fundamental of analytical chemistry*
8. Fifield and Kealey, *Principles & practice of analytical chemistry*

Course No: **STA 0542 3109K**	Credit: 1.5	Year: Third	Semester: First

Course Title: **Statistical tools for data analysis in chemistry**	Course Type: Lab (GEd)

Rationale of the Course:

In this course, students will learn the concepts of probability theory and statistical inference used to interpret experimental data. In particular, students will address the problems from a theoretical perspective and solve them using statistical software.

Course Objectives:

Objectives of the course are to:

- Acquaint students with the fundamental computing tools in quantitative analytical methods
- Provide the basic training of SPSS software to solve practical problems
- Enable the students to develop the skills of data analysis using SPSS software

Course Content

SPSS Software: Introduction to SPSS menus, creating new datasets, import data, data management in SPSS, introduction to MS Excel data analysis. **Descriptive Statistics:** Condensation and tabulation of data, frequency distribution, graphical representation of data (bar diagram, pie diagram, histogram, line chart, box-plot, stem and leaf plot, scatter plot), **Measures of Central Tendency:** Mean, median, mode and quantiles, **Measures of Dispersion:** Variance, standard deviation, and coefficient of variation. **Correlation regression Analysis**. **Basic Inferential Statistics from SPSS Output:** Statistical significance - test regarding population mean, population proportion, test of association.

Course Learning Outcomes (COs)

At the end of the course, the students will be able to: learn statistical software SPSS to

CO1. Use SPSS software and design the experiments to carry out chemistry experiments

CO2. Draw different types of graphs and diagrams using SPSS

CO3. Analyse data for the computation of descriptive statistical tools for their collected data using SPSS

CO4. Perform correlation analysis and various statistical significance tests

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3		1						
CO2		3	2							
CO3		3	2							
CO4		3		2						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board/Statistical software and hands-on training	Quiz/ assignment
CO 2	Lecture using board/Statistical software and assignment	assignment/presentation (individual/group)
CO 3	Lecture using board/Statistical software and tutorial	Quiz/ assignment
CO 4	Lecture using board/Statistical software and assignment	assignment/presentation (individual/group)

Books Recommended

1. Landau S. (2019) *A Handbook of Statistical Analyses Using SPSS*. Chapman & Hall.
2. George D, Mallery P. (2019) *IBM SPSS Statistics 26 Step by Step: A Simple Guide and Reference*, Routledge.
3. Morgan GA, Barrett KC, Leech NL, Gloeckner GW. (2019) *IBM SPSS for Introductory Statistics: Use and Interpretation*, Routledge.

Course No: **SPS 0613 3170**	Credit: 1.0	Year: Third	Semester: First
Course Title: **Computational Methods for Chemistry**		Course Type: Practical (GEd)	

Course Rationale:

Use of Computer applications become a valuable tool for scientists and researchers for the Computation of chemistry-related problems and calculations. This course aims to use computer applications for solving different chemistry-related problems.

Course Objectives:

The objectives of this course are:

- To acquaint students with the fundamentals of computational chemistry and different types of computational software to draw and optimize chemical structures.
- To make the students able to investigate physico-chemical properties of the chemical substances and molecular docking using various software related to chemistry.
- To acquire the knowledge of revealing different types of interactions between ligands and proteins in a protein-ligand complex.
- To make the students familiar with the relationships between the properties of drugs and their biological activities.
- To develop skills for data analysis and presentation.
- To provide realistic training on how to use computational tools in his/her studies or later career in academia or private industry.

Course Content:

Introduction: Basic idea on computational chemistry, Introduction to Computer-Aided Drug Design, different types of computational software and their functions.

Use of Computational Chemistry Software: Introduction to different computational software to draw 2D and 3D molecular structures; DFT calculation for molecular energy and geometry optimization, vibrational, rotational, and electronic transition studies; Molecular docking and visualization.

Data Collection and Analysis: Geometrical data analysis including the bond length, bond angle, and dihedral angle; Thermodynamic data analysis; Molecular charge distribution analysis (NBO and Mulliken); molecular orbital energy analysis (HOMO and LUMO); Spectroscopic data analysis (IR, Raman, UV-Vis, NMR and VCD); Non-bonding interaction analysis; Introducing different voluntary servers for data collection and analysis.

Use of Graphical Software: Introduction to Sigma Plot, MS Excel, Origin software for chemical spreadsheets analysis (using function wizard and formula), drawing and analysis of different types of graphs, calculation and presentation of errors within graphs.

Writing Chemistry Text and Presentation: Introduction to MS office for typing chemistry texts involving chemical formulas, equations, and symbols, constructing Tables, setting figures and diagrams within the text, Preparation of posters and slides by taking information concerning popular topics in chemistry using PowerPoint.

Course Learning Outcomes (CO):

After the successful completion of the course, students will be able to:

CO1. Choose an appropriate computational method for investigating the Physico-chemical properties, partial charge distribution and energy transitions of an optimized chemical substance.

CO2. Construct chemistry texts and equation involving chemical formula and symbol, figures setting, etc. and presentation

CO3. Express the importance of drug-like properties of a ligand and their prediction for pharmacological modeling.

CO4. Design, perform, interpret and present the results of the calculations and construct chemistry texts in a publication-ready form.

CO5. Perform the optimization of Geometry of different molecular structure and their properties from optimized structure and Designing new molecules and materials with desired properties.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		2			2					
CO2					3					
CO3					3					
CO4		2			2					
CO5			2		2					

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO2	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO3	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO4	Lecture, Demonstration, Group discussion	Lab performance (Individual), Assignment

Books Recommended:

1. Errol G. Lewars, Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics (Ver. 3), Springer.
2. Frank Jensen, Introduction to computational chemistry, Wiley (2006).
3. David Young, Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems, Wiley-Interscience (2001).
4. Ahindra Nag and Baishakhi Dey, Computer-Aided Drug Design and Delivery Systems, McGraw-Hill (2011).
5. Defang Ouyang and Sean C Smith, Computational pharmaceutics: Application of molecular modelling in drug delivery, John Wiley & Sons Ltd (2015).

Course No: **CHE 0531 3222**	Credit: 3.0	Year: Third	Semester: Second
Course Title: **Chemical Spectroscopy**		Course Type**:** Theory	

Course Rationale:

This course is offered with an aim to provide a fundamental understanding of the interaction of light with matters which is essentially necessary to determine the structure of compounds. This is also a pre-requisite course to study relevant higher courses.

Course Objectives:

The objectives of this course are:

- To introduce basic concepts / terminologies like, spectroscopy, spectrum, electromagnetic radiation etc to the students
- To understand the interaction of light with matters and change of their different kinds of energies like, rotational, vibrational, electronic and spin energy
- To acquire the knowledge on the formulation of principles of Microwave, Infra-red, Raman, Electronic and Nuclear Magnetic Resonance spectroscopy
- To interpret the number, separation and intensity pattern of different spectral lines
- To make the students familiar with instrumental components and sampling of different spectroscopic techniques
- To analysis the different spectral lines and get structural information of atoms/molecules

Course Content:

Introduction to Spectroscopy: Characterization of Electromagnetic radiation; Region of spectrum; Quantization of energy; General instrumentation in spectroscopy; Representation of spectra. Intensity and width of spectral lines; resolution; Signal to noise ratio. Beer-Lambert law.

Rotational Spectroscopy: Rotation of molecules; Moment of inertia and classification of molecules; Interaction of electromagnetic radiation with rotating molecules. Rotational energies of simple linear molecules; Rotational energy

levels and selection rules; Rotational spectra and determination of bond length of diatomic molecules; Intensity of spectral lines; Isotope effect; non-rigid rotator; Rotation of polyatomic molecules; Techniques and instrumentation.

Vibrational Spectroscopy: Introduction and principle; Vibration in molecule; Harmonic and inharmonic vibration in diatomic molecules and their spectra; Fundamental absorption, First overtones, Second overtones, hot band; Vibrational spectra of polyatomic molecules; Vibration-rotation spectra of diatomic molecules. Energy change in reaction, Instrumentation, structural analysis.

Raman Spectroscopy: Polarization of light; polarizability of molecules; Raman scattering of light; Elementary treatment of Raman spectra; Stokes's and anti-Stokes' lines; Pure rotational and Vibrational Raman Spectra; Raman shift; Rule of mutual exclusion, instrumentation and sampling in.

Electronic Absorption Spectrometry: Introduction; Spectra of hydrogen and hydrogen like element; The Zeeman effect; Electronic spectra of diatomic molecules; Franck-Condon principle and intensity of spectral lines. Electronic spectra containing electronic; vibrational and rotational information; Dissociation energy; Predissociation of molecules; Technique and instrumentation of UV-VIS spectrometry.

Magnetic Resonance Spectroscopy: Determination of spin of nuclei**;** The energies of nuclei in magnetic fields, Principle of Nuclear spin resonance (NMR), Chemical shifts and factors affecting chemical shift, Shielding and Deshielding effects, fine structure, Information obtained from NMR spectroscopy. Instrumentation and solvent use in NMR. Principle of Mossbauer spectroscopy.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. describe electromagnetic radiation and spectroscopic techniques, band width and intensity of spectral lines, Niose-to-signal ratio, Beer-Lambert law. Formulate mathematical expression for rotational energy of rigid molecules, describe rotational spectral lines, and explain relative population of rotational energy levels, intensity of rotational spectral lines, determine the moment of inertia and bond length

CO2. Formulate mathematical expressions for wave numbers of fundamental absorption, first and second overtones, hot band, explain temperature dependence of intensity of hot band, describe P and R branches of spectral lines, determine oscillation frequency, anharmonicity constant

CO3. Describe Raman Scattering, Stokes' and anti-Stokes' lines, mutual rule of exclusion, Raman shift.

CO4. Describe progressions and their intensities, dissociation and pre-dissociation of molecules, determination of bond dissociation energy

CO5. Describe magnetic properties of nuclei; resonance of nuclear spin with radiation, chemical shift, shielding and deshielding effect

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3		1							
CO4	2		2							
CO5	2		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Supply of Lecture handout,	Short question and Quiz Test
CO2	Lecture, Group discussion, Supply of Lecture handout, problem solving	Short question and Quiz Test
CO3	Lecture, Group discussion, problem solving	MCQ /Short question /Assignment
CO4	Lecture, Question-Answer session	MCQ / Short question /Assignment
CO5	Lecture, Video sharing, Supply of Lecture handout	MCQ/ Short question /Assignment

Books Recommended:

1. Fundamentals of Molecular Spectroscopy by *C. N. Banwell and E. M. Mccash*
2. Physical Chemistry by *P. K. Atkins*
3. Molecular Spectroscopy by *P. S. Sindhu*
4. Introduction to molecular spectra by *G. M. Barrow*
5. UV-VIS Spectroscopy by *C. N. Rao*
6. Modern Spectroscopy by *J. Michael Hollas*

Course No: **CHE 0531 3223**	Credit: 2.0	Year: Third	Semester: Second
Course Title**: Essential Physical Chemistry Practical**		Course Type: Practical	

Course Rationale:

This course is designed to give learners laboratory practical experience with a strong focus on developing skills on electrochemistry based experiments.

Course Objectives:

The objectives of this course are:

- To facilitate necessary practical knowledge of color and turbidity change towards kinetic study, common ion effect on solubility
- Develop skills to apply pH concept and pH titration curves for obtaining dissociation constant of weak acid
- Make them able to determining thermodynamics enthalpy changes in physical/chemical processes
- To facilitate necessary practical knowledge to determine the adsorption capacity of solid adsorbate, pKa of an indicator, degree of dissociation and dissociation constant of a weak acid by using spectroscopic and conductivity and pH measurements.
- To develop skills measure the parameters of the Langmuir and Freundlich adsorption isotherms
- Impart the skill to apply the equilibrium distribution to determine the value of partition coefficient and application of Henderson equation
- Make them able to determining the Critical Solution temperature (CST) for the two-phase system

Course Content

Students will perform the following experiments:

1. Study of adsorption of acetic acid from solution on a sample of charcoal.
2. Study of distribution equilibrium of benzoic acid in CCl_4/ H_2O system
3. Study of kinetics of base-catalyzed hydrolysis of an ester conductometrically at different temperatures.
4. Determination of the dissociation constant of acetic acid and succinic acid using pH metric titration.
5. Determination of the dissociation constant of Phenolphthelein indicator colorimetrically.
6. Determination of the degree of dissociation and dissociation constant of a weak acid conductometrically.
7. Determination of CST and composition at CST for the phenol-water system with and without impurity.
8. Determination of solubility and solubility product constant of $BaSO_4$ conductometrically
9. Determination of elevation of boiling point of naphthalene using Beckmann Thermometer
10. Determination of composition of Cu (II) and Fe (III) in a mixed solution by spectrophotometric titration using EDTA

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Determine the adsorption capacity of solid adsorbate, pKa of an indicator, degree of dissociation and dissociation constant of a weak acid by using spectroscopic and conductivity and pH measurements

CO2. Relate parameters of the Langmuir and Freundlich adsorption isotherms

CO3. Apply the equilibrium distribution to determine the value of partition coefficient and application of Henderson equation to calculate dissociation constant

CO4. Apply conductivity measurements in studying the kinetic parameters

CO5. Determine the Critical Solution temperature (CST) for the two-phase system and to study the effect of added impurity on CST

Mapping of Course Learning Outcomes (COs) with POs

COs	Program Learning Outcomes (POs)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3			3							
CO4			3							
CO5			3							

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture demonstration	Class test (Short Q and MCQ)
CO2	Lecture demonstration	Quiz,
CO3	Lecture demonstration, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture demonstration, Group discussion	Essay type test, problem solving
CO5	Lecture demonstration Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. Physical Chemistry by P. W. Atkins
2. Physical Chemistry by Gilbert W. Castellan
3. Principle of Physical Chemistry by Samuel H. Maron and Carl F. Prutton
4. Physical Chemistry by S. K Jain
5. Advance Physical Chemistry by Gurdeep Raj

Course No: **CHE 0531 3233**	Credit: 2.0	Year: Third	Semester: Second
Course Title: **Organometallic Chemistry**		Course Type: Theory	

Course Rationale:
This course aims to teach the chemical properties of different chemicals where both the organic and inorganic species are present, also known as organometallics. After this course, a student should be able to classify them, explain their bonding, and describe their properties. They should also know about the stability factors of the complexes, their application in different catalysis, and their synthetic procedures.

Course Objectives:
The objectives of this course are:
- To make the students understand the relation of molecular structures to the number and nature of the valence electrons
- To provide a clear concept of sigma and pi bonding donor-acceptor model of metal-carbon bonds
- To facilitate necessary knowledge of significant reactivities of various organometallic complexes including some general and important synthetic methods as well as their characterization and stability
- To develop innovative skills for the industrial applications of organometallic complexes as homogeneous catalysts

Course Content:
Introduction: Historical developments in organometallic Chemistry. Demarcation and classification of organometallic compounds.
Organometallic Chemistry of Transition Metals: 18 electron rule and classification of ligands.
Metal-carbon Sigma bonds: Metal carbonyl, Nitrosyl, and phosphine complexes- synthesis, structure, bonding, and reactivity. Metal alkyl complexes: structure and stability; synthesis and reactivity.
Metal-Carbon pi bonds: Metal alkene complexes: Structure and bonding, Synthesis and reactivity, Metal-alkyne complexes: Synthesis, bonding, and reactivity.
Metallocenes: Synthesis, bonding, and reactivity with special emphasis on Ferrocene.

Organometallic Chemistry of main group elements: Energy, Parity, and Reactivity of M-C bonds, Stability of M-C bonds, Thermodynamic and kinetic stability, Methods for the preparation of main group organometallics: Oxidative addition, Reductive elimination, Exchange reaction, and Insertion reaction.
Alkali Metal Organometallics: Structure and Bonding, Reaction of organolithium compounds.
Organomagnesium, Organoaluminium, Organotin, and Organosilicon compounds: Preparations and their applications in synthetic chemistry.
Metal–metal bonds and cluster: Formation and criteria of the metal-metal bond cluster, Electron count, Structure and isolobal analogies.
Organometallic catalysis: General principles of Catalysis, Homogeneous and Heterogeneous Catalysis, Catalytic Steps. a) Catalytic reactions and the 16/18 VE rule b) Arylation /Vinylation of olefins (Heck Reaction) c) Olefin oxidation (Waker Process) d) Hydrogenation of Alkenes e) Hydroformylation (Oxo Reaction)

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Distinguish different types of ligands along with their structures and insight into reactivity, synthesis, and stability of metal complexes with ligands such as CO, NO, and Phosphine.
CO2. Describe the general synthesis as well as industrial applications including the sensor, and catalysis.
CO3. Relate the structure with proper bonding scheme, synthesis, and applications in organic synthesis
CO4. Calculate the number of the valence electron in a complex and predict its stability.
CO5. Explain different catalytic cycles of organometallic complexes.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	1			2						
CO2	3									
CO3	2		1							
CO4	3									
CO5	2		1							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Discussion	Class test (Short Q and MCQ)
CO2	Lecture, PPT Demonstration	Quiz, assignment
CO3	Lecture, PPT Demonstration	Quiz
CO4	Lecture, PPT Demonstration	Class test
CO5	Lecture, PPT Demonstration, Group discussion for problem analysis	Class test (Short Q and MCQ)

Books Recommended:

1. M. Bochmann, Organometallics 1, Oxford university press, 1994
2. M. Bochmann, Organometallics 2, Oxford university press, 1994
3. Cotton, Wilkinson and Gaus, Basic Inorganic Chemistry, Third edition, John Wiley and Sons publishing
4. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6th Edition, John Wiley and Sons publishing,1999
5. James E. Huheey, Inorganic Chemistry, Fourth edition, Addsion-Wesley publishing
6. Douglas, McDaniels and Alexander, Concepts and Models of Inorganic Chemistry, Third edition, 1994. John Wiley and Sons Inc. publishing
7. P. Powell, Principles of Organometallic Chemistry, 2014
8. S. Z. Haider, Advanced Inorganic Chemistry, Asiatic civil military press, 1994

Course No: **CHE 0531 3234**	Credit: 1.5	Year: Third	Semester: Second
Course Title: **Inorganic Chemistry Practical**		Course Type: Practical	

Course Rationale:
This course aims to give a practical idea about the synthetic methods used in the production of different organometallic complexes, synthesizing isomeric compounds, and distinguishing those using scientific techniques.

Course Objectives:
The objectives of this course are:
- To impart knowledge on the synthetic of metal complexes with various ligands elucidation of structures using spectroscopic methods
- To understand basic instrumentation and sample preparation of IR spectroscopy.
- Using IR spectra as a tool, detecting various functional groups in the synthesized product.

Course Content:
1. Preparation and spectroscopic characterization (IR) of Potassiumtris (oxalate) Ferrate (III)
2. Preparation and IR spectroscopic characterization of linkage isomers having Nitrite ligand bonded to cobalt via N and O
3. Preparation and IR spectroscopic characterization of Cobalt acetylacetonate complex
4. Preparation and IR spectroscopic characterization of acetylferrocene
5. Determination of complex ion composition of $[Ni(en)_2]SO_4$ by Job's Methods.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Prepare mentioned organometallic complexes and determine the purity of complexes by measuring melting point.
CO2. Use basic sample preparation methods of IR spectroscopy and learn to utilize IR spectroscopy to detect/analyze various functional groups.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		2		1						
CO2		1		2						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Lab Work	Lab Performance (group), lab Report
CO2	Lecture, Lab Work	Lab Performance (group), lab Report, Viva, Written Examination

Books Recommended:

1. G. Pass and H. Sutcliffe, *Practical Inorganic chemistry*, second edition, Springer, 1974.
2. Robert J. Angelici, *Synthesis, and Technique in Inorganic Chemistry*, second edition, Univ Science Books, 1987

Course No: **CHE 0531 3241**	Credit: 2.0	Year: Third	Semester: Second
Course Title: **Polymer Chemistry**		Course Type: Theory	

Course Rationale:
Aim to understand the basic concepts of polymers and their molar masses, the structures and properties of polymers, and the fundamentals of polymerization reactions. Other important goals are to realize the structures, bonding, and properties of naturally occurring polymers and the basic techniques of polymer modification.

Course Objectives:
The objectives of this course are:
- To facilitate basic concepts of polymers and their molar masses
- To acquaint students with the structures and properties of polymers
- To make the students understand the fundamentals of polymerization reactions
- To provide the knowledge of structures, bonding, and properties of naturally occurring polymers
- To develop skills in basic techniques of polymer modification

Course Content:
Introduction: Introduction to natural and synthetic polymers. Difference between polymers and macromolecules. Molar mass and size of polymers: number average, mass average, *Z*-average, and viscosity average molar mass.
Polymer structure and properties: Primary, secondary, and tertiary structures of polymers. Thermal transitions in polymers: definition, theories, and factors affecting glass transition temperature and crystalline melting point.
Common polymerization reactions: Types of polymerizations, mechanism, and kinetics of step-growth polymerization, chain reaction polymerization, ionic polymerization, and coordination polymerization.
Naturally occurring polymers: Structures, bonding, shapes, and properties of rubber, cellulose, starch, wool, and silk.
Polymer modification: Copolymerization: styrene-butadiene copolymers, ethylene copolymers, acrylonitrile-butadiene-styrene copolymers (ABS), and condensation polymers (phenol-formaldehyde, melamine-formaldehyde, urea-formaldehyde, and epoxy resins).
Post polymerization: cellulose derivatives. dextrins, cross-linking polymers, block and graft copolymers, and polyurethanes.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Explain the concept of synthetic and natural polymers and their molar masses
CO2. Describe the structures of polymers and their thermal properties
CO3. Interpret the concept of different polymerization methods with mechanistic details
CO4. Outline the structures, bonding, shapes, and properties of common naturally occurring polymers
CO5. Illustrate the modification of polymers through copolymerization and post-polymerization techniques

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3		1							
CO3	3									
CO4	3			2						
CO5	3			2						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Group Discussion, Question-Answer session	Class test (Short Q and MCQ)
CO2	Lecture, Group Discussion, Question-Answer session	Quiz, Assignment
CO3	Lecture, Group Discussion, Question-Answer session	Essay type test, Assignment
CO4	Lecture, Group Discussion, Question-Answer session	Essay type test
CO5	Lecture, Group Discussion, Question-Answer session	Class test (Short Q and MCQ)

Books Recommended:

1. Robert T. Morrison and Robert N. Boyd, *Organic Chemistry*, 6th Ed., 1992, Prentice Hall
2. T. W. Graham Solomons and Craig B. Fryhle, *Organic Chemistry*, 12th Ed., 2015, John Wiley & Sons, Inc.
3. Billmayer F. W., *Textbook of Polymer Science*, 3rd Ed., 1984, John Wiley & Sons, Inc.
4. Robert O. Ebewele, *Polymer Science and Technology*, 2000, CRC Press, NY, USA
5. Charles E. Carraher Jr., *Introduction to Polymer Chemistry*, 2017, CRC Press, NY, USA

Course No: **CHE 0531 3142**	Credit: 2.0	Year: Third	Semester: First
Course Title: **Qualitative Identification of Organic Compounds**		Course Type: Practical	

Course Rationale:

This course is aimed to make the student practically skilled in the identification of unknown organic solid and liquid compounds which are important for chemistry study as well as for practical purposes.

Course Objectives:

The objectives of this course are:

- Make the students able to identify functional groups in organic compounds by chemical tests in the laboratory
- To enhance the skill to perform practical techniques employed for systematic identification of unknown organic solid and liquid compounds

Course Content:

Physical test of organic compounds: Physical appearance, solubility test, Elemental analysis.

Functional group identification of organic compounds: Unsaturation, oxygen, and nitrogen-containing functional groups**.**

Systematic identification of organic solids and liquids with the name: Identification of acidic, basic, phenolic, and neutral organic substances, Determination of N, S, and halogens, Test for aliphatic and aromatic nature of substances, Test for saturation and unsaturation.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Classify the organic compounds as acidic, basic or neutral by solubility measurements.
CO2. Identify common functional groups that present in an organic compound.
CO3. Apply the physical and chemical properties of organic compounds for their identification
CO4. Design systematic sequences of qualitative analysis of an unknown organic compound.
CO5. Synthesize the functional derivatives of organic compounds for their complete detection.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		3	1							
CO3		2	2							
CO4		3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Demonstration	Lab Performance (group)
CO2	Lecture, Demonstration	Lab Performance (group), lab Report, Viva
CO3	Lecture, Demonstration	Group Lab Performance, Quiz, Viva
CO4	Lecture, Demonstration	Individual Lab Performance or group

Books Recommended:

1. H. T. Clarke, B. Haynes, E. C. Brick, G. C. Shone, E. Arnold, *Handbook of Organic Analysis, Qualitative and Quantitative*, 5th edition
2. R. L. Shriner, R. C. Fuson and D. Y. Curtin, *Systematic Identification of Organic Compounds*, John Wiley Sons, Inc. New York, London, Sydney, 5th edition
3. *Vogel's* Text Book of Practical Organic Chemistry, 5th edition, ELBS with Longman

Course No: **CHE 0531 3252**	Credit: 2.0	Year: Third	Semester: Second
Course Title: **Environmental Chemistry**		Course Type: Theory	

Course Rationale:

This course is aim to provide basic knowledge of Environmental Chemistry that will be needed for environmental problem handling and management.

Learning Objectives:

The objectives of this course are:

- Acquaint students with the specific knowledge of chemistry for keeping environment safe and sound
- Accumulate basic ideas and information about environmental pollution and remedial measures
- To acquire theoretical reason of environmental hazards, and to utilize this for future handling of environmental issues
- Foster the analytical and critical thinking on the current threats to our energy harnessing issues, and planning for environmental benign methods for maintaining the sustainable technology

Course Content:

Introduction: Concept and scope of environmental chemistry, Dawn of the universe and time, creation of elements, environmental segments, Ecosystems, Biochemical cycles of carbon nitrogen and sulphur.

Atmosphere: Composition and components of the atmosphere, evolution of the atmosphere, earth radiation balance, particles, ions, and radicals in the atmosphere, chemical and photochemical reactions in the atmosphere, greenhouse effect/global warming- cause and effect, depletion of ozone in stratosphere- cause and effects, Antarctic ozone hole.

Hydrosphere and lithosphere: Water resources, hydrologic cycles, chemical reactions in water, complexation in natural and waste water, aquatic biochemical processes, composition of lithosphere and soil texture, rock formation, rock cycle and metamorphism, sedimentary rock soil erosion and pollution,

Air pollution: Classification of air pollutants, sources, sink and effects and control of CO, NO_x, SO_x, hydrocarbons, fluorides, asbestos and particulate matter,

photochemical smog, acid rain- causes and effect, airborne lead the effect and control, atmospheric stability and temperature inversions, air pollution from major industrial operations in Bangladesh.

Water pollution: Nature and types of water pollutants and their effects, water quality parameters, Algal nutrients and eutrophication, Heavy metals pollutants, acidity, alkalinity and salinity, bioaccumulation of organic pollutants, consequences of fertilizers, soap and detergents, persistence pesticides and their toxicity, trace elements (Hg, Pb, As) in water- sources and toxicity, microbial toxins, emerging water pollutants, pharmaceuticals and house hold wastes.

Soil pollution: Composition of the earth crust, formation of soil, inorganic and organic matter in soils, soil humus, acid-base and ion exchange reactions in soil, micronutrients in soil, pollutants cycle in soil, sources, effect of different pollutants on soil, impact and remedy.

Noise pollution: Noise pollution and its impacts on health, classification of noise pollution, different units and measurement techniques, controlling parameters of noise pollution.

Sustainable Energy: Conventional sources of energy and their demerits, importance of sustainable energy, hurdles of implementation of sustainable energy, Importance of biomass as a source of energy, synthetic route of biodiesel and other bio fuel and their application.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Express different terms of environmental segment and constituents of it and thereby to acquire depth of knowledge inside each segment.

CO2. Explain the causes of air pollution, and will be able to take steps for explaining the mechanism of different pollutant like NOx, Sox and related other pollutants.

CO3. Explain the causes of water pollution and will be able to take steps for keeping water bodies free from pollution

CO4. Express d the causes of soil pollution, and will be able to take steps for remedial measure related to these.

CO5. Express and the causes of noise pollution, and will be able to take steps for explaining the mechanism and also to take steps for remedial measure.

Explain the crisis of energy and to think about finding solution for sustainable energy management.

Mapping of CLOs with PLOs

COs	Program Learning Outcomes (POs)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2			3							
CO3	3									
CO4	3									
CO5			3							

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, presentation, Journal article reviews, problem analysis	Essay type test, problem solving

Books Recommended:

1. *S. E. Manahan, Environmental C*hemistry, 9th edition
2. A. K. Dey, *Environmental Chemistry, 7th edition*
3. R. W. Raiswell, *Environmental Chemistry*
4. Moore and Moore, *Environmental Chemistry*
5. B. K. Sharma and H. Kaur, *Environmental Chemistry*
6. A. K. Bhagi and G. R. Chatwal, *Environmental Chemistry*
7. H. J. M. Bowen, *Environmental Chemistry* Vols. I &III
8. Review articles from *Chemistry in Britain, Science*

Course No: **CHE 0531 3251**	Credit: 2.0	Year: Third	Semester: Second
Course Title: **Industrial Chemistry II**		Course Type: Theory	

Course Rationale:

This course is aim to give a smart understanding about fundamentals of raw materials section and processing, chemical reactions within processes and unit operation of industry based on organic materials.

Learning Objectives:

The objectives of this course are:

- To impart knowledge in understanding different basic concept of industrial technology and chemical processes
- To describe the sources, classification, composition, industrial manufacture and applications of pulp and papers, sugars, petroleum, oil and fat, paints and varnishes with special emphasize to Bangladesh perspective

Course Content:

Sugar Industries: Manufacture of cane sugar, refining of raw sugar, production of sugar from sugar beet, and sugar industry in Bangladesh.

Soap, Detergents and Cosmetics: Raw materials, fat splitting, manufacturing of laundry and toilet soaps, recovery and refining of glycerin, composition of different types of soaps. Detergents: definition, classification and their manufacture, builders, additives, biodegradability of detergents, comparison of soap and detergents, cleaning action of soap and detergent.

Pulp and Paper and Industries: Natural source of cellulose, different process for the manufacture of pulp, recovery of chemicals from waste cooking liquor, manufacture of paper board, cellulose acetate and cellulose nitrate. Pulp and paper industries in Bangladesh.

Food Processing Industries: Food classification, Basic principle of food processing, Milk and dairy products, Fruits and vegetables, Confectionary, Beverages, Meat & fish processing etc.; Food additives, food color, flavor, preservatives, stabilizer, thickener, etc, Safety consideration of food additives & Environmental aspects, Food adulteration & its toxic effect.

Petroleum and lubricant Industry: Definition, origin, composition and classification, refining and distillation of petroleum, cracking of petroleum, motor and aviation fuels, natural gasoline, aviation gasoline, octane number, cetane number, production of high octane, alkylation, polymerization, isomerization and reforming. Lubrication and its importance, classification of lubricant, mineral base vs synthetic lubricant-synthesis and application. Bio lubricant and its importance.

Oils, Fats and Waxes: Sources of fats, oils and waxes, difference between oil and fats, vegetable oil, production of soyabean oil by solvent extraction, essential oil and their extraction and uses, analysis of oil, fat and waxes (saponification value, ester value, acid value, Reichert-Meissl value, Henher value, and iodine value), Hydrogenation of oils.

Paints and Varnishes: Constituents of paints, varnishes, lacquers and enamels and their functions, factors influencing satisfactory performance of surface coating, properties of pigments, manufacture of paints and varnish, difference between paints and varnishes.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Demonstrate industrial manufacturing and refining process of sugar, manufacturing techniques of pulp and paper and explain the utilization of by-products associated with these industries.

CO2. Select and distinguish the proper and suitable raw materials, chemical reactions within the process for the industrial production of soap, detergent.

CO3. Explain the food processing importance of ethical point of view about food additives, color, flavor, food adulteration and its toxic effect. etc.

CO4. Interpret the processing of petroleum, cracking of petroleum, natural gasoline, octane number, cetane number, alkylation, polymerization, isomerization and reforming and thereby to utilize this knowledge in a practical field.

CO5. Explain the composition and extraction of fats and oils and the chemical analysis of these, also to explain about paints and vernishes and proper utilization of raw materials for sustainable industrial set of these type in Bangladesh.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10
CO1	3									1
CO2	3									
CO3	3									
CO4	2							2		
CO5	2							2		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture and Discussion	Class test (Short Q and MCQ)
CO2	Lecture and Discussion	Essay type test
CO3	Lecture and Question-Answer session	Class test (Short Q and MCQ) Quiz
CO4	Lecture, PPT presentation, and Group discussion	Essay type test
CO5	Lecture, PPT presentation, and Group discussion	Essay type test

Books Recommended:

1. Shreve, *Chemical Process Industries*
2. B. K Sharma, *Industrial Chemistry*
3. Roger's, *Manual for Industrial Chemistry*
4. J. A. Kent, *Regels' Hand Book of Industrial Chemistry*
5. Liegue, *Engineering materials*
6. Martins, *Industrial Chemistry* (Vol. I, II & III)

7. R. K. Das, *Industrial Chemistry* (Part I & II)
8. Othmer and Klerk, *Encyclopedia of Chemical Technology*
9. B. K Sharma, *Industrial Chemistry*

Course No: **CHE 0531 3253**	Credit: 1.5	Year: Third	Semester: Second
Course Title: **Industrial Chemistry Practical**		Course Type: Practical	

Course Rational:
This course is aim to provide pragmatic skill on chemical analysis feasible for industrially important product.

Learning Objectives:
The objectives of this course are:
- To develop skills to estimate different parameters of chemical samples which are important for specific sample analysis
- To provide the skill of examining industrial samples for justification of claimed quality.
- To make standard solution for calibrating UV-visible spectrophotometer followed by analysis of samples using UV-Vis spectrophotometer.
- Acquaint students with the basic experimental tools to measure the different quality parameters like iodine value, saponification value, hardness, TDS, etc.

Course Content (8-10 experiments to be done):
Complexometric Titration:
1. Determination of water hardness of the supplied samples with EDTA
2. Estimation of zinc content of the medicinal samples (zinc supplement tablet and solution) by using EDTA

Analysis of industrial waste water:
1. Estimation of dissolved oxygen from different waste water samples.
2. Estimation of residual chloride from industrial waste water.

Analysis of commercial bleaching powder:
Determination of percentage of available chlorine in bleaching powder samples.
Analysis Soft drink:
1. Determination of dissolved CO_2 from carbonated drink
2. Determination of the acid content of the soft drink by pH titrimetric method

Analysis of oil and fat:
1. Determination of iodine value of oil samples (soya bin and other edible oils available in the market)
3. Determination of saponification value of samples (butter and coconut oil)
4. Determination of acid value of oil samples
5. Determination of ester value of oil samples

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Prepare standard solutions and indicators, and also be able to perform titration of desired solution utilizing complexometric titration technique.
CO2. Perform experiment along with calculation to determine dissolved oxygen and chloride content of the waste water.
CO3. Determine the main constituent of bleaching agent quantitatively.
CO4. Perform experiment to know the amount of dissolved CO_2 and also the acid content of soft drink.
CO5. Distinguish between oil and fat based on experiment and can calculate different parameters for the quality of oils and fats.

Mapping of Course Learning Outcomes (COs) with POs

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		3								
CO3		3								
CO4		3								
CO5	1	2								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Demonstration in sampling, safety in the lab.	Assessment in the lab
CO2	Lecture, Practical Demonstration on accurate measurement for calibration of instrument, utilization of analytical tools like colorimeter etc.	Quiz, assignment
CO3	Demonstration on Data handling and graph drawing (hand and software aided graph practice) for result presentation.	Spot Assessment of experimental findings and report evaluations after completion and submission of lab report based on experimental findings.
CO4	Trouble shooting of instrumental error, comparison of different methods for sample analysis.	Oral assessment
CO5	Final Lab exam on specific experiment.	Oral assessment and evaluation of final presentation.

Books Recommended:
1. Vogel's Quantitative Analysis
2. Analytical Chemistry 2.1 by David Harvey.
3. Analytical Chemistry, 7th edition by Skoog, West, Holler
4. Analytical Chemistry, 5th edition by G. D. Christian
5. Vogel's Quantitative Analysis

Course No: **CHE 0531 3291**	Credit: 1.0	Year: Third	Semester: Second
Course Title: **Seminar and Oral Presentation**		Course Type: Oral	

Course Rationale:
Communication skill is now a day is very vital for professionalism. For academic, industrial and research purposes communication of scientific results and view as well as social communication is very important. This course aims to make the students capable of making proper communication, particularly in their subject matters.

Course Objectives:
The objectives of this course are:
- To train the students better prepare academic assignments based on a specific topic
- To acquaint the students with smart oral presentation
- Acquaint students with the academic viva-voce

Course Content:
Students will be assigned specific topics based on the curriculum of the previous two semesters. Students will prepare a detailed assignment (approximately 800 words) based on their assigned topics and give an oral presentation before the exam committee.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Prepare an assignment on specific topics
CO2. Prepare for smart oral presentations
CO3. Better adapt to the norms of academic presentation and viva-voce
CO4. Argue with his logic in front of the viva board

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2				2					
CO2					3					
CO3					1				3	
CO4			1		3					

Teaching- Learning and Assessment Strategies:
There will be no formal face-to-face instruction for the course. Students will learn throughout the semester from the respective related class lecture and discussions with teachers and among themselves. There will also be tutorial session where students will get the opportunity to discuss any related topics. The duration of the tutorial/ discussion class will be a total of 15 hours in a semester. Respective course teachers will provide the topics to each individual student for their presentation before the final presentation. Students will be evaluated and grades will be given on the basis of the marks given by the members of the examination committee individually or combinedly.

Assessment Rubric:

	Excellent (33p)	**Proficient (25p)**	**Satisfactory (20p)**	**Poor (15p)**
Content of the Assignment/ Presentation	-Students discuss the subject in great details -Student describes in detail about their topic	-Students discuss the subject with some details -Student outlines their topic	-Student discuss the subject with a few details -Student do not outline their topic	-Students discuss the subject with very minimal details -Students do not outline what they have learnt
Delivery	-Good posture -Eye contact with the audience most of the time -Appropriate gesture and expression	-Good posture -Frequent eye contact with the audience -Appropriate gesture and expression	-Intermittent good posture –Occasional eye contact with the audience –Appropriate gesture and expression	-Poor posture -Seldom eye contact with the audience -Not enough easy during presentation
Answering to the Question	-Answers All the questions asked properly	-Answers All the questions asked properly	-Answers All the questions asked properly	-Answers All the questions asked properly

Course No: **IPE 0413 3219K**	Credit: 3.0	Year: Third	Semester: Second
Course Title: **Industrial Management**		Course Type: Theory (GEd)	

Course Rationale:
This course aims to provide an understanding of the theories and principles of industrial management and encourage the course participants to appreciate these principles in relation to their own experiences and selected managerial case studies.

Course Objectives:
The objectives of this course are to:
- provide knowledge about the basic principles of management, the major functions of managers, e.g., planning, organizing, staffing, leading, and controlling, and the challenges managers face in each stage
- make students think critically and strategically about management theories and issues which will enable them to develop their decision-making and analytical skills
- Familiarize students with the sound employment function as well as implementing a good wage and incentive scheme
- let the students understand different marketing issues and the fundamental concepts of marketing management

Course Content:

Organization and management: evolution, management functions, organization structure, development of organization theories, study of various types of organization and management information systems, concepts, and scope of application.
Personnel management: importance, scope, need hierarchy, motivation theories, defense mechanism, productivity and satisfaction, leadership, group dynamics, job evaluation, merit rating, personnel development: hiring, training, and wage systems.
Marketing management: marketing concept, marketing organization, industrial and consumer selling, channel decisions, advertising decisions, new product strategy. *Basics of Technology management;* Case studies.

Course Learning Outcomes (COs):
After successful completion of the course, students will be able to:
CO1. Explain the theories, principles of management, contemporary theories of motivation, and apply these theories to tackle the managerial challenges
CO2. Apply leadership skills and implement its ideas in organizations/industries
CO3. Evaluate the different tasks of personnel management such as recruitment, selection, wages, and incentives
CO4. Identify what marketing strategies organizations might practice to attract and retain customer
CO5. Describe the concepts and techniques of strategic management of technology

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2							3			
CO3							2			1
CO4							2			1
CO5										3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture and Discussion	Class test (Short Q and MCQ)
CO2	Lecture and Discussion	Essay type test
CO3	Lecture and Question-Answer session	Class test (Short Q and MCQ) Quiz
CO4	Lecture, PPT presentation, and Group discussion	Essay type test
CO5	Lecture, PPT presentation, and Group discussion	Essay type test

Books Recommended:

1. Management-A Global Perspective, Heinz Weihrich and Harold Koontz, McGRAW HILL International Edition.
2. Industrial Engineering and Management -A New Perspective, Philip E. Hicks, McGRAW -HILL International Editions.
3. Industrial Engineering and Management, O.P. Khanna and A. Sarup, Dhanpat Rai Publication Ltd.
4. Andrew J. Dubrin, Essentials of Management, South-Western College Pub.

Course No: **CHE 0531 4121**	Credit: 3.0	Year: Fourth	Semester: First
Course Title: **Quantum Chemistry and Statistical Mechanics**		Course Type**:** Theory	

Course Rationale:
Quantum chemistry provides basic knowledge on mathematical description of motion and interaction of atomic and subatomic particles. The statistical mechanics combines the principles and procedures of statistics with the laws of both classical and quantum mechanics, particularly with respect to the field of thermodynamics.

Course Objectives:
The objectives of this course are:

- To introduce the failure of classical mechanics and introduction of quantum mechanics
- To make the students familiar with basic terminologies of quantum chemistry and statistical mechanics
- To solve Schrodinger wave equation for particles confined under different conditions and H atom to obtained their wave function and energy at various quantum states
- To transfer Schrodinger equation into polar coordinates for H atom, get equation for each variable, and solve them
- To formulate mathematical equations for atomic orbitals in different energy levels
- To acquire preliminary ideas about different approximate methods in finding energy states of many electron atoms
- To describe the formulation of equations of different statistical distributions and their applications
- To acquire knowledge on the various partition functions
- To bridge the rules and equations of statistical mechanics with thermodynamics and that of quantum chemistry with chemical spectroscopy and chemical bonding

Course Content:

Quantum Chemistry: Introduction and principles of quantum chemistry: Failure of the Classical mechanics: Blackbody radiation, Photoelectric effect, Compton Effect, Heat capacity of solid, H spectrum. Heisenberg uncertainty principle and Dual nature of particles. Planck's quantum theory. Schrödinger wave equation. Wave function and their significance.

Postulates of quantum mechanics and their applications: Different postulates of quantum mechanics. Eigen value and Eigen function, normalization and orthogonality of wave functions. Operators: Types of operators, Commutation of operators, Hermitian operators, reality and orthogonality of Hermitian operators.

Techniques and application of quantum theory: Schrodinger's equation for one electron system. Solution of Schrödinger's equation for a free particle and particle in a one-, two- and three-dimensional boxes, Calculation of energy and wave function. Degeneracy of quantum states.

Wave equation in polar co-ordinates: Schrödinger wave equation for hydrogen atom in spherical polar coordinates. Separation of the complete wave equation into the Θ, R and Φ-equations and their solutions. Significance of quantum numbers and energy levels. Angular wave function. Concept of different types of s, p and d-orbitals from angular wave function. Radial distribution function and calculation of radial distribution functions for (n + 1)s and (n + 1)p orbitals.

Approximate solutions: Perturbation theory, First order perturbation energy. Application of the first order perturbation theory to the normal helium atom. Variation theory, basis of the variation theory and application of variation technique to normal helium atom.

Wave function for many electron atoms: Self consistent field method. Application of SCF to many electrons systems

Statistical Mechanics: Quantum Statistics: Distinction between quantum mechanics, Statistical Mechanics and Classical Thermodynamic. System, assembly, probability. Stirling's approximation, Indistinguishability of similar particles, Bose-Einstein, Fermi-Dirac and Maxwell Boltzmann statistics and the range of their applications, comparison of three statistics, relationship between β and T.

Partition functions: Separation of partition functions, translational partition function, rotational partition function, vibrational partition function, electronic and nuclear partition functions. Significance of the partition functions.

Statistical thermodynamics: Entropy and probability. Entropy and number of Eigen states. Relationship between partition function and thermodynamic functions. The entropy of mixing.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. understand blackbody radiation, photoelectric effect, compton effect, dual nature of particle and Uncertainty principle and describe wave function, different operators, normalization, orthogonality, postulates of quantum mechanics, Eigen value and Eigen value equation

CO2. Apply Schrodinger equation for particles confined under different conditions to obtain their wave function and energy in different quantum states

CO3. Rewrite Schrodinger equation in polar coordinates for H atom, separate variables and solve Θ, R and Φ-equations and formulate mathematical equations for atomic orbitals in different energy levels

CO4. Describe and apply the approximate methods in finding energy of many electron systems like, He atom

CO5. Describe basic concept of statistical mechanics, postulates and formulation of equations for Bose-Einstein, Fermi-Dirac and Maxwell Boltzmann statistics and explain translational, rotational and vibrational partition functions and their significance, establish different thermodynamic relationships.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2			3							
CO3	3		1							
CO4	2		2							
CO5	2		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Supply of Lecture handout	Short Question and Quiz test
CO2	Lecture, Group discussion, Supply of Lecture handout, problem solving	Short question and Quiz Test
CO3	Lecture, Group discussion, problem solving	MCQ/Short question/ Assignment
CO4	Lecture	MCQ/Short question/Assignment
CO5	Lecture, Supply of Lecture handout	MCQ/Short question /Assignment

Books Recommended:

1. Donald A Mcquarrie, *Quantum Chemistry*
2. M. W. Hanna, *Quantum Mechanics in Chemistry*
3. N. Levine, *Quantum Chemistry*
4. K. Chandra, *Quantum Chemistry*
5. Kaufmann, *Advanced Physical Chemistry*
6. P. W. Atkins, *Molecular Quantum Mechanics*
7. P. W. Atkins, *Physical Chemistry*
8. Charles E. Reid, *Chemical Thermodynamics*
9. T. E. Hill, *Statistical Thermodynamics*
10. Davidson, *Statistical mechanics*
11. Gupta, *Statistical Mechanics*

Course No: **CHE 0531 4131**	Credit: 3.0	Year: Fourth	Semester: First
Course Title: **Electronic spectra and reaction mechanism**		Course Type: Theory (Core)	

Course Rationale:

This course is enabled to broadly explain the state of coordination compounds and reaction pathways as well as the origin for spectra of coordination compounds.

Course Objectives:

The objectives of this course are:

- To explain the thermal stability, kinetic inertness, reactivity, and properties of coordination compounds
- To achieve knowledge of the inorganic reaction mechanism for coordination complexes and redox reactions
- To understand the electronic spectra of metal complexes
- To make the students familiar with some applications of coordination compounds

Course Content:

Electronic Spectra of metal complexes: Selection rules, Hund's rule, Term, Term symbols, ground state term, splitting of electronic energy levels, spectroscopic states, R-S coupling, knowledge of microstates, Orgel diagrams, Tanabe-Sugano diagram, interpretation of UV-vis spectra, spectra of d^1, d^2, d^3, d^4, d^5, d^6, d^7, d^8, and d^9 complexes, charge transfer spectra.

Stability of coordination compounds: Thermodynamics stability (stable and unstable) and kinetic stability (labile and inert), are factors influencing the stability of complexes.

Reaction mechanism: Types of substitution reactions, introduction to ligand substitution reactions- lability and inertness, thermodynamic and kinetic stability, substitution reaction in octahedral complexes- lability and d-electron configuration, types of the mechanism of ligand substitution reactions, acid hydrolysis, and base hydrolysis reaction, the effect of charge, the effect of leaving group, non-leaving group, solvents, steric effect, etc. on reaction rates, substitution without breaking the metal-ligand bond, racemization reaction. Ligand substitution reaction on square planar complexes--general features, the significance of the rate law, effect on rates of entering and leaving ligands and solvents, steric effects of non-leaving ligand, trans effect, theories of trans effect.

Redox reactions: Inner and outer sphere reactions and their mechanism, theory of redox reactions, photochemical reactions, d-d, and charge transfer reactions.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Recognize the state, reactivity, and properties of coordination complexes

CO2. Explains different pathways for ligands substitution reactions of coordination complexes with various geometries.

CO3. Describe the roles of the inner and outer coordination sphere complexes in electron-transfer processes.

CO4. Calculate spectroscopic term symbol for d-block metal complexes and distinguish their energy level.

CO5. Demonstrate UV-Visible spectra and CT-Spectra of metal complexes of d-block metal complexes and interpret their transition using the Orgel and Tanabe-Sugano diagrams

Mapping of Course Learning Outcomes (COs) with Pos 3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT and discussion	Assignment by quiz
CO2	Lecture using PPT and open discussion	Class test (Short Q and MCQ)
CO3	Lecture using PPT and compare with previous lectures	Short Q, MCQ, Quiz, Explanation
CO4	Lecture using PPT and demonstration of practical data	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and demonstration practical data, Group discussion	Short Q, MCQ, Quiz, Explanation

Books Recommended:

1. Advanced Inorganic Chemistry, Purcell and Kotz
2. Inorganic Chemistry, J. E. Huheey
3. Inorganic Chemistry, J. D. Lee
4. Inorganic Reaction Mechanism, M. L. Tobe
5. Inorganic Chemistry, Shriver, Atkins and Langford, Fourth edition, Oxford University Press.
6. Concepts and Models of Inorganic Chemistry, Douglas, McDaniels, and Alexander
7. Mechanism of Inorganic Reactions, Katakis, and Gordon, 1987
8. Inorganic Chemistry, Catherine E. Housecroft.
9. Inorganic Chemistry, Gary L. Miessler

Course No: **CHE 0531 4141**	Credit: 3.0	Year: Fourth	Semester: First

Course Title: **Advanced Organic Chemistry**	Course Type: Theory

Course Rationale:

This course is aimed to give an idea about the theoretical calculation of the properties of chemical compounds and related chemistry.

Learning objectives:

The objectives of this course are:

- Make the students understand the different types of molecular rearrangements, mechanism and their stereoselectivity
- Acquaint the students with theoretical organic chemistry
- Provide quantitative explanation of structure and reactivity in reactions with reference to Hammett and Taft equation
- Provide foundation in photochemical, free radical reactions and rearrangement reactions
- To facilitate necessary knowledge to apply the understanding to predicting the outcome of organic reactions and the stereo- and conformational configurations of the products

Course Content:

Molecular rearrangements: Definition, types of molecular rearrangement, migrating group, migration terminus, migration origin, migratory aptitude, etc. Detailed mechanistic study of Wagner-Meerwein rearrangement, Pinacol-semipinacol rearrangement and stereochemistry, Wolff rearrangement, Hofmann rearrangement, Beckmann rearrangement, Bayer Villiger rearrangement, Favorskii rearrangement, Benzilic acid rearrangement, Wittig and Meisenheimer rearrangements.

Structure and reactivity: Quantitative treatment, The Hammett equation, Significance of substituent constant, reaction constant, Modification of substant constant, Separation of inductive resonance, and steric effects, Taft equation.

Photochemistry: Principles of photochemistry, excited states, photochemical processes, energy transfer and photosensitization. Photochemical reaction: photoreduction, photolysis, cycloaddition, isomerization and rearrangement. Chemiluminescence and bioluminescence.

Free radical chemistry: Formation of free radicals, shape and stability of free radicals, detection of free radicals. Free radical reactions: fragmentation, substitution, addition, oxidation, reduction, rearrangement etc.

Molecular orbitals and Orbital symmetry: Molecular orbital theory , wave equations for LCAO method, bonding and antibonding orbitals, electronic configurations, aromatic character. Orbital symmetry and the chemical reaction. Electrocyclic, cycloaddition and sigmatropic reactions.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Understand the classical and non classical carbocations and their generation during molecular rearrangements.

CO2. Relate the reactivity of organic compounds with their structure utilizing the Hammett equation, Taft equation and Yukawa-Tsuno equation.

CO3. Describe the photophysical and photochemical processes and different types of photochemical reactions and make a sense of the free radicals, their generation and detection and to understand different types of free radical reactions

CO4. Interpret the mode of electrocyclic reactions either by thermal or photochemical ring closure using the concept of HOMO and LUMO.

CO5. Predict the possibilities of occurring a reaction and their stereochemistry in the mode of photochemical and the thermal environment

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2			3							
CO3	3									
CO4			3							
CO5			2							1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test.
CO5	Lecture, presentation, Journal article reviews, problem analysis	Essay type test, problem solving

Books Recommended:

1. Mechanism and Theory in Organic Chemistry, Thomas H. Lowry and Kathleen S. Richardson, Harper Collins Publishers, Inc., New York
2. A Guide Book to Mechanism in Organic Chemistry, P. Sykes Orient Longman Ltd.
3. Advanced Organic Chemistry, J. March, McGraw Hill, Wiley Eastern
4. Physical Organic Chemistry, J. Hine, McGraw Hill
5. Stanley H. Pine, *Organic Chemistry, 5th edition, 2005 (Tata McGraw-*
6. R. T. Morrison and R. N. Boyd, *Organic Chemistry (6th edition)*
7. Glichrist and Storr, *Symmetry in organic Molecules*

Course No: **CHE 0531 4147**	Credit: 3.0	Year: Fourth	Semester: First
Course Title: **Spectroscopic Methods in Structural Analysis**		Course Type: Theory	

Course Rationale:

Spectroscopy is a fundamental tool of scientific study, with applications ranging from materials characterization to medicine. The course Spectroscopic methods in structural analysis course aim mainly at the structural elucidation of known or unknown compounds using common spectroscopic techniques. So this course is very much important in Chemistry Discipline.

Course Objectives:

The objectives of this course are:

- To acquaint students with the necessary knowledge of the fundamentals of UV-Visible, IR, ^{1}H- and ^{13}C-NMR, Mass, and ESR spectroscopy.
- To develop skills among students to interpret various spectral data for structural elucidation of organic compounds.
- To facilitate the to evaluate the structures of unknown organic compounds through systematic analysis of UV-Vis, IR, ^{1}H, and ^{13}C NMR, mass, and ESR spectra.

Course Content:

UV and Visible Spectroscopy: Introduction, formation of absorption bands, types of electronic transition, solvent effects. The chromophore concept, UV absorption and Woodward-Fieser rules in conjugated dienes, α,β-unsaturated carbonyl compounds, benzene and benzene derivatives, electronic transitions for charge-transfer complex, applications of UV spectroscopy.

Infra-Red Spectroscopy: Introduction, basic principles, the IR absorption process, instrumentation, Fourier-transform infrared spectroscopy (FT-IR), sampling technique, factors influencing vibrational frequencies, interpretation of IR-spectra, applications involving organic and inorganic complexes.

Nuclear Magnetic Resonance Spectroscopy: Theory, instrumentation, relaxation process, information from NMR spectra, chemical shift, factors influencing chemical shift, spin-spin coupling, spin-spin splitting patterns, factors affecting spin-spin coupling, spin decoupling, chemical shifts in case of proton exchange reaction, restricted rotation, temperature-sensitive NMR, the nuclear overhauser effect, Introduction to ^{13}CNMR, application of NMR spectroscopy.

Mass Spectrometry: Introduction, Instrumentation, determination of molecular formula, McLafferty rearrangement, metastable ions, fragmentation process, interpretation of mass spectra.

Electron Spin Resonance Spectroscopy: Theory, relaxation, instrumentation, spin-spin splitting. Application of ESR spectroscopy.

Identification of Compounds: Identification of Compounds by using UV, IR, NMR (^{1}H and ^{13}C), and Mass spectra

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Delineate the chromophore concept, theory of UV-Vis absorption, conjugation effect, solvent effect, sampling techniques, calculating UV-Vis absorption maxima from structure, the structural assumption from UV-Vis data, etc.

CO2. Understand the basic principle of IR spectroscopy, the instrumentation and sampling techniques and the application of IR to detect the functional groups of organic compounds.

CO3. Apply the basic knowledge of NMR spectroscopy like its principle, chemical shift position of signals, their splitting pattern and coupling constants in the structural elucidation of organic compounds.

CO4. Explain the basic concepts of ESR spectroscopy and Mass spectrometry and to conclude the structure of a compound by interpreting the hyperfine splitting of the ESR signal, the molecular ion and other mass fragmentation patterns from the mass spectrum.

CO5. Determine the structures of unknown organic compounds through systematic analysis of UV-Vis, IR, ^{1}H, and ^{13}C NMR, ESR, and mass spectra.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	2		2							
CO4	3									
CO5	2		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration	Class test (Short Q)
CO2	Lecture, PPT Demonstration, Discussion	Quiz
CO3	Lecture, PPT Demonstration, Discussion	Class test (Short Q)
CO4	Lecture, PPT Demonstration	Problem-solving
CO5	Group Discussion	Problem-solving, Assignment

Books Recommended:

1. Dudley H. Williams and Ian Fleming, *Spectroscopic Methods in Organic Chemistry*, 4th Ed., 1988, McGraw-Hill
2. Gary M. Lampman, Donald L. Pavia, George S. Kriz, and James R. Vyvyan, *Spectroscopy*, 5th Ed., 2015
3. Robert M. Silverstein, Francis X. Webster, and David J. Kiemle, *Spectroscopic Identification of Organic Compounds*, 8th Ed., 2015, John Wiley & Sons, Inc.
4. M. Rabiul Islam and Aminul H. Mirza, *Modern NMR spectroscopy (in Bangla)*, 3rd Ed., 2010, Ashrafia Boighar

Course No: **CHE 0531 4151**	Credit: 2.0	Year: Fourth	Semester: First
Course Title: **Chromatographic Methods**		Course Type: Theory	

Course Rationale: This course is aim to provide a fundamentals of separation science and theoretical skill of advanced separation techniques to implement for professional life after graduation.

Learning objectives:

The objectives of this course are:

- Acquaint students with the basic knowledge of separation techniques
- To conceptualize the chromatographic methods and its role in chemistry
- Make the students understand the theoretical background of existing chromatographic methods
- To develop skills to present a unified account of the techniques in current use for analytical purposes

Course Content:

Chromatography: IUPAC definition of chromatography, History of chromatography, Principles and classification of chromatographic methods**.**

Liquid phase chromatography on Column (Adsorption column chromatography, Partition column chromatography): Principle, methodology, stationary phases (adsorbents of different types-applicability and drawbacks) mobile phases, sample application, detectors and applications. Principle, methodology, elution procedures, stationary phases, solid supports and coating materials, mobile phases and application.

Gel Chromatography: Nature and structure of the gel, principle and methodology of gel permeation chromatography (GPC) and its application, Principle of affinity chromatography, coupling of ligands to gels, application of gel chromatography in biochemical and chemical studies.

Electrophoresis: Principle, classification, paper electrophoresis, gel electrophoresis, capillary electrophoresis, application.

Gas Chromatography: Principle, Instrumentation of GLC, Column resolution and efficiency, Sampling techniques, Column (packed, capillary), column oven, carrier gas, sample injection, separations of isomers in GC, Band broadening and van Deemter model, Detectors (TC, FID, ECD) application and overview of gas solid chromatography.

High performance liquid chromatography (HPLC): Basic principle, modes of HPLC, Instrumentation, retention, column efficiency, Column packing and stationary phases, solvent selection and delivery system (pump), reverse mode of HPLC**,** Handling of ionic and ionizaable and optically active materials, detectors and working principle**.**

GC-MS: Introductory materials and application of GC-MS

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Express principle of separation and classification of chromatographic methods in broad spectrum and their application in column chromatography, affinity chromatography and GC.

CO2. Demonstrate the importance of detectors and their pros and cons related to chromatography. Explain the stationary and mobile phases and their roles in separating the analytes from their mixture.

CO3. Select proper phases, handle samples and importance of sample derivatization, Explain the mechanism of GPC and its use in determine molecular weight.

CO4. Express the basic principle of electrophoresis and their application in analytical chemistry.

CO5. Justify the superiority of HPLC over other chromatographic techniques and can interpret the band broadening and their remedy process, Plan the practical analysis by using GC, HPLC, and GC-MC.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes (PLOs)									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2			3							
CO3							3			
CO4							3			
CO5						3				

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, presentation, Journal article reviews, problem analysis	Essay type test, problem solving

Books Recommended:

1. Chromatographic Methods, Braithwaite, A. and Smith, F. J. (5th ed.) Blackie Academic and Professional, 1996
2. Gas and Liquid Chromatography in Analytical Chemistry, Smith, R. M. John Willey and Sons, 1988
3. Gas Chromatography, Fowlis, I. A. John Willey and Sons, 1995
4. Introduction to High Performance Liquid Chromatography, Hamilton, R. J. and Sewell, P. A. (2nd Edition), Chapman and Hall, 1986

Course No: **CHE 0531 4152**	Credit: 1.5	Year: Fourth	Semester: First
Course Title: **Analytical Chemistry Practical**		Course Type: Practical	

Course Rationale:

This laboratory-based course is aimed to develop skills upon students based on Analytical Techniques to serve as a future professional chemists.

Learning Objectives:

The objectives of this course are:

- To develop skills to prepare a desired standard solution/sample and its standardization whenever necessary
- Acquaint students with the basic tools for extract the desired constituent from the samples which are important for specific sample analysis
- To make them able to design and perform an experiment for quantitative estimation maintaining accuracy and precision.

Course Content (7-10 experiments to be done):

Chromatographic technique:

1. Separation of amino acids by ascending paper chromatographic methods.
2. Anion ion exchange chromatographic separation of Cobalt and Ni

Back titrimetric methods: Estimation of acid neutralizing capacity of antacid tablet utilizing back titration technique.

Solvent extraction: Analysis of iron alloy or ore after extraction and then titration with $K_2Cr_2O_7$.

Spectrophotometric analysis:

1. Determination of iron content from iron supplement tablets. (iron chloride tablets and iron-folic acid combination)
2. Determination of iron content of shallow well and deep tube well water samples of locality.
3. Determination of PO_4 content of TSP fertilizer, detergent and from bone samples.

Assessment of Vitamins: 1. Estimation of vitamin C from green chili, citrus fruits, fruit juices. 2. Estimation of vitamin C from pharmaceutical samples.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to

CO1. To explain and implement standard operating procedures maintaining accuracy, precision, and also to prepare standard solutions, calibrating instrumentation, and competently set up experiment with their own for chemical analysis

CO2. To work both individually and collaboratively as part of a small team or group in order to accomplish an experimental goal, such as characterize a method of analysis or complete a specific chemical determination.

CO3. To acquaint with the practice of real time data analysis and presentation of data as per ISO standard.

CO4. To apply knowledge of the operating principles of specific analytical methods and instrumentation followed by error minimization by well referred methods (interpolation, extrapolation, standard addition method etc.) for practical sample analyses.
CO5. To apply analytical chemistry knowledge in quality management, problem solving, innovation, economic development, improvement in quality of life and environmental sampling and analysis.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		3								
CO2		3								
CO3		3								
CO4		3								
CO5		2						2		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Lab Demonstration	Class test (Short Q and MCQ)
CO2	Lab Demonstration on solution preparation and installation of equipment.	Spot test and experimental performance evaluation
CO3	Lab Demonstration on instrumental analysis	Assessment of instrumental handling and data presentation
CO4	Problem solving on data analysis and tips for good graphical presentation (hand written and software based graphs).	Oral test and report evaluation
CO5	Lab Exam on specific experiment	Assessment of Oral presentation and grading based on overall skill attained

Books Recommended
1. Analytical Chemistry, 7th edition by Skoog, West, Holler
2. Analytical Chemistry, 5th edition by Gary D. Christian
3. Vogel's Quantitative Analysis

Course No: SPS **1015 4153**	Credit: 1.0	Year: Fourth	Semester: First
Course Title: **Industrial Tour**		Course Type: GEd Exposer	

Course Rationale:
Industrial tour for a chemistry graduate is to provide valuable experiences that help bridge the gap between academic learning and real-world applications, leading to a more well-rounded education and better preparation for a career in the field.

Learning Objectives:
The objectives of this course are:
- To visit an industry and gather practical knowledge about industrial operational units.
- To acquire the management skill to do job in industrial operational sector.
- To know about the differences between theoretical suggestions and practical implementations of industrial rules and regulation, which will help to build up their future carrier.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Recognize the imparted knowledge of the industrial operational processes in real-world
CO2. Assure the quality of raw materials for the best industrial operational product output
CO3. Integrate the knowledge of the sustainable industrial sector based on his or her theoretical knowledge that has been delivered on this subject

CO4. Display the workplace culture, ethics, and regulations in the chemical industry
CO5. Be inspired and motivated for future careers in the field

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1						3				
CO2						2				2
CO3			2			2				
CO4							2			2
CO5										3

Assessment Method:
- Student will be assessed based on report submitted after the visit an industry, and
- Presentation/Viva performed by each student

Course No: **BUS 0413 4101K**	Credit: 2.0	Year: Fourth	Semester: First
Course Title: **Business Management and Entrepreneurship**		Course Type**:** Theory (GEd)	

Course Rationale:
This course provides students with an opportunity to explore the skills, interests, and values most likely to build up their careers perfectly and build the entrepreneurship mindset.

Course Objectives
The Objectives of the Course are:
- To conceptualize career along with the stages of career development
- To introduce the students with the concepts and practical scenario of enterpreneurship
- To acquaint them with job stress and how to manage it

Course Content:
1. **Introduction to the study of career:** Definition, the changing landscape of work; career concepts; need to understand career management.
2. **Model of Career Management:** Overview of the career management model, theory, model, career management as an ongoing process, indicators of effective career management. Guidelines for career exploration, types and techniques for effective Self-Exploration programs, career goal setting, career strategies, career appraisal, and career management.
3. **Occupational Choice, Preparation for Work:** Theories of occupational choice; guidelines for effective occupational decision making.
4. **Job Stress and Management:** Job stress; sources and consequences of stress; coping, social support, and stress.
5. **Entrepreneurship:** Concept, functions and need; Myths about Entrepreneurship, advantage and limitations of entrepreneurship; Choosing an entrepreneurial career, support for the entrepreneurial career, Entrepreneurship - The Bangladesh Scenario.

Course Learning Outcomes (COs)
After the successful completion of the course, students will be able to:
CO1. Analyze and apply career concepts for the development of one's career as an entrepreneur
CO2. Analyze and apply the common career management concepts and models to be guided for career exploration
CO3. Apply guidelines for effective occupational decision-making
CO4. Explain and evaluate sources and consequences of stress
CO5. Internalize the concepts and Functions and process of Entrepreneurship

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1						2	1			1
CO2						3				
CO3						3				1
CO4							3			
CO5										3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test.
CO5	Lecture, presentation, Journal article reviews, problem analysis	Essay type test, problem solving

Course No: **CHE 0531 4222**	Credit: 3.0	Year: Forth	Semester: Second
Course Title: **Solid State Chemistry and Crystallography**		Course Type: Theory	

Course Rationale: This course is designed to provide students with a sound concept on studying structure-property relationship of inorganic crystalline solids and their analysis using advanced characterization techniques, and their application in technology.

Learning Objectives:

The objectives of this course are:

- To provide students with basic concepts of atomic arrangements in crystalline solids.
- To introduce advanced characterization techniques to study crystal structures.
- To learn crystal defects and their effects on properties of solids.
- To familiarize with electrical, optical and magnetic properties of solids and their application in science and technologies.
- To learn solid state reactions and their mechanism.

Course Content:

Introduction: Scope of Solid State Chemistry and Chemical Crystallography, crystalline and amorphous solids, liquid crystals, Isomorphism and polymorphism.

Crystal Structure: Types of Crystals, Crystal system, Unit cell, crystal lattice, Bravis lattice, Miller indices, Brilluin zone, Reciprocal lattice, Symmetry operation and symmetry elements, point groups, space groups, close pack structures-- cubic and hexagonal, some important structure types-- sodium chloride, Zinc blend, Diamond, Wurtzite, Pervoskite and Spinel structure.

Diffraction Techniques: X-ray Diffraction, Nature and production of X-ray, Bragg's law. The Powder method--theory, technique and application. Single crystal X-ray diffraction. Principle of Neutron and electron diffraction.

Crystal Defects: Perfect and imperfect crystals. Types of crystal defects, thermodynamics and equilibrium concentration of intrinsic defects. Creation and properties of color centers, influence of defects on physical properties of solids, non-stoichiometry, Solid solution.

Electrical properties of solid: Band theory of solid, Band structure of metal. Semiconductor and Insulator, intrinsic and impurity semiconductors, Hall effect, transistors, superconductivity.

Magnetic and optical properties: Magnetic properties of metals. Optical properties: Luminescene, Lasers, Photocopying process.

Reactions of Solids: Solid–gas, solid-liquid, solid-solid reactions. Kinetics of thermal decomposition reactions. Factors influencing reaction in solids, photographic process.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe the properties of crystalline solids

CO2. Realize the internal structure (atomic level) of crystalline solids

CO3. Internalize the basic parts and principles of X-ray diffraction, neutron diffraction and electron diffraction techniques and how they are used to analyze crystalline solid samples

CO4. Explain various types of defects and their effects on the properties of crystalline solids

CO5. Explain the optical, magnetic and electrical properties of solids and utilize them in technology and interpret the reaction of solids and their preparation methodologies

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3			3							
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture Demonstration (PPT)	Class test
CO2	Lecture Demonstration (PPT), Question-Answer session, Group discussion for problem analysis, Video clips	Quiz, assignment
CO3	Lecture Demonstration (PPT), Question-Answer session	Class test, assignment
CO4	Lecture Demonstration (PPT), Group discussion	Short and Broad Question
CO5	Lecture Demonstration (PPT)	Short and Broad Question

Recommended Text Books:

L. V. Azaroff, *Introduction to solids*
L. S. Dent and Glasser, *Crystalllography and its application*
B. D. Cullity, *Elemnts of X- ray diffraction*
R. S. Drago, *Physical Methods in Chemistry*
R. West, *Basic Solid State Chemistry*
R. C. Evans, *An introduction to crystal chemistry*
P. W. Atkins, *Selected topics from Physical Chemistry*
Douglas, Mc Daniel, Alexander, *Concepts and Models of Inorganic Chemistry*

Course No: **CHE 0531 4232**	Credit: 2.0	Year: Fourth	Semester: Second
Course Title: **Bioinorganic Chemistry**		Course Type: Theory	

Course Rationale:

This course is designed to achieve knowledge of various essential elements, porphine, its derivatives, and metalloporphyrins, broadly explain photosynthesis and respiration, and primarily the chemistry of metal ions in medicine.

Course Objectives:

The objectives of this course are to:

- Provide students with a detailed knowledge of fundamental aspects of current topics, e.g. structure and functions of hemoglobin and myoglobin, photosynthesis, metabolism, and metalloenzymes.
- Make the students understand the concepts of coordination chemistry in biological environments
- Utilize the knowledge to analyze the reactivity of a metal center and electron transfer and energy transfer in biological systems
- Foster the analytical and critical thinking for the development of e.g. metalloenzyme applications, material synthesis, and pharmaceutical

Course content:

Essential Elements: General aspects, availability of elements, roles of essential trace metal ions, Na, K, Ca, Mg, Co, etc. ion pump.

Metalloporphyrins, Photosynthesis, and respiration: Porphyrin ring systems, chlorophyll, cytochromes, oxygen transport and storage, oxygen careers, model compounds, iron porphyrin, hemoglobin, and myoglobin function.
Biological chemistry of iron: Introduction to biological chemistry, non-hame iron-iron uptake, non-haem iron proteins, rubredoxin and ferredoxins, Heme iron-properties of isolated heme unit, heme protein functions, electron transfer, oxidase, and dioxygenase.
Metalloenzymes: Nonredox metalloenzymes, peroxidase, and catalase, the role of copper.
Metal ions in medicine: Inorganic drugs, chelate therapy

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Explain the roles of essential trace metal ions, Na, K, Ca, Mg, Co, etc. in the human body and other biological systems.
CO2. Relate the structure and functions of porphyrin ring systems in biological systems. Electron transfer and energy transfer in biological processes.
CO3. Interpret the Iron intake, storage, oxygen, CO_2 transfer, and electron transfer by heme and non-heme iron.
CO4. Explain the enzymes and their classifications and functions, biocatalysis.
CO5. Plan an application of metal ions and metal complexes in medicine and therapy.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2			3							
CO3	1		3							
CO4	3									
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture using PPT, *Whiteboards*, and discussion	Assignment and quiz
CO2	Lecture using PPT, *Whiteboards*, and demonstration	Class test (Short Q and MCQ)
CO3	Lecture using PPT, *Whiteboards*, and open discussion	Short Q, MCQ, Quiz, Explanation
CO4	Lecture using PPT, *demonstration*, and Group discussion	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT, demonstration, and Group discussion	Short Q, MCQ, Quiz, Explanation

Books Recommended:

1. Biological Inorganic Chemistry, Structure and Reactivity, Ivano Bertini, Harry B. Gray, Edward I. Stiefel, Joan S. Valentine, 2007, University Science Books, Sausalito, CA
2. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide, Wolfgang Kaim, Brigitte Schwederski, Wiley; (2nd edition) 2013
3. Inorganic Biochemistry: An Introduction, J. A. Cowan, 1996
4. The Biological Chemistry of the Elements: The Inorganic Chemistry of Life, J. J. R. Frausto Da Silva, R. J. P. Williams, Frausto Da Silva, 2001
5. Bioinorganic Chemistry: A Short Course, Rosette M. Roat-Malone, 2002
6. Principles of Bioinorganic Chemistry, Stephen J. Lippard, Jeremy M. Berg, 1994
7. Bioinorganic Chemistry, Ei-Ichiro Ochiai, 2008

Course No: **CHE 0531 4242**	Credit: 2.0	Year: Fourth	Semester: Second
Course Title: **Selected Topics on Biological and Medicinal Chemistry**		Course Type: Theory	

Course Rationale:
For chemistry students, it is necessary to have a basic idea about the chemistry of living systems and pharmaceutical products. This course is designed to provide fundamental knowledge of the chemistry of living systems and the preliminary concepts of common drugs and their formulation and application.
Course Objectives:
The objectives of this course are:
- To acquire the necessary knowledge on the components of vitamins and their basic requirement in the human body
- To conceptualize the knowledge about the structures of enzymes and their action in the living organisms
- To provide knowledge on the metabolism of common biomolecules
- To make them familiar with the basic concepts of drugs and their action regarding some common drugs

Course Content:
Vitamins (Fat and water-soluble): Definition, classification, structures, occurrences, the effect of deficiency, and human requirements.
Enzymes and coenzymes: Classification, characteristics, structure, and mechanism of action.
Metabolism: Definition, terminology, metabolic pathways. Outlines of Carbohydrate, lipid, and amino acids metabolism.
Drugs: Classification of drugs with examples, Major process of drug action (Pharmaceutical phase, pharmacokinetic phase, and pharmacodynamics phase), and Drug formulation.
Chemistry and application of some important drugs: Sulpha drugs, analgesics, narcotic analgesics, antihistamines, adrenergic drugs, antimalerial drugs, anesthetic agents and local anesthetics, antibiotics **(**General discussion and mode of action of penicillin and chloramphenicol).
Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Discuss different classes of vitamins and their role in the human body and the basic concepts of enzymes and coenzymes along with their mechanism of action
CO2. Delineate the fundamental points of metabolism and the metabolic pathways of common biomolecules
CO3. Describe the common classes of drugs, the major processes of action, formulation, and the mode of action
CO4. Explain the metabolic processes of carbohydrates, fat, and protein in the living system and the role of vitamins and enzymes involved in those processes
CO5. Interpret the common disorder of living systems and the action of drugs for their remedy
Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3			3							
CO4			3							
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration, Open discussion	Class test (Short Q and MCQ)
CO2	Lecture, PPT Demonstration, animated VDO clips, Discussion, Open discussion	Class test (Quiz, Short Q)
CO3	Lecture, PPT Demonstration, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ), Assignment
CO4	Lecture, PPT Demonstration, animated VDO clips, Group discussion	Short Q, MCQ, Quiz, Explanation)

CO5	Lecture, PPT presentation, Group discussion	Short Q, MCQ, Quiz, Explanation

Books Recommended:

1. Sally Solomon, *Introduction to General, Organic and Biological Chemistry*, 1987, McGraw Hill Book Company, NY, USA
2. David L. Nelson and Michael M. Cox, *Lehninger Principles of Biochemistry*, 8th Ed., 2021, W. H. Freeman Macmillan Learning, New York, USA
3. J. L. Jain, S. Jain, and N. Jain, *Fundamentals of Biochemistry*, 6th Ed., 2020, S. Chand Company Ltd., New Delhi, India
4. J. B. Taylor and P. D. Kennewell, *Modern Medicinal Chemistry*, 1st Ed., 1993, Ellis Horwood, NY, USA
5. I. L. Finar, *Organic Chemistry*, Vol. 2, 5th Ed., 1975**,** Longman, UK

Course No: **CHE 0531 4243**	Credit: 2.0	Year: Fourth	Semester: second
Course Title: **Organic Reagents and Syntheses**		Course Type: Theory	

Course Rationale:

This course will deal with the construction of organic structures with various synthetic strategies using organic reagents. The importance of chemical synthesis for organic compounds is evident and particularly the use of retrosynthesis for discovering new and improved synthetic routes. This course is extremely useful to students of undergraduate, and graduate studies.

Course Objectives:

The objectives of this course are:

- To get adequate knowledge on the reagent used for oxidation and reduction reactions of organic compounds
- To know about the reactivity of active methylene compounds
- To obtain desired organic compounds using the protection of required functional groups
- To know about the synthesis, properties, and applications of organometallic compounds
- To develop adequate knowledge on the design and synthesis of organic compounds by retrosynthetic approach.

Course Content:

Oxidation reaction: Oxidation of hydrocarbon, alcohols, Allylic oxidation; Oxidation with cromic acid, $KMnO_4$, peroxy acids, SeO_2, and Fremy's salts. Mechanism of Oppenheimer reaction.

Reduction reaction: Catalytic hydrogenations, metal hydride reduction ($LiAlH_4$, $NaBH_4$), dissolving metals reduction, Wolff-Kishner reduction, Clemmensen reduction.

Synthesis involving active methylene group: Reactivity and applications of active methylene compounds**.**

Protection and deprotection of functional groups: Synthesis involving interconversion and protection of functional groups like -OH, -CHO, C=O, -COOH, $-NH_2$, etc.

Designing of Organic Synthesis: Synthesis, basic terms of retrosynthetic analysis, initial consideration of the retrosynthetic approach, design, and synthesis applying disconnection approach. The importance of the order of events in organic synthesis, one group C-X and two groups C-X disconnections, chemoselectivity; One Group C-C Disconnections-Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenic compounds in organic synthesis. Two Group C-C Disconnections: Diels-Alder reaction, 1,3-difunctionalised compounds, unsaturated carbonyl compounds,1,5-difunctionalised compounds, Michael addition, and Robinson annulation.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Discuss the role of reagents in organic synthesis and apply oxidizing agents & reducing agents in an organic reaction.

CO2. Apply active methylene compounds and organometallic reagents in organic synthesis

CO3. Plan organic syntheses using the protection of the required functional group

CO4. Apply the disconnection approach for the planning of synthesis with suitable synthons

CO5. Identify suitable reaction sequences to achieve the synthesis of target molecules in a multi-step synthesis by retrosynthetic approach

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3			3							
CO4			1	2						
CO5			1	2						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO2	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO3	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ),
CO4	Lecture, PPT Demonstration, Open Discussion, Question-Answer session	Problem-solving assignment, Essay type assessment
CO5	Lecture, PPT Demonstration, Group discussion for problem analysis	Problem-solving assignment, Essay type assessment

Books Recommended:

1. Stuart Warren and Paul Wyatt, *Organic synthesis: The disconnection appr*oach, 2nd edition,2008 (John Wiley & Sons)
2. I. L. Finar, *Organic Chemistry* VOL. I (Longman Group Ltd.)
3. B. Smith, *Organic Synthesis*, 4th edition, 2016, (Academic Press)
4. *William Carruthers* & *Iain Coldham, Modern methods of Organic Synthesis,* 4th edition, 2004 (Cambridge University Press)
5. Jonathan Clayden, Nick Greeves, Stuart Warren, *Organic Chemistry*, 2nd Edition
6. H. O. House, *Modern Synthesis Reactions*, 2nd edition (W. A. Benjamin, New York)

Course No**: CHE 0531 4253**	Credit: 2.0	Year: Forth	Semester: Second
Course Title: **Electroanalytical Techniques**		Course Type: Theory	

Course Rationale:

This course is aimed to provide students about the basic principles as well as working mechanisms of some selected electroanalytical methods and their applications in analytical chemistry.

Learning Objectives:

The objectives of this course are:

- To achieve the necessary understanding of the fundamentals of electroanalytical techniques
- To provide the knowledge of instrumentation of electroanalytical techniques
- Apply the knowledge of the electroanalytical techniques in various practical applications

Course Content:

Potentiometry: Theory, potentiometry and standard potentials, liquid junction potentials. Theory of ion-selective electrodes, apparatus for potentiometry, quantitative analysis with ion-selective electrodes.

Fundamental principle of polarography: Principle, current - voltage relationship, the half wave potential, characteristics of the dropping mercury electrode (DME), Polarographic currents, factor affecting diffusion current, polarographic maxima, Oxygen interference, application.

Modern voltametric techniques: DC and alternating current polarography pulse polarography, Derivative pulse polarography, are polarography, first linear, cyclic voltametry, Anodic stripping voltametry**.**

Amperometic titration methods: Definition, illustration with examples, Methodology, successive titration comparison with other.

Coulometric methods: Principles, instrumentation, Applications of controlled potential coulometry. Constant current coulometry. Primary coulometric titration, secondary coulometric titration titration method.
Electrogravimetry: Principles, important terms used in electro gravimetric analysis (polarized electrode, current efficiency, decomposition potential overpotential), Completeness of deposition**,** Electrolytic separation of metals**,** Principle of constant current electrolysis, determination of copper by of constant current electrolysis, Principle of controlled electrode potentials, determination of metals from alloys (eg copper and lead in brasses by controlled electrode potentials electrolysis), potential buffers.

Course Learning Outcomes (COs):

Students who successfully complete the course will be able to

CO1. Explain the principle of, potentiometry and explain the function of the indicator electrode including metal electrode, membrane electrode in the potentiometric measurement and understand electrochemical reaction at electrode interface.
CO2. Explain the principles and understating the depth inside of the polarographic technique for the measurement of inorganic and organic substances in the samples. Explain the various factors that can influence the performance of polarographic and potentiometric analysis.
CO3. Explain the principles and applications of modern voltametric techniques, comparative study of DC and AC Voltammetry, functions of microelectrode in the analysis and various influential factors that has to be controlled for this analysis.
CO4. Interpret the fundamentals of electrogravimetry, coulometry, and amperometric titration, as well as how each of these techniques can be used to address a number of global issues.
CO5. Develop or build highly sensitive chemical sensors or biosensors for the qualitative or quantitative detection of analytes using the acquired knowledge of amperometry, potentiometry, and voltammetry.

Mapping of Course Learning Outcomes (COs) with Pos
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3									
CO4			3							
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. Bockris and Reddy, *Modern Electrochemistry*
2. D. R. Crow, *Principles and application of electrochemistry*
3. Electrochemical methods, *Bard & Faulkner*
4. P. W. Atkins, *Selected topics from physical Chemistry*
5. Skoog, *Analytical Chemistry*
6. Willard, Merit, Dean and Jones, *Instrumental Methods of Analytical Chemistry*
7. P. F. W. Fifield & D. Kraley, *Principles and Practice of Analytical Chemistry*

Course No: **SPS 0223 4281**	Credit: 2.0	Year: Fourth	Semester: Second
Course Title: **Personal Behaviors and Professional Ethics**		Course Type: Theory (GEd)	

Course Rationale
For Chemistry professional to know and practice the personal behaviors and professional ethical issues and societal challenges derived are very important for the professionalism.

Course Objectives:
The objectives of the course are:

- To introduce the students with the personal behaviors and basics of ethical framework that guides professional chemists in the conduct of their duties,
- Make them able to focuses on solving practical issues that arise in professional practice,
- To make them prepared to practice the fundamental principles, ethical behavior, social responsibility of organizations

Course Content:
Introduction: Definition of ethics and morality, relativist and absolute visions of ethics, difference between believes, behavior and aims of moral values, personal and social ethics
Profession and Ethics: Introduction to Professional Ethics for Chemists and Professionalism, Professional Conduct and Ethics
Interpersonal Relations: Interpersonal Behavior, Formation of Personal Attitudes, Language and Communication, Motivations and Emotions, Public Opinion
Social Ethics: Aristotle Nsicomachean Ethics (selection), Doing One's Duty, Creating Ourselves, Hearing the Feminine Voice
Introduction to Organizational Behavior: Organizational Disciplines and topics, Psychological Perspective, Social-Psychological Perspectives
Individual Differences: Personality and its factors, Personality dimensions and social learning, Intelligence
Ethics for Research and Scientific Communication: Plagiarism and improper authorship; falsification of data; misappropriation of the ideas of others; non-disclosure of information; misrepresentation of scientific experiments, funds or other resources; misrepresentation of qualifications; the violation of generally accepted research practices.
Commitment to Society: *Roles and commitments of Chemistry professionals and the ethical issues involved to serve society. False Qualifying and certifying of consumer products, Chemical safety measures, wastage and wastage management issues, etc.*

Course Learning Outcomes (COs):
On successful completion of the module, participants shall be able to:
CO1. Define and realize the of ethics, morality, ethical judgment, freedom of the will, and role of ethics in professional development
CO2. Describe and classify the individual attitude and organizational behavior
CO3. Identify, discuss and relate basic ethical terminology and concepts to ethical problems in Chemistry related professions and professionalism
CO4. Follow and implement the acquired knowledge of ethical skills in practical situations
CO5. Debate and recognize conflicts in an ethical way at national and international level

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1									3	1
CO2										3
CO3									2	2
CO4										3
CO5									2	2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**

CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test.
CO5	Lecture, presentation, Journal article reviews, problem analysis	Essay type test, problem solving

Course No: **CHE 0531 4271**	Credit: 2.0	Year: Fourth	Semester: Second
Course Title: **Research Project**		Course Type: Capstone	

Course Rational:

For the fulfillment of knowledge in chemistry and related subjects, chemistry graduate, it is very essential to carry out a research project to practice all the important skills they have gained during their graduation. This course ensures the students' attainment of different skills like cognitive, effective, communication, collaboration, working in a group, data collection, and manipulation, maintaining ethical matters, etc.

Course Objectives:

The objectives of this course are:

- To familiarize students with the academic research
- To give them in hand opportunity to do their own research with the help of a supervisor
- Make them able to collect the data and analyze them to make conclusion
- Help them to be skilled in writing a academic research report
- Make them able to communicate the scientific results in written, orally and representatively

Course Learning Outcomes (CO):

After the successful completion of the course, students will be able to:

CO1. Think critically and develop the solution to design a research project utilizing the common lab experiences
CO2. Incorporate knowledge and ideas to plan a good research project
CO3. Communicate the scientific results in written, orally and representatively
CO4. Practice norms and ethics for data manipulation, and scientific and academic research
CO5. Pave the way of life long learning

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1			3							
CO2			3							
CO3					3					
CO4							1		3	
CO5										3

Assessment Method:

Project experiment to be announced at the beginning of the 4th year 1st semester. The project will be given according to the result of the students and the availability of the project facilities. Final score/grade will be made by the examination committee based on evaluation done by the supervisor, experts and score of oral presentation. The evaluation by the respective examiners, supervisor and that for the presentation will be as described in the following rubric:
(Marks distribution: Supervisor: 30%, Examiners: 30% (average of two independent examiners (30+30)/2, Viva and presentation:4 0%), Total: 100

Report Evaluation (Marks: Supervisor, Examiner 30)			
	Excellent	**Good**	**Poor**
Project Title *Title of the needs to match with the objectives and should reflect the activities and expected outcomes.*	Project Title matches very perfectly and reflect the overall activities of the project	Project Title matches with objectives but do not reflect the overall activities of the project	Project Title does not match with the activities of the project
Background *Student should present a brief background on the significance of the project and the current research related to the topic.*	Background and significance of project fully explained	Background or significance given but not explained	No background or significance of project given
Purpose for choosing project *Student should share personal reasons for choosing this project.*	Purpose for choosing project explained	Purpose for choosing project mentioned	No purpose for choosing project given
Methodology and Experimental Procedure *Student should summarize the experimental procedure, including pictures.*	Experimental procedures thoroughly described and picture(s) present	Experimental procedures described and picture(s) present	Experimental procedures not described and no pictures presented
Presentation of Results *Student should use data tables to show the results of the experiment.*	Data tables present, properly titled and labeled, and thoroughly explained	Data tables present, properly labeled, and described	Data tables present but not described OR not properly labeled
Discussion and Conclusion *Student should explain whether the results support or refute the hypothesis and explain their conclusions.*	Hypothesis supported or refuted and conclusions demonstrate deep understanding of the project	Hypothesis supported or refuted and conclusions are thoughtful	Surface level conclusions reached but no mention of original hypothesis

Presentation (Marks:40)			
	Excellent	**Good**	**Poor**
Content of the Presentation	-The facts are clear, understandable -Students discuss the subject in great details -Student describes in detail about their topic	-The facts are clear, understandable -Students discuss the subject with some details -Student outlines their topic	-The facts were not correct -Students discuss the subject with very minimal details -Students do not outline what they have learnt
Delivery	-The presentation was very creative -Good posture -Eye contact with the audience most of the time -Appropriate gesture and expression -Deliverance with confidence	-The presentation was somewhat creative -Good posture -Frequent eye contact with the audience -Appropriate gesture and expression	-The presentation was not good. -Poor posture -Seldom eye contact with the audience -Not enough easy during presentation
Answering to the Question making logical Arguments	-Answers All the questions asked properly -Makes logical argument nicely	-Answers some of the questions asked properly -Makes logical argument vey weekly	-No Satisfactory Answer for most of the Questions asked -Unable to make logical argument

Course No: **SPS 0031 4272**	Credit: 2.0	Year: Fourth	Semester: Second
Course Title: **Industrial Assignment**		Course Type: Exposer (GEd)	

Course Rationale:

This course is to give practical experiences of the work environment of the chemical industry to the students. The student will gather hands on experience in different chemical industries.

Learning Objectives:

The objectives of this course are:

- to expertise students on the real industrial duties
- to prepare them for their future carrier in suitable industry
- Acquiring hands-on experience in industry-specific tasks and processes

Course Content:

Each student will be assigned to a chemical industry for the duration of two weeks under the supervision of a teacher. During their staying in the industry, h/she will follow the chemical process and the related mater under the assigned authority of that industry. After the visit, the student will submit a report to the examination committee that will be evaluated jointly by the supervisor, examiners, and viva/ presentation as per the following assessment rubric.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Students will get in depth knowledge of chemical industry and get the opportunity to apply theoretical knowledge to practical problems

CO2. Connect with industrial authority and may secure jobs for the future

CO3. Build professional connections and relationships with industry professionals

CO4. Expose to potential job opportunities and a better understanding of the job market

CO5. Recognize the current trends and latest technologies

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1							2			1
CO2						3				
CO3						3				
CO4						3	1			
CO5							1			2

Assessment Method:

Students will submit detailed report on the industry they will visit and will present the report with a PowerPoint presentation and face viva voce. Final evaluation will be made by the examination committee based on supervisor's opinion, experts' opinion and oral presentation. (Marks distribution (30+30×2/2+40)

(Marks distribution: Supervisor: 30%, Examiners: 30% (average of two independent examiners (30+30)/2, Viva and presentation: 40%), Total: 100

Report Evaluation (Marks: Supervisor, Examiner 30)			
	Excellent	**Good**	**Poor**
Project Title *Title of the needs to match with the objectives and should reflect the activities and expected outcomes.*	Project Title matches very perfectly and reflect the overall activities of the project	Project Title matches with objectives but do not reflect the overall activities of the project	Project Title does not match with the activities of the project
Background *Student should present a brief background on the significance of the project and the current research related to the topic.*	Background and significance of project fully explained	Background or significance given but not explained	No background or significance of project given
Purpose for choosing project *Student should share personal reasons for choosing this project*.	Purpose for choosing project explained	Purpose for choosing project mentioned	No purpose for choosing project given
Methodology and Experimental Procedure *Student should summarize the experimental procedure, including pictures.*	Experimental procedures thoroughly described and picture(s) present	Experimental procedures described and picture(s) present	Experimental procedures not described and no pictures presented
Presentation of Results *Student should use data tables to show the results of the experiment.*	Data tables present, properly titled and labeled, and thoroughly explained	Data tables present, properly labeled, and described	Data tables present but not described OR not properly labeled
Discussion and Conclusion *Student should explain whether the results support or refute the hypothesis and explain their conclusions.*	Hypothesis supported or refuted and conclusions demonstrate deep understanding of the project	Hypothesis supported or refuted and conclusions are thoughtful	Surface level conclusions reached but no mention of original hypothesis

Presentation (Marks:40)			
	Excellent	**Good**	**Poor**
Content of the Presentation	-The facts are clear, understandable -Students discuss the subject in great details -Student describes in detail about their topic	-The facts are clear, understandable -Students discuss the subject with some details -Student outlines their topic	-The facts were not correct -Students discuss the subject with very minimal details -Students do not outline what they have learnt
Presentation and Delivery	-The presentation was very creative -Good posture -Eye contact with the audience most of the time	-The presentation was somewhat creative -Good posture -Frequent eye contact with the audience	-The presentation was not good. -Poor posture -Seldom eye contact with the audience
Answering to the Question making logical Arguments	-Answers All the questions asked properly -Makes logical argument nicely	-Answers some of the questions asked properly -Makes logical argument vey weekly	-No Satisfactory Answer for most of the Questions asked

Course No: **CHE 0531 4273**	Credit: 2.0	Year: Fourth	Semester: Second
Course Title: **Advanced Practical**		Course Type: Practical	

Course Rationale: This course is aimed to develop among students the skills in advanced practical work through the design and implementation of experimental procedures, techniques, and data interpretation.

Course Objectives:

The objectives of this course are:

- To impart knowledge on the advanced level experiments

Course Content:

Requisite numbers of experiments are to be chosen based on available facilities, some of the experiments are indicated below

1. Determination of equilibrium constant of reaction by the measurement of e.m.f. and by titration
2. Characterization of polymers by measurements of destiny, viscosity. I spectrum and by DTA
3. Determination of excess surface concentration and thermodynamic parameters by measurement of surface and interfacial tensions of different liquid paints
4. Determination of the industry of a UV source and study of various photochemical reactions
5. Determination of Hait parameters of different types of semiconductors
6. Study of the electronic phenomena
7. Study of adsorption of gases on solid surface
8. Preparation of colloids and study of their catalytic properties

9. Preparation and characterization of carbonatotraammniceobalt(III)[$Co(NH_3)_4Co_3]NO_3$ and chloro penta ammine cobalt(III) chloride[$Co(NH_3)_5CH]Cl_2$
10. Aquation of $[Co(NH_3)_5CI]$
11. Preparation of hexamineiron(III) chloride [$Fe(NH_3)_6]CI_3$ or hexaammine cobalt(III) chloride and study of their magnetic properties
12. Determination of composition of the complex ion by Job's method
13. Preparation of 1,10- phenanthroline complex of Co(III) and characterization by UV-visible spectroscopy
14. Quantitative determination of metal ions by polarographic method
15. Multistep Synthesis of Organic and Inorganic molecules
16. Quantitative estimation of functional groups by volumetric analysis
17. Determination of ascorbic acid in supplied sample
18. Analysis of some common drugs
19. Estimation of reducing end groups and degree of polymerization of cellulose samples
20. Fermentation of supplied starch sample
21. Some analysis based on Ion-exchange chromatography
22. Some analysis based on Gel-Filtration
23. Separation of sample components by Paper chromatography (one dimensional, amino acid/carbohydrates, two ways separation of amino acids)
24. Purification of macromolecules by solvent extraction method
25. Spectrophotometry: Study of biologically active metal compounds
26. Experiments based on utilization of IR- spectroscopy
27. Separation of sample components by Combined method: TLC, column

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to
CO1. Demonstrate knowledge on advanced experiments.
CO2. Develop the skills necessary to conduct an independent investigation.
CO3. Deduce knowledge, experience and skills related to a variety of instrumental analytical and separation techniques

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1			3							
CO2										3
CO3			2							1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lectures, Lab demonstration	Reports, Viva Voce
CO2	Lectures	Reports, Oral Presentation
CO3	Instrumental demonstration	Reports, Oral Presentation

Course No: **SPS 1015 4280**	Credit: 0.0	Year: Fourth	Semester: Second
Course Title: **Study Tour**		Course Type: Exposer (GEd)	

Course Rationale:
This study tour provides educational and cultural experiences for students and enhances learning and understanding through exposure to new experiences and environments. Overall, the aim is to foster personal and professional growth, foster an appreciation for diversity, and provide a unique educational experience that cannot be replicated in the classroom.

Course Objectives:
The objectives of this course are:

1. Develop intercultural awareness and communication skills
2. Explore new perspectives and broaden one's worldview
3. Network and collaborate with individuals from different backgrounds and cultures
4. Gain practical experience and apply knowledge learned in the classroom to real-world situations

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Realized the enhanced self-confidence and independence
CO2. Think new perspectives and broadened worldview
CO3. Networking for career advancement opportunities and practical experience
CO4. Express the practice of personal and professional growth and development

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1										3
CO2										3
CO3							2			1
CO4										3

Assessment Method:
Students will not be assessed for this course as it bears no credit.

Course No: **CHE 0531 4291**	Credit: 1.0	Year: Fourth	Semester: Second
Course Title: **Academic and Scientific Presentation**		Course Type: Capstone	

Course Rationale
Communication skill is now a day is very vital for professionalism. For academic, industrial and research purposes communication of scientific results and view as well as social communication is very important. This course aims to make the students capable of making proper communication, particularly in their subject matters.

Course Objectives:
The objectives of this course are:
- To train the students to prepare a professional assignment
- To acquire skills in professional presentation
- Acquaint students with a proficient oral examination and critical thinking
- Train them to make a PowerPoint presentation

Course Content: Students will be assigned specific topics based on the curriculum of the previous two semesters. Students will prepare a detailed assignment (approximately 1000 words) based on their assigned topics and give an oral presentation before the exam committee. Besides the selected topic, the student will be asked any question on the basic topic studied throughout his/her 4-year program.
Course Learning Outcomes (COs): *After the successful completion of the course, students will be able to:***CO1.** Prepare a professional assignment on specific topics
CO2. Prepare for academic presentation
CO3. Make logic for the scientific statement on Chemistry
CO4. Prepare for a professional presentation, instant critical thinking, and problem-solving
CO5. Make an argument in front of the viva board and defend the viva board

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
O1	2				2					
CO2					3					
CO3			2		2					
CO4			3		1					1
CO5			3							1

Teaching- Learning and Assessment Strategies:
There will be no formal face-to-face instruction for the course. Students will learn throughout the semester from the respective related class lecture and discussions with teachers and among themselves. There will also be tutorial session where students will get the opportunity to discuss any related topics. The duration of the tutorial/ discussion class will be a total of 15 hours in a semester. Respective course teachers will provide the topics to each individual student for their presentation before the final presentation. Students will be evaluated and grades will be given on the basis of the marks given by the members of the examination committee individually or combinedly.

Assessment Rubric:

	Excellent (33p)	Proficient (25p)	Satisfactory (20p)	Poor (15p)
Content of the Presentation	-The facts are clear, understandable -Students discuss the subject in great details	-The facts are clear, understandable -Students discuss the subject with some details	-The facts are OK -Student discuss the subject with a few details -Student do not outline their topic	-The facts were not correct -Students discuss the subject with very minimal details

Course No: **CHE 0531 1101C**	Credit: 3.0	Year: First	Semester: First
Course Title: **Basic Chemistry for Engineer**		Course Status: Theory (GEd for CEE)	
Presentation and Delivery	-The presentation was very creative -Good posture -Eye contact with the audience most of the time	-The presentation was somewhat creative -Good posture	-The presentation was OK. -Intermittent good posture	-The presentation was not good. -Poor posture
Answering to the Question making logical Arguments	-Answers All the questions asked properly -Makes logical argument nicely	-Answers Most of the questions asked properly -Makes logical argument	-Answers Some of the questions asked correctly -Makes logical vey weekly	-No Satisfactory Answer for most of the Questions asked -Unable to make logical argument

(GEd) Courses offered by Chemistry Department
(2024-2025 session)

First Year: *Semester I*

Course No	Course Name	Hours/Week Theory + Lab	Credits	Department
CHE 0531 1101C	Basic Chemistry for Engineer	3 + 0	3.0	CEE
CHE 0531 1101P	General Chemistry	3 + 0	3.0	FES
CHE 0531 1102P	Chemistry Practical	0 + 4	2.0	FES
CHE 0531 1101J	General Chemistry	3 + 0	3.0	GEB
CHE 0531 1102J	Qualitative and Quantitative Chemical Analysis	0 + 4	1.5	GEB
CHE 0531 1101Q	Basic Chemistry for Engineers	3 + 0	3.0	MEE
CHE 0531 1112Q	Chemistry Sessional	0 + 4	1.5	MEE
CHE 0531 1101I	Organic Chemistry I	2 + 0	2.0	BMB
CHE 0531 1115 H	Engineering Chemistry	3+ 0	3.0	PME

CHE 0531 1112 H	Engineering Chemistry Lab	0 + 4	1.5	PME
CHE 0531 1101F	Organic chemistry	3 + 0	3.0	FET
CHE 0531 1102F	Organic Chemistry Practical	0 + 4	1.5	FET
CHE 0531 1109 B	Organic Chemistry	2 + 0	2.0	CEP

First Year: *Semester II*

Course No	Course Name	Hours/Week Theory + Lab	Credits	Department
CHE 0531 1202C	Experimental Chemistry for Engineers	0 + 4	1.5	CEE
CHE 0531 1201E	Basic Chemistry for Engineers	3 + 0	3.0	EEE
CHE 0531 1202E	Experimental Chemistry for Engineers	0 + 4	1.5	EEE
CHE 0531 1201G	Basic Chemistry for Engineers	3 + 0	3.0	IPE
CHE 0531 1202G	Experimental Chemistry for Eng	0 + 4	1.5	IPE
CHE 0531 1201N	General Chemistry for Physics	3 + 0	3.0	PHY
CHE 0531 1202N	Chemistry Practical	0 + 4	1.5	PHY
CHE 0531 1203Q	Chemistry of Engineering Materials	3 + 0	3.0	MEE
CHE 0531 1201S	Basic Chemistry for Oceanographers	3 + 0	3.0	OCG
CHE 0531 1202I	Organic Chemistry II	2 + 0	2.0	BMB
Second Year: *Semester II*				
CHE 0531 2201L	Chemistry for Geographers	3 + 0	3.0	GEE
CHE 0531 2202L	Environmental Chemistry Practical	0 + 3	1.5	GEE

Course Rationale:
Candidates are expected to understand the structures, properties, and applications of atoms, molecules, and chemical compounds.

Course Objectives:
The objectives of this course are:
- Describe the basic concept of electronic structure in atoms and molecules.
- Acquire knowledge of the physical and chemical properties of elements in the periodic table
- Analyze the properties of molecular compounds from various types of mathematical calculations using chemical formulas.
- Identify properties of acids and bases based on various acid-base concepts.
- Understand the various state and properties of materials.
- Study and gain preliminary knowledge on reaction equilibrium and chemical kinetics.
- Familiarize the students with the basic chemistry of environment, agriculture, food and industry
- Recognize the fundamental aspects and applications in various fields for organic compounds.

Course Content:
Electronic Structure: The quantum theory, atomic spectrum of hydrogen and the Bohr model, Quantum numbers, Energy levels and orbital, Electronic configuration, Chemical bonding, and molecular structure.
The periodic Table: Development of the periodic table, Electron arrangements, and the periodic table, Summarized chemical properties of s-block, p-block, d-block, and f-block elements.
Chemical formulas and equations: Types of formulas, Percent composition from the formula, Formulas from experiment, Formulas of ionic compounds, Names of compounds, Writing and balancing chemical equations, Mass relations in reactions, Limited reactant, and theoretical yield. Concept of mole, Solution: different concentration units.

Acids and Bases: Theories and Modern definitions of acids and bases, Dissociation constant, strength, pH, Buffer solution, etc.
Gases: Measurement of gases, the ideal gas law, Volumes of gases involved in reactions, Gas mixtures, Partial pressure, Kinetic theory of gases, and Real gases.
Introduction to Chemical Kinetics: Rate laws, rate constant, equilibrium constant, order of reaction, etc.
Organic Chemistry: Introduction**,** Classification, Nomenclatures, preparations and Properties (Physical & Chemical) of (i) Aliphatic and aromatic hydrocarbons, (ii) Aldehydes and ketones, (iii) Carboxylic acids and (iv) Alcohols and phenols (v) Carbohydrates (mono- and disaccharides).
Chemistry of Fuels (Hydrocarbon, Hydrogen), **Fertilizer, & Medicine.**

Course Learning Outcomes:
After the successful completion of the course, students will be able to:
CO1 Recognize the basic structural properties in atomic and molecular levels of atoms and molecules, respectively, using various recognized Theories and Laws.
CO2 Describe the physical and chemical properties periodically of metal and non-metal. Demonstrate about chemical kinetics.
CO3 Predict and analyze the properties of molecular compounds from various types of mathematical calculations using chemical formulas.
CO4 Identify and explain various properties in qualitatively and quantitatively solid, liquid, and gaseous substances based on fundamental parameters.
CO5 Distinguish the chemical features and properties between inorganic and organic substances and understand their potential application in various applied fields.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1										
CO2	3											
CO3	3	1										
CO4	3	1										
CO5	3											

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT and demonstration of practical data	Assignment
CO2	Lecture using PPT	Class test (Short Q and MCQ)
CO3	Lecture using PPT and model demonstration	Final Exam (Short Q, MCQ, Quiz, Explanation)
CO4	Lecture using PPT	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and Group discussion	Final Exam (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
2. Haque and Mollah, *Physical Chemistry*
3. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
4. Raymond Chang, *General Chemistry*

Course No: CHE 0531 **1202C**	Credit: 1.5	Year: First	Semester: Second
Course Title: **Experimental Chemistry for Engineers**		Course Status: Practical (GEd for CEE)	

Course Rationale:
This course is aimed to make the student practically skilled in handling chemical compounds and focus on understanding their properties.

Course Objectives:
The objectives of this course are:
- Qualitative identification of cations and anions, and functional groups containing the inorganic and organic compounds, respectively.
- Demonstrate and analyze the recorded data in the report obtained from the laboratory.

Course Content:
Qualitative analysis of inorganic salts:
- Separation and identification of group I cations
- Separation and identification of group II cations
- Separation and identification of group IIIA and IIIB cations
- Separation and identification of group IV cations
- Separation and identification of group V cations
- Identification of anions

Qualitative analysis of organic salts:
- Analysis of the functional groups of organic compounds

Quantitative analysis:
- Standardization of NaOH solution with the standard oxalic acid solution

Course Learning Outcomes:
After the successful completion of the course, students will be able to:
CO1 Prepare and use the aqueous solution of inorganic compounds accurately for the identification of cations and anions using necessary reagents
CO2 Identify and understand the properties of various functional groups contained in the organic compounds
CO3 Determine and acquire knowledge on the concentration of solution using titrimetric analysis.
CO4 Demonstrate and analyze the recorded data in the report, and draw appropriate conclusions from the laboratory
CO5 Handle the chemicals and apparatus safely individually as well as work in a group

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1		3								
CO2		1		3								
CO3				3								
CO4		1						3				
CO5							3			1		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures and experiment demonstration	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination
CO5	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. Vogel, *Qualitative Inorganic Analysis*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)
4. Vogel, *Textbook of Quantitative Analysis.*

Course No: CHE 0**531 1101**P	Credit: 3.0	Year: First	Semester: First
Course Title: **GENERAL CHEMISTRY**		Course Status: Theory (GEd for FES)	

Course Rationale:
Students will learn basic concept of atomic structure, will learn to analyze periodic table, will learn how to read and write chemical formulae. This course will teach them concept of acid-base and reaction kinetics.

Course Objectives:
The objectives of this course are to

- Familiarize the students with the basic concept of electronic structure
- Acquire the knowledge about the properties of elements on the periodic table
- Understand the concept of chemical formula and equation
- Acquire the basics of acid-base concepts and apply them to identify different acids and bases
- Understand gaseous state of matter and their properties
- Introduce preliminary ideas of chemical equilibrium and kinetics
- Acquaint students with the fundamentals of organic chemistry

Course Content:

1. **Atoms, molecules and ions:** Atomic Theory, components of atoms.
2. **Electronic Structure:** Quantum theory, atomic spectrum of hydrogen and the Bohr model, Quantum numbers, Concept of Energy levels and atomic orbital, Electronic configuration, Chemical bonding and molecular structure.
3. **The periodic Table:** Development of the periodic table, Electron arrangements and the periodic table, Summarized chemical properties of s-block, p-block, d-block and f-block elements.
4. **Chemical formulas and equations:** Types of formulas, Percent composition from formula, Formulas from experiment, Formulas of ionic compounds, Names of compounds, Writing and balancing chemical equations, Mass relations in reactions, Limited reactant and theoretical yield. Concept of mole, Solution: Different concentration units.
5. **Acids and Bases:** Theories and Modern definition of acids and bases, Dissociation constant, strength, pH, Buffer solution etc.
6. **Gaseous state:** Measurement on gases, the ideal gas law, Volumes of gases involved in reactions, Gas mixtures, Partial pressure, Kinetic theory of gases, Real gases.
7. **Introduction to Chemical Kinetics:** Rate laws, rate constant, equilibrium constant, order of reaction etc.
8. **Organic Chemistry:** Introduction**,** Classification, Nomenclatures and Properties (Physical & Chemical) of (i) Aliphatic and aromatic hydrocarbons, (ii) Carbonyl compounds, (iii) Carboxylic acids and (iv) Carbohydrates (mono- and disaccharides).

Course Learning Outcomes (COs) :
After the successful completion of the course, students will be able to
CO1 Identify elements, orbit & orbitals, electron distribution & energy level, apply different principles to determine the configuration for any atom or ion
CO2 Explain the development of the periodic table, analyze physical and chemical properties of elements, Identify and explain the metallic and non-metallic characters of elements across the periodic table
CO3 Calculate the percent composition of a compound, describe the concept and use of different concentration unit, limiting reactant and percent of yield
CO4 Define and apply the modern concepts of acids and bases, understand the ideal gas laws and its application on real system
CO5 Understand chemical kinetics and discuss fundamentals of organic chemistry

Mapping Course Learning Outcomes (COs) with the POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Fundamental Skill			Social Skill		Thinking Skill		Personal Skill		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3		1							
CO3	3		1							
CO4	3								1	
CO5	2		1						1	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO1	Lecture and demonstration of practical data	Assignment
CO2	Lecture, demonstration	Class test (Short Q and MCQ)
CO3	Lecture and model demonstration	Final Exam (Short Q, MCQ, Quiz, Explanation)
CO4	Lecture, demonstration	Class test (Short Q and MCQ), presentation
CO5	Lecture and Group discussion	Final Exam (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
2. Haque and Mollah, *Physical Chemistry*
3. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
4. Raymond Chang, *General Chemistry*

Course No: CHE **0531 1102**P	Credit: 2.0	Year: First	Semester: First
Course Title: **CHEMISTRY PRACTICAL**		Course Status: Practical (GEd for FES)	

Course Rationale:
This course is going to introduce the students with different analytical techniques. They will learn to identify anions and cations in unknown molecules. Students will also learn to estimate different concentration of acids and bases.

Course Objectives:
The objectives of this course are to

- Familiarize students with the qualitative analysis of inorganic salts
- Acquaint students with the qualitative analysis of organic functional groups
- Accumulate practical skill on titration

Course Content:

1. Qualitative analysis of inorganic salts:

- Separation and identification of group I cations
- Separation and identification of group II cations
- Separation and identification of group IIIA and IIIB cations
- Separation and identification of group IV cations
- Separation and identification of group V cations
- Identification of anions

2. Qualitative analysis of organic salts:

- Analysis of the functional groups of organic compounds

3. Quantitative analysis:

- Standardization of NaOH solution with standard oxalic acid solution

Course Learning Outcomes (COs) (3-5):
After the successful completion of the course, students will be able to

CO1	Identifying and determining analytical group cations in the solution of inorganic salt
CO2	Use an analytical scheme to separate and identify the known ions from a mixture of inorganic salts
CO3	Apply designed analytical scheme to separate and identify the unknown ions from a mixture of inorganic salts
CO4	Identify the functional group(s) presence in an organic compound and then perform a confirmatory test
CO5	Determine the concentration of an unknown solution using a standard solution of known concentration

Mapping Course Learning Outcomes (COs) with the POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs vs POs	Fundamental Skill			Social Skill		Thinking Skill		Personal Skill		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

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

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO2	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO3	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO4	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO5	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment

Books Recommended:

1. Vogel, *Qualitative Inorganic Analysis*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)
4. Vogel, *Text book of Quantitative Analysis.*

Course No: **CHE 0531 1101J**	Credit: 3.0	Year: First	Semester: First
Course Title: **General Chemistry**	Course Status: Core Theory (GEd for GEB)		

Course Rationale: This course is designed to make students familiar with the scope and application of modern chemistry.

Course Objectives:

The objectives of this course are to

- Familiarize the students with the basic concept of electronic structure
- Acquire the knowledge about the properties of elements on the periodic table
- Familiarize the students with the basic concept of thermodynamics and thermodynamic law's
- Acquire the basics of acid-base concepts and apply them to identify different acids and bases
- Understand gaseous state of matter and their properties
- Introduce preliminary ideas of chemical equilibrium and kinetics
- Acquaint students with the fundamentals of organic chemistry

Course Content:

Electronic Structure: Quantum theory, atomic spectrum of hydrogen and the Bohr model, Quantum numbers, Concept of Energy levels and atomic orbital, Electronic configuration, Chemical bonding and molecular structure.

The periodic Table: Development of the periodic table, Electron arrangements and the periodic table, Summarized chemical properties of s-block, p-block and d-block elements.

Introduction to Thermodynamics: *The Basic Concepts:* Systems and surroundings, State and state functions, Equilibrium states and reversibility, Energy, Heat and work. *The First Law*: Statement and formulation, Derivation of expression for expansion work and its application at different conditions, Heat capacity. Relation between *Cp* & *Cv*.

Acids and Bases: Theories and Modern definition of acids and bases, Dissociation constant, strength, pH, Buffer solution etc.

Gaseous state: Measurement on gases, the ideal gas law, Volumes of gases involved in reactions, Gas mixtures, Partial pressure, Kinetic theory of gases, Real gases.

Introduction to Chemical Kinetics: Rate laws, rate constant, equilibrium constant, order of reaction etc.

Organic Chemistry: Introduction**,** Classification, Nomenclatures, preparations and Properties (Physical & Chemical) of (i) Aliphatic and aromatic hydrocarbons, (ii) Aldehydes and ketones, (iii) Carboxylic acids and (iv) Alcohols and phenols (v) Carbohydrates (mono- and disaccharides).

Course Learning Outcomes:

After the successful completion of the course, students will be able to

CO1. Describe the electronic structure of atoms and explain periodic trends in physical and chemical properties of elements in periodic table

CO2. Explain basic concepts of thermodynamics, chemical kinetics.

CO3. Define and apply the modern concepts of acids and bases to identify and classify the acids and bases and their strength.

CO4. Explain the properties and behaviors of ideal and real gases

CO5. Describe the structure and properties of aliphatic and aromatic hydrocarbons, aldehydes, ketones, carboxylic acids, and carbohydrates.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	1								
CO2	3									
CO3	3	1								
CO4	3	1								
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Teaching-Learning Strategies	Short and broad Q and MCQ
CO2	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO3	Lecture, Demonstration, Discussion	Quiz, assignment
CO4	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO5	Lecture, Group discussion	Semester end test, problem solving

Books Recommended:

1. S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
2. Haque and Mollah, *Physical Chemistry*
3. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
4. Raymond Chang, *General Chemistry*

Course No: **CHE 0531 1102J**	Credit: 1.5	Year: First	Semester: First
Course Title: **Qualitative and Quantitative Chemical Analysis**		Course Status: Practical (GEd for GEB)	

Course Rationale:

This course is designed to provide students a foundation for carrying out analysis using quantitative and qualitative methods.

Course Objectives:

The objectives of this course are to

- Familiarize students with the qualitative analysis of inorganic salts
- Acquaint students with the qualitative analysis of organic functional groups
- Accumulate practical skill on titration

Course Content:

Qualitative analysis of inorganic salts:

- Separation and identification of group I cations
- Separation and identification of group II cations
- Separation and identification of group IIIA and IIIB cations
- Separation and identification of group IV cations
- Separation and identification of group V cations
- Identification of anions

Qualitative analysis of organic salts:

- Analysis of the functional groups of organic compounds

Quantitative analysis:

- Standardization of NaOH solution with standard oxalic acid solution

Course Learning Outcomes:

After the successful completion of the course, students will be able to

CO1. Identify analytical group cations in the solution of inorganic salt
CO2. Design an analytical scheme to separate and identify the known ions from a mixture of inorganic salts
CO3. Apply designed analytical scheme to separate and identify the unknown ions from a mixture of inorganic salts
CO4. Identify the functional group(s) presence in an organic compound and then perform a confirmatory test
CO5. Determine the concentration of an unknown solution using a standard solution of known concentration

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3			3							
CO4			2			2				
CO5										

Mapping Course Learning Outcomes (Cos) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO2	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO3	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO4	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment
CO5	Lecture, Demonstration, Group discussion	Lab performance (group), Assignment

Books Recommended:

1. Vogel, *Qualitative Inorganic Analysis*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)
4. Vogel, *Text book of Quantitative Analysis.*

Course Code: **CHE 0531 1115 H**	Credits: 3.0	Year: First	Semester: First
Name of the Course: Engineering Chemistry	Type of Course: **Theory for PME (GED)**		

Rationale:

The fundamental concept of chemistry is vital to understand mineralogy, drilling fluid chemistry, and enhanced oil recovery.

Course Objectives: The objectives of this course are:

1. To provide students with important fundamental concepts relevant to general chemistry
2. To develop students' understanding of the application of fundamental concepts of chemistry in the engineering field.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CO1 Apply knowledge of molecular structure and properties in describing and solving technological problems.
CO2 Explain and appreciate the relationship between experiment and theory in science in general and chemistry in particular.

CO3 Demonstrate quantitative problem-solving skills in many aspects of chemistry, including stoichiometry, thermochemistry, chemical equilibrium, and reaction kinetics.
CO4 Describe the modern theoretical basis for understanding important areas of chemistry, including atomic structure, chemical bonding, and molecular structure.

Course content:

Atoms: Connection between chemistry and engineering, unit conversion and numerical calculation, estimation of atomic weight from mass and abundance of isotopes.

Molecules & Moles: Definition of molecules; the concept of moles; unit conversion; interconversion between mass, number of molecules, and number of moles.
Chemical Formulas & Composition of Substances: calculation of the mass % composition of a substance from its chemical formula, the definition of the concentration of a solution, and calculation of the molarity of solutions from various data. Ions & Reactions in Solutions–Electrolytes and non-electrolytes, the difference between the electrolyte and non-electrolyte solutions, both molecular and ionic equations for solution reactions.
Reaction Stochiometry: calculation of the amount of product from reactants; calculation of the amount of raw materials required from that of product. Limiting reagent–identification of a limiting reagent and calculate the amount of product formed from a non-stoichiometric mixture of reactants. Reactions in Solution, Acids & Bases–definitions, strong and weak acids or bases, acid-base reaction equations, concentration calculation based titration data, solution stochiometry.
Introduction to Gases: Gas law and relevant calculations, the Ideal gas Law & the kinetic theory of gases, non-ideal behavior, Maxwell-Boltzmann distribution.
Atomic Structure and Periodic Table: Fundamental concept of wave and electromagnetic wave in particular; photoelectric effect and relevant experiment; difference and similarity between Bohr model and quantum mechanical model; derivation of Schrodinger wave equation and solution of the wave function for the 1D system; Shape of different orbitals based on the polar model of Schrodinger wave function; Brief of electron shielding and penetration; Application of Pauli's exclusion principle and Hund's rule in electron configuration; Variation of atomic radius, ionization energy, and electron affinity with the position in the periodic table.
Chemical Bonding and Molecular Structure: Different types of bonding, Lewis Structure for different molecules, Bond polarity, orbital overlapping, hybridization and 3D shape of molecules.
Molecules and Molecular Structure: Different packing in brief, Metallic bonding model-band theory and conduction, semiconductor; Intermolecular forces; Surface tension; Brief of polymer.
Electrochemistry: Types of corrosion; Oxidation-reduction and Galvanic cell – Oxidation Reduction and Half-Reactions' Building a Galvanic Cell, Terminology of Galvanic Cells, Atomic Perspective on Galvanic Cells, Galvanic Corrosion and Uniform Corrosion; Cell potential under standard condition (taken from libre-text, chemistry).
Fuel and Combustion: Heating value, Higher Heating Value, Lower Heating Value, proximate and ultimate analysis of coal.

Colloid and surface chemistry: Types of colloid, absorption and adsorption, application of colloid.

Mapping of COs to POs:

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3											
CO2				2								
CO3		1										
CO4	3											

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

(COs)	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board and Assignment	Assignment, Midterm Exam 1, and Semester-end Exam
CO 2	Lecture using board/ projectors and Assignment	Assignment, Midterm Exam 1, and Semester-end Exam

CO 3	Lecture using board and Assignment	Assignment, Midterm Exam 2, and Semester-end Exam
CO 4	Lecture using board/ projectors	Assignment and Semester-end Exam

References:

1. Chemistry for Engineering Students , *Lawrence Brown and Thomas Holme, Brooks/Cole-Cengage Learning, 4th edition*
2. Chemistry , *Raymond Chang and Jason Overby, 13th Edition.*
3. Engineering Chemistry , *S.S. Dara.*
4. Engineering Chemistry , *Raghupti Mukhopadhyay and Sriparna Datta.*
5. A Text Book of Engineering Chemistry , *M.M. Uppal.*

Course Code: CHE 0531 1112 H	**Credits: 1.5**	Year: First	Semester: First
Name of the Course: Engineering Chemistry Lab	**Type of Course: Lab PME (GED)**		

Rationale:
Mud chemistry and enhanced oil recovery involve several experiments performed in the general chemistry lab.

Course Objectives: The objectives of this course are to:
1. Understand common laboratory techniques including pH measurement, acid/base titrations
2. UV/Visible spectroscopy in both emission and absorption mode, calorimetry, and colorimetry.
3. Apply the techniques mentioned above to solve chemical problems.
4. Carry out self-directed experiments
5. Perform practical laboratory experiments

Course Learning Outcomes:
Upon successful completion of this course, students will be able to:
CO1 Understand the use of graduated cylinders, graduated pipettes, and volumetric pipettes for volumetric measurement, use of thermometers and temperature probes, perform titrations.
CO2 The calibration and use simple spectrophotometers, p^H meters, centrifuges, etc. Use of an analytical balance for mass measurement, use of an electrolysis cell to determine the equivalent mass of an unknown metal analyze of data using a spreadsheet program such as Excel.
CO3 Understand and follow most common safety rules followed in a general chemistry lab
CO4 Design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
CO5 Communicate the results of experimental work in oral, written and electronic formats.

Summary of the course:
Laboratory Introduction and General Information
Laboratory Safety
Laboratory Safety and Precision and Accuracy: Measuring the Density of Coke
Aqueous Solutions and Reactions
Thermochemistry
The Six Solution Problem
Introduction to Spectroscopy
Electrolytic determination of equivalent mass

Mapping of COs to POs:
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

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

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

(COs)	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board and Assignment	Assignment, Midterm Exam 1, and Semester-end Exam
CO 2	Lecture using board/ projectors and Assignment	Assignment, Midterm Exam 1, and Semester-end Exam
CO 3	Lecture using board and Assignment	Assignment, Midterm Exam 2, and Semester-end Exam
CO 4	Lecture using board/ projectors	Assignment and Semester-end Exam
CO 5	Lecture using board/ projectors and Assignment	Assignment, Midterm Exam 2, and Semester-end Exam

Reference:

1. Chemistry for Engineering Students , *Lawrence Brown and Thomas Holme, Brooks/Cole-Cengage Learning, 4th edition.*

Course No: CHE **0531 1101Q**	Credit: 3.0	Year: First	Semester: First
Course Title: **Basic Chemistry for Engineers**		Course Status: Theory (GEd for MEE)	

Course Rationale:
Candidates are expected to understand the structures, properties, and applications of atoms, molecules, and chemical compounds.

Course Objectives:
The objectives of this course are:
- Describe the basic concept of electronic structure
- Acquire knowledge about the thermochemistry
- Introduce preliminary ideas of chemical equilibrium and kinetics
- Make the students understand and relate the colloids and their applications
- Facilitate the necessary knowledge of common phenomena of Electrochemistry
- Recognize the fundamental aspects and applications in various fields for organic compounds.

Course Content:
Concept of Atomic Structure: Quantum numbers, electronic configuration, and the periodic table; Properties and uses of noble gases; hybridization and molecular structure of compounds; selective organic reactions.
Thermo-chemistry: Laws of thermo-chemistry; the heat of reaction, heat of solution, heat of combustion, the heat of formation, and heat of neutralization; experimental determination of thermal changes during chemical reactions.
Chemical kinetics: Definition, rate of reaction, order, and molecularity of reaction, determination of the order of reaction; collision theory and activated complex theory; effect of catalyst on kinetics.
Chemical Equilibrium (reaction control): Definition, classification, properties, the law of mass action, the relation between k_p, k_c, and, k_x; Effect of pressure, concentration, and temperature on equilibrium for various chemical reactions.
Colloids: Classification of colloids; methods of preparation and purification of colloidal solutions, properties of colloids, applications of colloids.
Electrochemistry: Electrolysis; theories of electrolytic dissociation, ionic equilibrium, Ostwald's dilution law, ionization of water and pH concept, and buffer solution.
Fundamentals of Organic Chemistry: Introduction**,** Classification, Nomenclatures, preparations, and Properties (Physical & Chemical) of (i) Aliphatic and aromatic hydrocarbons, (ii) Aldehydes and ketones, (iii) Carboxylic acids and (iv) Alcohol s and phenols

Course Learning Outcomes:
After the successful completion of the course, students will be able to:
CO1. Explain the basic structural properties in atomic and molecular levels of atoms and molecules, respectively, using various recognized Theories and Laws.
CO2. Describe and explain basic concepts of thermodynamic properties associated with both phase transitions and chemical reactions.
CO3. Understand the properties of electrolytes in solution and electrochemical energy generation

CO4 Discuss the rate of reaction and apply the chemical equilibrium with different effects of equilibrium on systems and chemical kinetics
CO5 Distinguish the chemical features and properties of organic substances and understand their potential application in various applied fields.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	1								
CO2	3									
CO3	3	1								
CO4	3	1								
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture using PPT and demonstration of practical data	assignment
CO2	Lecture using PPT	Class test (Short Q and MCQ)
CO3	Lecture using PPT and model demonstration	Final Exam (Short Q, MCQ, Quiz, Explanation)
CO4	Lecture using PPT	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and Group discussion	Final Exam (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
2. Haque and Mollah, *Physical Chemistry*
3. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
4. Raymond Chang, *General Chemistry*
5. An Introduction to Electrochemistry, S. Glasstone, Littion Eductional Publishing Inc., New York
6. Text Book of Physical Chemistry (2nd Edition), S. Glasstone, Macmillan Press Ltd., 1974
7. Physical Chemistry (7th Edition), P.W. Atkins, Oxford University Press Inc., New York, 2002
8. Electrochemical Methods: Fundamentals and Applications 2nd edition, Allen J. Bard & Larry R. Faulkner

Course No: CHE **0531 1112Q**	Credit: 1.5	Year: First	Semester: First
Course Title: Chemistry Sessional		Course Status: GEd Practical MEE	

Course Rationale:
This course is designed to give the students hand on experience in chemistry experiments for chemical analysis.

Course Objectives:
The objectives of this course are to
- Familiarize students with the basic concept of different titration techniques
- Develop student's necessary practical skills to experiment with quantitative estimation

Course Content:
Volumetric analysis; Acidimetry-alkalimetry, Titrations involving redox reactions, determination of Fe, Cu, and Ca volumetrically, Complexometric titration, determination of Ca and Mg ions in water, saponification and esterification analysis of crude oil.

Course Learning Outcomes:
After the successful completion of the course, students will be able to
CO1. Calculate mole quantities, reaction ratio, molar concentration, etc.
CO2. Choose a suitable indicator for a particular titration technique
CO3. Prepare standard solution and standardization of a solution of unknown concentration
CO4 Design an oxidation-reduction reaction to determine the amount of specific metal in a sample solution

CO5. Perform complexometric titration technique for determining the hardness of water

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes (PLOs)									
COs	1	2	3	4	5	6	7	8	9	10
CO1		1		3						
CO2		1		3						
CO3				3						
CO4		1						3		
CO5							3			1

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	type test, problem-solving
CO5	Lecture, presentation, Journal article reviews, problem analysis	type test, problem-solving

Books Recommended:

1. Vogel, *Qualitative Inorganic Analysis*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)
4. Vogel, *Textbook of Quantitative Analysis.*

Course No: CHE **0531 1203Q**	Credit: 3.0	Year: First	Semester: Second
Course Title: **Chemistry of Engineering Materials**		Course Status: Theory for MEE	

Course Rationale:
This course aims to provide basic principles, and processes of Industrial Manufacturing process of some industries that will be needed for professional life after graduation.

Course Objectives:
The objectives of this course are to
- Provide the knowledge on sources, classification, and composition of glass, ceramic, cement, plastic, carbon, Lubricant, and Paint
- Provide knowledge on industrial manufacture and applications of glass, ceramic, cement, plastic, carbon, Lubricant, and Paint
- Facilitate necessary knowledge about the process of metal corrosion and its prevention

Course Content:
Glass: Raw materials for normal glass, classification, manufacturing processes, Manufacturing of optical fibers, raw materials and methods of manufacturing optical fiber and its application, glass transition temperature and its importance, Annealing and its importance, tempered glass and other special glass composition and related chemistry.
Ceramics and Refractories: Fundamentals of ceramic industry, raw materials, and industrial manufacturing processing, comparison with metals, classification, and special application of refractory materials.
Cement Industry: Raw materials, different processes of cement manufacturing (dry and wet methods), clinker composition and formation reactions, the importance of additives, fly ash, and slag in cement industries. Setting theories and setting and hardening of cement, chemical reactions in the kilns.
Plastics: Polymers and polymerization reactions, Different polymerization reactions (free radical, condensation, and step growth polymerization reactions and mechanism), Thermosetting and thermoplastics, additives and their impact on plastics and environment, degradability of plastics and biodegradable plastics.

Carbon: Up-to-date knowledge of Allotropes of carbon, diamond, graphite, amorphous carbon, and porous carbon and their related chemistry, Advanced carbon nanomaterials (fullerene, graphene, and carbon nanotubes CNTs) fabrication, and industrial application

Lubricant and crude oil: Principle of lubrication, viscosity and its relationship with lubrication, Fluidostatic lubrication, and Fluid-fluid lubrication, mechanical properties of lubricants, synthetic route of lubricant manufacturing, classification of lubricants, crude oil distillation and application.

Paints and Varnishes: Difference between paints and pigments, composition and application of paints, acrylic and synthetic emulsions paints, enamel paints and coating into metals, varnishing materials and application.

Corrosion: Nature forms and types of corrosion, electrochemical mechanism, and prevention of corrosion.

Water treatments and their importance: Importance of water treatment in industries, different chemical methods, primary and secondary water treatment processes, activated sludge, and its proper handling for water treatment.

Course Learning Outcomes:

After the successful completion of the course, students will be able to

CO1. Identify the raw materials and understand the composition, properties, and uses of different types of glass, ceramic, carbon, Lubricant, and Paint, also able to understand the chemical reactions that take place during the manufacturing process.

CO2. Express the basic concept of raw materials and manufacturing processes of cement, explain the mechanism of setting and hardening of cement that will help acquire knowledge related to structural reinforcement.

CO3. Explain the use, function, and importance of additives and their impact on plastics and the environment; and understand the degradability of plastics and biodegradable plastics

CO4. Understand about the function of lubricant in the field of tribology. Explain the related chemistry of different allotropic forms of carbon elements and their applications

CO5. Describe the manufacture of paint and varnishes by using chemical substances and the prospect of the paint industry in Bangladesh. Also able to handle water pollutant treatment mechanisms and implementation into the plant.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes (POs)									
COs	1	2	3	4	5	6	7	8	9	10
CO1	3	1								
CO2	3									
CO3	3	1								
CO4	3	1								
CO5	3									

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	type test, problem-solving
CO5	Lecture, presentation, Journal article reviews, problem analysis	type test, problem-solving

Books Recommended:

1. Shreve, *Chemical Process Industries*
2. *Morrison and Boyd, Organic Chemistry.*
3. B. K Sharma, *Industrial Chemistry*
4. Roger's, *Manual for Industrial Chemistry*
5. J. A. Kent, *Regels' Hand Book of Industrial Chemistry*
6. Colin Frayne, Boiler Water Treatment Principles and Practice, Volume I, CHEMICAL PUBLISHING CO. INC. New York, N.Y
7. Igor L. Shabalin, Ultra-High Temperature Materials I (Carbon (Graphene/Graphite) and Refractory Metals), Springer Dordrecht Heidelberg New York London.
8. Malkiat S. Johal Lewis E. Johnson, Understanding Nanomaterials, 2nd edition, CRC press.

Course No: CHE 0531 1101I	Credit: 2.0	Year: First	Semester: First
Course Title: O**rganic Chemistry I**		Course Status: Theory for BMB	

Course Rational: Organic chemistry-I is aimed to provide the knowledge of theories on types of bonding that exist in compounds. It is also planned to let the students learn the properties, synthesis, detection and uses of various compounds with specific functional groups.

Course Objectives:

- To familiarize the students with the fundamentals of synthesis, identification, modeling, and chemical reactions of aliphatic and aromatic compounds.
- To provide the basic knowledge of chemical structures and nomenclature.
- To make students able to grasp the role of organic chemistry in life sciences.
- To build the basic foundation of organic chemistry to solve the problems in biochemistry.
- To equip the students with the skills needed for learning advanced chemical reactions that are found in cellular atmosphere.

Course Contents:

Chemical bonding: Types of bond, Covalent bond, ionic bond, hybrid orbital, polarity of bonds, electronegativity, dipole moment, hydrogen bond and hydrophobic interactions. Intermolecular forces, solubility, Valence shell electron pair repulsion theory (VSEPR), hybridization, preliminary treatment of valence bond theory and molecular orbital theory, linear combinations of atomic orbitals, bonding and antibonding orbitals, symmetry and overlap, molecular orbital diagram of homonuclear and heteronuclear diatomic molecules (H_2, He_2,NO), the biochemical reactivity of O_2 and N_2, biochemistry of NO, the unique role of carbon in biochemistry.

Alkanes: Occurrence, structure, nomenclature, synthesis, physical and chemical properties, free radical substitution, stability of free radicals, halogenation.

Alkenes and alkynes: Occurrence, structure, nomenclature, synthesis, physical and chemical properties including electrophilic addition and free radical reactions, polymerizations, free radical halogenation of alkenes, allylic rearrangement, stability of allylic radical.

Alkyl halides: Nucleophilic substitution reactions, S_N1 and S_N2 reactions, carbocations, carbocation rearrangement, E_1 and E_2 elimination reactions, Grignard reagents and the organometallic compounds.

Alcohols, ethers, epoxides and diols: Occurrence, nomenclature, structure, synthesis, physical and chemical properties and uses.

Aldehydes and ketones: Nomenclature, synthesis, properties and reactions of carbonyl compounds, enolisation in biological system, aldol and crossed-aldol condensation, benzoin condensation, Wittig reaction.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to

CO1: Explain the basic features of the chemical bonding, valance bond theory, and molecular orbital theory

CO2: Make sense of the structures, and properties of chemical bonds observed in organic compounds as well as biomolecules.

CO3: Formulate the proper structure, name, outline of the synthesis, and predict the physical and chemical properties of alkanes, alkenes, dienes, and alkynes and their derivatives.

CO4: Apply the concepts of Grignard Reagent in organic synthesis and demonstrate the S_N1 and S_N2 mechanisms.

CO5: Design the synthesis of simple organic compounds. Explain the synthesis, reaction, and properties of carbonyl compounds, chemical analysis, and their uses in organic chemistry. Identify and solve organic chemical problems.

Mapping of COs with the POs:

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

CO/PO	**Fundamental Skill**			**Social Skill**		**Thinking Skill**		**Personal Skill**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3								

CO2	2					1			
CO3	3								
CO4	3								
CO5	3								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy:

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lectures using projector	Semester end exam, Midterm exam 1
CO2	Lectures using projector, assignment	Semester end exam, class assignment
CO3	Lectures using projector, presentation	Semester end exam, Midterm exam 2
CO4	Lectures using projector, tutorial	Semester end exam, quiz
CO5	Lectures using projector, group study	Semester end exam, class assignment

Books Recommended:

1. Organic Chemistry. R. T. Morrison and R. N. Boyd; (5th Edition.) Prentice Hall of India, New Delhi, India, 1989.
2. Advanced Organic Chemistry. Arun Bahl and B.S. Bahl; (5th edition) 2014.
3. Organic Chemistry (Vol -I: The Fundamental Principles). L. Finar; (5th edition) London, 1986.

Course No: CHE 0531 1202I	Credit: 2.0	Year: First	Semester: Second
Course Title: O**rganic Chemistry II**		Course Status: Theory for BMB	

Course Rational: The purpose of organic chemistry-II course is to extend the knowledge of Organic Chemistry-I. This course specifically encompasses the similar discussion on different compounds with specific functional groups that has not been discussed in CHE 0531 1101I.

Course Objectives:

- To familiarize the students with the fundamentals of synthesis, identification, modeling, and chemical reactions various organic compounds.
- To provide the basic knowledge of chemical structures and nomenclature.
- To make students able to grasp the role of organic chemistry in life sciences.
- To build the basic foundation of organic chemistry to solve the problems in biochemistry.
- To equip the students with the skills needed for learning advanced chemical reactions that are found in cellular atmosphere.
- To give the basic concept of the role of light in biology and its theoretical aspects.

Course Contents:

Aromaticity: Introduction to aromatic compounds. Structure of benzene, sources of aromatic hydrocarbons, industrially important aromatic compounds, nomenclature of benzene derivatives, electrophilic and nucleophilic aromatic substitution, chemistry of aromatic compounds.
Carboxylic Acids and Their Functional Derivatives: Sources, nomenclature structures, preparation, properties and reactions of aliphatic and aromatic carboxylic acids and their functional derivatives especially esters.
Aromatic Nitro Compounds: Occurrence, nomenclature, synthesis, classification, properties, reactions, uses, diazonium compounds.
Aromatic Amines: Sources, nomenclature structures, preparation and properties.
Phenols: Occurrence, nomenclature, synthesis, properties and reactions, polyhydric phenols.
Heterocyclic compounds: Sources, preparation, properties, reactions and uses of heterocyclic compounds e.g., pyrrole, furan, thiophene, pyridine, pyrimidine and purine.
Antimalarials: Syntheses of pamaquine and chloroquine.
Photochemistry: Principles of photochemistry, excited states, photochemical processes, energy transfer, photosensitization and Photochemical reactions.

Course Learning Outcomes (COs):

On completion of this course, students will be able to:
CO1: Demonstrate the basic features of aromatic compounds.

CO2: Describe the governing principles of the structures of aromatic compounds
CO3: Make sense of the structures, and properties of chemical bonds observed in organic compounds as well as biomolecules.
CO4: Explain the reactivity and stability of aromatic organic molecules based on structure and the fundamentals of aromatic compound detection.
CO5: Describe the photochemical excitation, photochemical process and different types of photochemical reactions; and demonstrate the fundamentals of aromatic compound detection.

Mapping of COs with the POs:
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Fundamental Skill			**Social Skill**		**Thinking Skill**		**Personal Skill**	
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3								
CO2	3								
CO3					3				
CO4						2			
CO5			3						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy:

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lectures using PPT	Semester end exam, Midterm exam 1
CO2	Lectures using PPT, assignment	Semester end exam, class assignment
CO3	Lectures using PPTr, presentation, group study	Semester end exam, Midterm exam 2
CO4	Lectures using projector, tutorial	Semester end exam, quiz
CO5	Lectures using projector, group study	Semester end exam, class assignment

B**ooks Recommended:**

1. Organic Chemistry. R. T. Morrison and R. N. Boyd; (5th Edition.) Prentice Hall of India, New Delhi, India, 1989.
2. Advanced Organic Chemistry. Arun Bahl and B.S. Bahl; (5th edition) 2014.
3. Organic Chemistry (Vol -I: The Fundamental Principles). L. Finar; (5th edition) London, 1986.
4. Organic Chemistry (Vol -II: Stereochemistry and Chemistry of Natural Products). L. Finar; Orient Longmans, London, 1986

Course No: **CHE 0531 1201E**	Credit: 3.0	Year: First	Semester: Second
Course Title: **Basic Chemistry for Engineers**		Course Status: **Theory for EEE**	

Course Objectives:

The objectives of this course are to

- Familiarize the students with the basic concept of electronic structure
- Acquire the knowledge about the properties of elements on the periodic table
- Learn to prepare different ways preparing solutions.
- Acquire the basics of acid-base concepts and apply them to identify different acids and bases
- Understand gaseous state of matter and their properties
- Understand the relation of chemical reaction with energy production and apply them for producing energy storage devices.
- Introduce preliminary ideas of chemical equilibrium and kinetics
- Acquaint students with the fundamentals of organic chemistry

Course Content:

Atomic theory of Matter: Atoms, the experimental basis for modern concepts of the atom (Cathode Ray Experiment Millikan's Oil Drop Experiment, Rutherford's Nuclear atom), the emission spectra of atomic hydrogen, the Bohr Theory of hydrogen atom and the introduction of the quantum concept.
The Electronic Structure of Atoms: Atomic orbitals and the quantum numbers, the Pauli Exclusion principle, the building up (Aufbau) process.

Gaseous state: Measurement on gases, the ideal gas law, Volumes of gases involved in reactions, Gas mixtures, Partial pressure, ideal and real gases, Kinetic theory of gases, the mean-square speed, the root-mean square speed and the mean speed, equation of states of gases.
The periodic Table: Development of the periodic table, Electronic configuration and the periodic table, Summarized chemical properties of s-block, p-block, d-block and f-block elements, chemical bonding and molecular structure
Solutions: Definition and components of a solution, Concept of mole, different concentration units: Concept of mole, mole fraction, Normality, Molarity, Molality, Weight Percentage, relation among the concentration units.
Acids and Bases: Theories and Modern definition of acids and bases, Dissociation constant, strength, pH and pH scales, Buffer solution etc.
Introduction to Chemical Kinetics: Rate laws, rate constant, equilibrium constant, order of reaction etc.
Electrochemistry: Oxidation-Reduction reaction (REDOX) and the concept of Battery (Galvanic Cell/Voltaic Cell). The design of Battery/Galvanic Cell: Electrode, Half-cell (Electrode), Half-cell reaction (anode/cathode), Net-cell reaction, Salt Bridge, Definition of the Faraday, Life time calculation of a Galvanic cell. EMF of a Galvanic cell, standard hydrogen electrode, cell notation, the standard single electrode potential and cell potential. Relation of net reaction free energy (G) with the cell potential (e), Concentration dependence of cell potential: The Nernst Equation (NE), application of NE to determine equilibrium constant. Commercial Batteries: Lead Storage Battery, Dry cell, Mercury cell, Nickel-Cadmium battery, Lithium-Ions battery. Electrolysis: Definition and its application in metal extraction, electroplating and metal purification.
Organic Chemistry: Introduction**,** Classification, Properties (Physical & Chemical) of (i) Aliphatic and aromatic hydrocarbons, (ii) Carbonyl compounds, (iii) Carboxylic acids and (iv) Carbohydrates (mono- and disaccharides).

Course Learning Outcomes:
After the successful completion of the course, students will be able to
CO1. Classify elements, correlate atomic models, orbit & orbitals, electron distribution & energy level, hydrogen spectral series etc.
CO2. Understand the ideal gas laws and its application on real system and explain the development of the periodic table of elements, the metallic and non-metallic characters of elements across the periodic table
CO3. Define and apply the modern concepts of acids and bases to identify and classify the acids and bases and their strength. Understand the relationship between chemical kinetics and equilibrium
CO4. Explain the fundamental principles of Oxidation-Reduction reactions (REDOX) and relate them to the generation of electric current in batteries and its construction.
CO5. Develop a fundamental understanding of key organic compounds, including important functional groups.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes											
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**
CO1	3											
CO2	3											
CO3	3											
CO4	3											
CO5	3											

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with model, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis	Essay type test, problem solving

Books recommended:

1. Chemistry for Engineering Students by Lawrence Brown and Thomas Holme, Brooks/Cole-Cengage Learning, 4th edition
2. S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
3. Haque and Mollah, *Physical Chemistry*
4. Chemistry By Raymond Chang and Jason Overby, 13th Edition.
5. 5 .R. T. Morrison & R. N. Boyd, *Organic Chemistry* (6th edition)
6. G. Solomon, *Organic Chemistry* (11th edition)

Course No: CHE 0531 1202E	Credit: 1.5	Year: First	Semester: Second
Course Title: Experimental Chemistry for Engineers		Course Status: Practical (GEd for EEE)	

Course Rationale:
The purpose of this course is to learn the techniques to detect, identify and separate anions and cations in a sample using quantitative analysis.

Course Objectives:
The objective of this course is to
- Make the students skilled for the theoretical and practical knowledge
- Make them able to perform the qualitative analysis of inorganic salts

Course Content:
Qualitative analysis of inorganic salts:
- Separation and identification of group I cations
- Separation and identification of group II cations
- Separation and identification of group IIIA and IIIB cations
- Separation and identification of group IV cations
- Separation and identification of group V cations
- Identification of anions

Course Learning Outcomes:
After the successful completion of the course, students will be able to:
CO1 Prepare and use the aqueous solution of inorganic compounds accurately for the identification of cations and anions using necessary reagents
CO2 Identify and understand the properties of various functional groups contained in the organic compounds
CO3 Determine and acquire knowledge on the concentration of solution using titrimetric analysis.
CO4 Demonstrate and analyze the recorded data in the report, and draw appropriate conclusions from the laboratory
CO5 Handle the chemicals and apparatus safely individually as well as work in a group

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		1		3								
CO2		1		3								
CO3				3								
CO4		1						3				
CO5							3			1		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures and experiment demonstration	Lab Performance, Viva Voce

CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. Vogel, *Qualitative Inorganic Analysis*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)
4. Vogel, *Textbook of Quantitative Analysis.*

Course No: CHE **0531 1201G**	Credit: 3.0	Year: First	Semester: Second
Course Title: **Basic Chemistry for Engineers**		Course Status: Theory (GEd for IPE)	

Course Rationale:

Candidates are expected to understand the structures, properties, and applications of atoms, molecules, and chemical compounds.

Course Objectives:

The objectives of this course are:

- Describe the basic concept of electronic structure in atoms and molecules.
- Acquire knowledge of the physical and chemical properties of elements in the periodic table
- Analyze the properties of molecular compounds from various types of mathematical calculations using chemical formulas.
- Identify properties of acids and bases based on various acid-base concepts.
- Understand the various state and properties of materials.
- Study and gain preliminary knowledge on reaction equilibrium and chemical kinetics.
- Recognize the fundamental aspects and applications in various fields for organic compounds.

Course Content:

Atoms, molecules, and ions: Atomic Theory, components of atoms.

Electronic Structure: The quantum theory, atomic spectrum of hydrogen and the Bohr model, Quantum numbers, Energy levels and orbital, Electronic configuration, Chemical bonding, and molecular structure.

The periodic Table: Development of the periodic table, Electron arrangements, and the periodic table, Summarized chemical properties of s-block, p-block, d-block, and f-block elements.

Chemical formulas and equations: Types of formulas, Percent composition from the formula, Formulas from experiment, Formulas of ionic compounds, Names of compounds, Writing and balancing chemical equations, Mass relations in reactions, Limited reactant, and theoretical yield. Concept of mole, Solution: different concentration units.

Acids and Bases: Theories and Modern definitions of acids and bases, Dissociation constant, strength, pH, Buffer solution, etc.

Gases: Measurement of gases, the ideal gas law, Volumes of gases involved in reactions, Gas mixtures, Partial pressure, Kinetic theory of gases, and Real gases.

Introduction to Chemical Kinetics: Rate laws, rate constant, equilibrium constant, order of reaction, etc.

Organic Chemistry: Introduction**,** Classification, Nomenclatures, preparations and Properties (Physical & Chemical) of (i) Aliphatic and aromatic hydrocarbons, (ii) Aldehydes and ketones, (iii) Carboxylic acids and (iv) Alcohols and phenols (v) Carbohydrates (mono- and disaccharides).

Chemistry of Fuels (Hydrocarbon, Hydrogen),**Fertilizer, & Medicine.**

Course Learning Outcomes:

After the successful completion of the course, students will be able to:

CO1 Recognize the basic structural properties in atomic and molecular levels of atoms and molecules, respectively, using various recognized Theories and Laws.

CO2 Describe the physical and chemical properties periodically of metal and non-metal.

CO3 Predict and analyze the properties of molecular compounds from various types of mathematical calculations using chemical formulas. Understand the relationship between chemical kinetics and equilibrium.

CO4 Identify and explain various properties in qualitatively and quantitatively solid, liquid, and gaseous substances based on fundamental parameters.

CO5 Develop a fundamental understanding of key organic compounds, including functional groups, and understand their potential application in various applied fields.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture using PPT and demonstration of practical data	assignment
CO2	Lecture using PPT	Class test (Short Q and MCQ)
CO3	Lecture using PPT and model demonstration	Final Exam (Short Q, MCQ, Quiz, Explanation)
CO4	Lecture using PPT	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and Group discussion	Final Exam (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
2. Haque and Mollah, *Physical Chemistry*
3. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
5. Raymond Chang, *General Chemistry*

Course No: CHE 0531 **1202G**	Credit: 1.5	Year: First	Semester: Second
Course Title: Experimental Chemistry for Engineers		Course Status: Practical (GEd for IPE)	

Course Rationale:

This course is aimed to make the student practically skilled in handling chemical compounds and focus on understanding their properties.

Course Objectives:

The objectives of this course are:

- Qualitative identification of cations and anions, and functional groups containing the inorganic and organic compounds, respectively.
- Demonstrate and analyze the recorded data in the report obtained from the laboratory.

Course Content:

Qualitative analysis of inorganic salts:

- Separation and identification of group I cations
- Separation and identification of group II cations
- Separation and identification of group IIIA and IIIB cations
- Separation and identification of group IV cations
- Separation and identification of group V cations
- Identification of anions

Qualitative analysis of organic salts:

- Analysis of the functional groups of organic compounds

Quantitative analysis:

- Standardization of NaOH solution with the standard oxalic acid solution

Course Learning Outcomes:

After the successful completion of the course, students will be able to:

CO1 Prepare and use the aqueous solution of inorganic compounds accurately for the identification of cations and anions using necessary reagents

CO2 Identify and understand the properties of various functional groups contained in the organic compounds

CO3 Determine and acquire knowledge on the concentration of solution using titrimetric analysis.

CO4 Demonstrate and analyze the recorded data in the report, and draw appropriate conclusions from the laboratory

CO5 Handle the chemicals and apparatus safely individually as well as work in a group

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3										
CO2	1	3										
CO3	1	3										
CO4										3		
CO5			3						1			

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures and experiment demonstration	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. 1 Vogel, Qualitative Inorganic Analysis
2. 2 A.I. Vogel, A Text Book of Practical Organic Chemistry
3. 3 A.I. Vogel, Elementary Practical Organic Chemistry (Part 1)
4. 4 Vogel, Textbook of Quantitative Analysis.

Course No: **CHE 0531 1201N**	Credit: 3.0	Year: First	Semester: Second
Course Title: **General Chemistry for Physics**		Course Status: Theory (GEd for PHY)	

Course Rationale:

Candidates are expected to understand the structures, properties, and applications of atoms, molecules, and chemical compounds.

Course Objectives:

The objectives of this course are:

- Describe the basic concept of electronic structure
- Acquire knowledge of the physical and chemical properties of elements in the periodic table
- Analyze the properties of molecular compounds from various types of mathematical calculations using chemical formulas.
- Identify properties of acids and bases based on various acid-base concepts.
- Understand the various state and properties of materials.
- Study and gain preliminary knowledge on reaction equilibrium and chemical kinetics.
- Recognize the fundamental aspects and applications in various fields for organic compounds.

Course Content:

Atoms, molecules, and ions: Atomic Theory, components of atoms.

Electronic Structure: The quantum theory, the atomic spectrum of hydrogen and the Bohr model, Quantum numbers, Energy levels, and orbitals, Electronic configuration, Chemical bonding, and molecular structure.

The periodic Table: Development of the periodic table, Electron arrangements, and the periodic table, Summarized chemical properties of s-block, p-block, d-block, and f-block elements.

Chemical formulas and equations: Types of formulas, Percent composition from the formula, Formulas from experiment, Formulas of ionic compounds, Names of compounds, Writing and balancing chemical equations, Mass relations in reactions, Limiting reagent, and theoretical yield. Concept of mole, Solution: different concentration units.

Acids and Bases: Theories and Modern definitions of acids and bases, Dissociation constant, strength, pH, Buffer solution, etc.

Gaseous State: Measurement of gases, the ideal gas law, Volumes of gases involved in reactions, Gas mixtures, Partial pressure, Kinetic theory of gases, and Real gases.

Introduction to Chemical Kinetics: Rate laws, rate constant, equilibrium constant, order of reaction, etc.

Organic Chemistry: Introduction, Classification of Organic compounds, Nomenclature, Synthesis, Physical & Chemical properties, and application of (i) Aliphatic and aromatic hydrocarbons, (ii) alcohols and amines, (iii) Carbonyl compounds, (iv) Carboxylic acids and their derivatives, (v) Carbohydrates (mono- and disaccharides), etc.

Modern Perspective of Chemistry: (a) Fuels e. g. Hydrocarbon, Hydrogen (b) Fertilizer (c) Medicine (d) Electronic Industries e.g. LCD, pure Silicon for IC, Semiconductor, insulator, etching materials, etc.

Course Learning Outcomes:

After the successful completion of the course, students will be able to:

CO1 Explain the basic structural properties in atomic and molecular levels of atoms and molecules and interpret the periodic table and its trends, such as atomic radius, ionization energy, electron affinity, electronegativity, and metallic character.

CO2 Analyse the properties of molecular compounds from various types of mathematical calculations using chemical formulas.

CO3 Explain the fundamental theories, properties, and applications of acids and bases in chemical systems and their role in maintaining equilibrium in various solutions, various properties in qualitatively and quantitatively solid, liquid, and gaseous substances based on fundamental parameters.

CO4 Predict the rates of chemical reactions and grasp the concept of chemical equilibrium, analyse dynamic equilibria in reversible reactions, and predict the effects of changing conditions on equilibrium constants.

CO5 Distinguish the chemical features and properties between inorganic and organic substances. Gain a fundamental understanding of organic compounds, including functional groups and their reactivities, and understand their potential application in various applied fields.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes								
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	2			1	1	2			1
CO2	2			1	1	2			1
CO3	2		3	1	1	2			1
CO4	2		2	1	1	2			1
CO5	2			1	1	2			1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT and demonstration of practical data	assignment
CO2	Lecture using PPT	Class test (Short Q and MCQ)
CO3	Lecture using PPT and model demonstration	Final Exam (Short Q, MCQ, Quiz,

		Explanation)
CO4	Lecture using PPT	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and Group discussion	Final Exam (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. 1.S. Z. Haider, *Introduction to Modern Inorganic Chemistry.*
2. 2.Haque and Mollah, *Physical Chemistry*
3. 3.R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)

4.Raymond Chang, *General Chemistry*

Course No: CHE 0531 1202N	**Credits: 1.5**	**Year: First**	**Semester: Second**
Course Title: Chemistry Practical		**Course Status: Practical (GEd)**	

Course Rationale: This course is aimed to make the student practically skilled in handling chemical compounds and focus on understanding their properties.

Course Objectives:

The objectives of this course are:

1. qualitative identification of cations and anions, and functional groups containing the inorganic and organic compounds, respectively.
2. to demonstrate and analyze the recorded data in the report obtained from the laboratory.

Course Contents:

Qualitative analysis of inorganic salts:

- Separation and identification of group I cations
- Separation and identification of group II cations
- Separation and identification of group IIIA and IIIB cations
- Separation and identification of group IV cations
- Separation and identification of group V cations
- Identification of anions

Qualitative analysis of organic functional groups:

- Test for carbonyl groups, carboxylic acid groups and unsaturation test

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1	prepare the aqueous solution of inorganic compounds accurately for the identification of cations and anions using necessary reagents.
CO2	explain the properties of various functional groups contained in the organic compounds.
CO3	determine the concentration of solution using titrimetric analysis.
CO4	analyze the recorded data in the report to draw appropriate conclusions from the experiment.
CO5	use the chemicals and apparatus safely individually and as a group.

Mapping of the COs with the POs:

COs\POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1		2	3		1	3	3		2
CO2	2	2		2	2	3			2
CO3	2	2			1	3	3		2
CO4					2	2	3	3		2
CO5				3	1		3	3	3	2

Mapping of the COs with the Teaching-Learning & Assessment Strategy:

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures and experiment demonstration	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination
CO5	Individual experiment	Lab Performance (individual), Viva voce

Recommended Books:

1. Vogel, *Qualitative Inorganic Analysis*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)
4. Vogel, *Textbook of Quantitative Analysis.*

Course No: **CHE 0531 1201S**	Credit: 3.0	Year: First	Semester: Second
Course Title: **Basic Chemistry for Oceanographers**		Course Status: **Theory** (GEd for OCG)	

Course Rationale: This course is aim to give a preliminary understanding of Chemistry that will be needed for the further study of higher courses.

Course Objectives:

The objectives of this course are to

- Familiarize the students with the basic concept of electronic structure
- Acquire the knowledge about the properties of elements on the periodic table
- Understand the concept of chemical formula and equation
- Acquire the basics of acid-base concepts and apply them to identify different acids and bases
- Understand gaseous state of matter and their properties
- Introduce preliminary ideas of chemical kinetics
- Acquaint students with the fundamentals of organic chemistry

Course Content:

Atoms, molecules and ions: Atomic theory, components of atoms.

Electronic structure: Quantum theory, atomic spectrum of hydrogen and the Bohr model, quantum numbers, concept of energy levels and atomic orbital, electronic configuration, chemical bonding and molecular structure.

The periodic table: Development of the periodic table, electron arrangements and the periodic table, summarized chemical properties of *s*-block, *p*-block and *d*-block elements.

Chemical formulas and equations: Types of formulas, percent composition from formula, formulas from experiment, formulas of ionic compounds, names of compounds, mass relations in reactions, limited reactant and theoretical yield. Concepts of mole. Solution: Different concentration units.

Acids and bases: Theories and modern definition of acids and bases, dissociation constant, strength, pH, buffer solution.

Gaseous state: Measurement on gases, the ideal gas law, volumes of gases involved in reactions, gas mixtures, partial pressure, kinetic theory of gases, real gases.

Introduction to chemical kinetics: Rate laws, rate constant, equilibrium constant, order of reaction.

Organic chemistry: Introduction**,** Classification, Nomenclatures, Preparations and Properties (Physical and Chemical) of (i) aliphatic and aromatic hydrocarbons, (ii) carbonyl compounds, (iii) carboxylic acids, and (iv) carbohydrates

(mono- and disaccharides).

Course Learning Outcomes:

After the successful completion of the course, students will be able to

CO1. Classify elements, correlate atomic models, orbit and orbitals, electron distribution and energy level, hydrogen spectral series, apply different principles to determine the configuration for any atom or ion and capable of explaining the development of the periodic table of elements, analyze and compare periodic trends in physical and chemical properties of elements in periodic table and explain the metallic and non-metallic characters of elements across the periodic table

CO2. Calculate the percent composition of a compound and derive empirical formulas from experimental data and explain the concept and use of different concentration unit, limiting reactant and percent of yield

CO3. Define and apply the modern concepts of acids and bases to identify and classify the acids and bases and their strength and explain acidic and basic properties of species and understand the kinetics of chemical reactions

CO4. Understand different gas laws, partial pressures and kinetic theory of gases, and can differentiate between ideal and real gases

CO5. Describe the nomenclature, physical and chemical properties of organic compounds having different functional groups

Mapping of COs with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

CO	**Program Learning Outcomes (PLOs)**									
	1	2	3	4	5	6	7	8	9	10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ) and Semester end exam.
CO2	Lecture, Demonstration, Discussion	Quiz, assignment and Semester end exam.
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ) and Semester end exam.
CO4	Lecture, Group discussion	Problem solving and Semester end exam.
CO5	Lecture, presentation, Journal article reviews, problem analysis	Problem solving and Semester end exam.

Recommended Books:

1. 1. S. Z. Haider, *Introduction to Modern Inorganic Chemistry*, 2nd Ed., 2000, Friends International, Dhaka, Bangladesh
2. 2. M. M. Huque and M. Y. A. Mollah, *Principles of Physical Chemistry*, Revised Ed., 2009, Brothers Publication, Dhaka, Bangladesh
3. 3. R. T. Morrison, R. N. Boyd, and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011, Dorling Kindersley Pvt. Ltd., India
4. 4. R. Chang and J. Overby, *General Chemistry-The Essential Concepts*, 6th Ed., 2011, McGraw-Hill, New York, USA

Course No: CHE **0531 2201L**	Credits: 3.0	Year: Second	Semester: Second
Course Title: **Chemistry for Geographers**		Course status: Theory (GEd for GEE)	

Course Rationale:

This course is aim to give a preliminary understanding of Chemistry that will be needed for the further study of higher courses. This introductory course will cover basic aspects of chemistry with emphasis placed on the relationship between the real world and the chemical world.

Course Objectives:

The objectives of this course are –

- To familiarize the student with electronic structure.
- To illustrate and describe electron arrangements and the periodic table.
- To elaborate theories and definition of acids and bases.
- To acquire preliminary ideas of atmospheric chemistry.
- To interpret composition of the lithosphere and soil.
- To acquire knowledge on nature of solids in the Geosphere.
- To understand fundamentals of Aquatic chemistry based on water quality parameters and water pollutants.
- To explain toxic and hazardous chemicals and its impact on Environment.
- To demonstrate different instrumental techniques used in environmental chemical analysis.

Course Contents:

Electronic Structure and the periodic table: The Quantum theory, The atomic spectrum of hydrogen and the Bohr model, Quantum numbers, Energy levels and the orbitals, Electronic configuration, Chemical bonding and molecular structure Electron arrangements and the periodic table, importance of periodic table, Chemical properties of different block elements.

Acids and bases: Theories and modern definition of acids and bases, Dissociation constants, strength, pH, Buffer solution, indicator and its mechanism, and principle and application of acid base titrations.

Gaseous state: Measurement of gases, the ideal gas laws, Gas mixtures, Partial pressure and real gases.

Atmospheric chemistry: Evolution of the Atmosphere, Earth's radiation balance, Composition of the Atmosphere, Particles and Physical process for particle formation in the atmosphere, Ions and Radicals in the Atmosphere, Chemical and photochemical reaction in the atmosphere, Ozone chemistry, NOx chemistry, Climate change and Anthropogenic Effects, Global warming and related chemistry, Atmospheric Mass Transfer, Meteorology and Weather, EL Nino and phenomenon.

Lithosphere and related Chemistry: Composition of the lithosphere and soil, Water and air in soil, Inorganic and organic components in Soil, Acid base and ion exchange reactions in soil, Micronutrients and macronutrients, Humic acids and related chemistry in soil, waste and pollutants in soil.

Geosphere and Geochemistry: Physical forms of the Geosphere, nature of solids in the Geosphere, Structure and process of Minerals, Evaporites and Volcanic Sublimates, Rock cycle, Igneous, Sedimentary, and Metamorphic Rocks, Weathering Environmental aspects of the Geosphere etc.

Aquatic chemistry and water pollutant: Fundamentals of Aquatic chemistry, Characteristics of bodies of water, Complexation and chelation in water, surface water and underground water quality parameters, Broad classification of water pollutants, hardness and its impact on environment, determination of hardness by EDTA method, Fertilizers and its backlashes on aquatic environment, Algal Nutrients and Eutrophication, Organic pollutants and bioaccumulation of Organic pollutants, Bio refractory Organic pollutants etc.

Air pollutants and related chemistry: Classification of air pollutants, Photochemical Smog and mechanism of its formation, SO_X and acid rain, stationary and mobile sources of air pollutants, automotive pollutants, 3-way catalytic converter and its mechanism to purify pollutants.

Toxic and hazardous chemicals and its impact on Environment: Definition and examples of toxic and Hazardous chemicals, acute and chronic toxicity, Toxic chemicals in the Environment, Impact of toxic and hazardous chemicals on Enzymes, Biochemical effects of Cd, Pb, As, CO, O_3, PAN, CN, additives in paints, plasticizers and its impact, nuclear waste and its hazardous impacts on health and environment.

Instrumental Techniques in Environmental Chemical Analysis: UV-visible Spectrophotometry and basic principles, instrumentation and deduction of Beer-Lambert law and calibration of instrument, Analysis of sample by it.

Course Learning Outcomes (CO):

After the successful completion of the course, students will be able to:

CO1: Study the concepts of electronic structure, different aspects of periodic table, state of gases, details of acids acid and bases.
CO2: Characterize the atmospheric and lithospheric environment related aspects of chemistry.
CO3: Explore the geo-environmental features of geosphere, aquatic environment and its pollution problem.
CO4: Figure out the chemical properties of the air pollutant and the impact of toxic and hazardous chemical on environment.
CO5: Apply the chemical analytical tools for solution of different environmental problems.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes (POs)									
	1	2	3	4	5	6	7	8	9	10
CO1	3	1								
CO2	3									
CO3	3	1								
CO4	3	1								
CO5	3									

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Semester end exam, problem solving
CO5	Lecture, presentation, Journal article reviews, problem analysis	Semester end exam, problem solving

Books Recommended:

1. General Chemistry (5th Edition)- Raymond Chang, McGraw-Hill (February 23, 2007)
2. Principles of Physical Chemistry (2nd Edition)- Haque and Mollah, Brothers Publications (2015)
3. Introduction to Modern Inorganic Chemistry- S.Z. Haider, Dhaka Friends International (1994)
4. Concise Inorganic Chemistry (5th Edition - J.D. Lee, Oxford University Press (1 February 2008)
5. Environmental Chemistry (9th Edition)- Stanley E. Manahan, CRC Press (December 17, 2009)
6. Environmental Chemistry (7th edition)- AK Dey, New Age International Pvt. Ltd. (June 14, 2010)

Course No: **CHE 0531 2202L**	Credits: 1.5	Year: Second	Semester: Second
Course Title: Environmental Chemistry Practical		Course status: Practical (GEd for GEE)	

Course Rationale:
Candidates are expected to understand how to correctly set up the experiments to carry out the qualitative and quantitative chemical analysis feasible for industrially important product.

Course Objectives:
The objectives of this course are –
- To develop skills to estimate different parameters of chemical samples which are important for specific sample analysis
- To provide the skill of examining industrial samples for justification of claimed quality.
- To make standard solution for calibrating UV-visible spectrophotometer followed by analysis of samples using UV-Vis spectrophotometer.
- Acquaint students with the basic experimental tools to measure the different quality parameters like iodine value, saponification value, hardness, TDS, etc.

Course Contents:
Lab demonstration and safety: About lab maintenance and safety related lectures.
Acid Base titration: Preparation of standard solution; Determination of the strength of unknown acid or base by titrimetric methods.
Complexometric Titration: Determination of water hardness of the supplied samples with EDTA.
Analysis of waste water: Estimation of dissolved oxygen (DO) from different waste water samples; Estimation of residual chloride from industrial waste water.
Analysis Soft drink/juice: Determination of dissolved CO2 from carbonated fluid; Determination of the acid content of the soft drink by pH titrimetric method.
Spectrophotometric determination of iron content from soil: Estimation of iron content of soil samples by UV-visible spectrophotometric method.
Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to –
CO1. Prepare standard solutions and indicators, and also be able to perform titration of desired solution utilizing complexometric titration technique.
CO2. Perform experiment along with calculation to determine dissolved oxygen and chloride content of the waste water.
CO3. Estimate iodine valu, hardness of water TDS etc.
CO4. Perform experiment to know the amount of dissolved CO_2 and also the acid content of soft drink.
CO5. Determine the iron contents of soil by spectroscopic method.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes (POs)									
	1	2	3	4	5	6	7	8	9	10
CO1		1		3						
CO2		1		3						
CO3				3						
CO4		1						3		
CO5							3			1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration in sampling, safety in the lab.	Assessment in the lab
CO2	Lecture, Practical Demonstration on accurate measurement for calibration of instrument, utilization of analytical tools like colorimeter etc.	Quiz, assignment
CO3	Demonstration on Data handling and graph drawing (hand and software aided graph practice) for result presentation.	Spot Assessment of experimental findings and report evaluations after completion and submission of lab report based on experimental findings.
CO4	Trouble shooting of instrumental error, comparison of different methods for sample analysis.	Oral assessment
CO5	Final Lab exam on specific experiment.	Oral assessment and evaluation of final presentation.

Books Recommended:

1. Vogel's Quantitative Analysis
2. Analytical Chemistry 2.1 by David Harvey.
3. Analytical Chemistry, 7th edition by Skoog, West, Holler
4. Analytical Chemistry, 5th edition by G. D. Christian

Course No: CHE 0531 1101F	Credit: 3.0	Year: First	Semester: First
Course Title: Organic chemistry		Status: Theory GED for FET	

Course Rationale:
This course is designed to provide the learners to acquire a fundamental knowledge on chemistry which would make them understand the chemistry behind the biochemical nature of food, its properties and how they are processed in the body.

Course Objectives:
The objectives of this course are to

- To acquaint students with the fundamentals of Organic Chemistry.
- To make the students familiar with the structure, synthesis, physical and chemical properties and the uses of aliphatic and aromatic hydrocarbons, alcohols and phenols, aldehydes and ketones, aliphatic and aromatic amines, and carboxylic acids and their functional derivatives, etc.
- To acquire the basics of acid-base concepts and apply them to identify different acids and bases
- To acquaint students with the fundamentals of common biomolecules

Course Content:
Introduction to basic organic chemistry: Chemical bonding, atomic and molecular orbitals, hybridization, shapes of molecules with special reference to carbon compounds, polar covalent bonds, dipole moment, polar and nonpolar compounds, ionic species from carbon compounds, resonance, inductive effect, electrophiles and nucleophiles.
Acids and Bases: Theories and Modern definitions of acids and bases, Dissociation constant of weak acids and bases, Strength of acids and bases, pH- A measure of acidity, Buffer solution etc.
Structure, Physical and Chemical Properties: Aliphatic and aromatic hydrocarbons, Alcohols and phenols, Aldehydes and ketones, Carboxylic acids and their functional derivatives and Aliphatic and aromatic Amines.
Structural features of Common Bio-molecules: Carbohydrates (mono-, di- and polysaccharides); Lipids and phospholipids; Amino acids, peptides and proteins; Nucleic acids, DNA, and RNA; Vitamins.
Specialized Organophosphorous and Organosulfur Compounds: Structure, chemistry, synthesis and uses of organophosphorus and organosulphur compounds of biological interest, mode of their action in biological system.
Persistent Organic Pollutants (POPs): Agricultural, industrial, disease associated with POPs.

Course Learning Outcomes:
After the successful completion of the course, students will be able to

CO1. Describe the fundamentals of Organic Chemistry
CO2. Define and apply the modern concepts of acids and bases to identify and classify the acids and bases and their strength and explain acidic and basic properties of species
CO3. Formulate the proper structure, name the molecule, and predict physical and chemical properties of aliphatic and aromatic hydrocarbons, aldehydes, ketones, carboxylic acids and their functional derivatives, alcohol, phenol and amines .
CO4. Explain the structural features of common biomolecules such as Carbohydrates (mono and disaccharides); Lipids and phospholipids; Amino acids, peptides and proteins; Nucleic acids, DNA, and RNA; Vitamins.
CO5. Explain the reactions, outline preparations and application of organosulfur and organophosphorus compounds. Describe the properties and structure of persistent organic pollutants and their impact on human health and environment

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	3	1										
CO2	3											
CO3	3	1										
CO4	3	1										
CO5	3											

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment strategy

CO	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, presentation, Journal article reviews, problem analysis	type test, problem solving

Books Recommended:

1. R. T. Morrison and R. N. Boyd, *Organic Chemistry* (6th edition)
2. Raymond Chang, *General Chemistry*
3. G. Solomon, *Organic Chemistry* (11th edition)
4. I. L. Finar, *Organic Chemistry* vol-I (6th edition)
5. I. L. Finar, *Organic Chemistry* vol-II (5th edition)

Course No: CHE 0531 1102F	Credit: 1.5	Year: First	Semester: First
Course Title: Organic chemistry lab		Course Status: Practical (GEd for FET)	

Course Rationale: This course is aim to give experimental practice to develop skill for professional life.

Course Objectives:
The objectives of this course are to

- Familiarize students with the basic lab equipment and lab safety rules
- Develop student's skill to measure the purity of organic compounds by using melting and boiling points
- Introduce students with the basic techniques of organic compound purification
- Acquaint students with the qualitative analysis of organic functional groups

Course Content:
Introduction to Basic Laboratory Equipment: Glassware and other personal items. Assembly and precaution in using glassware. Cleaning glassware, heating and cooling.
Melting points and Boiling points of Organic compounds: Discussion on melting point and boiling point, Determination of melting point of solid, Determination of boiling point of liquid.
Recrystallization: Discussion on crystallization, Purification of organic compounds using recrystallization technique.
Distillation: Simple distillation and Fractional distillation.
Solvent Extraction and Purification.
Identification of Typical Functional Groups in Organic Compounds.

Course Learning Outcomes:
After the successful completion of the course, students will be able to
CO1. Explain the use of common lab equipment and familiar with the safety rules in the chemistry lab
CO2. Check the purity of organic compounds by determining melting and boiling points
CO3. Purify both solid and liquid organic compounds by recrystallization, distillation and extraction techniques
CO4. Identify the functional group(s) presence in an organic compound and then perform a confirmatory test
CO5 Represent report based on experimental data and graph data.

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1		3								
CO2		1		3								
CO3				3								
CO4		1						3				
CO5							3			1		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

CO	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture along with Lab demonstration	Assessment on spot
CO2	Lab demonstration	Viva
CO3	Lab demonstration	Group discussion and trouble shooting
CO4	Lecture, Group discussion	Individual test MCQ
CO5	presentation, Journal article reviews, problem analysis	assessment of PPT presented by students

Books Recommended:

1. Clark, *Experimental Organic Chemistry*
2. A.I. Vogel, *A Text Book of Practical Organic Chemistry*
3. A.I. Vogel, *Elementary Practical Organic Chemistry* (Part 1)

Course Code: CHE 0531 1109 B	**Credit:** 2.0	**Year:** First	**Semester:** First
Course Title: Organic Chemistry	**Course Status: Theory (GEd) for CEP**		

Rationale of the Course: As a chemical engineering student, one must have knowledge about the structure, properties, composition, reactions, and preparation of carbon-containing organic compounds that will have a long-lasting impact throughout the whole learning and professional career.

The objectives of this course are to:

- Familiarize the students with chemical substances, their symbols, structures, and physical and chemical properties
- Acquaint students with the different transformation processes and condition of transformations of chemical substances along with their uses.
- Introduce students with the structures and chemistry of carbohydrates and dyes

Course Content:

Bonding in Organic Molecules: Bonding, structural formulas of organic compounds, electronegativity and dipoles, atomic orbital, electron configurations, molecular orbital and bonding – LCAO, sigma and pi-bonds, hybrid orbitals, bond angles and bond energies.

Aliphatic hydrocarbons: Classification and nomenclature, preparation, uses, physical and chemical properties of saturated and unsaturated hydrocarbons. Dienes and polymerization: isolated double bond, cumulated double bonds, conjugated double bonds, polymerization, and Diels-Alder reaction.

Aromatic Hydrocarbon: Structure and bonding in benzene; aromaticity, nomenclature, electrophilic aromatic substitution; Fridel Craft alkylation and acylation, direction and ease of aromatic substitution resonance and inductive effect, the steric effect, principles of higher substitutions.

Properties, Synthesis and Application of: Halides, Phenols, Ether and Epoxide, Carbonyl Compound, Carboxylic acid and their derivatives.

Chemistry of Carbohydrates: Classification and characteristics, structure and configuration of monosaccharides, epimerization and mutarotation, reactions, polymers of carbohydrates: cellulose and starch.

Dyes: Color and constituents, definition, classification, basic idea of dye formation, some typical dye preparation and uses.

Course Outcomes (COs): At the end of the course, student will be able to

CO1. Analyze the bonding and chemical structure of organic compounds

CO2. Classify organic compounds and learn the common preparation method, physical and chemical properties of different types of organic compounds; discuss different types of dienes and their preparation and uses.

CO3. Describe the complex structure, synthesis, characterization, and reaction mechanism of selected organic, aliphatic, and aromatic compounds

CO4. Classify and describe the structure, characteristics of different types of carbohydrate and their polymers along with their corresponding monomeric units.

CO5. Define different types of dyes with their constituents and know their preparation methods and uses.

Course Outcomes (COs): At the end of the course, student will be able to-

CO1 analyze the bonding and chemical structure of organic compounds

CO2 classify organic compounds and learn the common preparation method, physical and chemical property of different types of organic compounds; discuss different types of dienes and their preparation and uses.

CO3 describe the complex structure, synthesis, characterization and reaction mechanism of selected organic, aliphatic, and aromatic compounds.

CO4 classify and describe the structure, characteristics of different types of carbohydrate polymers and their monomeric units.

CO5 define different types of dyes with their constituents and know their preparation methods and uses.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Fundamental Skills			Social Skills			Thinking Skills		Personal Skills			
	PO1	PO2	PO3	PO7	PO10	PO11	PO4	PO5	PO6	PO8	PO9	PO12
CO 1	3	3									2	
CO 2	3	3					2				2	
CO 3	3	2					2				2	
CO 4	3						2					
CO 5	3										2	

Mapping Course Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Classroom lecture using board/projector and Assignment	Class evaluation, Assignment, Midterm Exam, and Semester-end Exam
CO 2	Classroom lecture using board/projector, tutorial and Assignment	Class evaluation, Assignment, Midterm Exam, and Semester-end Exam
CO 3	Classroom lecture using board/projector, homework	Class evaluation, Assignment, Midterm Exam, and Semester-end Exam
CO 4	Classroom lecture using board/ projectors	Class evaluation, Assignment and Semester-end Exam
CO 5	Classroom lecture using board/projector, homework,	Quiz test, Class evaluation, Assignment and Semester-end Exam

Recommended Books

1. R. T. Morrison, R. N. Boyd, and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011, Dorling Kindersley Pvt. Ltd., India
2. T. W. G. Solomons, C. B. Fryhle, and S. C. Snyder, *Organic Chemistry*, 12th Ed., 2016, John Wiley & Sons, Inc,, New Jersy, USA
3. F. A. Carey, R. M. Giuliano, N. T. Allison, and S. L. Bane, *Organic Chemistry*, 12th Ed., 2024, McGraw-Hill Education, New York, USA
4. I. L. Finar, *Organic Chemistry*, Vol. 2, 5th Ed., 1997, Addison Wesley Longman Ltd., Essex, England

Graduate Curriculum

Session: 2024-2025

Department of Chemistry

Shahjalal University of Science and Technology
Sylhet, Bangladesh

Department of Chemistry
Shahjalal University of Science & Technology
Sylhet-3114, Bangladesh
Curriculum for MS Program
Session: 2024-2025

1. Title of the Academic Program: Master of Science (MS) in Chemistry

2. Name of the University: Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh

3. Vision of the University: *To be a leading university of excellence in Science and Technology with a strong national commitment and significant international impact.*

4. Mission of the University:

- To advance learning and knowledge through teaching and research in science and technology.
- To serve as a center for knowledge creation, technological innovation and transfer among academia, industry, and society.
- To assist in transferring Bangladesh a country with sustainable economic growth and equitable social development.

5. Name of the Program offering Entity: Department of Chemistry, SUST

6. Vision of the Department of Chemistry, SUST:

The Department of Chemistry, SUST endeavors to be a nationally recognized model for producing chemistry graduates to compete in and contribute to the needs of time-demanding and technology-centered chemistry world.

7. Mission of the Department of Chemistry, SUST:

M1. To achieve the highest possible standards of teaching and research in chemistry and allied subjects by providing a high quality of education that will allow graduates to be active, productive, engaged members of society on local, national and international levels.
M2. To prepare students as successful professionals for employment in any of the vast array of chemistry-related industries including: Chemical, Pharmaceuticals, Biotechnology, Environmental, and Quality Control-Quality Assurance sectors.
M3. To achieve personal academics by use of modern educational technology in secondary and tertiary level, independent thought, collegial exchange of ideas and high ethical standards.
M4. To develop the students as effective researchers on fundamental and applied problems and promoting the development of innovative interdisciplinary research programs (**For mix mode**)

8. Objectives of the Department of Chemistry, SUST:

Providing high-quality education: Chemistry departments aim to provide students with a strong foundation in the principles and practices of chemistry, and to equip them with the skills and knowledge needed to pursue careers in various fields related to chemistry.
Conducting research: Chemistry departments conduct research to advance our understanding of chemical reactions, properties, and structures. They aim to develop new technologies, materials, and medicines that can benefit society.
Promoting scientific discovery: Chemistry departments aim to promote scientific discovery by developing new theories and hypotheses, and testing them through experimentation and analysis. They also strive to disseminate their findings through publications, conferences, and other forms of communication.
Fostering interdisciplinary collaboration: Chemistry departments often work closely with other departments and disciplines, such as biology, physics, and engineering, to solve complex scientific problems that require a multidisciplinary approach.
Engaging with the community: Chemistry departments aim to engage with the broader community through outreach programs, public lectures, and other educational activities. They aim to promote a greater understanding and appreciation of chemistry, and to inspire the next generation of scientists.

9. Name of the Degree

Master of Science (MS) in Chemistry is awarded in four different branches of Chemistry, namely:
Master of Science in Physical Chemistry

Master of Science in Inorganic Chemistry
Master of Science in Organic Chemistry
Master of Science in Analytical and Environmental Chemistry

10. Description of the Program:

Master's degree in Chemistry is a postgraduate program that focuses on advanced course works and research in the field of chemistry. Department of Chemistry, SUST graduate program offers three distinct pathways to a Master's degree: Master's by Coursework, Master's by Mixed Mode (with options for a dissertation), and Master's by Research.
Both Master's by Coursework and Master's by Mixed Mode (with options for a dissertation), are further classified in four groups of specialization, namely Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical and Environmental Chemistry. For Master's by Coursework, the duration is one year and for Master's by Mixed Mode , it is one and half year.
The curriculum of a Master's in Chemistry program includes advanced courses in organic, inorganic, physical, and analytical chemistry, as well as specialized courses in areas such as biochemistry, materials science, and environmental chemistry, and some others special courses related to chemistry. Students are also expected to engage in research projects, which may involve laboratory work, data analysis, and scientific writing.
After completing a Master's in Chemistry, graduates can, pursue various career paths, including research and development in academia, government, or industry, teaching at the college level, or working in fields such as pharmaceuticals, materials science, or environmental science. Many students also use the Master's degree as a stepping stone towards pursuing a Doctoral by Research. in Chemistry or related fields.

The degree offers in three different categories:

i. Master's by Coursework (Taught Program) (1 Year, 2 Semesters)
ii. Master's by Mixed Mode (with options for a dissertation (1.5 Years, 3 Semesters)
iii. Master's by Research (2 years, 4 semesters)

11. Graduate Attributes (GA):

Graduate attributes refer to the skills, knowledge, and qualities that students are expected to have acquired upon completing their degree program. For a chemistry graduate, some of the key graduate attributes would include:
GA1. Subject Specific Knowledge: In-depth knowledge of all major areas of Chemistry
GA2. Analytical and critical thinking: Have the ability to analyze data and information, evaluate arguments and evidence, and draw logical conclusions. They should be able to think critically to solve chemistry problems.
GA3. Scientific literacy: Deep understanding of the scientific method, including design experiments, collect and analyze sample, interpret results.
GA4. Communication skills: Able to communicate effectively with different audiences, including scientific peers, policymakers, and the general public. They should be able to write and speak clearly and use appropriate scientific language and terminology.
GA5. Teamwork and collaboration: Able to work effectively as part of a team, collaborating with other scientists and professionals to achieve common goals. They should be able to contribute their own ideas, listen to others, and work towards consensus.
GA6. Ethics and professionalism: Understand the ethical principles and standards of their profession, and be able to demonstrate professionalism.
GA7. Adaptability and lifelong learning: Able to adapt to new situations and technologies, and be willing to learn and acquire new knowledge and skills throughout their career. They should have a growth mindset and be able to embrace change and uncertainty.

12. Program Educational Objectives of the Department of Chemistry, SUST (PEO):

Objectives of the MS program in Chemistry

It is given that all students obtaining a certified degree in chemistry should be well trained in chemical concepts and laboratory practices. However, to be effective and productive scientists, students need to master a variety of skills that go beyond course content alone. The objectives or learning targets of the curriculum are categorized in the following

dimensions:

- *Knowledge and Understanding*
- *Skills and Processes, and*
- *Values and Attitudes*

To meet these goals, the following are the program objectives:

PEO1. Help the students to be enriched with the advanced knowledge, processes and procedures of the major areas of chemistry; and particularly specialized in a field among the physical, inorganic, organic, analytical and environmental.

PEO2. Make the students able to demonstrate high level analytical and critical thinking skills to solve conceptual and quantitative problems in chemistry through the application competencies achieved in all four major fields of chemistry.

PEO3. Develop skill to demonstrate safe and acceptable skills in laboratory procedure, experimental design and to expose students to modern instrumentation and laboratory techniques used in chemical analysis (**and research**).

PEO4. Help the students to acquire the expertise with the necessary tools to carry out chemistry research independently and in team and to prepare them for doctoral or higher studies in chemistry or related fields.

PEO5. To enhance the skill for communicating scientific results effectively in written, oral and in interactive presentation.

PEO6. Help students develop curiosity and interest in making scientific investigations, personal integrity and to realize the roles of chemist on industrial, environmental social and economic aspects nationally and globally.

PEO7. Acquaint students with moral and ethical values to handle the research findings, maintaining the secrecy of Intellectual Properties (IP) and development of patriotism.

13. PEO to Mission Statement Mapping

Mission/ PEO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO16	PEO7
M1	X	x	x	x	x	x	x
M2	X	x	x		x	x	
M3	X	x	x			x	x
M4	X	x	x	x	x	x	x

14. Program Learning Outcome for MS in Chemistry (POs)

POs	Learning Attribute	PO statement *After successful completion of the program, graduate will be able to-*	BNQF Domain
PO1	*Advanced Knowledge of Chemistry*	Explain and apply the advanced knowledge and expertise in the field of chemistry, including physical, inorganic, organic, and analytical & environmental chemistry.	Fundamental
PO2	*Laboratory Equipment and Sophisticated Instrumental Skills*	Design and carry out qualitative and quantitative chemistry experiments, synthesis, isolation and characterize the materials, analyze the results using statistical and computational methods. Familiarity with a range of experimental techniques and methodologies, including the latest advances in instrumentation and technology	Fundamental
PO3	*Critical Thinking and Problem-Solving Skills*	Demonstrate strong problem-solving and critical thinking skills, integrate concepts and ideas and skills to perform qualitative and quantitative analysis and analytical reasoning.	Thinking and Problem-solving
PO4	*Research Skill* ***(For Thesis group)***	Search and explore the chemistry literature and scientific resources to design, execution and report on independent research projects in the field of chemistry, demonstrate mastery of laboratory techniques and data analysis as individuals, and collaboratively to explore new knowledge in chemistry and allied fields. Collaborate effectively with other scientists and professionals from related fields.	Fundamental and Thinking
PO5	*Communication, ICT, and digital Fluency*	Use knowledge and proficiency to communicate the results of scientific work in oral, written and electronic visual formats and be able to prepare logical, organized and concise written articles or reports; able to use modern devices and platforms for general, social and professional communication.	Social
PO6	*Employability and Entrepreneurships*	Plan and manage activities required for professional development in chemical and related industries; have the skills to work in interdisciplinary research/industries; be competence in keeping up with global innovations and developments in chemistry and in related fields; Prepare for further study or research at the PhD level, or find gainful employment in academics, industry and government organizations and develop entrepreneurships and professional career.	Personal
PO7	*Professional Integrity and Leadership*	Demonstrate professional integrity, safety, and environmental stewardship and display effective cooperation with others on projects in various learning and work environments. Be realize the interdisciplinary nature of chemistry and be able to collaborate effectively with other scientists and professionals from related fields.	Personal
PO8	*Environment and sustainability*	Realize the environmental protection and work/laboratory safety and integrate the rules of chemist and impact of chemical solutions in societal and environmental contexts and realize the needs for sustainable development of society and country.	Social
PO9	*Ethics and morality*	Aware of the ethical and social implications of scientific research and apply ethical principles in research and professional practice. Demonstrate the moral and professional ethical values to handle the research findings, data manipulation and maintaining the secrecy of Intellectual Property (IP).	Personal
PO10	*Life-long Learning*	Understand the current trends, developments, and issues in the field of chemistry, and the ability to stay abreast of new advances.	Personal

15. Mapping of the Mission Statement of the Department with PEO

Mission/ PEO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO16	PEO7
M1	x	x	x	x	x	x	X
M2	x	x	x		x	x	
M3	x	x	x	x	x	x	X

M4	**x**	**x**	**x**			**x**	**X**

16. Program Objectives (PEO) to Program Learning Outcome (PO) Mapping:

PO	PEO1	PEO2	PEO3	PEO4	PEO5	PEO16	PEO7
PO1	X						
PO2		x					
PO3			x				
PO4				x			
PO5					x		
PO6						x	X
PO7						x	x
PO8	X	x	x	x	x	x	x
PO9							x
PO10						x	

17. Mapping of Courses with Program Learning Outcomes (POs)

Sr. No	Course Code No	Course Title	Program Learning Outcomes (POs)									
			1	2	3	4	5	6	7	8	9	10
01	CHE 0531 5121	Electrochemical Methods	3	3	3					1		1
02	CHE 0531 5122	Surface Chemistry and Spectroscopy	3	3	3							3
03	CHE 0531 5123	Molecular Photochemistry	3		3	3	1		3		2	
04	CHE 0531 5224	Advanced Chemical Kinetics	3		3	3				2	1	1
05	CHE 0531 5225	Advanced Electrochemistry	3	3	3					1		1
06	CHE 0531 5226	Biophysical Chemistry	3		3					1		1
07	CHE 0531 5227	Chemical Energy	3	3	3						2	3
08	CHE 0531 5220	Advanced Physical Chemistry Lab		3	1							
09	CHE 0531 5131	Inorganic Materials Chemistry	2		1							
10	CHE 0531 5132	Inorganic Spectroscopic Methods	2		2	2	1	1				
11	CHE 0531 5233	Advanced Bioinorganic Chemistry	2		3			1				
12	CHE 0531 5234	Advanced Crystallography and Group Theory	3		1							
13	CHE 0531 5235	Frontiers Solid-state Materials	3	1	1							
14	CHE 0531 5130	Advanced Inorganic Chemistry Lab		3	3							
15	CHE 0531 5141	Advanced Heterocyclic& Organometallic Chemistry	3		1							
16	CHE 0531 5142	Advanced Biochemistry	3		2							
17	CHE 0531 5143	Advanced Natural Products Chemistry	3		2	3						
18	CHE 0531 5244	Supramolecular Chemistry	3		2							
19	CHE 0531 5245	Advanced Spectroscopy and Stereochemistry	3		2					1		1
20	CHE 0531 5246	Advanced Medicinal Chemistry	3	1	2			3		2	1	
21	CHE 0531 5240	Advanced Organic Chemistry Lab		3		2						1
22	CHE 0531 5151	Analytical Spectroscopy	3									
23	CHE 0531 5152	Advanced Environmental Chemistry	3	2						2		
24	CHE 0531 5253	Waste Management and Treatment	3									
25	CHE 0531 5254	Sustainable Chemistry and Bio Nanotechnology	3							2		
26	CHE 0531 5150	Advanced Analytical & Environmental Chemistry Practical		3						2		2
27	CHE 0531 5161	Topics on Nanoscience and Nanotechnology	2	3								
28	SPS 0111 5170	Research methodology for chemistry			3	2	1			3	1	1
29	CHE 0531 5271	Seminar and presentation	2		3		2					1
30	SPS 0417 5180	In Plant Training						3	1			2
31	CHE 0531 5291	Comprehensive viva voce	2		3		2					1
32	CHE 0531 5310	Thesis			3		3		1			2

18. Course Structure:

1. Program duration: one (1) year for Master's by Coursework; one year (1) & six (6) months for Master's by Mixed Mode

Numbers of Semesters: Two (2) Semester for Master's by Coursework, three (3) Semesters for Master's by Mixed Mode

2. Admission Requirements (for Master's by Mixed Mode): Based on the B.Sc. (Hons.) results, top students having minimum CGPA of 3.0 may apply for admission.

3. Graduating Credits: **40 (**Master's by Coursework) **/44 (**Master's by Mixed Mode**)**

4. Duration of each semester will be as follows:

Classes:	14 weeks
Recess before final examination:	02 weeks
Final Examination:	04 weeks
Semester break (Result processing and publication):	02 weeks
Total:	22 weeks

5. **Minimum CGPA requirements for graduation: 2.00**

Description of the Program

MS in Chemistry is offered in two main streams, Master's by Coursework and Master's by Mixed Mode.
The details for both groups are as follows:

Branch identification:

To belong a particular group of specialization in Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical and Environmental Chemistry (i) at least four theoretical courses from his/her own branch and an optional course from other branches for Master's by Coursework and (ii) four theoretical courses from his/her own branch, an optional course from other branches and (iii) thesis work relevant to own group (under the supervision of own group teacher) for Master's by Mixed Mode must have to be taken.

I) Master's by Coursework:

MS degree will be awarded in Master of Science in Chemistry (Coursework) from the chemistry department of SUST under the following terms and conditions.

Eligibility for admission: A student with B.Sc. (Hons.) Degree in Chemistry from SUST will be eligible for admission into MS by Coursework at the Department of Chemistry.

Duration of the course: The duration of the course will be one year (two semesters).

Section selection: A student will have to choose one Special branch out of four branches of chemistry Physical, Inorganic, Organic, and Analytical and Environmental Chemistry.

Semester and Credit: A student will have to complete **40.0** credits to obtain his/her MS degree in MS by Coursework. A student enrolled in this program must register for a minimum of 10 (ten) credits and a maximum of 20 (twenty) credits per semester. A student can complete the necessary courses (theory and lab) either in MS 1st Semester or in MS 2nd Semester (providing the availability of the courses) offered by the Department. MS Degree will be given as specialized in Physical/Inorganic/Organic/Analytical & Environmental Chemistry with MS by Coursework.

Selection of courses:

1. Theory courses (26 credits): Students will have to complete **4.0 credits four theory courses** (two in each semester) in the specialized branch in related branch in Physical, Inorganic, Organic, and Analytical & Environmental Chemistry. In addition to that, (i) Topics on Nanoscience and Technology (3.0 credits), (ii) Research Methodology for Chemistry (3.0 credits**)** and (iii) one course of 4.0 credit from the other group will have to be taken. The evaluation will be based on term test, assignment, quiz, class attendance and semester final examinations. The marks will be distributed as attendance 10%, term test, assignment, quiz, etc., 30% and final examination on 60% marks.

2. Laboratory courses (4 × 2 = 8.0 credits): Students will have to complete **04 (Four) advanced practical courses** from (one from each specialized branch). The teachers will design the contents of the laboratory courses. At least 2 teachers will be assigned in laboratory courses. The assigned course teachers will evaluate the course in 100 marks.

3. In plant training (2.0 credits): In plant Training Program will be completed at TICI (Training Institute for chemical Industries) by the joint collaboration of Chemistry Department, Shahjalal University of Science and Technology, Sylhet and Training Institute for Chemical Industries, Sarkarkhana, Polash, Narsingdi-1611, Bangladesh. Teacher (2-3) will be

assigned for this course. The department will select an industry/ laboratory or training institute so that students can get practical training regarding technologies. Based on the (i) report received from TICI and (ii) oral examination conducted by course teacher, students will be evaluated within 100 marks.

4. **Seminar and presentation (2.0 credits)**: Students will have to make a presentation on a selected topic from his/her own branch courses offered in MS program or an open topic in recent trends in chemistry and present it before the examination panel. The examination panel will evaluate the students based on the (i) clarity and quality of making the presentation, (ii) fluency of presentation and (iii) pleasantness of addressing the question and answer session.

5. Comprehensive viva voce (2.0 credits): At the end second semester, the examination committee will arrange a viva board. The board member will individually give marks for each student out of 100. An average of the marks given will be counted for the evaluation of the students.

II) Master's by Mixed Mode:

MS degree will be awarded in Chemistry (mixed mode) from the chemistry department of SUST under the following terms and conditions.

Eligibility for admission: Based on the B.Sc. (Hons.) results, top students having minimum CGPA of 3.00 may apply for admission.

Section selection: At first a student will search a supervisor. In appropriate cases a co-supervisor will also be engaged with the student. The students will choose a branch (Physical/Inorganic/Organic/Analytical & Environmental) consulting with his/her own branch related supervisor.

Semester and Credit: A Student must complete offered **44** credits in three semesters and he/she enrolled in this program must register for a minimum of 8 (eight) credits and a maximum of 16 (sixteen) credits per semester.

Selection of courses:

1. Theory courses (26 credits): Students will have to complete **4.0 credits four theory courses** (two in each semester) in the specialized branch in related branch in Physical, Inorganic, Organic, and Analytical & Environmental Chemistry. In addition to that, (i) Topics on Nanoscience and Technology (3.0 credits), (ii) Research Methodology for Chemistry (3.0 credits**)** and (iii) one course of 4.0 credit from the other group will have to be taken. The evaluation will be based on term test, assignment, quiz, class attendance and semester final examinations. The marks will be distributed as attendance 10%, term test, assignment, quiz, etc., 30% and final examination on 60% marks.

2. In plant training (2.0 credits): In plant Training Program will be completed at TICI (Training Institute for chemical Industries) by the joint collaboration of Chemistry Department, Shahjalal University of Science and Technology, Sylhet and Training Institute for Chemical Industries, Sarkarkhana, Polash, Narsingdi-1611, Bangladesh. Teacher (2-3) will be assigned for this course. The department will select an industry/ laboratory or training institute so that students can get practical training regarding technologies. Based on the (i) report received from TICI and (ii) oral examination conducted by course teacher, students will be evaluated within 100 marks.

3. **Seminar and presentation (2.0 credits)**: Students will have to make a presentation on a selected topic from his/her own branch courses offered in MS program or an open topic in recent trends in chemistry and present it before the examination panel. The examination panel will evaluate the students based on the (i) clarity and quality of making the presentation, (ii) fluency of presentation and (iii) pleasantness of addressing the question and answer session.

4. Comprehensive viva voce (2.0 credits): At the end second semester, the examination committee will arrange a viva board. The board member will individually give marks for each student out of 100. An average of the marks given will be counted for the evaluation of the students.

5. Thesis (12.0 credits): Students will start their thesis works from the beginning of the MS first semester and they will register for this course at the beginning of third semester. The thesis will be evaluated as per the examination ordinance. Research ethics are strictly to be followed.

Evaluation:

The marks distribution of a given course will be as follows:

Class Attendance	10%
Assignments and Mid-Semester Examinations	20%
Quiz, Assignment, etc.	10%
Final Examination	60%

Assessment and Attainment of COs:

There should be at least two mid-semester examinations for every course. The course teacher may decide the relative marks distribution between the assignments, tutorial, and mid-semester examinations, however at least 50% of contribution should come from the mid-semester examinations. The course teacher may decide the relative marks distribution between the assignments, tutorial, and mid-semester examinations. The course teacher of each course will design the distribution of COs for the Class test, mid-semester, and final exam in the course plan that will be submitted to the department prior to the start of class. A copy of this course plan will also be provided to the chairman of the examination committee so that it can be used during the moderation of the questions so that the attainment of all the COs will be confirmed throughout all the assessments.

Course Structure for both modes (Mixed and Coursework):

Course	**Branch**	**Mode**	Mixed Mode	Coursework Mode
Four (04) theory courses	Own Branch	Both	4.0 × 4 = 16.0	4.0 × 4 = 16.0
One (01) theory course	Other branch	Both	4.0 × 1 = 4.0	4.0 × 1 = 4.0
Four (04) Lab courses:	All branch	Coursework Mode	-	2.0 × 4 = 8.0
Topics on Nanoscience and Nanotechnology	Compulsory	Both	3.0	3.0
Research methodology for chemistry		Both	3.0	3.0
In plant Training in TICI		Both	2.0	2.0
Seminar and Presentation		Both	2.0	2.0
Comprehensive viva voce		Both	2.0	2.0
Thesis	Own branch	Mixed Mode	12.0	-
		Total credits	**44.0**	**40.0**

List of Courses offered by the four branches for MS program in Chemistry

Branch	**Course Code**	**Course Title**	**Course type**	**Credit**
Physical Chemistry	CHE 0531 5121	Electrochemical Methods	Core Theory	4.0
	CHE 0531 5122	Surface Chemistry and Spectroscopy	Core Theory	4.0
	CHE 0531 5123	Molecular Photochemistry	Core Theory	4.0
	CHE 0531 5224	Advanced Chemical Kinetics	Core Theory	4.0
	CHE 0531 5225	Advanced Electrochemistry	Core Theory	4.0
	CHE 0531 5226	Biophysical Chemistry	Core Theory	4.0
	CHE 0531 5227	Chemical Energy	Core Theory	4.0
	CHE 0531 5220	Advanced Physical Chemistry Lab	Core Lab	2.0
Inorganic Chemistry	CHE 0531 5131	Inorganic Materials Chemistry	Core Theory	4.0
	CHE 0531 5132	Inorganic Spectroscopic Methods	Core Theory	4.0
	CHE 0531 5233	Advanced Bioinorganic Chemistry	Core Theory	4.0
	CHE 0531 5234	Advanced Crystallography and Group theory	Core Theory	4.0
	CHE 0531 5235	Frontiers Solid-state Materials	Core Theory	4.0
	CHE 0531 5130	Advanced Inorganic Chemistry Lab	Core Lab	2.0

Organic Chemistry	CHE 0531 5141	Advanced Heterocyclic and Organometallic chemistry	Core Theory	4.0
	CHE 0531 5142	Advanced Biochemistry	Core Theory	4.0
	CHE 0531 5143	Advanced Natural Products Chemistry	Core Theory	4.0
	CHE 0531 5244	Supramolecular Chemistry	Core Theory	4.0
	CHE 0531 5245	Advanced Spectroscopy and Stereochemistry	Core Theory	4.0
	CHE 0531 5246	Advanced Medicinal Chemistry	Core Theory	4.0
	CHE 0531 5240	Advanced Organic Chemistry Lab	Core Lab	2.0
Analytical Chemistry	CHE 0531 5151	Analytical Spectroscopy	Core Theory	4.0
	CHE 0531 5152	Advanced Environmental Chemistry	Core Theory	4.0
	CHE 0531 5253	Waste Management and Treatment	Core Theory	4.0
	CHE 0531 5254	Sustainable Chemistry and Bio Nanotechnology	Core Theory	4.0
	CHE 0531 5150	Advanced Analytical & Environmental Chemistry Practical	Core Lab	2.0
Compulsory Courses: Skill Enhancement and Capstone	SPS 0111 5170	Research methodology for Chemistry	GEd Theory	3.0
	CHE 0531 5161	Topics on Nanoscience and Nanotechnology	Core Theory	3.0
	CHE 0531 5271	Seminar and presentation	Core capstone	2.0
	SPS 0417 5180	In Plant Training	GEd Exposer	2.0
	CHE 0531 5291	Comprehensive viva voce	Core Viva	2.0
Thesis	CHE 0531 5310	Thesis	Core Capstone	12.0
Percentage of GED courses (coursework mode) 12.5% and (mixed mode) 11.4%				

By Course work

M1:Two courses (8) + Nano (3)+ Research method (3)+Two lab (4) +TICI (2) =20

M2:Three courses (12)+Two lab (4) + Oral (3) + seminar (2) =20

By Mix mode

M1:Two courses (8) + Nano (3)+ Research method (3)+ TICI (2) =16

M2:Three courses (12) + Oral (2) + Seminar (2.0) =16

M3: Thesis: 12.0 Credits

Detailed Semester wise Course Structure for Physical Chemistry Branch

Semester I			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5121 **CHE 0531 5122** **CHE 0531 5123**	Electrochemical Methods Surface Chemistry and Spectroscopy Molecular Photochemistry	4.0×2 = 8.0	4.0×2 = 8.0
CHE 0531 5161	Topics on Nanoscience and Nanotechnology	3.0	3.0
CHE 0531 5130 **CHE 0531 5150**	Advanced Inorganic Chemistry Lab Advanced Analytical & Environmental Chemistry Practical	-	2.0×2=4.0
SPS 0111 5170	Research methodology for chemistry	3.0	3.0
SPS 0417 5180	In Plant Training	2.0	2.0
	Total credits in Semester I	**16**	**20**

Semester II			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5224 **CHE 0531 5225** **CHE 0531 5226** **CHE 0531 5227**	Advanced Chemical Kinetics Advanced Electrochemistry Biophysical Chemistry Chemical Energy	4.0×2 = 8.0	4.0×2 = 8.0
Optional Courses	One theory course from other branch	4.0	4.0
CHE 0531 5220 **CHE 0531 5240**	Advanced Physical Chemistry Lab Advanced Organic Chemistry Lab	-	2.0×2=4.0
CHE 0531 5291	Comprehensive viva voce	2.0	2.0

CHE 0531 5271	Seminar and presentation	2.0	2.0
	Total credits in Semester II	**16**	**20**
Total credits in Semester I & II (Program completion for Master's by Coursework) = (20+20) = 40			

Semester III		
Course Code	**Course Title**	**Credits (**Mixed Mode**)**
CHE 0531 5310	Thesis	12.0
Total credits in Semester I, II, III (Program completion for Mixed Mode) = (16+16+12) = 44.0		

Detailed Semester wise Course Structure for Inorganic Chemistry Branch

Semester I			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5131 **CHE 0531 5132**	Inorganic Materials Chemistry Inorganic Spectroscopic Methods	4.0×2 = 8.0	4.0×2 = 8.0
CHE 0531 5161	Topics on Nanoscience and Nanotechnology	3.0	3.0
CHE 0531 5130 **CHE 0531 5150**	Advanced Inorganic Chemistry Lab Advanced Analytical & Environmental Chemistry Practical	-	2.0×2=4.0
SPS 0111 5170	Research methodology for chemistry	3.0	3.0
SPS 0417 5180	In Plant Training	2.0	2.0
	Total credits in Semester I	**16**	**20**

Semester II			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5233 **CHE 0531 5234** **CHE 0531 5235**	Advanced Bioinorganic Chemistry Advanced Crystallography and Group theory Frontiers Solid-state Materials	4.0×2 = 8.0	4.0×2 = 8.0
Optional Courses	One theory course from other branch	4.0	4.0
CHE 0531 5220 **CHE 0531 5240**	Advanced Physical Chemistry Lab Advanced Organic Chemistry Lab	-	2.0×2=4.0
CHE 0531 5271	Seminar and presentation	2.0	2.0
CHE 0531 5291	Comprehensive viva voce	2.0	2.0
	Total credits in Semester II	**16**	**20**
Total credits in Semester I & II (Program completion for Coursework Mode) = (20+20) = 40			

Semester III		
Course Code	**Course Title**	**Credits (Thesis group)**
CHE 0531 5310	Thesis	12.0
Total credits in Semester I, II, III (Program completion for Mixed Mode) = (16+16+12) = 44.0		

Detailed Semester wise Course Structure for Organic Chemistry Branch

Semester I			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode

CHE 0531 5141 **CHE 0531 5142** **CHE 0531 5143**	Advanced Heterocyclic and Organometallic Chemistry Advanced Biochemistry Advanced Natural Chemistry Product	4.0×2 = 8.0	4.0×2 = 8.0
CHE 0531 5161	Topics on Nanoscience and Nanotechnology	3.0	3.0
CHE 0531 5130 **CHE 0531 5150**	Advanced Inorganic Chemistry Lab Advanced Analytical & Environmental Chemistry Practical	-	2.0×2=4.0
SPS 0111 5170	Research methodology for chemistry	3.0	3.0
SPS 0417 5180	In Plant Training	2.0	2.0
	Total credits in Semester I	**16**	**20**

Semester II			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5244 **CHE 0531 5245** **CHE 0531 5246**	Supramolecular Chemistry Advanced Spectroscopy and Stereochemistry Advanced Medicinal Chemistry	4.0×2=8.0	4.0×2=8.0
Optional Courses	One theory course from other branch	4.0	4.0
CHE 0531 5220 **CHE 0531 5240**	Advanced Physical Chemistry Lab Advanced Organic Chemistry Lab	-	2.0×2=4.0
CHE 0531 5271	Seminar and presentation	2.0	2.0
CHE 0531 5291	Comprehensive viva voce	2.0	2.0
	Total credits in Semester II	**16**	**20**
Total credits in Semester I & II (Program completion for Coursework Mode) = (20+20) = 40.0			

Semester III		
Course Code	**Course Title**	**Credits (**Mixed Mode**)**
CHE 0531 5310	Thesis	12.0
Total credits in Semester I, II, III (Program completion for Mixed Mode) = (16+16+12) = 44.0		

Detailed Semester wise Course Structure for Analytical and Environmental Chemistry Branch

Semester I			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5151 **CHE 0531 5152**	Analytical Spectroscopy Advanced Environmental Chemistry	4.0×2=8.0	4.0×2=8.0
CHE 0531 5161	Topics on Nanoscience and Nanotechnology	3.0	3.0
CHE 0531 5130 **CHE 0531 5150**	Advanced Inorganic Chemistry Lab Advanced Analytical & Environmental Chemistry Practical		2.0×2=4.0
SPS 0111 5170	Research methodology for chemistry	3.0	3.0
SPS 0417 5180	In Plant Training	2.0	2.0
	Total credits in Semester I	**16**	**20**
Semester II			
Course Code	**Course Title**	**Credits**	
		Mixed Mode	Coursework Mode
CHE 0531 5253 **CHE 0531 5254**	Waste Management and Treatment Sustainable Chemistry and Bio Nanotechnology	4.0×2=8.0	4.0×2=8.0
***Optional Courses**	One theory course from other branch	4.0	4.0
CHE 0531 5220 **CHE 0531 5240**	Advanced Physical Chemistry Lab Advanced Organic Chemistry Lab	-	2.0×2=4.0
CHE 0531 5271	Seminar and presentation	2.0	2.0
CHE 0531 5291	Comprehensive viva voce	2.0	2.0
	Total credits in Semester II	**16**	**20**

Total credits in Semester I & II (Program completion for Master's by Coursework**) = (20+20) = 40**

Semester III		
Course Code	**Course Title**	**Credits (**Mixed Mode**)**
CHE 0531 5310	Thesis	12.0
Total credits in Semester I, II, III (Program completion for Thesis Group) = (16+16+12) = 44.0		

Description of all courses (Course Profile)

Course No: **CHE 0531 5220**	Credit: 2.0 (8h/week)	Year: MS	Semester: Second
Course Title: **Advanced Physical Chemistry Lab**		Course Type: Core Lab	

Course Rationale:
This course is designed to give learners advanced laboratory experience with a strong focus on developing skills to develop and analyze data based on electrochemical, kinetics and spectroscopic experiments.

Course Objectives:
The objectives of this course are to:
- Provides training in advanced physical chemistry laboratory techniques.
- The investigation provides an introduction to research methods: a group of 3-4 students are given a theme or problem and some apparatus; they must devise, build and execute experiments using less guidance than for the standard experiments. Data analysis and structured report writing are key components of the course.

Course Content
Students will perform the following experiments:
1. Study of primary salt effect on the base catalyzed hydrolysis of ethyl acetate and determination of the activation energy of the reaction by conductometric method.
2. Study of the primary salt effect on the oxidation of iodide using persulphate and determination of activation energy of the reaction.
3. Spectroscopic determination of the pKa value of methyl orange indicator.
4. Determination of activation energy of base catalyzed hydrolysis of ethyl acetate conductometrically.
5. Study of ionic strength effect on base catalyzed hydrolysis of ethyl acetate.
6. Study of primary salt effect on the formation of colloidal sulphur by the reaction of thiosulphate with an acid and determination of the activation energy of the reaction.
7. Cyclic Voltammetric Study of ferrocyanide/ferricyanide Redox Couple

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Determine the primary salt effect on the base catalyzed hydrolysis of ethyl acetate and determination of the activation energy of the reaction by conductometric method
CO2. Study the primary salt effect on the oxidation of iodide using persulphate and determination of activation energy of the reaction
CO3. Apply the spectroscopic method to determine the value of the pKa of an indicator
CO4. Apply conductivity measurements in studying the kinetic parameters
CO5. Apply the basics of cyclic voltammetry with a well-behaved electroactive species

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3								
CO2		3								
CO3		3								
CO4		3								
CO5		2	1							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Demonstration on data handling and graphical representation	Assessment in the lab, report evaluation
CO2	Lecture demonstration	Assessment in the lab, report evaluation
CO3	Group discussion, Instrumental demonstration.	Assessment in the lab, report evaluation
CO4	Lecture demonstration , Group discussion	Assessment in the lab, report evaluation
CO5	Group discussion, Instrumental demonstration.	Assessment in the lab, report evaluation

Books Recommended:

1. P. W. Atkins, Physical Chemistry
2. K.J. Laidler, Reaction Kinetics
3. Steinfeld, Francisco & Hase, Chemical Kinetics and Dynamics

Course No**: CHE 0531 5121**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Electrochemical Methods**		Course Type: Core Theory	

Course Rationale: This course is designed to give learners the advanced concepts of modern aspects of electrochemistry and electrochemical methods. This course will help the MS students to gain advances on electrochemistry

Course Objectives:

The objectives of the course are to:

- Familiarize the students with principle of electrochemistry
- Understand double layer capacitance
- Make them able to differentiate between Faradaic and non Faradaic processes
- Understand Kinetics of electron transfer reaction
- Understand electrochemical Impedance spectroscopy
- Understand outersphere and innersphere reactions

Course Content:

1. Overview of Electrode processes: Electrochemical cells, Faradaic and non Faradaic processes, Ideal polarized and non polarized electrodes, Electrical double layer, Double layer Capacitance and Charging current in electrochemical measurements, Factors affecting rates of electrode reactions, Electrochemical cells and resistance, Double layer structures, Surface excess. Various types of potentials: standard potential, formal potential, applied potential, half wave potential, half-peak potential, concentration over potential, activation overpotential. Nernst equation of adsorbed species.

2. Mass transfer controlled reactions: Modes of mass transfer: Diffusion and migration, Steady state mass transfer, Transient response, coupled reversible and irreversible reactions.

3. Kinetics of Electrode reactions: Dynamic equilibrium, Arrhenius equation, Transition state theory, Butler-Volmer and Nernst models of electrode kinetics, Transfer co-efficient and Tafel plot, Approximate forms of i-η equation, Exchange current density, rate determining electron transfer, multistep processes, polarization and overpotential, Determination number of electron, exchange current density, standard rate constant and potential dependent rate constant.

4. Basic potential step methods: Chronoamperometry, Cottrel's equation, Steady state voltammetry, Planner and spherical electrode, Diffusion controlled reactions, Single step and multistep reaction analysis. Chronoamperometry of adsorbed species.

5. Potential sweep methods: Linear sweep voltammetry, Cyclic voltammetry, measurements of reversibility, Quasi-reversible reactions. Coupled reactions (EE, CE, EC, ECE mechanism, Voltammetry of adsorbed species, Votammetric determination of heterogeneous rate constant.

6. Bulk electrolysis: Controlled current and controlled potentials methods, Current efficiency, current- time behavior, Flow electrolysis, coulometric measurements, thin layer electrochemistry.

7. Hydrodynamic electrodes: Concept of rotating disk electrode. Levich and Kouteky-Levich equations, Channel Electrodes, determination of Renolds number, Mechanism study: Nitrate reduction reaction, Oxygen reduction reaction.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain fundamentals of Electrochemistry
CO2. Execute research works with electrochemical work stations
CO3. Resolve various problems related to voltammetry, I-E curve, bulk electrolysis etc.
CO4. Perform electrokinetic experiments based on Chronoamperometry, Voltammetry, EIS etc.
CO5. Characterize electron transfer reactions by means of different physical parameters

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes (POs)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2			3							
CO3			3					1		1
CO4	3		2							
CO5		3	1							

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture demonstration	Class test (Short Q and MCQ)
CO2	Lecture demonstration	Quiz,
CO3	Lecture demonstration, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture demonstration, Group discussion	Essay test, problem solving
CO5	Lecture demonstration Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. P.W. Atkins, Physical Chemistry
2. A. J. Bard, Electroanalytical Methods
3. L. Glasston, Introduction to Electrochemistry
4. R.G. Compton et at., Understanding Voltammetry (Imperial College Press)

Course No: **CHE 0531 5122**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Surface Chemistry and Spectroscopy**		Course Type: Core Theory	

Course Rationale:

This course is designed to give learners the advanced understanding of surface phenomena and techniques which will help the students to solve problems related to these topics.

Course Objectives:

The objectives of this course are to:

- Familiar with the concepts of surface chemistry
- Teach how to characterize a surface with surface sensitive techniques
- Analyze principles of kinetics and mechanisms of surface reactions

- Be acquainted with the techniques to find the composition of a surface

Course Content:

Surface Sensitivity & Surface Specificity: General Sensitivity Problems, surface sensitive technique, Inelastic Mean Free Path (IMFP) of electrons, UHV (Ultra High Vacuum (UHV), Effects of Gas Pressure.

Adsorption of Molecules on Surfaces: Kinetics of adsorption, Adsorption Isotherms, Langmuir, Hinshelwood, BET, Tempkin, Elley-Rideal etc. Adsorption with dissociation, Competitive adsorption, Non ideal adsoroption Thermodynamics and statistical mechanics of adsorption.

Surface reactions: Unimolecular surface reactions, Inhibition and Activation. Bimolecular surface reactions, Reactions between two adsorbed molecules, Reaction between a adsorbed molecule and a gas molecule, Adsorption of two gases without mutual displacement, Inhibition, Activation Energies.

Surface Analytical Techniques: Auger Electron Spectroscopy (AES); Principle, instrumentation, application. X-ray Photoelectron Spectroscopy (XPS); Principle, instrumentation, application. Infrared Spectroscopy; IR Spectroscopy of various forms, e.g. RAIRS, MIR, Electron Energy Loss Spectroscopy (EELS), Applications of Vibrational spectroscopy, LEED (low energy electron diffraction); principles and application, NEXAFS Near edge X-ray absorption fine structure analysis; basic principle and application.

Surface Imaging and Depth Profiling: Basic Concepts in Imaging & Localised Spectroscopy, Electron Microscopy (SEM & TEM), Imaging XPS, SIMS Imaging & Depth Profiling, Auger Depth Profiling, Scanning Probe Microscopy (STM/AFM).

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Outline the principles and problems of surface sensitivity and surface specificity

CO2. Describe the kinetics different adsorption isotherms and apply the knowledge of statistical mechanics in adsorption

CO3. Explain the mechanism of uni and bio molecular surface reactions

CO4. Demonstrate the fundamental and practical aspects of many surface analytical techniques

CO5. Execute the modern surface imaging technique for sample analysis

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2			3							
CO3	3									
CO4										3
CO5		3	2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture Demonstration	Class test (Short Q and MCQ)
CO2	Lecture Demonstration	Quiz, assignment
CO3	Lecture Demonstration, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture Demonstration, Group discussion	Short and Broad Q
CO5	Lecture Demonstration, Group discussion for problem analysis	Short and Broad Q

Books Recommended:

1. Rita Kakkar, Atomic and Molecular Spectroscopy
2. Yip-Wah Chung, Practical Guide to surface science and spectroscopy.
3. Anwar Ul-Hamid, A Beginners' Guide to Scanning Electron Microscopy

Course No: **CHE 0531 5123**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Molecular Photochemistry**		Course Type:	Core Theory

Course Rationale:

This course aims to give the inside idea and to analyze the internal molecular dynamics of electronic transition based on quantum chemical approach especially for organic molecules that is needed for the further study at research levels. This also makes a bridge between higher researches with their previous knowledge.

Course Objectives

The objectives of this course are to:

- Acquaint students with the fundamentals of Molecular Photochemistry
- Make the students familiar with Molecular wave function, the structure, electronic configuration, molecular states, and spin state using quantum molecular operators
- Acquire the concept of chemical dynamics, transition between states, and probability of transition, vibronic coupling and motion
- Provide the knowledge inter conversion of Electronic states with orbital mixing
- Analyzed the electronic spectrum of radiative and non radiative transition of organic molecule

Course Content:

1. Photochemistry- An overview: Photochemical Reactions, Electronic excitation and de-excitation of molecules, State energy diagram: Electronic and spin examples. Calibration point of Molecular motion and Molecular dimensions. Calibration point for molecular energies and reaction dynamics. The nuclear geometry of electronically excited states. An energy surface description of molecular photochemistry

2. Electronic orbital, Configurations and States: Molecular wave function and molecular states. The Born-Oppenheimer Approximation. The spirit of the use of quantum molecular operators. The construction of electronic states from electronic configurations. Visualization of electron spin. Electronic energy differences between Singlet and Triplet States. Experimental measurement of Orbital energy.

3. Transition between states: Chemical Dynamics as Transition between stares: chemical dynamics, Quantum dynamics. Transition between stares: Evaluation of Transition Probability, Nuclear Motion, Vibronic states. Singlet-Triplet inter conversion

4. Radiative Transitions- The absorption and emission of light: Absorption and emission spectra of molecules. The nature of light: Electromagnetic waves and Oscillating electronic dipoles. Shape of absorption and emission spectra. State mixing, Breakdown of the single orbital configuration and pure multiplicity Approximations. Spin-Orbit coupling and spin forbidden radiations. Experimental examples of orbit-spin forbidden radiative transitions. Flash Spectroscopy. Excited state structures and dipole moments. Radiative transition involving more than one molecules: Charge transfer absorption, Excimers and Exciplexes. Delayed Fluorescence and Phosphorescence. Emission from 'Upper' Excited singlet and triplet; The Azulene Anomaly.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe and explain Electronic excitation and de-excitation, State energy diagram, Molecular motion and Molecular dimensions, reaction dynamics, nuclear geometry of electronically excited states

CO2. Explain the transition probability along with orbital mixing and geometry of excited state

CO3. Explain the Absorption and emission spectrum of spin allowed spin forbidden states, triplet sublevel, and delayed fluorescence **CO4.** Apply state mixing, Spin-orbit coupling, and orbital symmetry in transition between states in molecules

CO5. Handle experiments of Photo electron spectroscopy and Flash spectroscopy

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2			3							
CO3			3							
CO4										
CO5							3		2	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, PPT Demonstration, Discussion	Quiz, assignment
CO3	Lecture, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, PPT presentation, Group discussion	Essay type test, problem solving
CO5	Lecture, Demo experiment of VDO clips, Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. Modern Molecular Photochemistry: N.J. Jurro
2. Elements of Organic Photochemistry: D. O. Crown and R.L. Drikoz
4. El-Sayed H, Excited States, ed len E.C. New York Academic Press.
5. Theory and Interpretation of florescence and Phosphorescence: R. Becleer

Course No: **CHE 0531 5224**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Advanced Chemical Kinetics**			Course Type: Core Theory

Course Rationale:

This course is designed to provide the learners insight into different aspects of advanced level of chemical kinetics so that learners can get maximum benefits for learning and doing research in the area of chemical kinetics, polymerization process and thermal decomposition.

Course Objectives:

The objectives of this course are to:

- Acquire knowledge about kinetics and reaction monitoring system for advanced complex reactions
- Gain necessary knowledge for experimentation and application of complex kinetic reactions
- Develop skills in the design and analysis of experiments to study chemical kinetics, including the determination of rate constants and activation energies
- Understand the reaction dynamics and optimized condition for polymerization and combustion process
- Develop communication skills to effectively present and discuss research findings in chemical kinetics

Course Content:

1. Fast reactions: Flow method, Flash photolysis, Relaxation method: Temperature Jump, Pressure Jump, Periodic potential method, Relative method, Production of free radicals and techniques.

2. Reaction in solution: Single sphere and double sphere activated complex, ion-dipole and dipole-dipole reactions, Influence of hydrostatic pressure: van't Hoff's equation, volumes of activation.

3. **Autocatalysis and Oscillating reaction**: Lotka-Voltera mechanism, Brusselator, The oregonator, Bistability, Chemical chaos.

4. Catalysis in gaseous systems: Chain mechanisms, Catalysis by ions of variable valency, activation of Molecular hydrogen.

5. Decomposition reactions: Goldfinger-Letort rules, Molecular process, Inhibition mechanism, combustion of hydrocarbon, Hydrogen-oxygen reactions, Gas phase combustion.

6. **Thermodynamics and Kinetics of Polymer**: Polymer solutions, the thermodynamics of polymer solution, Polymerization reactions: Stepwise polymerization, Chain polymerization, Cationic polymerization, Anionic polymerization, Emulsion polymerization.

7. **Molecular reaction dynamics:** The dynamics of molecular collisions, reactive collisions, experimental probes of reactive collisions, Potential energy surfaces: The symmetrical potential energy barrier, General features of early potential energy barriers for exothermic and endothermic reactions, Reactions with a collision complex and a potential energy well.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Defining range of fast and slow reactions and ways for monitoring the mechanism

CO2. Explain the variation of reactions in solution and gas phase, the factors affecting the reactions in solution, van't Hoff's equation, the effects of solvent and solution nature on the reactions

CO3. Defining the aoutocatalytic and oscillation reactions with understanding the mechanism and reasons behind some typical oscillation reactions including Lotka-Voltera mechanism, Brusselator, The oregonator, Bistability, Chemical chaos

CO4. Explain the processes of decomposition systems in laboratory and industries and deducing the mechanisms of various combustion and decomposition reactions

CO5. Explain and apply the mechanism and thermodynamics of various polymerization reactions and Explain the molecular reaction dynamics, collision theory, potential energy barriers and optimized kinetic conditions for successful chemical reactions

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

COs	Program Learning Outcomes (POs)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3		2							
CO3	3		1							
CO4	1								1	1
CO5	2							1		

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

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture	Class test (Short Q and MCQ)
CO2	Lecture, Discussion	Quiz, assignment
CO3	Lecture, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Test, problem solving
CO5	Lecture, Group discussion for problem analysis	Test, problem solving

Books Recommended:

1. P.W. Atkins, Physical Chemistry
1. 2 Margaret Robson Wright, An Introduction to Chemical Kinetics
2. Santosh K. Upadhyay, Reaction Dynamics
3. K. J. Laidler, Chemical Kinetics

Course No: **CHE 0531 5225**	Credit: 4.0	Year: MSc	Semester: Second
Course Title: **Advanced Electrochemistry**		Course Type: Core Theory	

Course Rationale: This course is designed to give learners the advanced concepts of modern advancements on electrochemistry and electrochemical methods. This course will help the MSc students to understand critical reasoning on advanced electrochemistry

Course Objectives:

The objectives of this course are to:

- Familiarize the students with principle of electrochemistry
- Understand double layer and electrode - solution interface
- Identify difference between Faradaic and non Faradaic processes
- Understand corrosion process and fuel cells
- Study irreversible ET reactions with hydrodynamic electrode
- Explain principles of various electrochemical techniques

Course Content:

1. Polarization and over voltage: Electrolysis and polarization, Dissolution and deposition potentials, Concentration polarization, Decomposition voltage of aqueous solution, Over voltage, Metal deposition over voltage, Hydrogen over voltage, Influence of (i) C.D (ii) pH and (iii) temperature on over voltage, Growth of over voltage, Theories of over voltage.

2. Deposition: Physical nature of electrodeposited metals, factors influencing the deposition of metals, Throwing power, Simultaneous discharge of cations, Depolarization of metal deposition, Separation of metals by electrolysis,

3. Passivity and Corrosion: Electrochemical passivity, Passivity and current density, Chemical passivity, Theories of passivity, Mechanical passivity, Corrosion of metals, H_2 evolution type corrosion, Corrosion by O_2, Corrosion in the presence of a depolarizer. Types of corrosion, Explanation of corrosion by Evans diagrams, Corrosion protection.

4. Electrochemical power sources: Electrochemical cells, Type of electrochemical cells, Fuel cells, various types of fuel cells and their description in brief, working principle of a typical fuel cell, applications of fuel cells. O_2 reduction reaction in fuel cells, Electrocatalysts for the O_2 reduction reaction, Mechanism of O_2 reduction, various importance of O_2 reduction. Solar energy: Mechanism and applications

5. Principles and applications of various electrochemical techniques: (i) Different types of voltammetry: Cyclic voltammetry, Linear sweep voltammetry, Normal pulse voltammetry, Differential pulse voltammetry and Square-wave voltammetry, (v) Steady-state voltammetry, Kinetics and reaction mechanism studies using steady-state voltammetry, Ring-disk electrode (RDE), Rotating ring-disk electrode (RRDE), Levich equation, Koutecky-Levich equation, Tafel plot.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Delineate fundamentals of Electrochemistry
CO2. Explain how to perform research works with electrochemical work stations
CO3. Resolve various problems related to voltammetry, I-E curve, RDE etc.
CO4. Perform ET kinetic experiments based on Chronoamperometry, Voltammetry, EIS etc.
CO5. Correlate electron transfer reactions with various physical parameters

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

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

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture demonstration	Class test (Short Q and MCQ)
CO2	Lecture demonstration	Quiz
CO3	Lecture demonstration, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture demonstration, Group discussion	Essay test, problem solving
CO5	Lecture demonstration Group discussion for problem analysis	Essay type test, problem solving

Books Recommended:

1. P.W. Atkins, Physical Chemistry
2. A. J. Bard, Electroanalytical Methods
4. L. Glasstone, Introduction to Electrochemistry
5. Bockris and Reddy, Advanced Electrochemistry

Course No**: CHE 0531 5226**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Biophysical Chemistry**		Course Type: Core Theory	

Course Rationale: The course on biophysical chemistry is designed to provide students with a comprehensive understanding of the physical and chemical principles underlying the behavior of biological molecules and systems.

Course Objectives:

The objectives of this course are to:

- Understanding the principles of thermodynamics and kinetics and their application to biological systems
- Develop an understanding of the physical and chemical properties of biological macromolecules, such as proteins, nucleic acids, and lipids
- Understanding the principles of biophysical techniques
- Understanding the relationship between structure and function in biological molecules and systems.
- Developing an appreciation for the interdisciplinary nature of biophysical chemistry and its importance in fields such as biochemistry, biotechnology, and drug discovery
- Acquiring the skills necessary to design and carry out experiments in biophysical chemistry, including data collection, analysis, and interpretation

Course Content:

1. Noncovalent bonding and pH buffering: Water the biological solvent, stabilizing and organizing forces of nature, acid base equilibria, principle of pH buffering, buffering of blood, laboratory use of buffers, ionic strength.

2. Biomolecules: Building block molecules of biomolecules, amino acid structures, polypeptides, ionic properties of amino acids and polypeptides, nucleotides and nucleic acids, base composition and base sequence of nucleic acids, simple idea about carbohydrates and lipids.

3. Proteins: Classifications, primary, secondary, tertiary and quaternary structure of globular proteins, salting in and salting out of proteins, chemistry of ion exchange and chromatographic technique in isolation/purification of protein, characterization of proteins, molecular weight determination of proteins by PAGE and get filtration techniques

4. Enzymes: Nomenclature, cofactor, principle of catalysis, enzyme catalyzed reactions having one substrate, M-M equation, K_m and V_m values determination, pH and temperature effects on catalysis, competitive, non-competitive and uncompetitive inhibition of catalysis, Transport of oxygen and CO_2 (The role of hemoglobin)

4. Bioenergetics: ATP and its role in bioenergetics, control points in metabolic pathways, carbohydrate metabolism, the energetic of the citric acid cycle, lipid metabolism, oxidative phosphorylation, nitrogen metabolism.

5. Specificity and modification of proteins/ enzymes: Trypsin, chymotrypsin, elastase, carboxypeptidase, aminopeptidase, cynanogen bromide cleavage, -SH, -S-S-, $-NH_2$, $-SCH_3$ group modification.

6. Biological membrane: Constituents and structure, the fluid mosaic model, factors affecting the physical properties of membranes, the theory and thermodynamic of biological transport, energy coupling mechanisms in biological transport, molecular mechanism of biological transport.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the fundamental principles of thermodynamics and kinetics, and apply these principles to the analysis of biological systems
CO2. Understand of the physical and chemical properties of biological macromolecules and their role in biological processes
CO3. Design and interpret experiments using biophysical techniques

CO4. Appreciate for the interdisciplinary nature of biophysical chemistry and its importance in fields such as biochemistry, biotechnology, and drug discovery

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes (POs)									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2	3									
CO3			3					1		1
CO4	3		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs/POs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture demonstration	Class test (Short Q and MCQ)
CO2	Lecture demonstration	Quiz,
CO3	Lecture demonstration, animated VDO clips, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture demonstration , Group discussion	Essay test, problem solving

Books Recommended:

1. A.W. Lehninger: Principle of Biochemistry
2. R.C. Bohinski: Modern Concept of Biochemistry
3. G. Zubay: Biochemistry
4. D. Freifelder: Physical Biochemistry
5. R.K. Scopes: Protein Puripication
6. C.N. Price & R.A. Dwek: Principles and Problems in Physical Chemistry for Biochemists
7. W.H. Elliott & D.C. Elliott: Biochemistry

Course No: **CHE 0531 5227**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Chemical Energy**		Course Type: Core Theory	

Course Rationale: This course is Aim to understand the fundamental concepts of energy-matter relation, the effective and efficient operations to design, re-design, and development of sustainable processes and materials for particular energy conversions and storage.

Course Objectives

The objectives of this course are to:

- Facilitate necessary knowledge about science of energy conversion
- Acquire knowledge about carbon free energy
- Interpret the applications of functional materials about energy storage
- Gain ideas energy harvesting from renewable sources
- Facilitate necessary knowledge about fuel cells

Course Content:

Basics of energy: Energy and Power, Kinds of energy, origin of energy, conversion of energy and corresponding efficiency, renewable and nonrenewable energy, Properties of a good fuel, Galvanic cell, free energy.

Carbon based fuel: Formation of fossil fuel, Types of fossil fuel, Heat of combustion of various hydrocarbons and their calorific values, Octane number, advantage and disadvantage of fossil fuels, biodiesel, biogas.

Alternative fuel: Hydrogen synthesis via photochemical and electrochemical water splitting, Carbon neutral fuel, mechanisms: Oxygen reduction reactions, hydrogen peroxide oxidation and reduction reactions, Ammonia oxidation reactions, Ascorbic acid oxidation and CO_2RR; Turn over frequency & Tafel analysis of HER, OER and ORR at an electrode surface.

Fuel cell: Fundamentals of fuel cell, PEMFC, DMFC, alkaline fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, solid oxide fuel cells, reversible fuel cells, hydrogen fuel cells, microbial fuel cells, functional membranes for fuel cells.

Solar cell: Fundamentals of solar cells, types of solar cells (Amorphous Silicon solar cell, Biohybrid solar cell, Dye sensitized solar cell, thin film solar cell), Evaluation of cell performance.

Energy storage materials and battery: Concept of rechargeable and non-rechargeable batteries Lead storage battery, Lithium-ion battery, charge storage in capacitor, charge-discharge phenomenon of battery and capacitor.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to :

CO1. Describe the ways of energy conversion
CO2. Explain how energy could be generated from carbon free sources
CO3. Illustrate the difference among various energy devices.
CO4. Explain the ways chemical electrochemical energy generation
CO5. Interpret the kinetics of various energy related reactions and fabricate small fuel cells for real life applications

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately aligned 1: Weakly aligned

	Program Learning Outcomes (POs)									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3									
CO2								2		
CO3	3									
CO4	3									3
CO5		3	3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, Group discussion, Question-Answer session	Class test (Short Q and MCQ)
CO2	Lecture, Group Discussion, Question-Answer session	Quiz, Assignment
CO3	Lecture, Group Discussion, Question-Answer session	Essay type test
CO4	Lecture, Group Discussion, Question-Answer session	Class test (Short Q and MCQ)
CO5	Lecture, Group Discussion, Question-Answer session	Essay type test

Books Recommended:

1. Physical Chemistry (7th Edition), P.W. Atkins, Oxford University Press Inc., New York, 2002
2. Handbook of Electrochemical Energy, Editors: Cornelia Breitkopf, Karen Swider-Lyons, ISBN: 978-3-662-46657-5
3. Electrochemical Methods: Fundamentals and Applications 2nd edition, Allen J. Bard & Larry R. Faulkner
4. Chemical Energy Storage, 1st Edition by Robert Schlögl, ASIN : 3110264072
   Publisher : De Gruyter; 1st edition (December 13, 2012)

Course No: CHE **0531 5130**	Credit: 2.0	Year: MS	Semester: First
Course Title: **Advanced Inorganic Chemistry Lab**		Course Type: Core Practical	

Course Rationale:

This course is designed mainly to prepare the student practically skilled in the techniques involved in the separation of different ionic species from a mixture and synthesizing, purifying, and examining the various inorganic compounds in a normal and inert atmosphere.

Course Objectives:

The objectives of this course are to:

- Impart knowledge on the separation of ionic complexes and identify them by UV-Visible spectroscopy
- Prepare and characterize multiple Coordination Complexes in a normal and inert atmosphere.

Course content:

1. Ion exchange separation of ionic complexes and identify them by spectrophotometry

2. Preparation and identification of the copper (II) bipyridine complex
3. The synthesis and characterization of a macrocyclic complex
4. Preparation and spectroscopic characterization of an Iron dinitrogen complex
5. Synthesis and spectroscopic characterization (UV, IR) of metal salen complex
6. Preparation of carbonatotetraamine cobalt(III) nitrate $[Co(NH_3)_4CO_3]NO_3$ and its characterization using conductometric and spectroscopic techniques.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Prepare and use a different solution of various ingredients of inorganic compounds accurately for inorganic compounds' synthesis using necessary reagents

CO2. Separate ionic complexes by UV-Visible spectroscopy in the supplied sample

CO3. Synthesize and characterize the Coordination Complexes by physical, conductometric, and spectroscopic methods

CO4. Prepare, separate, and analyze inorganic complexes in a normal and inert atmosphere and characterize them

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		2	3							
CO2		3	3							
CO3		3	3							
CO4		3	3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Apparatus demonstration and presenting MSDS	Lab Performance (group)
CO2	Lectures, experiment demonstration	Lab Reports, Viva Voce
CO3	Lectures for characterizations	Lab Performance, Viva Voce
CO4	Lectures and experiment demonstration	Lab Performance (individual), Written Examination

Books Recommended:

1. G. Pass and H. Sutcliffe, *Practical Inorganic chemistry*
2. Robert J. Angelici, *Synthesis, and Technique in Inorganic Chemistry*
3. J. Derek Woolins, Inorganic Experiment

Course No: CHE **0531 5131**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Inorganic Materials Chemistry**		Course Type: Core Theory	

Course Rationale:

This course aims to provide real-life use of different materials in terms of a chemist's point of view, how they are fabricated, and the advanced research done in these fields. The different optical and electrical characteristics of materials will be discussed here and their correlation with the properties of these materials will be explained.

Course Objectives:

The objectives of this course are to:

- Learn about the optical properties of some large complexes, especially their second and third-order nonlinear properties
- Discuss the electrical and magnetic properties of materials and their influence on the semiconduction properties of materials
- Explain the liquid crystalline properties of materials and how to change their optical properties
- Express the synthetic and separation techniques involving zeolites

Course Content:

Metal containing materials for nonlinear optics: Some basic concepts of nonlinear optics. Nonlinear optical properties of organometallic and coordination compounds.

Metal containing liquid crystals: Classes, physical properties, and characterization. Metal complexes as liquid crystals. Mesomorphic coordination complexes of bidentate and polydentate ligands.

Electronic and magnetic properties of inorganic materials: Introduction to band theory, band structure, and electronic properties- metals, insulators and semiconductors, Interactions in binuclear compounds; magnetic chain compounds, long-range ordering in molecular compounds. Conductors and superconductors based on metal complexes.

Luminescent Materials: Luminescent metal complexes of transition metal and lanthanides. Biological and medicinal chemistry of metal complexes.

Zeolites: Intercalation in layer materials and solid electrolytes: zeolites, zeolite structures, the properties of zeolites, intercalation chemistry in zeolites.

Metal oxide-based materials: Structure, optical, catalytic, and sensor applications.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe the nonlinear optical properties of materials and explain their correlation with the structure of these compounds

CO2. Explain the relationship of bandgap with electrical and magnetic properties of materials and express the liquid crystalline properties of different materials

CO3. Design materials for drug delivery assessment study

CO4. Apply their knowledge to separate products after reactions based on size and use the steric effect of zeolite to control suitable reactions

CO5. Explain the luminescent properties of metal complexes and their application in the medicinal sector

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2		1							
CO2	2		1							
CO3	2		1							
CO4	3									
CO5	2		1							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Discussion	Class test (Short Q and MCQ)
CO2	Lecture, Discussion	Class test (Short Q and MCQ)
CO3	Lecture and demonstration	Class test
CO4	Lecture and demonstration	Class test
CO5	Lecture, PPT Demonstration, Group discussion for problem analysis	Class Test (Problem-Solving)

Books recommended:

1. Inorganic materials chemistry, Mark A Weller, Oxford Science Publications, 1995.
2. Inorganic Spectroscopic Methods, Allan K. Brisdon, Oxford Science Publications, 1998.
3. Inorganic materials chemistry, Duncan W Bruce and Dermot O'Hare, 2nd Edition, John Wiley & Sons, Inc., 1997.
4. Nano-Optics, Satoshi Kawata, Motichi Ohtsu and Masahiro Irie, Springer, 2002.

Course No: **CHE 0531 5132**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Inorganic Spectroscopic Methods**		Course Type: Core Theory	

Course Rationale:

This course aims to give an understanding of spectroscopic methods for inorganic compounds which will be needed for further study at research levels. This is also to make a bridge with their previous knowledge of this.

Course Objectives:

The objectives of this course are to:

- Acquaint students with the principles of various spectroscopic methods
- Make the students understand the application of these methods for inorganic compounds
- Train to determine molecular structures of inorganic and organic compounds based on the above spectral information
- Make them skilled to identify and characterize an unknown compound

Course content:

1. Vibrational spectroscopy: The basics, symmetry, and vibrational bands, infrared experiments - group frequencies, fingerprints, analysis of mixtures.

2. Raman spectroscopy: The basics, Raman applications, depolarization measurements, complementary nature of Raman, and IR spectroscopy.

3. Resonance spectroscopy: The basics, are chemical shift, chemical environment, integration, coupling, magnetic versus chemical equivalence, decoupling, non-spin-1/2 systems, exchange processes, and relaxation processes. Nuclear quadrupole resonance (NQR)–The principle and applications. Electron spins resonance- The principle and applications.

4. UV-visible spectroscopy: The basics, metal-metal transitions, crystal field splitting, crystal field splitting into common shapes, spin states, strong field model and weak field model, selection rules, Jahn-Teller distortions, charge transfer transitions, metal-ligand transitions, ligand-centered transitions.

5. Luminescence spectroscopy: Basics and application.

6. Mass spectrometry: Basics, ionization methods, electron impact, fast atom bombardment, chemical ionization, interpretation of mass spectra, accurate mass measurements, isotopic pattern, and fragmentation patterns. McLafferty Rearrangement

7. Determination of molecular structures of inorganic and organic compounds based on the above spectral information.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain different spectroscopic methods used in the study of inorganic and organic compounds
CO2. Apply the methods to determine the structure of a compound
CO3. Explain various properties of an inorganic compound
CO4. Monitor the progress of a reaction
CO5. Interpret spectral data of unknown compounds

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2				1					
CO2			1	2						
CO3			2			1				
CO4				2		1				
CO5				2		1				

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lecture, PPT Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, PPT Demonstration, Discussion	Quiz, assignment
CO3	Lecture, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, PPT presentation	Semester end exam, problem-solving
CO5	Lecture, PPT presentation	Semester end exam, problem-solving

Books Recommended:

1. Inorganic materials chemistry, Mark A Weller, Oxford Science Publications.
2. Inorganic Spectroscopic Methods, Allan K. Brisdon, Oxford Science Publications.
3. Inorganic materials chemistry, Duncan W Bruce and Dermot O'Hare.
4. Nano-Optics, Satoshi Kawata, Motichi Ohtsu, and Masahiro Irie.
5. Interpretation of mass spectra (Benjaunia), F. W. Mc Lafferty.
6. Introduction to Spectroscopy (Sanndus Golden Snburet Series), Pavia
7. Spectro reactive identification of Organic Compounds (John Williamson), Silverstein, Bassler, Morrid.

Course No: CHE **0531 5233**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Advanced Bioinorganic Chemistry**		Course Type: Core Theory	

Course Rationale:

This course is designed to achieve knowledge on essential elements, metalloporphyrin and their involvement in O_2 and CO_2 transport in humans, biological electron transfer and energy transfer, proteins, enzymes, metalloenzymes, enzyme function, and inhibition, and to widely comprehend the chemistry of metal ions in medicine and human health.

Course Objectives:

The objectives of this course are to:

- Offer graduate students a thorough knowledge of essential metal ions in humans and important features of the structure and functions of hemoglobin and myoglobin, photosynthesis, metabolism, and nitrogen fixation
- Prepare the students to understand the significance and dynamics of coordination chemistry in the biological environment
- Improve the knowledge to apply for evaluating the reactivity of a metal center and electron transfer and energy transfer in biological systems
- Advance the systematic and critical thinking about protein, enzyme, enzyme action and inhibition, metalloenzyme functions and applications, metal overload and toxicity, and biological catalysis
- Recognize different diseases such as cancer, heart disease, and HIV, and apply knowledge for material design and synthesis for therapeutic, diagnostic, and theragnostic interventions in medicine and pharmaceutical platforms

Course content:

Introduction: Inorganic chemistry is behind the requirement of biological cells for metals such as Zn, Fe, Cu, Mo, S, Se, etc.

1. Binding of metal ions to proteins: (a) Metal-dependent lyases and hydrolases. carboxypeptidases A, Purple acid phosphatase (metal-dependent), carbonic anhydrase. (b) Zink binding domains. (c) Calcium and Calcium-binding proteins. (d) Copper binding proteins, and (e) manganese binding proteins.

2. Special cofactors and metal clusters: (a) Electron transfer protein, (b) cobalamin, and (c) Molybdenum cofactors enzyme.

3. Transport and storage of iron: (a) Transport and storage of iron with oxygen, and (b) Obtaining iron from organisms

4. Oxygen metabolism: (a) Reactivity of oxygen and its reduced forms, (b) Dioxygen carriers, (c) Enzymes that get rid of superoxides, (d) Enzymes that utilize peroxides, and (e) Oxygen activating enzymes, cytochrome P-450

5. Interactions of DNA with metal salts and complexes:

6. Metals and Health: (a) Metals-based drugs, Cisplatin, Carboplatin, Platinum anticancer drugs, Radiopharmaceuticals, MRI, Contrast agents, anti-infective drugs for skin HIV, AIDS, etc., and (b) Metal toxicity Cu overload, iron overload, mercuric ion reductases, Lead and porphobilinogen synthases.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Recognize the roles of essential trace elements, Na, K, Ca, Mg, Co, Mo, Se, etc. in humans

CO2. Correlates the structure and functions of porphyrin ring systems in essential biological processes. Significance of electron transfer and energy transfer in biological systems
CO3. Realize the iron intake, storage, and mobilization in humans and organisms; oxygen and CO_2 transfer and metabolism, and the importance of electron transfer by heme and non-heme iron
CO4. Elucidate the enzymes, metalloenzymes, enzyme action and inhibition, and their functions as biocatalysts
CO5. Recognize fetal disease and prevention by application of metal- and metal complex-based systems in medicine and therapy, diagnosis, and theragnostic

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2			3							
CO3	2		3							
CO4	2		3			1				
CO5	2		3			1				

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lecture, discussion, group study	Assignment, Class assessment, term test, final semester examination (Short Q and MCQ)
CO2	Lecture, discussion, group study, assignment	Final semester examination (Short Q and MCQ)
CO3	Lecture, discussion, group study, assignment	Assignment, Class assessment, and term test (Short Q and MCQ)
CO4	Lecture, discussion, group study, assignment	Final semester examination (Short Q, MCQ, Quiz, Explanation)
CO5	Lecture, discussion, group study, assignment	Final semester examination (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. R.W Hay, Bioinorganic Chemistry
2. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry
3. Sally Solomon, Introduction to General, Organic, and Biological Chemistry - McGraw Hill
4. Hughes, Inorganic Chemistry in Biological process
5. J. E. Huheey, Inorganic Chemistry
6. Y. Satake, S. Mido, Bioinorganic Chemistry
8. Douglas, McDaniel, and Alexander: Concepts and Models of Inorganic Chemistry
9. Articles from J of Inorganic biological Chemistry and relevant journals
10. J.B. Taylor and P. D. Kennewell, Modern Medicinal Chemistry, Ellis Horwood, NY,- 1st ed.

Course No: CHE **0531 5234**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Advanced Crystallography and Group theory**			Course Type: Core Theory

Course Rationale:
Students are expected to understand and explain the structures, geometries, and properties of atoms, molecules, and compounds at atomic and molecular levels.

Course Objectives:
The objectives of this course are to:
- Acquire knowledge of crystal structures, morphology, and properties
- Explain elaborately the symmetric properties and point groups of molecules and compounds
- Provide clear knowledge of space groups and apply this knowledge to spectroscopic and bonding concepts.
- Understand the space groups of molecules and compounds and the relationship between space groups, point Groups, and physical properties

Course Content:
Crystallography: Crystals and lattices, disorder, Crystal systems and geometry, Classification of unit cells, Restrictions imposed by symmetry on unit cell dimensions, Crystal systems, Limitations on symmetry in crystals, Hermann-Mauguin notation, Bravais lattices, Distinction between Trigonal and Hexagonal systems, Crystal planes and indices, Law of rational indices, Interplanar spacings.
Symmetry: Symmetry Elements and Operations, Point groups, List of 32 Point Groups, Properties, and Representations of Groups, Translational Matrices, Representations of Point Groups, Reducible and Irreducible Representations, reduction formula, Character Tables, symmetry labels.
Applications of group theory to vibrations spectroscopy: Polarity, Chirality, Molecular vibrations, Infrared, and Raman spectroscopy.
Applications of group theory to structures and bonding: The symmetries of molecular orbitals, Symmetry-adapted linear combinations, fundamental and construction of molecular orbital theory. Linear, angular, planner, pyramidal, and octahedral complexes.
Space groups and equivalent positions: Translational Symmetry Elements, Screw axis, Glide plane, Space groups, the relationship between Space groups, Point Groups and physical properties, Equivalent positions, Wyckoff Sites.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Interpret crystal structures and properties using various crystallographic parameters
CO2. Explain symmetric properties and identify point groups of molecules and compounds
CO3. Understand the group theory for molecules and compounds through symmetry operations to understand the nature of molecules
CO4. Apply group theory knowledge in understanding structures, spectroscopic, and bonding of molecules and compounds
CO5. Illustrate Space groups and equivalent positions and understand the relationship between Space groups, Point Groups, and physical properties

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3		1							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT and demonstration of practical data	assignment
CO2	Lecture using PPT and demonstration of practical data	Class test (Short Q and MCQ)
CO3	Lecture using PPT and model demonstration	Final Exam (Short Q, MCQ, Quiz, Explanation)
CO4	Lecture using PPT and model demonstration	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and Group discussion	Final Exam (Short Q, MCQ, Quiz, Explanation)

Books Recommended:

1. Haas et al. Duke University, Inorganic Chemistry
2. Kieran C. Molloy; Group theory for chemists Fundamental theory and applications
3. Donald E. Sands; Introduction to Crystallography
4. Peter Atkins, Tina Overton; Inorganic Chemistry 5th edition
5. James E. Huheey, Inorganic Chemistry 4th edition

Course No: CHE **0531 5235**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Frontiers Solid-state Materials**			Course Type: Core Theory

Course Rationale:
This course aims to gain knowledge on the design, synthesis, characterizations, properties, and applications of various solid-state materials.

Course Objectives:

The objectives of this course are to:

- Acquire knowledge on the synthesis of materials
- Gain knowledge on the characterizations of materials
- Understand structures and properties of materials
- Explain the structure-property relationships of materials
- Use the materials in various applied fields

Course Content:

A. Synthesis and crystal growth of materials: The formation of bulk material: Methods of direct synthesis, Solution and hydrothermal methods, High and low-temperature reactions, Solid solution methods, Sol-gel methods, Sealed tubes, and special atmospheres. Chemical deposition, Phase diagrams, and synthesis

B. Physical Methods for Characterizing Solids: Powder X-ray diffraction, uses of powder x-ray diffraction, The Rietveld Method, single crystal X-ray diffraction, neutron diffraction, electron microscopy, extended x-ray absorption fine structure (EXAFS), thermal analysis.

C. Structures and properties of various materials: Strategy for the synthesis of Noncentrosymmetric (NCS) materials, monoxides of the metals, higher oxides and complex or mixed oxides, metal nitrides, carbonates, nitrates, sulfates, phosphates, halides, and oxyhalides, rechargeable battery materials.

D. Chalcogenides, intercalation compounds, and metal-rich phases: Layered MS_2 compounds and Intercalation, Chevrel phases, and chalcogenide thermoelectrics.

E. Framework structures: Structures based on tetrahedral oxoanions; Aluminophosphates, Phosphates, and silicates. Structures based on octahedral and tetrahedral; Clays, pillared clays, and layered double hydroxides, Advance in inorganic framework chemistry. Metal-organic frameworks (MOFs) and Polyoxometalates (POMs).

F. Perovskites materials and their related phases: Structures, properties, and applications of

G. Metal–metal bonded compounds and clusters: Formation and criteria of the metal-metal bond clusters, Electron count, and Structure and isolobal analogies.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Distinguish the design and various synthesis methods of materials

CO2. Explain different characterization techniques of solid-state materials

CO3. Describe properly the crystal structures of various types of materials and understand the bonding nature within compounds

CO4. Recognize the various physical and chemical properties of materials and applications in different technological fields

CO5. Explain the structure-properties relationships of the solid-state materials

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1								
CO2	3	1								
CO3	3									
CO4	3									
CO5	3		1							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture using PPT and discussion	assignment by quiz
CO2	Lecture using PPT and open discussion	Class test (Short Q and MCQ)
CO3	Lecture using PPT and compare with previous lectures	Final Exam (Short Q, MCQ, Quiz, Explanation)
CO4	Lecture using PPT and demonstration of practical data	Class test (Short Q and MCQ), presentation
CO5	Lecture using PPT and demonstration practical data, Group discussion	Semester end Exam ; problem solving

Books Recommended:

1. Lesley E. Smart, Elaine A. Moore; Solid State Chemistry
2. Peter Atkins, Tina Overton; Inorganic Chemistry 5th edition
3. Mark T. Weller; Inorganic Materials Chemistry, Oxford Chemistry premiers
4. Anthony R. West; Solid State Chemistry and its Applications, Second Edition
5. Donald E. Sands; Introduction to Crystallography
6. James E. Huheey, Inorganic Chemistry 4th edition
7. Douglas, McDaniel, and Alexander: Concepts and Models of Inorganic Chemistry
8. Ch. Elschenbroich, A. Salzer: Organometallics
9. P.Shiv Halasyamani and Kenneth R. Poeppelmeier; Noncentrosymmetric Oxides, *Chem. Mater*. 1998, *10*, 2753-2769
10. Kang Min Ok, Eun Ok Chi, and P. Shiv Halasyamani; Bulk characterization methods for non-centrosymmetric materials: second-harmonic generation, piezoelectricity, pyroelectricity, and ferroelectricity
11. Kang Min Ok and P. Shiv Halasyamani; Distortions in Octahedrally Coordinated d0 Transition Metal Oxides: A Continuous Symmetry Measures Approach

Course No: CHE **0531 5240**	Credit: 2.0	Year: MS	Semester: Second
Course Title: **Advanced Organic Chemistry Lab**		Course Type: Core Practical	

Course Rationale:

Aim to acquire knowledge of various preparation techniques, purification and identification of organic compounds, and the estimation, determination, and analysis of various organic materials. In addition, other goals are to develop knowledge of the separation techniques of different mixture as well as improve skills in the extraction of organic compounds

Course Objectives:

The objectives of this course are to:

- Acquire knowledge of various preparation techniques, purification, and identification of organic compounds
- Make them expertise students in the estimation, determination, and analysis of various organic compounds
- Develop knowledge of the separation techniques of different mixtures of organic compounds
- Make them demonstrate as well as improve skill in the extraction of organic materials

Course Content:

1. Preparation of benzilic acid from benzaldehyde.
2. Preparation, Purification & Identification of dibenzalacetone.
3. Preparation of 4, 4 - diphenyl but - 3 - ene - 2 - one from ethylacetoacetate or preparation of 1, 1 -diphenyl -1 - propanal using Grignard reagent.
4. Preparation of 4,5-dialkoxy-1,2-dibromobenzene from catechol.
5. Estimation of Carboxylic acid by the iodometric method.
6. Determination of Polyhydric alcohols by the iodometric method.
7. Determination of the concentration of an aqueous phenolic solution by bromination method.
8. Analysis of vitamin C.
9. Qualitative and quantitative analysis of sugar.
10. Separation of a mixture of organic compounds by column chromatography using suitable solvents and detection of separated compounds with thin layer chromatography.
11. Extraction:
    (a) Acid-base extraction
    (b) Solid-liquid extraction
    (c) Isolation of caffeine from tea

N.B. Experiments may be added or removed from the above list if necessary.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Demonstrate the various preparation techniques, purification, and identification of organic compounds, such as benzaldehyde, dibenzalacetone, 4,4-diphenylbut-3-ene-2-one, 4,5 –dialkoxy-1,2-dibromobenzene, etc.

CO2. Outline the estimation, determination, and analysis of various organic compounds

CO3. Perform the separation techniques of different mixtures of organic compounds

CO4. Accomplish the extraction of organic materials

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3		2						1
CO2		3								1
CO3		3		1						1
CO4		3		2						1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Group work, Question-Answer session	Class test (Short Q and MCQ)
CO2	Lecture, Group work, Question-Answer session	Quiz, Assignment
CO3	Lecture, Group work, Question-Answer session	Essay type test, Assignment
CO4	Lecture, Group work, Question-Answer session	Class test (Short Q and MCQ)

Books Recommended:

1. Organic Syntheses, 1932, 12, 22, DOI: 10.15227/orgsyn.012.0022
2. H. T. Clarke, B. Haynes, E. C. Brick, G. C. Shone, E. Arnold, *Handbook of Organic Analysis, Qualitative and Quantitative*, 5th edition
3. R. L. Shriner, R. C. Fuson and D. Y. Curtin, *Systematic Identification of Organic Compounds*, John Wiley & Sons, Inc. New York, London, Sydney, 5th edition
4. Vogel's Text Book of Quantitative Chemical Analysis, John Wiley & Sons Inc.
5. Scott D. Murray and Peter J. Hansen, *J. Chem. Educ.* 1995, 72, 9, 851, https://doi.org/10.1021/ed072p851

Course No: CHE **0531 5141**	Credit: 4.0	Year: First	Semester: First
Course Title: **Advanced Heterocyclic and Organometallic Chemistry**		Course Type: Core Theory	

Course Rationale:

This course provides an introduction to the broad field of heterocyclic organic chemistry by reviewing the major classes of heterocyclic compounds in terms of nomenclature, structure, properties, preparations, and reactions. This course also aims to provide the students with a thorough understanding of the relationship between the structures, chemical bonding, and chemical properties of organometallic chemistry.

Course Objectives:

The objectives of this course are to

- Acquiring knowledge about the structure, properties, nomenclature, chemical reactions, and the role of three, four, five, and six-membered **saturated** and **unsaturate**d (aromatic and non-aromatic) heterocyclic compounds. Developing the ability to interpret the transformation of heterocyclic compounds
- Impart knowledge of the designing of synthetic routes for different heterocyclic compounds
- Form an image of the use of heterocyclic compounds in pharmaceuticals, cosmetics, and household chemicals
- Give knowledge on the synthesis, structure, and bonding of Organo copper, organozinc, organo-boron, and organotin compounds
- Introduce content from the fundamentals to advanced aspects of transition metal organometallic chemistry. Convey knowledge of the reactions of organometallic compounds and their mechanisms such as insertion, oxidative addition, and reductive elimination

- Application of metal-catalyzed different coupling reactions
- Study the carbene, nitrene, and enamine intermediate and their application in organic synthesis

Course Content:

1. Heterocyclic Chemistry:

(i) Introduction: Physiological and industrial significance of heterocyclic compounds, classification, and systematic nomenclature.

(ii) Compounds with three- and four-membered heterocyclic rings containing Nitrogen, Oxygen, and Sulphur: Synthesis, physic-chemical properties and uses of oxiranes and oxetans, thirans and thietans, aziridines and azetidines.

(iii) Compounds containing a five-membered ring with two heteroatoms: Nitrogen-nitrogen (pyrazole and imidazole groups and related compounds), nitrogen-oxygen (oxazole and isooxazole), and nitrogen-sulfur (thiazole, isothiazole, and related compounds).

(iv) Condensed Five-membered rings with one heteroatom: Synthesis and physico-chemical properties of indoles, benzofurans, benzothiophenes, and carbazoles.

(iv) Compounds containing a six-membered ring with two heteroatoms: Pyrimidines, pyrazines, oxazines, thiazines, dioxins, and their analogs.

(v) Compounds containing seven-membered rings: Azepines, diazepines, oxazepines, thiazepines, and related compounds.

(v) Saturated heterocyclics with one and two heteroatoms.

2. Organometallic Chemistry:

(i) Preparations, structures, properties, and applications of Organo- copper, Organo zinc, organo-boron, and organo-tin reagents.

(ii) Transition metal catalysts in organic synthesis: Introduction to organometallic chemistry of transition metals. Organopalladium Chemistry, and Organo-Platinum compounds: Metal Catalyzed Coupling Reactions: Suzuki coupling, Heck coupling, Stille coupling, Sonogashira coupling, Kumada coupling, and related cross-couplings. Alkene metathesis.

(iii) Reaction intermediates in organic synthesis regarding carbenes, ketenes, and enamines.

Course Learning Outcomes (COs):

Upon completion of this course, the students will be able to

CO1. Explain the importance of heterocyclic compounds in biological systems, pharmaceuticals, and other industrial applications. Distinguish the molecular structure, classification

CO2. Explain and apply the reactions for Syntheses, reactions, and properties of three and four-membered heterocyclic compounds containing Nitrogen, Oxygen, and Sulphur and condensed five-membered heterocyclic compounds with one hetero atom

CO3 Discuss and explain the chemistry and mechanistic aspects of five and six-membered aromatic heterocyclic compounds containing two hetero atoms and identify their the chemical and physical properties

CO4 Rationalize the synthesis, structure, bonding, properties, and reactivity of organo-copper, organo zinc, organo boron, tin, and transition metal organometallic compounds. Illustrate the reactivity of selected organometallic compounds such as organo cuprates, organo-boron, and tin and show how these may be used as a tool for the synthesis of complex molecules

CO5 Apply the following reagents for coupling and other reactions for organic synthesis: Grignard reagent, Organolithium, organocuprates, carbenes, nitrenes, enamines, and their application in organic synthesis

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3		1							
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT demonstration	Class test, (Short Q and MCQ), Quiz
CO2	Lecture, Demonstration with the model, Discussion	Quiz, Assignment, Mid –term-1 exam.
CO3	Lecture, animated VDO clips, Question-Answer session	Mid-Term-2 exam., Assignment
CO4	Lecture, Group discussion	Problem-solving, Assignment, Final Assessment
CO5	Lecture, PPT presentation, group discussion for problem analysis	Problem-solving, Final Assessment

Books Recommended:

1. E. H. Rodd, Chemistry of Carbon Compounds (Heterocyclic Compounds) IV A, B, C.
2. A. R. Katritzky, Advances in Heterocyclic Chemistry, vols. I-X.
3. J. Joule and G. Smith, Heterocyclic Chemistry. Fifth Edition.
4. R. K. Bansal, Heterocyclic Chemistry.
5. Stanley H. Pine, Organic Chemistry, Fifth Edition, McGraw-HILL.
6. Francis Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B, Third Edition.
7. T. L. Gilchrist, Heterocyclic Chemistry.

Course No: CHE **0531 5142**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Advanced Biochemistry**		Course Type: Core Theory	

Course Rationale:

This course aims to provide progress in understanding the core principles and topics of Biochemistry, which are involved in the chemistry of the biological system.

Course Objectives:

The objectives of this course are to :

- Acquaint students with the molecular logic of living organisms and the history of life
- Make them familiar with the metabolic concepts and bioenergetics
- Acquire the concepts of glycolysis, gluconeogenesis, pyruvate oxidation, and TCA cycle
- Make them understand the electron transport and oxidative phosphorylation
- Provide the knowledge of catabolism of triacylglycerol, amino acids, and Urea cycle
- Recognize the basics of oxidation of fatty acids
- Make them familiar with the biosynthesis of fatty acids and amino acids and nucleic Acids
- Recognize the concept of hormones, and their regulation, function & mechanism

Course Content:

1. Introduction: Definition, branches, biochemistry as the molecular logic of living organisms. Origin and history of life, chemical evolution of life.

2. Bioenergetics and Metabolism: (i) Metabolic concepts, bioenergetics. (ii) Glycolysis, pyruvate oxidation, and TCA cycle. Electron transport and oxidative phosphorylation. Gluconeogenesis. (iii) Catabolism of triacylglycerol, *β*-oxidation of saturated, monounsaturated, polyunsaturated, and odd-chain fatty acids. (iv) Catabolism of amino acids and the Urea cycle. (v) Outline the biosynthesis of fatty acids and amino acids.

3. Introduction to Heredity and Nucleic Acids: The structure of genetic materials. Replication and transcription of DNA, mutation. Genetic code, protein biosynthesis, and its regulation.

4. Hormones: Classification, the function of hormones, and general mechanism of hormone action. Hormone regulation and action with special reference to insulin and testosterone. Birth control.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe and recognize the molecular logic of living organisms and the origin and history of life, the chemical evolution of life, the metabolic concepts, and bioenergetics

CO2. Describe and explain the catabolism of glycolysis, pyruvate oxidation and TCA cycle, triacylglycerol, amino acids and Urea cycle, fatty acids oxidations, electron transport, and oxidative phosphorylation

CO3. Describe and demonstrate the anabolism of Gluconeogenesis, fatty acids, and amino acids

CO4. Explain and analyze the structure of genetic materials, Replication and transcription of DNA, mutation, genetic code, protein biosynthesis, and its regulation

CO5. Describe and recognize hormones classification, function, general mechanism, regulation, and action with special reference to insulin and testosterone

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3		2					1		
CO5	3		2							1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration	Class test (Short Q)
CO2	Lecture, Demonstration with the model, Discussion	Quiz, assignment
CO3	Lecture, Question-Answer session	Class test (Short Q)
CO4	Lecture, Group discussion	type test, problem-solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis	type test, problem-solving

Books Recommended

1. Lehninger, Nelson and Cox, Principles of Biochemistry.
2. S. Solomon, General, Organic and Biological Chemistry.

Course No: CHE **0531 5143**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Advanced Natural products Chemistry**		Course Type: Core Theory	

Course Rationale:

A vast area of our daily life is involving the use of different types of large-size natural molecules called natural products. These natural products cover food supplements, vitamins, medicines, and even different hormones. This course aims to deal with the chemical and other related properties, preparation, and analysis of those natural product molecules.

Course Objectives:

The objectives of this course are to:

- Acquaint the students with the advanced ideas of important classes of compounds of natural products chemistry
- Facilitate necessary knowledge of the structure, biosynthesis, occurrence, analysis, and pharmaceutical perspectives
- Teach about the structural elucidation of Steroids and Hormones
- Provide knowledge on the properties and structural elucidation of alkaloids, terpenoids
- Give the students ideas and knowledge on antibiotics
- Help to expose knowledge of Carotenoids, Flavonoids, Xanthones, and Porphyrins.
- Develop knowledge of Vitamins
- Impart knowledge on the biosynthesis of terpenoids, steroids, and flavonoids

Course Content:

6. A broad concept leading to the formation of different types of Naturally Occurring Substances.
7. **Alkaloids:** Elucidation of the Structures of Morphine and Quinine.
2. **Terpenoids:** Chemistry of higher terpenoids concerning Zingiberene, Phytol, *α*-Pinene, and Squalene.

3. **Antibiotics:** Chemistry of Streptomycin and Penicillin.
4. **Chemistry of Steroids** with special reference to Cholesterol; Stereochemistry of Steroids; Introduction to saponins. Study of Hormones: Chemistry of sex hormones (Testosterone and Estrogen); Non-steroidal hormone (Thyroxin) and Adernel cortical hormone (Cortisone).
5. **Natural pigments:** Introduction and classification; basic idea about Carotenoids, Flavanoids, Xanthones, and Porphyrins; Chemistry of Carotenes; Characterization of flavonoids by degradation experiments concerning Quercetin.
6. **Vitamins:** Introduction, Chemistry of Thiamine, Riboflavin, Ascorbic acid, and Calciferol.

Course Learning Outcome (COs):

After the successful completion of the course, students will be able to:

CO1. Explain the importance of natural compounds. Elucidate the structure of alkaloids, terpenoids, and antibiotics by chemical as well as physical methods

CO2. Explain and apply the basic chemistry of different types of steroids and hormones; saponin

CO3. Explain the constituents of Carotenoids, Flavonoids, Xanthones, and Porphyrins

CO4. Analyze the functions of vitamins and the Physiological significance of Vitamin

CO5. Plan a synthetic route for the synthesis of exemplary natural products, able to know biosynthesis & learn advanced methods of structural elucidation of compounds of natural origin

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2							
CO3	3		2							
CO4	3		2	2						
CO5	3		2	3						

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO2	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO3	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO4	Lecture, PPT Demonstration, Open Discussion, Question-Answer session	Problem-solving assignment, Final Assessment
CO5	Lecture, PPT Demonstration, Group discussion for problem analysis	oral, Final Assessment

Books Recommended:

1. L. Finar, Organic Chemistry, Vol. 2
2. Agarwal, Chemistry of Organic Natural Products, Vol. I and II
3. Natural Products Chemistry, P. S. Kalsi, Kalyani Publishers, New Delhi.
4. Natural Product Chemistry, K.B.G. Torssell, J. Wiley and sons New York.

Course No: CHE **0531 5244**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Supramolecular Chemistry**		Course Type: Elective Theory (Core)	

Course Rationale: For chemistry students it is very important to have the knowledge on contemporary topics of chemistry. This course is aimed to give the fundamental knowledge of supramolecular chemistry, which basically deals with spatial organization of discrete molecules through non-covalent interactions.

Course Objectives:

The objectives of this course are to:

- Acquaint students with the development of supramolecular chemistry, nature of supramolecular interactions, and supramolecular host-guest compounds
- Make the students familiar with cation- and anion-binding and molecular hosts
- Understand the fundamentals of the formation of host-guest compounds in the solution and in the solid-state
- Acquire the concepts of the formation of network solids such as zeolites, layered solids, intercalates, Werner clathrates and metal organic frameworks
- Make them familiar with the role of self-assembly in supramolecular architecture
- Provide the knowledge of different supramolecular mimics used in biological processes

Course Content:

Concepts of Supramolecular Chemistry: Definition and development of supramolecular chemistry, Classification of supramolecular host–guest compounds, Receptors, Coordination and the lock and key analogy, Binding constants, Cooperativity and the chelate effect, Preorganisation and complementarity, Thermodynamic and kinetic selectivity, Nature of supramolecular interactions, Solvation and hydrophobic effects, Supramolecular chemistry of life.

Cation- and Anoin-Binding Hosts: Crown ethers, Podants, Cryptands, Spherands, Calixarenes, Corands, Macrocycles, Biological anion receptors, Inert metal-containing receptors, Ion pair receptors.

Molecular Hosts and Molecular Guests in Solution: Introduction, Cyclodextrins, Cucurbiturils, Cyclophanes, Cryptophanes, Carcerands and Hemicarcerands.

Solid-State Host-Guest Compounds: Clathrates, Urea and thiourea clathrates, Cyclotriveratrylene.

Network Solids: Introduction, Zeolites, Layered solids and intercalates, Hoffman inclusion compounds and Werner clathrates, Coordination polymers and metal organic frameworks (MOFs).

Self-Assembly: Introduction, Proteins and foldamers, Biochemical self-assembly, Self-assembly in synthetic systems, Self-assembling coordination compounds, Self-assembly of closed complexes by hydrogen bonding, Catenanes and rotaxanes, Helicates and helical assemblies.

Biological Mimics and Supramolecular Catalysis: Introduction, Cyclodextrins as enzyme mimics, Corands as ATPase mimics, Cation-binding hosts as transacylase mimics, Metallobiosites, Haem analogues, Ion channel mimics, Supramolecular catalysis.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Describe supramolecular chemistry, their development and the nature of supramolecular interactions

CO2. Explain different types of hosts and guests and their formation of supramolecular compounds in solution and solid-state

CO3. Discuss the concepts of network solids, self-assembly in supramolecular architecture and different mimics used as supramolecular catalysts in the biological processes

CO4. Interpret different factors, effects, hosts and guests necessary for the formation of supramolecules

CO5. Illustrate the concepts of network solids, self-assembly and biological mimics as catalysts in supramolecular chemistry

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		1							
CO2	3		1							
CO3	3		1							
CO4			3							
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO2	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz

CO3	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz
CO4	Lecture, PPT Demonstration, Open Discussion	Assignment, Final Assessment
CO5	Lecture, PPT Demonstration, Open Discussion	Assignment, Final Assessment

Books Recommended:

1. J. W. Steed and J. L. Atwood, *Supramolecular Chemistry*, 3rd Ed., 2022, John Wiley & Sons Ltd.
7. J. M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, 1995, Wiley-VCH, Weinheim, Gemany.
8. K. Ariga and T. Kunitake, *Supramolecular Chemistry–Fundamentals and Applications*, 2006, Springer-Verlag, Berlin, Germany.

Course No: CHE **0531 5245**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Advanced Spectroscopy & stereochemistry**		Course Type: Core Theory	

Course Rationale: Applications of spectroscopy are essential for a variety of fields, including analytical chemistry, biochemistry, materials science, and medical imaging. The course aims mainly at structural elucidation of known or unknown compounds using common advanced spectroscopic techniques. Stereochemistry is the study of the relative spatial arrangement of atoms in molecules and how this affects their properties and reactivity. Understanding stereochemistry is an important factor for understanding the behavior of many important classes of chemical compounds, including pharmaceuticals, natural products, and polymers and useful for understanding reaction pathways.

Course objectives:

Objectives of the course are to:

- Acquire the common features and applications of the following spectroscopies: including UV-Vis, IR, NMR, and Mass spectrometry
- Make them able to select the appropriate techniques among the different spectroscopic techniques and be able to make a proper analysis of organic structures and to apply them for medical and other fields.
- Give the idea about the optical isomerism of compounds devoid of chiral center like biphenyls and allenes
- Internalize the basic principles of ORD and CD; Develop the ability to analyze and interpret ORD and CD spectra, including understanding the relationship between spectra and molecular structure and conformation
- Make them familiar about the basic principles of stereochemistry, including the relationships between stereochemistry and molecular structure, and the influence of stereochemistry on chemical reactivity and reactivity for asymmetric synthesis

Course Content:

1. Spectroscopy

(i) NMR spectroscopy: ^{1}H-, ^{13}C-, ^{19}F- and ^{31}P-NMR spectroscopy: Basic principles, chemical shift, spin-spin coupling and its patterns, spin decoupling. 2D NMR, COSY, HETCOR, DEPT, NOESY, and NOE. Application of ^{1}H- and ^{13}C-NMR for structural and reaction study.

(ii) Mass spectrometry: Introduction to different modern mass spectrometric techniques and their working principles, e.g., GC-MS, LC-MS, TOF MS, FAB MS. Elucidation of the structure of organic compounds by analyzing fragmented ion peaks.

(iii) Elucidation of the structure of unknown organic compounds by analyzing combined spectral (e.g., UV-Vis, IR, ^{1}H NMR, ^{13}C NMR, DEPT ^{13}C, COSY and HETCOR) analysis.

2. Stereochemistry

(i) Stereochemistry of fused ring systems: Conformations, relative stability and molecular dissymmetry in (i) Bicyclic systems e.g., Decalin, 2-Decalol, (ii) Polycyclic systems e.g., Perhydrophenanthrene, Perhydroanthracene.

(ii) Atropisomerism: Atropisomers, Biphenyl isomerism, Isomerism in Polyphenyls, The configuration of optically active biphenyls, Isomerism in Stilbenes and Naphthalene derivatives.

(iii) Stereochemistry of allenes, spirans and related compounds.

(iv) Optical rotation and optical rotatory dispersion: Chiroptical Properties (i) Relation between optical rotation and configuration, atomic asymmetry, conformational asymmetry. (ii) Circular birefringence and circular dichroism (CD). Optical rotatory dispersion (ORD), Cotton effect. Description of ORD curves, Differences between ORD and CD, Rotatory dispersion of ketones. Sector rules: the axial Haloketone rule, the Octant rule, Application of these rules in determining the structure, conformation, and configuration of different compounds.

(v) Stereochemistry of reaction mechanism: Asymmetric synthesis**,** Introduction, R/S stereo descriptors, Stereoselective syntheses: nucleophilic attack on acyclic chiral carbonyl compounds (Cram's rule),

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain common features and applications of the following spectroscopies: including UV-Vis, IR, NMR, and Mass spectrometry

CO2. Select the appropriate techniques among the different spectroscopic techniques and be able to make a proper analysis of organic structures and to apply them for medical and other fields

CO3. Explain the optical isomerism of compounds devoid of chiral center like biphenyls and allenes

CO4. Internalize the basic principles of ORD and CD; Develop the ability to analyze and interpret ORD and CD spectra, including understanding the relationship between spectra and molecular structure and conformation

CO5. Explain the basic principles of stereochemistry, including the relationships between stereochemistry and molecular structure, and the influence of stereochemistry on chemical reactivity and reactivity for asymmetric synthesis

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	**Program Learning Outcomes**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3		2							
CO2			3							
CO3	3		2							
CO4	3		2							
CO5	3		2							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	**Teaching-Learning Strategies**	**Assessment Strategies**
CO1	Lecture, PPT Demonstration, Open discussion	Class test (Short Q and MCQ)
CO2	Lecture, PPT Demonstration, Discussion, Open discussion	Class test (Quiz, Short Q)
CO3	Lecture, PPT Demonstration, Question-Answer session	Class test (Short Q and MCQ), Assignment
CO4	Lecture, PPT Demonstration, animated VDO clips, Group discussion	Final Exam (Short &broad Q, Explanation)
CO5	Lecture, PPT presentation, Group discussion	Final Exam (Short &broad Q, Explanation)

Books Recommended

2. William and Flemming (McGraw Hill), Spectroscopy of Organic Compounds.
3. D. Pavia Lampen and Kniz, Introduction to Spectroscopy.
4. Silverstien, Bassien and Morril, Spectrometric Identification of Organic Compounds
5. P. S. Kalsi, Stereochemistry of Organic Compounds
6. D. Nasipuri, Stereochemistry of Organic Compounds
7. E. E. Eliel, S. H. Wilen, and L. N. Mander, Stereochemistry of Organic Compounds 7.I. L. Finar, Organic Chemistry, Vol. 2

Course Code: **CHE 0531 5246**	Credit: 4.0	Year: MS	Semester: Second

Course Title: Advanced Medicinal Chemistry	Course Type: Theory core

Course Rationale:
This course is aim to provide a progress to understanding the mechanism of action of selected classes of drugs and applications, which are involved the Pharmaceutical terms in the chemistry of living system.

Course Objectives
The objectives of this course are to:

- To get introduced to pharmaceutical chemistry and its terms involved.
- To understand the various classes of drugs with examples with special reference to Structure, Mechanism of action, Structure Activity Relationships.
- To acquainted with drug metabolism.

Course Contents

1. An introduction to drug design: What are drugs and why do we need new ones? Sources of drugs and lead compounds. The general steps in the design of a new drug, Stereochemistry and drug design, Solubility and drug design, Solubility and drug structure, Salt formation, The incorporation of water solubilizing groups in a structure. Effect of functional groups on physiological activity of drugs: hydroxy, acidic, alkyl, aldehyde, ketone, cyano, halogens, ether and ester groups with examples. Prodrug.

2. The SAR and QSAR approaches to drug design: Structure–activity relationships (SARs), Changing size and shape, Introduction of new substituents, The introduction of a group in an unsubstituted position, The introduction of a group by replacing anexisting group. Quantitative structure–activity relationships (QSARs), Lipophilicity, Partition coefficients (P), Lipophilic substitution constants (p), Electronic effects, The Hammett constant (s), Steric effects, The Taft steric parameter (Es), Molar refractivity (MR), Other parameters, Hansch analysis, Craig plots, Isotere and bioisostere.

3. Acting way of drug that target enzymes and receptors: Reversible, Irreversible and transition state inhibitors; Agonist, Antagonist, and partial agonist.

4. Antiulcer agents: Definition, causes, treatment of peptic ulcer, Gastric acid release, H_2 antagonist, Histamine and its receptors, searching for a lead, Cimitidine and its structure, activity & metabolism; Ranitidine and its SAR; Proton pump inhibitors: Parital cells and the proton pump, mechanism of inhibition & metabolism, Helicobacter pylori and use of antibacterial agents, treatment.

5. Anxiolytics, sedative–hypnotics, and antipsychotics agents: Structure activity relationship (S.A.R.), uses, mode of action, and effects of Benzodiazepines, Nonbenzodiazepines, Barbiturates, chloral hydrate, Phenothiazine, Fluorobutyrophenones with suitable examples.

6. Antifungal agents: General mode of action of antifungal agent. Azoles, Allyl amines, Phenols.

7. Antianginal agents and vasodilators, and Antithrombotic Agents: Intermediary myocardial metabolism, Nitrovasodilators, Antianginal action of nitrovasodilators, ACE inhibitors- Enalapril. Aspirin and Clopidogrel.

8. Antiviral agents: Viruses and viral diseases, vaccination, general mode of action of antiviral drugs. Acting against DNA virus: Aciclovir, Valaciclovir, Desiclovir, Ganciclovir, Valganciclovir, Penciclovir and Cidofovir. Acting against RNA virus: Zidovudine, Lamivudine, Didanosine, Abacavir, Nevirapine, Delavirdine, Efavirez, Ritonovir, Lopinavir, Palinavir, Zanamivir.

9. **Newer antibacterial agents and resistance**: **Antibacterial** action and synthesis of Quinolone and fluoroquinolone such as Ciprafloxacin, Levofloxacin. Drug resistance by mutation, Drug resistance by genetic transfer, Other factors affecting drug resistance.

10. **Anticancer agents:** Definition and causes of cancer, genetic faults leading to cancer, treatment of cancer. Drug acting on nucleic acids, Drug acting on enzymes, Antibodies, antibody conjugates and gene therapy.

11. **Drug Metabolism**: Definition and concepts, biological factors effecting drug metabolism, biotransformation, metabolic conjugate reactions, significance of drug metabolism in medicinal chemistry.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:
CO1: In order to construct drugs, students will be able to recognize certain functional groupings that have physiological action.
CO2: The students will have a clear understanding of concepts on SAR analysis.
CO3: Students will gain understanding about drug receptors, resistance, metabolism, and treatment of selective diseases.
CO4: Students will be in a position to understand the mechanism of action of selected classes of drugs.
CO5: The students will be able to apply synthetic organic chemistry knowledge in devising a synthesis for a drug, and to write names and chemical structure of drugs.

Mapping of Course Learning Outcomes (COs) with Pos3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

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

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

CO	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration	Class test
CO2	Lecture, Demonstration with model, Discussion	Quiz, assignment, Short Q
CO3	Lecture, Question-Answer session	Type test, problem solving, Short Q
CO4	Lecture, Group discussion	Class test
CO5	Lecture, PPT presentation, Group discussion	Type test, problem solving, Short Q

Books Recommended:

1. Wilson and Gisvold's, Organic Medicinal and Pharmaceutical Chemistry, 12th Edition.
2. Graham L. Patrick, Introduction to Medicinal Chemistry, 5th Edition.
3. Gareth Thomas, Fundamentals of Medicinal Chemistry, John Wiley & Sons Ltd, England, 2003.
4. D. Sriram *and* P. Yogeeswari, Medicinal Chemistry, 2nd Edition

Course No: **CHE 0531 5151**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Analytical Spectroscopy**		Course Type: Core Theory	

Course Rationale:
This course is aim to provide advanced knowledge on Analytical Spectroscopic methods that will be needed to be a professional analyst for different chemical analysis both in research as well as industrial sectors.

Course Objectives
The objectives of this course are to:

- Acquaint students with the specific knowledge of analytical spectroscopic techniques.
- Accumulate basic ideas and advanced information about specific application of these analytical spectroscopic techniques environmental pollution and remedial measures
- Acquire theoretical knowledge and precision of different techniques and their real time analysis capacity.
- Foster the analytical and critical thinking on the utilization of the techniques in proper way
- Make them familiar with sample specific chemical analysis as per ISO standard which will be helpful after completion of the degree

Course Content:

Fundamentals of spectroscopy: Refreshment of basic principles, the interaction of matter and energy, concise knowledge on various spectroscopic methods (eg. UV-Visible, IR, NMR and Mass spectrophotometry) and its application.
Atomic Absorption Spectroscopy: Atomization, Flame Atomization, Graphite Furnace Atomizers, Volatile Hydrides, Sources for Atomic Absorption Spectroscopy (AAS), Principle of AAS, Background Correction, Interferences, Applications of AAS in water and soil analysis.
Atomic Emission Spectroscopy: Flame Emissive Spectrometry: Instrumentation, Analytical Measurement and Applications. Plasma Emission Spectroscopy:
Inductively Coupled Spectrometry: Principle, Instrumentation; Sources (Inductively Coupled Plasma ICP, dc Plasma DCP), isotopic interferences and remedy (eg. Arsenic analysis by ICP), Applications.
X-Ray diffraction spectroscopy: X-Ray Processes, Instrumentation, Powder diffraction methods and its application, Electron Microprobe, X-Ray Diffraction Analysis, Applications.
Fluorometry: Principle of Fluorescence, Chemical Structure and Fluorescence, Fluorescence Quenching, Relationship Between Concentration and Fluorescence Intensity, Fluorescence Instrumentation, Spectrofluorometer.
Chromatographic and attached mass spectrometry techniques: Advanced chromatographic methods (GC, LC and HPLC) for pharmaceutical and pollutant analysis, Mass spectroscopy in chromatographic analysis, fundamentals of mass spectroscopy, mass analyzer, GC-MS and its application: gas chromatographic techniques in environmental pollutant, food, pesticides and forensic analysis, analytical requirements of samples for this techniques. Mass Spectrometer as a detector.
Forensic analysis using Analytical spectrophotometric techniques: Fundamentals of forensic analysis, methods used for forensic analysis, precision and accuracy related to analysis.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Compare different spectroscopic techniques for application purposes, explain the mechanism of different spectroscopic techniques
CO2. Explain the principle of AAS and will be able to utilize in specific field of pollutant analysis
CO3. Express and utilize knowledge of ICP spectrometry for trace elemental analysis and other analysis purposes
CO4. Explain the principle and application of XRD for structural as well as other analysis purposes
CO5. Express advanced separation processes (GC-MS), acquire skill related to forensic analysis and will be able to utilize the taught methods for industrial application purposes as well as research oriented works.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT presentation related to lecture materials, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with theoretical problem solving, Discussion and make students thinking in real problem solving phenomena.	Quiz, assignment
CO3	Lecture, animated VDO clips, workshop type interactive discussion, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis.	Essay type test, problem solving

Books Recommended:

1. William Schrenk, Analytical Spectroscopy
2. Raymond P.W. Scott, Analytical Spectroscopy
3. Kamlesh Bansal, Analytical Spectroscopy
4. Robert D. Braun, Introduction to instrumental analysis
5. Galen W. Ewing, Instrumental methods of chemical analysis
6. Skoog, West, Holler, Analytical chemistry
7. A. Braithwaite and F.J.Smith, Chromatographic methods

Course No: **CHE 0531 5152**	Credit: 4.0	Year: MS	Semester: First
Course Title: **Advanced Environmental Chemistry**		Course Type: Core Theory	

Course Rationale:
This course is aimed to provide advanced knowledge on Environmental Chemistry that will be needed for environmental problem handling and management purposes.

Course Objectives
The objectives of this course are to:
- Acquaint students with the specific knowledge of chemistry for keeping environment safe and sound
- Accumulate basic ideas and advanced information about environmental pollution and remedial measures
- Acquire theoretical reason of environmental hazards, and to utilize this for future handling of environmental issues
- Foster the critical thinking on the local and international environmental issues and to handle these to make the earth sustainable for all
- Make students deal with pollutant remedial strategies suitable for our Bangladesh perspective as well as internal

Course Content:
The Atmosphere and Atmospheric Chemistry: Importance of the atmosphere, meteorology and weather, temperature inversion, plume behavior, chemical and photochemical reactions in the atmosphere, introduction to particles in the atmosphere, chemical processes for the inorganic particle formation, particulate materials and their impact on health, air quality standards and monitoring methods for air pollutants, chemical fate and transport in the atmosphere, climate change and anthropogenic effect.
The Geosphere and Geochemistry: Physical forms of the geosphere, internal processes (earthquakes and volcanic eruption), sediments, Clays, threat of rising sea levels, environmental effects of mining and mineral extraction, Minerals (composition, structure, properties and grouping), rocks (composition and its classification), the plate tectonic system, Origin and crystallization of magma, weathering and erosion, earth resources and the factors that influence its economic exploitation.
Chemistry of Hydrosphere and Aquatic Microbial Biochemistry: Global historical cycle and water, basic climatological concepts, Force and scale of wind motion, El Nino, tropical cyclone and thunderstorms, Infiltration, evaporation and evapotranspiration, catchments hydrology, Aquatic biochemical processes, Factors affecting bacterial metabolism, microbial oxidation and reduction, Microbial transformations of halogens and organohalides.
Soil and Agricultural Environmental Chemistry: Soil and Agriculture, water and air in soil, the inorganic components of soil, organic matter in soils, soil humus, acid-base and ion exchange reactions in soils, soil loss and degradation, saving the land (agroforestry and soil preservation), nitrogen pathways, pest and pesticides.
Toxicological chemistry and Environmental Toxicology: Fundamentals of toxicology, ATSDR Toxicological profiles**,** Dose response relationships, Nonlethal effects, reversibility and sensitivity, Hypersensitivity and hyposensitivity, Teratogenesis, Mutagensis, carcinogenesis and effects, In vivo and in Vitro toxicity, enzyme actions, biological effects of Cd, Pb, Hg, As,. Toxic inorganic compounds (eg. Cyanide, CO, NOx) and their toxicity, toxicology of organic compounds (eg Benzene and aromatic hydrocarbons, phenols and derivatives), organohalogen compounds, organohalide pesticides, toxic natural products, etc. Ecotoxicology.
Methods of Measuring Environmental Parameters: Absorption and atomic absorption method for water wastewater analysis, GC-MS for pesticides and gaseous pollutant analysis, Fluorescence spectrometric methods for atmospheric

particulate matter analysis.
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Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Express different terms of environmental segment and chemicals species and their chemistry related to these segments, their formation and impacts on environment. Also explain the mechanism of reactions within environmental segments including microbial mediation to transport pollutant.

CO2. Explain the causes of water pollution and will be able to take steps for keeping water bodies free from pollution and Also Express d the causes of soil pollution, and will be able to take steps for remedial measure related to these.

CO3. Express and the knowledge related to toxicology and their pathways and consequences on our health.

CO4. Explain the role and application of biotechnology as a safe environmental techniques to remediate pollutants

CO5. Handle and analyze the data and their management of some pollutants.

Mapping of Course Learning Outcomes (COs) with POs

3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	2							2		
CO3	3									
CO4	3									
CO5	2	2								

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT presentation related to lecture materials, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with theoretical problem solving, Discussion and make students thinking in real problem solving phenomena.	Quiz, assignment
CO3	Lecture, Review article session on recent topics on environmental hazards, workshop type interactive discussion, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Semester end test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis.	Semester end test, problem solving

Books Recommended:

1. Colin Baird, Environmental Chemistry
2. Stanely E. Manahan, Environmental Chemistry , 9th edition
3. J. W. Moore, Environmental Chemistry
4. I. F. Fergussow, Environmental Chemistry
5. S. S. Dara, A text book of Environmental Chemistry and Pollution control
6. C. S. Rao, Environmental pollution control Engineering
7. Ernest Hodgson, A Textbook of Modern Toxicology, 3rd Edition

Course No: **CHE 0531 5253**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Waste Management and Treatment**		Course Type: Core Theory	

Course Rationale:

This course is aimed to provide up to date knowledge about different types of Waste and their management strategies followed by sustainable treatment

Course Objectives:

The objectives of this course are to:

- To get on broader understanding on various aspects of solid waste management practiced in different municipalities
- Introduce the new approaches toward recovery of products from solid waste to compost and biogas, incineration and energy recovery
- Foster students about the importance of water treatment both in domestic as well as industrial sector, problems and remedial measures to tackle these economically and environmentally friendly manner
- Help to increase the consciousness about the concept of zero waste philosophy and thereby to implement it in industrial sectors
- Ensure the protection of the environment through and effective waste management system
- Explain the hazards of waste management and treatment options of some risky waste and their worldwide treatment philosophy

Course Content:

Introduction: Human Impact on environment and pollution phenomena, chemical fates and transport, importance of waste management and treatment, zero waste philosophy.

Solid waste: Types of solid wastes; pollution, treatment and disposal methods, municipal solid wastes, industrial wastes, hazardous wastes, Sources of solid wastes and waste treatment, Waste reduction and minimization, Recycling and re-use strategy, Physical and chemical methods of waste treatment- an overview, biological factors involved in waste treatment, methods of waste disposal-composting, sanitary land filling, thermal processes-incineration, pyrolysis, Green waste treatment by photolysis and sonolysis, Biodegradation of wastes, Disposal site and proper steps to dump wastes.

Waste Water treatment and management: Sources of waste water, properties of waste water, water treatment for municipal use, industrial use and disposal, water conditioning and treatment for different purposes. Different treatment processes (primary, secondary and tertiary), Industrial waste water treatment: removal of solids, removal of metals, removal of dissolved Organics and Inorganics, Sludge, Water disinfection. Comparison among different filtration techniques.

Gaseous waste and pollutants management: Sources of gaseous pollutants, Types and classification of air pollutants: particulate, hydrocarbons, carbon monoxide, oxides of sulfur, oxides of nitrogen, photochemical oxidants, Gaseous waste and pollutants in Portland cement, glass, fiber glass, petroleum refineries, iron and steel and acid manufacturing industries, pharmaceutical. Fly ash management in coal burning industries.

Integrated waste Management strategy: Overview of current Water and Waste-Water Management, Effluent treatment plant and its importance in industrial sector, Water Regulations, Solid-Waste Reduction and Minimization, Risk Assessment and Management, Hazardous Waste Management, treatment and disposal of hazardous chemical waste-physical, chemical and biological processes, off-side disposal and co-disposal, security concerns of handling hazardous waste, Air quality management concept, Abatement of NOx, Sox and particulate matter from stationary and mobile sources, Selective catalytic reduction versus low NOx burner technologies, Flue gas de-sulpherization techniques, 3-way catalyst and importance of vehicle pollutant reduction, Controlling devices for gaseous contaminants.

Resource recovery from waste: Characterization of waste for resource recovery, treatment of mining waste and their management, energy harnessing from biomass and fuel cell based on organic waste.

Nuclear Waste Management: Nuclear wastes and consequences of un-treated waste, spent fuel and their proper management, short-lived and long-lived radioactive waste management techniques and their improvement. Nuclear waste management-Bangladesh perspectives.

Biological Treatment of Solid and Hazardous Waste: Bioreactors; anaerobic decomposition of solid waste; principles of biodegradation of toxic waste; inhibition; co-metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Explain basic concepts on waste characterization and of solid waste management, beginning from source generation to waste disposal in a system of municipality organizational structure.

CO2. Interpret various technological applications for processing of waste and their disposals in various ways.

CO3. Design the ways to convert waste to energy productions in the perspectives of sustainable development.

CO4. Apply basic concepts in hazardous waste management and integrated waste management for urban areas
CO5. Demonstrate the waste water characterization and its management practiced in various cities of Bangladesh.

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	3									
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT presentation related to lecture materials, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with theoretical problem solving, Discussion and make students thinking in real problem solving phenomena.	Quiz, assignment
CO3	Lecture, animated VDO clips, workshop type interactive discussion, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Group discussion	Essay type test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis.	Essay type test, problem solving

Books Recommended:

8. Jacqueline Vaughn, Waste Management
9. John Pichtel, Waste Management Practices
10. Stanley E. Manahan, Environmental Chemistry, 9th eidition
11. Howard S. Peavy Donald Rowe, Environmental Engineering
12. James L. Pyle, Chemistry and Technological Backlash
13. A. K. De, Environmental Chemistry

Course No: **CHE 0531 5254**	Credit: 4.0	Year: MS	Semester: Second
Course Title: **Sustainable Chemistry and Bio Nanotechnology**		Course Type: Core Theory	

Course Rationale: This course is aim to provide advanced knowledge on Chemistry for maintaining Sustainable development and also to provide knowledge of some greener chemical routes for sustainable industry.

Course Objectives
The objectives of this course are to:
- Acquaint students with knowledge of chemistry for fulfilling the requirements of sustainable development
- Accumulate basic ideas and advanced information about greener routes of synthesis
- Acquire theoretical reason of environmental hazards, and to utilize this for future handling of waste less chemistry
- Foster critical thinking on safe and sustainable energy for the future generation
- Acquire knowledge on bio nano technology as a safer option for maintaining sustainable development

Course Content:
Sustainability and sustainable development: Definition of sustainability, importance of sustainable development and role of chemistry towards sustainable development, UN SDG Goals and their achievement strategies, Current situation of Sustainable development worldwide, Further improvement or innovative suggestions related SDG**.**
Resources and Sustainable Materials: Minerals in the Geosphere, Classification and evaluation of Mineral Resources, Extraction & hazards related to some mining, Mining site rehabilitation, Management of metal resources and nonmetal resources, safe disposal options of metallurgical waste.
Green Chemistry and Industrial Ecology: Principles of Green Chemistry, reduction of risks related to hazardous materials, synthetic chemistry versus Green Chemistry, Feedstocks, Stoichiometric and catalytic reagents, various solvents and their merits and demerits, industrial ecosystem, industrial metabolism, materials flow and recycling in an industrial ecosystem, The Kalundborg industrial ecosystem as an ideal model, economic advantages of green chemistry.

Solvent free Chemistry: Alternative approach to solvent Chemistry, exploring solvent free reactions, microwave assisted chemical synthesis, ionic liquids as an alternative solvents, supercritical fluids and their application in green chemistry, supported catalyst and reagents for green chemistry.
Sustainable Energy: Energy problem, Nature of energy, Sources of energy used in the atmosphere, Energy devices and conversions, Green Technology and energy conversion Efficiency, Renewable energy sources, Petroleum and natural Gas, Geothermal Energy, Nuclear Energy, Biomass Energy, bio-fuel and its future and new route of synthesis, Fuel Cells and its hope and limitations.
Nano Structured Materials and Bio nanotechnology: Chemistry of Nano materials, Scaling laws applied to, nanotechnology, Nanoparticle Morphology and Electronic Structure, Properties of Nano materials, Synthesis of Nano materials (Top down and bottom up techniques), Characterization Techniques of Nano materials, Bio-nano technology, biological machines, Application of Nanotechnology, Nano materials in catalysis, Nano technology in environmental problem abatement (waste water treatment and gaseous pollutant reduction, drug delivery), State of the art in nanotechnology, Safety issues of Nanotechnology, hazards in nano technology and its remediation.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Describe and explain the significance sustainable chemistry to maintain sustainable development
CO2. Explain the importance of green chemistry as a sustainable method and its application
CO3. Address the energy issues and importance of safer methods to tackle next generation energy mitigation strategy. and the knowledge related to supercritical fluid and ionic liquid for environmental applications purposes.
CO4. Express the fundamentals of nano science and technology to utilize it next
CO5. Express the role and application of biotechnology as a safe environmental techniques

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									
CO3	3									
CO4	2							2		
CO5	3									

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT presentation related to lecture materials, Demonstration	Class test (Short Q and MCQ)
CO2	Lecture, Demonstration with theoretical problem solving, Discussion and make students thinking in real problem solving phenomena.	Quiz, assignment
CO3	Lecture, animated VDO clips, workshop type interactive discussion, Question-Answer session	Class test (Short Q and MCQ)
CO4	Lecture, Review journal articles on up to date isses related to sustainable chemistry and Group discussion	Essay type test, problem solving
CO5	Lecture, PPT presentation, Group discussion for problem analysis.	Essay type test, problem solving

Books Recommended:

1. Manahan, Stanley E , Environmental Chemistry, 9th ed.
2. C. Baird and M. Cann, Environmental Chemistry, 3rd ed.
3. J. C Jones, Atmospheric Pollution
4. Rashmi Sanghi and MM Srivastaba, Green Chemistry-Environmental Friendly Alternatives

5. Jeremy Ramsden, Essentials of Nanotechnology
14. J. Richard Wilson, Minerals and Rocks
15. J.C Jones, Thermal Processing of Waste

Course No: **CHE 0531 5150**	Credit: 2.0	Year: MS	Semester: 1st
Course Title: **Advanced Analytical and Environmental Chemistry Practical**		Course Type: Core Practical	

Course Rationale: This course is aim to provide students hand on pragmatic skill on Analytical methods and instrument for characterization and analysis of environmental sample.

Course Objectives

The objectives of this course are to:

- Accumulate advanced information practical skill on ISO standard sample collection and processing for environmental sample analysis
- Acquaint students with the specific skill of analytical spectroscopic techniques
- Acquire hand on skill on precision and accurate determination techniques maintaining legislative stringint restrictions
- Foster the analytical and critical thinking on the utilization of the techniques along with repetition of data for publication in international journal format

Course Content:

Collection of samples: Direct collection of samples from different surface and underground water spot from in and around the campus and subsequent Measurement of some water quality parameters eg. Suspended solid, dissolved solid, total solid, acidity, alkalinity, hardness, iron content etc. by various analytical techniques.
Experimental set up: Collection of same samples from industrial polluted zone from Sylhet city and determination of Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Chemical Oxygen Demand (COD) of these samples.
Rock or soil analysis: Collection of some soil and rock samples from in and around campus and Estimation of ion-exchange capacity and other metal contents of soil by various analytical techniques.
Estimation of cholesterol from the supplied edible oil/butter by spectrophotometric method: Estimation will be based on different trademark butter or oil samples and their characterization will be completed individually by students.
Comparative examination of some heavy metal levels: Pb, Cr from polluted samples and their estimation will be doe by using spectroscopic methods.
Experiment based on different adsorption models: Langmuir and Freundlich curve fitting analysis will be designed by the students with their own for some adsorptive removal of heavy metals using biosorbents.
Thermodynamic and Kinetic study of adsorptive removal of pollutant: sample pollutants like Pb and Cr from polluted samples collected before.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:
CO1. Collect and process the sample in a ISO specific method followed by calibration of proper instrument
CO2. Compare different spectroscopic techniques for application purposes, also will be able to handle individually different spectroscopic techniques
CO3. Utilize instrument for pollutant analysis
CO4. Express and utilize knowledge of different analytical techniques for trace elemental analysis and other biochemical analysis purposes
CO5. Explain the data and represent in a proper way to publish in a international journal

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Alienied 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		3								
CO2		3								
CO3		3								
CO4		2						2		
CO5		2								2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning & Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, Demonstration in field level sampling safety and hazardous of direct sampling of environmental pollutant.	Assessment in the lab
CO2	Lecture, Practical Demonstration of instrument set up tips to take care instrument properly.	Quiz, on spot assignment during experimental analysis.
CO3	Demonstration on Data handling and graph drawing (hand and software aided graph practice) for result presentation	Assessment of report along with computer aided graph interpretation.
CO4	Group discussion, trouble shooting of instrumental error.	Assessment based on PPT and Oral presentation of the students.
CO5	Journal article reviews, problem analysis	Evaluation of overall report writing in a scientific journal style and final Power point presentation of students.

Books Recommended:

1. Skoog, West, Holler, Analytical chemistry
2. A. Braithwaite and F.J.Smith, Chromatographic methods
3. David Harvey, Analytical Chemistry 2.1

Course No: **CHE 0531 5161**	Credit: 3.0	Year: MS	Semester:1st
Course Title: **Topics on Nanoscience and Nanotechnology**			Course Type: Core Theory

Course Rationale: Design and development of nanostructured materials have gained potential interest due to their intrinsic properties for the last three decades. This course is aimed to give the basic knowledge on the important topics of nanoscience and nanotechnology.

Course Objectives

The objectives of this course are to:

- Acquaint students with the development, classification, and properties of nano-sized materials
- Understand the fundamentals of the different characterization techniques of nanomaterials
- Make the students familiar with the synthesis and properties of nanoparticles, nanorods, nanowires, nanotubes, and nanofibers
- Acquire the concepts of the formation of nanostructured polymers
- Familiarize students with nanolithography techniques and nanomanipulation
- Provide basic knowledge of nano-bio technology

Course Content:

Introduction: History and scope of nanomaterials, Definition of nanomaterials, Nano-size and related properties: Electronic, optical, magnetic and catalytic properties. Classification of nanostructured materials.
Characterization: Characterization of nanomaterials using SEM, TEM, Confocal Microscopy, AFM, DLS, XRD, and XPS techniques.
Nanoparticles: a) Metal nanoparticles: Synthesis, properties and application of nanoparticles b) Metal oxide nanoparticles: Synthesis, properties and applications of copper oxide, iron oxide, aluminium oxide, and titanium oxide nanoparticles.
Nanorods and nanowires: Synthesis, properties and application of gold, silver, zinc oxide, and titanium oxide nanorods and nanowires.
Nanotubes and nanofibers: Classification, synthesis, properties and application.

Nanostructured polymers: Introduction, Macromolecular structural control, Polymer conformational control, Morphology of block copolymers, Nanostructures based on bulk phase separation, Nanostructures based on lyotropic mesophases, Core crosslinked systems, Shell-crosslinked systems, Nanocages, Nanostructures from polymerized surfactant assemblies.
Nanolithography and nanomanipulation: Introduction, Template fabrication, Deposition, Fabrication of nanostructures in the templates e.g., electrodeposition, sol-gel method, and chemical vapor deposition (CVD) method, scanning probe based anodic oxidation as a tool for the fabrication of nanostructures, Oxidation of metallic substrates, Use of scanning probe microscopy in Dip Pen nanolithography, Use of scanning probe microscopy in nanomanipulation.
Nano-bio technology: Introduction, Nanomachines based on biomolecules.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Describe development, classification, and properties of nano-sized materials along with their characterization techniques
CO2. Discuss synthetic procedures and the application of the different types of nanomaterials
CO3. Explain nanolithography techniques, nanomanipulation, and nano-bio technology
CO4. Interpret different synthetic protocols and properties of nanomaterials according to their nature, shape, and size
CO5. Illustrate the concepts of different techniques of nanolithography, nanomanipulation, and nanomachines based on biomolecules

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2		3							
CO2	2		3							
CO3	2		3							
CO4			3							
CO5			3							

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy

CO	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration, Animated Video clips, Open Discussion	Class test (Short Q and MCQ), Quiz
CO2	Lecture, PPT Demonstration, Open Discussion	Class test (Short Q and MCQ), Quiz
CO3	Lecture, PPT Demonstration, Open Discussion	Class test (Short Q and MCQ), Quiz
CO4	Lecture, PPT Demonstration, Open Discussion	Assignment, Final Assessment
CO5	Lecture, PPT Demonstration, Open Discussion	Assignment, Final Assessment

Books Recommended:

1. C. N. R. Rao, A. Muller, and A. K. Cheetham, *The Chemistry of Nanomaterials*, 2004, Wiley-VCH, Weinheim, Germany.
2. B. S. Murty, P. Shankar, B. Raj, B. B. Rath, and J. Murday, *Textbook of Nanoscience and Nanotechnology*, 2013, Universities Press (India) Private Limited, Hyderabad, India.
3. T. Pradeep, *Nano: The Essentials*, 2007, Tata McGraw-Hill Publishing Company Ltd., New Delhi, India.
4. W. C. Sanders, *Basic Principles of Nanotechnology*, 2019, CRC Press Taylor & Francis Group, USA.

Related research articles.

Course No: **SPS 0111 5170**	Credit: 3.0	Year: MS	Semester: 1st
Course Title: **Research methodology for chemistry**		Course Type: Capstone (Core)	

Course Rationale: For research students it is very important to have fundamental concepts of research methodology for chemistry. This course is aimed to gather the detailed knowledge about finding out a research problem and the methods of solving the problems in a systematic way.

Course Objectives
The objectives of this course are to:
- Acquaint students with the meaning of research, objectives and motivation of research, significance and importance of doing research, process of research, and the criteria of a good research
- Make the students familiar with the methods of reviewing literature from different sources
- Acquire the knowledge of formulating research problem and design and planning of a research
- Understand how to collect data and their analysis and interpretation
- Achieve the skill of writing a research report
- Accumulate the knowledge of required computer softwares and chemical safety issues for chemistry research
- Familiarize students with patents and its registration procedure

Course Content:
Introduction: What does research mean? Objectives and motivation of research. Types of research. Research approach and its significance. Difference between research methods and research methodology for chemistry. Scientific method of research. Importance of knowing how research is done. Process of research. Criteria of a good research.
Literature survey: Need for reviewing literature. Introduction to chemical abstracts and Beilstein: subject index, substance index, author index, formula index and other indices with examples. Web resources and E-journals: E-books, Search engines- Google scholar, Chemical industry, ChemSpider, Science Direct, SciFinder, Scopus, ACS, RSC, Wiley online library, etc.
Formulating a research problem: Research problem. The importance of formulating a research problem. Considerations in selecting a research problem. Steps in formulating a research problem. The formulation of research objectives.
Research design and planning: Meaning and necessity. Features of a good design. Important concepts relating to research design. Different research designs. Basic principles of experimental designs. Planning of research.
Data collection and analysis: Collection of data from different experimental and instrumental methods. Analysis and interpretation of collected data toward the solution of formulated research problem.
Report writing: Significance of report writing. Different steps in writing a report. Layout of the research report. Types of reports. Oral presentation. Mechanics of writing a research report. Precautions for writing research reports.
Basic knowledge of computer systems: Softwares and their application. Programming languages. General awareness of software packages and other scientific applications. Application and uses of common softwares in chemistry-Origin, SigmaPlot, ChemSketch, and ChemDraw. Checking plagiarism.
Concepts of chemical safety: Chemical safety and ethical handling of chemicals. Safe working procedure and protective environment. Emergency procedure and first aid. Laboratory ventilation, safe storage and use of hazardous chemicals. Procedure for working with substances that pose hazards, flammable or explosive hazards. Procedures for working with gases at pressures above or below atmosphere. Safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals.
Patents: What is patent? Ethical and moral issues for filing patents. Methods of writing and filing a patent for registration.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Explain the meaning of research, objectives and motivation of research, research approach and its significance, difference between research methods and research methodology for chemistry, scientific method of research, importance of knowing how research is done, criteria of a good research, and literature survey
CO2. Describe the process of designing and planning research after formulating the research problem, the methods of collecting research data and their analysis and interpretation toward writing a research report and the registration of patents
CO3. Discuss the necessity of computer softwares and chemical safety issues for chemistry and allied fields
CO4. Analyze and interpret data and information with the use of the necessary technology, adapt situation for decision making, work individually or with a team, criticize any problem, and produce free, creative and inductive thinking
CO5. Apply the step by step knowledge of research methodology

to solve a chemical research problem

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aliened 1: Weakly Aliened

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			3	1						
CO2				3					1	
CO3					1			3		
CO4			3	2						
CO5				3	1					2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning and Assessment Strategy

COs	Teaching-Learning Strategies	Assessment Strategies
CO1	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Quiz, Assignment
CO2	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Assignment
CO3	Lecture, PPT Demonstration, Group Discussion	Class test (Short Q and MCQ), Assignment
CO4	Lecture, PPT Demonstration, Open and Group Discussion	Seminar, Final Assessment
CO5	Lecture, PPT Demonstration, Open and Group Discussion	Seminar, Final Assessment

Books Recommended:

1. C. R. Kothari, *Research methodology for chemistry-Methods and Techniques*, 2nd Ed., 2004, New Age International (P) Ltd., India
2. A. M. Novikov and D. A. Novikov, *Research methodology for chemistry-From Philosophy of Science to Research Design*, 2013, CRC Press Taylor & Francis Group, USA
3. R. Kumar, *Research methodology for chemistry*-A Step-by-Step Guide for Beginners, 3rd Ed., 2011, Sage Publications Inc., New Delhi, India
4. U. K. B. Dubey and D. P. Kothari, *Research methodology for chemistry-Techniques and Trends*, 2022, CRC Press Taylor & Francis Group, USA
5. A. L. Durham, *Patent Law Essentials-A Concise Guide*, 5th Ed., 2018, ABC-CLIO, LLC, California, USA
6. A. N. Goldstein, *Patent Law for Scientists and Engineers*, 2005, CRC Press Taylor & Francis Group, USA
7. Research articles of different interests

Course No: **SPS 0417 5180**	Credit: 2.0	Year: MS	Semester: First
Course Title: **In Plant Training**		Course Type: Exposer (GEd)	

Course Rationale:
This course is to give practical experiences of the work environment of the chemical industry to the students. The student will gather hands on experience in different chemical industries.

Course Objectives
The objectives of this course are to:
- Expertise students on the real industrial duties
- Prepare them for their future carrier in suitable industry
- Acquiring hands-on experience in industry-specific tasks and processes

Course Content:
Each student will be assigned to take residential training for the duration of one month at Training Institute for Chemical Industries (TICI), Narsingdi

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Students will get in depth knowledge of chemical industry and get the opportunity to apply theoretical knowledge to practical problems
CO2. Connect with industrial authority and may secure jobs for the future
CO3. Build professional connections and relationships with industry professionals
CO4. Expose to potential job opportunities and a better understanding of the job market
CO5. Recognize the current trends and latest technologies

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1							2			1
CO2						3				
CO3						3				
CO4						3	1			
CO5							1			2

Assessment Method:
This intensive residential training will be conducted by the TICI authority, and two teachers of the Department will be assigned as guides. During their straining h/she will follow the chemical process and the related mater in real industry environment in a real pilot plan. The evaluation of the training will be done by the academics of the TICI and a formal mark sheet will be provided by the TICI authority. After the visit, the student will submit a report to the assigned teachers / examination committee give a presentation, that will be evaluated by the teachers / committee and the final score will be made by the combination of it with that of TICI's evaluation report.

Course No: **CHE 0531 5271**	Credit: 2.0	Year: MS	Semester: Second
Course Title: **Seminar and presentation**		Course Type: (Chemistry Core)	

Course Rationale
Now a day audio-visual presentation is a very effective way to present any topic in an easy understandable manner to audiences. This course aims to make the students capable of making a suitable presentation, presenting it satisfactorily before the audience and pleasant management of question-and-answer session.

Course Objectives:
The objectives of this course are to:
- Help the student to choose a topics of presentation
- Train the students to prepare a presentation
- Learn to use the proper audio-visual effect in the presentation
- Acquire skills in professional presentation
- Train the students to address the question and answer session

Course Content:
Students will be assigned a specific topic from his/her own branch, namely physical chemistry, inorganic chemistry, organic chemistry, analytical and environmental chemistry. Student may also be assigned a topic from his/her research work, any topics on recent trends in Chemistry, Modelling and simulation. The student will have to prepare a presentation (approximately to be presented in 10 min) using Poer Point, Chem Draw, graph preparing tools and other softwares, animation, audio-visual effects etc.

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:
CO1. Prepare a presentation on selected or open topics
CO2. Use power point, Chem Draw, MS excel, others tools or softwares for preparing a presentation
CO3. Learn the uses of animation, audio-visual effects to make the presentation lively
CO4. Achieve skills for preparing single (or multi) page poster for presentation
CO5. Pleasantly manage the question and answer session and build professionalism

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2				2					
CO2					3					
CO3			2		2					
CO4			3		1					1
CO5			3							1

Course No: **CHE 0531 5291**	Credit: 2.0	Year: MS	Semester: Second
Course Title: **Comprehensive viva voce**		Course Type: Capstone (Core)	

Course Rationale
Communication skill is now a day is very vital for professionalism. For academic, industrial and research purposes communication of scientific results and view as well as social communication is very important. This course aims to make the students capable of making proper communication, particularly in their subject matters.

Course Objectives:
The objectives of this course are to:
- Assess holistic understanding of key both theoretical, practical topics in Chemistry
  Encourage knowledge synthesis from different sub-disciplines
- Test oral communication and critical thinking of the students
- Prepare the students for future academic, competitive and teaching roles.

Course Content:
The Comprehensive viva voce course will include (but not limited to) all courses (both theoretical and practical) of physical chemistry, inorganic chemistry, organic chemistry, analytical and environmental chemistry offered in MS first and second semesters. Students may also be asked question on research methodology, research topics and any topic of recent trends in Chemistry.

Course Learning Outcomes (COs):
After the successful completion of the course, students will be able to:
CO1. Demonstrate mastery of theoretical and practical concepts in all branches of chemistry
CO2. Explain and defend answers to oral questions with clarity and accuracy
CO3. Apply theoretical, practical knowledge to problem-solving and interrelated chemical context
CO4. Prepare for a professional presentation, instant critical thinking
CO5. Build self-confidence and professionalism
Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

COs	Program Learning Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2				2					
CO2					3					
CO3			2		2					
CO4			3		1					1
CO5			3							1

Teaching- Learning and Assessment Strategies:
There will be no formal face-to-face instruction for the course. Students will learn throughout the semester from the respective related class lecture and discussions with teachers and among themselves. Respective course teachers will provide the topics to each individual student for their presentation before the final presentation. Students will be evaluated and grades will be given on the basis of the marks given by the members of the examination committee individually or combinedly.
Assessment Rubric:

	Excellent (33p)	Proficient (25p)	Satisfactory (20p)	Poor (15p)
Content Of the Presentation	-The facts are clear, understandable -Students discuss the subject in great details -Student describes in detail about their topic -Students indicate what they have learned	-The facts are clear, understandable -Students discuss the subject with some details -Student outlines their topic -Students show what they have learned	-The facts are OK -Student discuss the subject with a few details -Student do not outline their topic –Student's misconceptions are still seen	-The facts were not correct -Students discuss the subject with very minimal details -Students do not outline what they have learnt -Students still sound confused on this topic
Presentation and Delivery	-The presentation was very creative -Good posture -Eye contact with the audience most of the time -Appropriate gesture and expression -Deliverance with confidence	-The presentation was somewhat creative -Good posture -Frequent eye contact with the audience -Appropriate gesture and expression	-The presentation was OK. -Intermittent good posture –Occasional eye contact with the audience –Appropriate gesture and expression	-The presentation was not good. -Poor posture -Seldom eye contact with the audience -Not enough easy during presentation
Answering to the Question making logical Arguments	-Answers All the questions asked properly -Makes logical argument nicely	-Answers Most of the questions asked properly -Makes logical argument	-Answers Some of the questions asked correctly -Makes logical vey weekly	-No Satisfactory Answer for most of the Questions asked -Unable to make logical argument

Course No: **CHE 0531 5310**	Credit: 12.0	Year: MS	Semester: Third
Course Title: **Thesis**		Course Type: Capstone (Core)	

Course Rational:
For the fulfillment of knowledge in chemistry and related subjects, and for getting hands on experience in critical thinking and problem solving, it is very essential to carry out a thesis. This course ensures the students' attainment of different skills like cognitive, effective, communication, collaboration, working in a group, data collection, and manipulation, maintaining ethical matters, etc.

Course Objectives:
The objectives of this course are to:
- Make the students expert in academic research
- Give them in hand opportunity to do their own research with the help of a supervisor
- Make them able to collect the data and analyze them to make a conclusion

- Help them to be skilled in writing an academic research report
- Make them able to communicate the scientific results in written, orally and representatively

Course Learning Outcomes (COs):

After the successful completion of the course, students will be able to:

CO1. Think critically and develop the solution to design a research project utilizing the common lab experiences
CO2. Incorporate knowledge and ideas to plan a good research project
CO3. Communicate the scientific results in written, orally and representatively
CO4. Practice norms and ethics for data manipulation, and scientific and academic research
CO5. Pave the way for lifelong learning

Mapping of Course Learning Outcomes (COs) with POs
3: Strongly aligned 2: Moderately Aligned 1: Weakly Aligned

	Program Learning Outcomes									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1			3							
CO2			3							
CO3					3					
CO4							1		3	
CO5										3

The thesis work can be started from the beginning of MS 1st semester and thesis course registration will be at the beginning of the 3rd Semester.

Dissertation Evaluation

Dissertation of Master's by Mixed Mode program must be evaluated using a prescribed rubric as outlined in Clause B6.4.1. Two examination committees, namely the dissertation evaluation committee (DEC) and the oral examination committee (OEC), will assess the dissertation work. The distribution of marks for both the dissertation evaluation and oral examination is as follows: i) Supervisor: 30% ii) Two (2) Examiners (Dissertation evaluators): 40% (20% + 20%) iii) Oral Examination Committee Members: 30%

Report Evaluation (Marks: Supervisor 30%, Examiners 40%)			
	Excellent	**Good**	**Poor**
Project Title *Title of the needs to match with the objectives and should reflect the activities and expected outcomes.*	Project Title matches very perfectly and reflect the overall activities of the project	Project Title matches with objectives but do not reflect the overall activities of the project	Project Title does not match with the activities of the project
Background *Student should present a brief background on the significance of the project and the current research related to the topic.*	Background and significance of project fully explained	Background or significance given but not explained	No background or significance of project given
Purpose for choosing project *Student should share personal reasons for choosing this project.*	Purpose for choosing project explained	Purpose for choosing project mentioned	No purpose for choosing project given
Hypothesis *Student should state and explain the hypothesis.*	Hypothesis is clearly stated in the correct form, demonstrates a cause and effect relationship, and is testable	Hypothesis stated but not in the correct form	No hypothesis stated
Methodology and Experimental Procedure *Student should summarize the experimental procedure, including pictures.*	Experimental procedures thoroughly described and picture(s) present	Experimental procedures described and picture(s) present	Experimental procedures not described and no pictures presented

Presentation of Results *Student should use data tables to show the results of the experiment.*	Data tables present, properly titled and labeled, and thoroughly explained	Data tables present, properly labeled, and described	Data tables present but not described OR not properly labeled
Discussion and Conclusion *Student should explain whether the results support or refute the hypothesis and explain their conclusions.*	Hypothesis supported or refuted and conclusions demonstrate deep understanding of the project	Hypothesis supported or refuted and conclusions are thoughtful	Surface level conclusions reached but no mention of original hypothesis

Presentation Quality (Marks:30%)			
	Excellent	**Good**	**Poor**
Content of the Presentation	-The facts are clear, understandable -Students discuss the subject in great details -Student describes in detail about their topic -Students indicate what they have learned	-The facts are clear, understandable -Students discuss the subject with some details -Student outlines their topic -Students show what they have learned	-The facts were not correct -Students discuss the subject with very minimal details -Students do not outline what they have learnt -Students still sound confused on this topic
Presentation and Delivery	-The presentation was very creative -Good posture -Eye contact with the audience most of the time -Appropriate gesture and expression -Deliverance with confidence	-The presentation was somewhat creative -Good posture -Frequent eye contact with the audience -Appropriate gesture and expression	-The presentation was not good. -Poor posture -Seldom eye contact with the audience -Not enough easy during presentation
Answering to the Question making logical Arguments	-Answers All the questions asked properly -Makes logical argument nicely	-Answers some of the questions asked properly -Makes logical argument vey weekly	-No Satisfactory Answer for most of the Questions asked -Unable to make logical argument
Professionalism	Presenter is well prepared, speaks loudly and clearly, maintains eye contact with the audience, and avoids all distracting behaviors (i.e. pacing, saying "um" or "ah", etc.)	Presenter is well prepared, speaks loudly and clearly, generally maintains eye contact, and avoids most distracting behaviors (i .e. pacing, saying "um" or "ah", etc.)	Presenter is not organized, does not speak loudly or clearly, avoids eye contact, or exhibits distracting behaviors (i.e. pacing, saying "um" or "ah", etc.)

Master's by Research: A Master's by Research program is primarily centered around the development of a thesis or dissertation, with the possibility of including some taught components. However, it is important to note that any taught components within this program are non-credit bearing, and the students' evaluation is solely based on their thesis or dissertation work. Every candidate is required to submit a progress report to the Graduate Studies Committee (GSC) through the Supervisor at the end of each semester which will be evaluated by an examination committee. The research work is supposed to be conducted at SUST. However, it can be carried out outside SUST, subject to consultation with the Supervisor and approved by the Graduate Studies Committee (GSC).(ordinance C6-7 & C6-8)

Program requirement and duration:

Graduates of the Master's by Research program will receive a degree, Master of Philosophy (MPhil) in Chemistry
Eligibility: i) Graduates with a Bachelor's degree in a relevant Discipline from SUST or any other university or equivalent foreign university, with a minimum CGPA of 3.00, are eligible to apply for the Master's by Research program. **ii)** A candidate holding a Master's by Coursework (General) degree in a relevant Discipline from SUST is eligible for admission to the Master's by Research program, provided s/he has achieved a minimum CGPA of 3.25 in his or her Master's by Coursework program iii) A candidate currently enrolled in a Master's by Coursework program at SUST, who has already completed 18 credits of coursework with a CGPA of 3.25 or higher, is eligible to apply for the conversion from his/her current program to this program.

Duration: Minimum duration for the degree is four (4) semesters, two years.
Credit Requirement: To obtain the Master's degree by Research, a student must complete a minimum of forty-eight (48) credit hours through research.

Master's by Research course structure

Semesters	Courses	Credits
Semester 1	**CHE 600A: Progress of research work**	**10**
Semester 2	**CHE 600B: public seminar (Progress of research works)**	**10**
Semester 3	**CHE 600C: (Progress of research work)**	**12**
Semester 4	**CHE 600D: Final Thesis dissertation**	**16**
Any semester	**Two international conference presentations**	**0**
	Total	**48.0**

Note: (i) The individual course will be considered completed upon scoring at least 60 % marks. (ii)An examination committee will be formed to conduct the course evaluation in each semester.

Description of the courses:
Theory courses: The students will complete non-credit theory courses if admission committee recommended.

CHE 600 A (Progress of research work), 10 credits (5+5): This course will be included the following parts
(i) Research proposal
In consultation with supervisor, a student will prepare a research proposal. In the proposal, idea and plan of the future research must be given related to his/her MPhil work. Evaluation: Students will be evaluated out of 100 (Supervisor: 30, two examiners: 40, oral: 30). The examiners must provide required observations / suggestions /recommendations to improve the quality of the research work.

(ii) Review of articles
The students will prepare one review article report based on contemporarily published articles. Each time, the students will read at least 15 articles (at least 5 articles must not be older than 2 years) and write a review report following a format of review articles published by the standard journals. The mentor of this course will be supervisor/co-supervisor/ any faculty member of the department. Evaluation: reports will be evaluated out of 100 (mentor: 30, Average of two examiners: 70). The report will be accepted if a student can score at least 50% marks.

CHE 600B: Public seminar (Progress of research works), 10 credits
At the end of 2nd semester, the students will submit their progress report of research works to the examination committee. **Evaluation:** Students will be evaluated out of 100 (Supervisor: 30, two examiners: 40, oral: 30).
Seminar-talk on research progress: This constitutes an obligatory element of this program. At the end of the first year, the registered student is mandated to deliver a public seminar talk, organized by the Graduate Studies Committee (GSC), at the respective discipline or institute. The topic of talk must be aligned to the field of research. A protocol for the seminar must be meticulously maintained, encompassing essential details, such as: (i) the total number of GSC members within the Discipline and the percentage in attendance; (ii) the overall number of participants and their categorization (Professors, Associate Professors, Assistant Professors, Lecturers, PhD/Master students, undergraduate students, experts, and guests); (iii) the presentation's topic; date, time, and duration; as well as noteworthy questions and suggestions raised during the event. The seminar presentation should be accessible to all.

CHE 600C: (Progress of research work), 12 credits
The students will submit their progress report of research works to the examination committee. Evaluation: Students will be evaluated out of 100 (Supervisor: 30, two examiners: 40, oral: 30).

CHE 600D: Final Thesis dissertation, 16 credits
At the end of final semester, the student/s will prepare a thesis dissertation and submit to the department for evaluation. The dissertation will contain all the research works including previous works and have to be presented in CHE 600D.
The GSC of the department will follow the University graduate ordinance to construct examiners' panels (both thesis dissertation and oral presentation), and the evaluation will be made accordingly.
Paper-presentation in conferences: The dissemination of the research work within the scholarly community and relevant stakeholders is an imperative facet of this program. The student is required to present his/her research work at a minimum of two international conferences. The evidence of participation and presentation, including conference proceedings and / or abstract books, must be submitted to the GSC and be incorporated into the respective semester progress report.
Dissertation Evaluation: Dissertation of Master's by Research must be evaluated using a prescribed rubric as outlined in Clause B6.6.1. Two examination committees, namely the dissertation evaluation committee and the oral examination committee, will assess the dissertation work. The distribution of marks for both the dissertation evaluation and oral examination is as follows: iv) Supervisor: 30% v) Two (2) Examiners (Dissertation evaluators): 40% (20% + 20%) vi) Oral Examination Committee Members: 30%

Report Evaluation (Marks: Supervisor 30%, Examiners 40%)			
	Excellent	**Good**	**Poor**
Project Title *Title of the needs to match with the objectives and should reflect the activities and expected outcomes.*	Project Title matches very perfectly and reflect the overall activities of the project	Project Title matches with objectives but do not reflect the overall activities of the project	Project Title does not match with the activities of the project
Background *Student should present a brief background on the significance of the project and the current research related to the topic.*	Background and significance of project fully explained	Background or significance given but not explained	No background or significance of project given

Purpose for choosing project *Student should share personal reasons for choosing this project*.	Purpose for choosing project explained	Purpose for choosing project mentioned	No purpose for choosing project given
Hypothesis *Student should state and explain the hypothesis.*	Hypothesis is clearly stated in the correct form, demonstrates a cause and effect relationship, and is testable	Hypothesis stated but not in the correct form	No hypothesis stated
Methodology and Experimental Procedure *Student should summarize the experimental procedure, including pictures.*	Experimental procedures thoroughly described and picture(s) present	Experimental procedures described and picture(s) present	Experimental procedures not described and no pictures presented

Presentation of Results *Student should use data tables to show the results of the experiment.*	Data tables present, properly titled and labeled, and thoroughly explained	Data tables present, properly labeled, and described	Data tables present but not described OR not properly labeled
Discussion and Conclusion *Student should explain whether the results support or refute the hypothesis and explain their conclusions.*	Hypothesis supported or refuted and conclusions demonstrate deep understanding of the project	Hypothesis supported or refuted and conclusions are thoughtful	Surface level conclusions reached but no mention of original hypothesis

Presentation Quality (Marks:30%)			
	Excellent	**Good**	**Poor**
Content of the Presentation	-The facts are clear, understandable -Students discuss the subject in great details -Student describes in detail about their topic -Students indicate what they have learned	-The facts are clear, understandable -Students discuss the subject with some details -Student outlines their topic -Students show what they have learned	-The facts were not correct -Students discuss the subject with very minimal details -Students do not outline what they have learnt -Students still sound confused on this topic

Non-credit bearing theory course:

The GSC of Chemistry Department can recommend **non-credits bearing taught course** from the Bachelor and Masters level of Chemistry Department or relevant discipline. If recommended by the GSC, a PhD student has to registrar the courses with regular students whenever available and must be completed.

Shahjalal University of Science and Technology, Sylhet
Department of Chemistry
Syllabus for Doctoral by Research (Ph. D) Degree
Session 2024-2025

2.0 Admission: Students will apply for admission as per ordinance of the graduate program of the University.

2.1 Doctoral by Research (PhD) course structure

Year	Semester	Course Number (Course Title)	Credits
First	**First Semester**	**CHE 700A (Research Progress)**	**10**
	Second Semester	**CHE 700B (Research Progress)**	**12**
Second	**Third Semester**	**CHE 700C (Research Progress)**	**10**
	Fourth Semester	**CHE 700D (Research Progress)**	**12**
Third	**Fifth Semester**	**CHE 700E (Research Progress)**	**12**
	Sixth Semester	**CHE 700F (Dissertation)**	**16**

Total credits: 10 + 12 +10 + 12+ 12 + 16 = 72

2.2 Course description

2.2.1 CHE 700A (10.0 credits), CHE 700B (12.0 credits), CHE 700C (10.0 credits), CHE 700D (12.0 credits) and CHE 700E (12.0 credits):

A PhD student has to prepare progress report **CHE 700A (10.0 credits), CHE 700B (12.0 credits), CHE 700C (10.0 credits), CHE 700D (12.0 credits) and CHE 700E (12.0 credits)** covering his/her research findings at the end of **First, Second, Third, Fourth, Fifth and Sixth** semester, respectively, and submit to the GSC through supervisor. The student also has to submit documents regarding participation in seminar and published article (if any) along with the progress report. The GSC will evaluate the report and send recommendation to the BAS at the end of each semester.

2.2.2 CHE 700 F (Dissertation) 16.0:

A PhD student has to prepare a complete dissertation in sixth semester. The dissertation will contain new and those findings presented in **progress reports CHE 700A, CHE 700B, CHE 700C, CHE 700D and CHE 700E.** The Dissertation Evaluation Committee (DEC) **(Supervisor as Chairman, one foreign expert, one foreign/home (external to SUST) expert**) and Oral Evaluation Committee (OEC) **(Chairman of the Graduate Studies Committee as Chair (If the PhD candidate is not the chairman of the GSC), Supervisor or Co-supervisor in absence of the Supervisor, one external member from DEC, and one dean nominated GSC member)** will evaluate the dissertation and send recommendation to BAS for the award.

2.3 Non-credit-bearing taught course(s):

The GSC of Chemistry Department can recommend a maximum of 12 credits equivalent course as **non-credits bearing taught course** from the Bachelor and Masters level of Chemistry Department or relevant discipline. If recommended by the GSC, a PhD student has to registrar the courses with regular students whenever available and must be completed.