Outcome-based Curriculum of
Master of Science in Inorganic Chemistry

Chemistry Discipline
Khulna University

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PART-A

01. Title of the Academic Program: Master of Science in Inorganic Chemistry

Program Overview	
Degree	Master of Science in Inorganic Chemistry
Type of Program	Non Professional
Abbreviated form of the Degree	MS in Inorganic Chemistry
Discipline/Program Offering Entity (POE)	Chemistry Discipline
School	Science, Engineering and Technology School
Awarding Institution	Khulna University
Location	Khulna, Bangladesh
Bangladesh National Qualifications Framework (BNQF) Level	9
International Standard Classification of Education (ISCED) Code	0531
Mode of Study	Full Time
Language of Study	English
Applicable Session	2022-23 and onwards

02. Name of the University: Khulna University

03. Vision of the University: Creation of global leaders who will contribute to make knowledge-based just society through accelerating inclusive and transformative growth of Bangladesh and the world. The university aims to achieve this vision through scholarly enquiry and contribution to the global knowledge pool.

04. Mission of the University

No. of Missions	Missions
UM1	To explore human potential to its fullest extent and produce self-motivated, aspiring leaders to work for the betterment of the humankind on wisdom, freethinking, creativity and unhindered intellectual exercises.
UM2	To ensure a transformative educational experience that enables creative learning, entrepreneurship and inquisitiveness among the students.

UM3	To create an inclusive research environment that enables graduates to make demonstrable economic and social impacts through translating knowledge and innovation into practice driven by moral values and professional ethics.

*UM = Mission of the University

05. Name of the Discipline/Program Offering Entity (POE): Chemistry

06. Vision of the Discipline/POE: Chemistry Discipline endeavours to be a nationally-recognized model for educating and graduating students prepared to compete in and contribute to the ever-changing, technology-centred world of the 21st century. Our focus is to achieving excellence and leadership in chemistry-based teaching, fundamental research and innovative applications to ensure industrial and socio-economic development of Bangladesh.

07. Mission of the Discipline/POE

No. of Missions	Missions
M1	To provide students with educational and research experience in a specialized branch in Chemistry
M2	To build talent in innovation, self-learning and career competitiveness
M3	To expertise students on experiment designing, execution, analysis with relevant instrumentation and troubleshooting
M4	To contributes in scientific progress and environmental adaptation for socio-economic enhancement

*M = Mission of the Discipline/POE

08. Objectives of the Discipline/POE

No. of Objectives	Objectives
O1	To offer both basic and advanced chemistry courses, lab experiences, and research activities
O2	To develop students' ability and skill to acquire expertise over solving both theoretical and applied chemistry problems
O3	To enable students to undertake further studies in multidisciplinary areas
O4	To provide an environment that ensures development of students in a holistic manner
O5	To enable the graduates to overcome the national as well as international competitive environment
O6	To enable the graduates for self-employment/entrepreneurship

*O = Objective of the Discipline/POE

09. Name of the Degree: Master of Science in Inorganic Chemistry

10. Description of the Program

The Master of Science Program in Inorganic Chemistry goes in depth into advanced aspects of inorganic chemistry and modern experimental techniques. The specialization is oriented towards fundamental inorganic chemistry, but it also includes the inorganic and chemical

foundations as well as optimum general education needed to take part in the development of new solutions to achieve the sustainable development goals (SDGs). The Master of Science in Inorganic Chemistry program offered by Chemistry Discipline at Khulna University has "Master's by mixed mode." The student must complete at least 50 credits to earn his/her degree, which involves coursework to a minimum of 32 credits along with the research work of 18 credits. The duration of the course will be one and half years of full-time study consisting of three terms each of 14 weeks. The details of the course plan are described in the ongoing sections.

11. Graduate Attributes

No. of Graduate Attributes	Graduate Attributes	Domains
GA1	Demonstration of depth of specialised disciplinary knowledge and skills and be able to apply them in different contexts to solve problems.	Fundamental
GA2	Ability to apply critical and creative thinking to conceive innovative responses.	Fundamental & Thinking
GA3	Achieving professional behaviour and leadership to role the chosen occupations or careers.	Personal
GA4	Dissemination of ideas and innovation to a range of stakeholders for a variety of purposes and contribute in a positive and collaborative manner to achieving common goals.	Social
GA5	Capability of managing behaviour, action, thought, and emotion in ways that self-awareness, emotional intelligence, adaptability, effective communication, and time management are aligned with the requirements.	Personal & Social
GA6	Innovation of new knowledge of chemical synthesis, characterization of compounds, and measurement of chemical reactivity and understanding through research and inquiry.	Fundamental & Thinking

*GA = Graduate Attributes

12. Program Educational Objectives (PEOs)

No. of Program Educational Objectives	Program Educational Objectives	Domain
PEO1	To produce graduates possessing a strong fundamental knowledge of inorganic chemistry	Fundamental
PEO2	To enable graduates contributing to economic and social impacts through knowledge and innovation	Fundamental & Social
PEO3	To apply laboratory techniques to carry out quantitative analysis, chemical synthesis, characterization of compounds, and measurement of chemical reactivity	Fundamental & Personal

PEO4	To construct theoretical bases, operating principles, and experimental uses of scientific instrumentation and software applications, and apply these technologies appropriately to study chemical systems	Personal & Thinking
PEO5	To teach collecting, analysing, and evaluating experimental data	Fundamental, Thinking & Personal
PEO6	To engage students in problem-solving activities that require analysis, synthesis, and evaluation as a means of testing and strengthening their developing knowledge	Fundamental, Social, Thinking & Personal
PEO7	To encourage in searching and evaluating, the primary scientific literature	Social, Thinking & Personal
PEO8	To make the students able to organize, evaluate, summarize, and communicate experimental data and scientific concepts in both written and oral formats	Fundamental, Social & Personal

*PEO = Program Educational Objective

13. Program Learning Outcomes (PLOs)

After successful completion of the degree, the learner will be able to:

A. Fundamental Skills	
PLO1	Demonstrate fundamental and advanced skills in inorganic chemistry and other associated branches
PLO2	Apply advanced knowledge and skill to solve chemistry problems in different perspective
PLO3	Have firm foundations in the fundamentals and application of current chemical theories to measure as well as quantify chemical compounds
PLO4	Gain knowledge to design and carry out advanced chemical techniques
B. Social Skills	
PLO5	Work with different people in learning and working community and other groups and networks
PLO6	Disseminate research outcomes in various social platforms
PLO7	Communicate efficiently both in verbal and written form in their work place
C. Thinking Skills	
PLO8	Conceptualize theoretical bases and principles in real life
PLO9	Criticize and evaluate various scientific literatures
D. Personal Skills	
PLO10	Implement scientific instruments and software applications in various chemical analysis

PLO11	Evaluate and explain experimental data
PLO12	demonstrate self-advancement through continuous academic and/or professional development

*PLO = Program Learning Outcome

14. Mapping Mission of the University with PEOs

PEOs \ Missions	UM1	UM2	UM3
PEO1	2	2	3
PEO2	3	3	2
PEO3	2	3	2
PEO4	2	2	2
PEO5	2	2	3
PEO6	2	3	2
PEO7	3	2	2
PEO8	2	3	3

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

15. Mapping PLOs with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)							
		PEO1	PEO2	PEO3	PEO4	PEO5	PEO6	PEO7	PEO8
A. Fundamental Domain	PLO1	●				●	●		
	PLO2	●		●					●
	PLO3	●				●	●		
	PLO4	●	●				●		
B. Social Domain	PLO5		●				●		●
	PLO6		●					●	●
	PLO7		●					●	
C. Thinking Domain	PLO8				●		●	●	
	PLO9				●	●			

D. Personal Domain	PLO10			●	●				●
	PLO11			●		●		●	
	PLO12			●			●	●	

16. Mapping of Courses with PLOs

Course Code and Course Title	Fundamental Domain				Social Domain			Thinking Domain		Personal Domain		
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
First Year First Term												
0531 18 Chem 5101 (Spectroscopic Techniques and Applications)	●	●	●	●				●	●	●		
0531 18 Chem 5103 Macromolecular Chemistry	●	●	●	●					●		●	●
0531 18 Chem 5111 Chemical Analysis and Instrumental Techniques	●		●	●				●	●	●		
0531 18 Chem 5113 Reaction Mechanism and Properties of Coordination Compounds	●	●	●	●				●	●	●	●	
0531 18 Chem 5115 Inorganic Polymers	●		●	●		●		●		●	●	
0531 18 Chem 5117 Nanomaterials	●	●	●	●		●		●	●		●	
0531 18 Chem 5119 Chemistry of Pollution	●		●	●	●	●	●	●	●			
0531 18 Chem 5123 Chemical Kinetics and Reaction Dynamics	●	●	●	●				●	●		●	
First Year Second Term												
0531 18 Chem 5200 Dissertation Part-I-M: Research Design and Proposal Submission	●	●	●	●	●	●	●	●	●	●	●	●
0531 18 Chem 5211 Advanced Concept of Chemical Bonding	●	●			●				●			●
0531 18 Chem 5240 Communication Skill Sessional					●	●	●					●
0531 18 Chem 5242 In-plant Training/ Industrial Tour and Field Visit	●	●			●		●	●		●		●
0711 18 ChE 5251 Chemical Weapons Convention and Basics of Chemical Hazard and Safety	●	●			●							●
0533 18 Phy 5253 Sustainable Energy	●			●				●	●			●
0521 18 ES 5255 Industrial Hazards and Waste Management	●	●	●	●				●		●		
0413 18 HRM 5257 Career Planning and Development					●		●	●	●			●
Second Year First Term												
0531 18 Chem 6100 Dissertation Part-II-M: Research Outcome and Final Defense	●	●	●	●	●	●	●	●	●	●	●	●

PART-B

17. Structure of the Curriculum

a) Duration of the Program	1.5 Year	3 terms
b) Admission Requirements	Candidates seeking admission into a Master's program must possess a three/four/five-year Bachelor degree from a recognized university (home and abroad)with 16 years schooling (or 15 years schooling with 2 years job experience for candidates having three-year Bachelor degree) and a minimum CGPA-2.5/2nd class/2nd division	
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program	50 credits	
c2) Available Credits	70 credits	
d) Total Class Weeks in a Term*	14	
e) Minimum CGPA Requirements for Graduation	2.50	
f) Maximum Academic Years of Completion	3 Years	

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

17.1. Area-wise Credit Distribution

Master in Inorganic Chemistry				
Area	Course Type	Number of Courses	Credits	Total Credits
General Education (GEd) (Core)	Theory	1	1	13**
	Sessional	0	0	
General Education (GEd) (Optional)	Theory	3	12	
	Sessional	0	0	
Core/Compulsory Courses	Theory	5	20	23
	Sessional	2	3	
Optional/Elective Courses	Theory	4	16	16
	Sessional	0	0	
Capstone Courses***	Dissertation	2	18	18
Total		17	70	70
**Credits from GEd Courses (18.57 % of Total Credits)				

*** Thesis, project, internship etc. courses

17.2. Category of Courses

Master in Inorganic Chemistry by Mixed-mode			
Area	Course Type	Course Title	Credits
General Education (GEd) Courses	Theory	1. Chemical Weapons Convention and Basics of Chemical Hazard and Safety 2. Career Planning and Development 3. Sustainable Energy 4. Industrial Hazards and Waste Management	13
	Sessional	-	0
Core/ Compulsory Courses	Theory	1. Chemical Analysis and Instrumental Techniques. 2. Reaction Mechanism and Properties of Coordination Compounds 3. Inorganic Polymers 4. Advanced Concept of Chemical Bonding 5. Nanomaterials	20
	Sessional	1. In-plant Training/ Industrial Tour and Field Visit 2. Communication Skill Sessional	3
Optional/ Elective Courses	Theory	1. Spectroscopic Techniques and applications 2. Macromolecular Chemistry 3. Chemical Kinetics and Reaction Dynamics 4. Chemistry of Pollution	16
	Sessional	-	
Capstone Courses	Sessional	1. Dissertation Part-I-M: Research Design and Proposal Submission 2. Dissertation Part-II-M: Research Outcome and Final Defense	18
Total			70

18. Year/Term-wise Distribution of Courses

Master in Inorganic Chemistry

First Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 5101	Spectroscopic Techniques and Applications	Optional	4.0	-	4.0	None
0531 18 Chem 5103	Macromolecular Chemistry	Optional	4.0	-	4.0	None
0531 18 Chem 5111	Chemical Analysis and Instrumental Techniques	Core	4.0	-	4.0	None
0531 18 Chem 5113	Reaction Mechanism and Properties of Coordination Compounds	Core	4.0	-	4.0	None
0531 18 Chem 5115	Inorganic Polymers	Core	4.0	-	4.0	None
0531 18 Chem 5117	Nanomaterials	Core	4.0	-	4.0	None
0531 18 Chem 5119	Chemistry of Pollution	Optional	4.0	-	4.0	None
0531 18 Chem 5123	Chemical Kinetics and Reaction Dynamics	Optional	4.0		4.0	None
Total	Core courses: 04, Optional courses: 04, Theory courses: 08, Sessional courses: 00		32.0	-	32.0	-
			32.0			
First Year Second Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 5200	Dissertation Part-I-M: Research Design and Proposal Submission	Core	-	4.5	3.0	None
0531 18 Chem 5211	Advanced Concept of Chemical Bonding	Core	4.0	-	4.0	None
0531 18 Chem 5240	Communication Skill Sessional	Core	-	1.5	1.0	None
0531 18 Chem 5242	In-plant Training/ Industrial Tour and Field Visit	Core	-	4.0	2.0	None
0711 18 ChE 5251	Chemical Weapons Convention and Basics of Chemical Hazard and Safety	Core	1.0	-	1.0	None
0533 18 Phy 5253	Sustainable Energy	Optional*	4.0	-	4.0	None
0521 18 ES 5255	Industrial Hazards and Waste Management	Optional*	4.0	-	4.0	None
0413 18 HRM 5257	Career Planning and Development	Optional*	4.0	-	4.0	None

Total	Core courses: 05, Optional Course: 03, Theory courses: 05, Sessional: 03	17.0	10.0	23.0	…
		27			

*Students have to achieve minimum 5.0 credits from GEd courses with Chemical Weapons Convention and Basics of Chemical Hazard and Safety

Second Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0531 18 Chem 6100	Dissertation Part-II-M: Research Outcome and Final Defense	Core	-	30.0	15.0	None
Total	Core Course: 01, Optional courses: 00, Theory course: 00, Sessional course: 01		-	30.0	15.0	…

PART-C

19. Course Description:

Course Code: 0531 18 Chem 5101	**First Year**	**First Term**
Course Title: Spectroscopic Techniques and Applications		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge of different spectroscopic techniques, which will be useful in various chemical analysis	
Course Objectives:	• To provide knowledge about different spectroscopic techniques used in chemistry • To provide knowledge in reaction monitoring by spectroscopic methods • To make skilled to determine an unknown structure using spectroscopic techniques	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	signify the UV-Visible, IR and Raman spectra	1, 2
	CLO 2	realize the importance of fingerprint region in IR	1, 2
	CLO 3	get idea about group frequencies	1
	CLO 4	use IR in qualitative and quantitative purpose	3, 4
	CLO 5	criticize between IR and Raman spectroscopy	9
	CLO 6	learn about resonance and mass spectroscopy	3, 4
	CLO 7	understand deeply about ^{13}C-NMR, ^{19}F-NMR and heteronuclear coupling	3, 4
	CLO 8	know different terms associated with mass spectroscopy	1
	CLO 9	characterize a compound by NMR, mass and DEPT	3, 8, 10
	CLO 10	imply the spectroscopic knowledge in unknown structure elucidation	8, 10

Course Contents		CLOs
Section A		
1	**UV-Visible Spectroscopy**: The basics, hyperchromic and hypochromic effect, bathochromic and hypso chromic effect, metal-metal transitions, crystal field splitting, crystal field splitting in 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, UV-Vis analysis of wastewater, qualitative and quantitative use, clinical, industrial, forensic application.	1,8,10
2	**FT-IR Spectroscopy:** The basics, modes of vibration, influencing factors of force constant, overtone, combination and difference bands in IR spectroscopy, different effects on IR frequency, infrared experiments– group frequencies, fingerprints, approach towards the analysis of an IR spectra, structural study of simple and complex organic compounds, qualitative and quantitative uses.	1, 2, 3, 4, 5
3	**Raman Spectroscopy:** The basics, instrumentation, difference between IR and Raman spectra, stokes and anti-stokes lines**,** polarization of Raman **lines,** depolarization measurements, hyper raman effect**,** complementary nature of Raman and IR spectroscopy**,** applications of Raman spectroscopy.	5,8,10
Section B		
5	**Resonance Spectroscopy:** NMR basics, instrumentation, ^{1}H-NMR, magnetic vs. chemical equivalence, non-equivalence within a group, ^{13}C-NMR: correlation chart, calculation of chemical shift, proton-coupled and decoupled ^{13}C spectra, origin of NOE, off-resonance decoupling, DEPT, sample ^{13}C-NMR spectra, heteronuclear coupling of ^{13}C, ^{19}F-NMR spectra, spin dilute system, non-spin ½ system, magic angle NMR, relaxation process, NQR, ESR, problem solving.	6,7,9
6	**Mass Spectrometry:** The basics, instrumentation, ionization methods, mass analyzers, interpretation of mass spectra– accurate mass measurements, isotopic pattern, structural analysis and fragmentation patterns	6,8,10
7	**Combined Problem Solving:** Determination of molecular structures of inorganic and organic compounds on the basis of above spectroscopic methods.	10

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam

CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam
CLO6	Lecture and Group Discussion	Quiz and Class Test
CLO7	Lecture and Group Discussion	Quiz and Class Test
CLO8	Lecture and Team Teaching	Quiz and Class Test
CLO9	Problem-based Learning and Presentation	Assignment and Final Exam
CLO10	Problem-based Learning and Presentation	Assignment and Final Exam

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

Course Code: 0531 18 Chem 5103			**First Year**	**First Term**
Course Title: Macromolecular Chemistry				
Course status: Optional				
Credit: 04				
Prerequisite(s): None				
Rationale:	The course is designed to let the students understand about the macromolecules and their applications in our daily life			
Course Objectives:	• To knowledge about macromolecule • Understand characteristics and properties of polymer • Know the practical uses of polymer			
Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)				
Course Learning Outcomes (CLOs):	Upon completion of this course, the students will be able to:			Mapping with PLO
	CLO 1	give a strong thought on the subject of different types of macromolecules		1, 9, 12

	CLO 2	make clear understanding about various properties of polymer and their reactions	1
	CLO 3	analyze different types polymer	11, 3, 4
	CLO 4	estimate the practical uses of polymer	2

Course Content		CLOs
Section-A		
1	**Macromolecules:** Polymer, monomer, oligomer, repeating units, raw materials for polymers, concept of functionality, configuration and conformation of polymers, coil formation, crystallinity of Polymers, biological and industrial importance of polymers, end group analysis, polymer solutions: thermodynamics of polymer dissolution, size and shape of macromolecules in solution	1
2	**Polymer Reactions and Mechanism:** Hydrolysis, acidolysis, aminolysis, hydrogenation, addition and substitution reaction, cyclization reaction, crosslinking reaction, types of polymerization reaction: chain polymerizations (free radical, ionic and coordination), step polymerizations (poly-condensation, poly-addition, Ziegler/Natta and ring-opening), mechanism of each polymerization, chain length and degree of polymerization, initiation and initiator efficiency in free radical polymerization, gel effect, inhibition and retardation	2
3	**Controlled Polymerization Methods:** Nitroxide mediated polymerization (NMD), atom transfer radical polymerization (ATRP), group transfer polymerization (GTP), reversible addition fragmentation termination (RAFT).	2
4	**Kinetics of Polymerization:** Kinetics of chain polymerizations (free radical, ionic and coordination), step polymerizations (poly-condensation, poly-addition and ring-opening). Kinetics of free radical copolymerization	2
Section-B		
5	**Polymer Colloids:** Latex, chemistry of polymer colloid formation, brief introduction on emulsion and dispersion polymerizations, general idea on solution, bulk and suspension polymerizations. Colloidal stability, applications of polymer colloids in paper, adhesives, coating and other industries	3
6	**Polymer Characterization and Testing:** Molecular weight determination: End group analysis, Membrane Osmometry, viscometry, and gel permeation chromatography; Spectroscopic techniques: UV-visible spectroscopy, FT-IR spectroscopy, NMR of polymers in the solid state, pyrolysis GC-MS; X-ray diffraction, Transmission electron microscopy, scanning electron microscopy, thermal analysis (TGA, DTA, DSC), Electrical and optical properties	3
7	**Monomers and Related Petrochemicals:** Petrochemicals, classification of petrochemicals, distillation products from petroleum, reactions of alkanes, alkenes and aromatics, solvents and specific applications, synthesis of butadienes, acrylonitrile, acrylic acid, styrene, glycerin, surfactants etc.	4

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Group Discussion	Quiz and Class Test
CLO2	Lecture, Problem-based Learning and Power Point Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Brain storming and Final Exam
CLO4	Problem-based Learning and Power Point Presentation	Quiz and Class Test

Learning Materials	
Recommended Readings	1. Odian, G. Principles of polymerization, 4th edition, John Wiley & Sons, UK, 2004. 2. Stevens, M.P. Polymer Chemistry: An Introduction, 3rd edition, Oxford University Press, New York, 1999. 3. Flory, P.J. Principles of Polymer Chemistry, 1st edition, Cornell University Press, UK, 1953. 4. Allcock, H.R. Lampe, F.W. Mark, J.E. Contemporary Polymer Chemistry, 3rd edition, Prentice-Hall, 2003.
Supplementary Readings	1. Alka L. Gupta. *Polymer Chemistry*, 5th edition, Pragani Publisher, 2005. 2. Billmeyer, F.W. Textbook of Polymer Science, 3rd edition, WileyInterscience, 1984. 3. Fried, J.R. Polymer Science and Technology, 2nd edition, PrenticeHall, 2003. 4. Sperling, L.H. Introduction to Physical Polymer Science, 4th edition, John Wiley & Sons, 2005.

Course Code: 0531 18 Chem 5111	**First Year**	**First Term**
Course Title: Chemical Analysis and Instrumental Techniques		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	**Learning different techniques of analysis through various instruments is the basis of this course.**	
Course Objectives:	• To understand about different separation techniques • To provide knowledge of separation mechanism by different chromatographic instrumentation.	

	• To learn about surface characterization techniques • To make skilled to use thermo-analytical instruments To know details about the absorption and emission spectroscopy

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	conceptualize fundamentals of separation techniques in chemistry	3, 4
	CLO 2	explain the basic principles and applications of surface analytical technique	3, 4, 8
	CLO 3	illustrate the importance and use of different types of instruments	4, 8, 9, 10
	CLO 4	investigate thermal properties of a compound	3, 4
	CLO 5	distinguish between fluorescence and phosphorescence	1
	CLO 6	criticize between different techniques	9
	CLO 7	imply the spectroscopic knowledge to study various compounds	3, 4, 8, 10

Course Contents		**CLOs**
Section A		
1	**Separation Techniques:** Introduction, principles of chromatographic separation, classification of chromatographic methods, elution in column chromatography, migration rates of solute, band broadening and column efficiency, variables that affect column efficiency, column resolution, application of chromatography.	1,2
2	**Gas Chromatography:** Introduction, instruments for GLC: carrier gas system, sample injection system, column configuration and column oven, detection systems, gc/mass instrument, gas chromatography column and stationary phases, gas solid chromatography, applications of GLC, GC-mass: introduction, principle, resolution, ionization sources, mass analyzers.	1,2,3
3	**High Performance Liquid Chromatography (HPLC):** Introduction, principles, instrumentation: mobile phase reservoirs and solvent treatment systems, pumping systems, sample injection, columns for HPLC, detectors; high-performance partition chromatography: bonded-phase packing, normal and reverse phase packing, choice of mobile and stationary phases; applications; high-performance adsorption chromatography: stationary and mobile phases, application; comparison of HPLC and GC.	1,2,3

4	**Thermal Analysis:** Thermogravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC)	4
Section B		
5	**Surface Analytical Techniques:** Auger electron spectroscopy (AES), x-ray photoelectron spectroscopy (XPS), Ultraviolet photoelectron spectroscopy (UPS), Low energy electron diffraction (LEED), metastable atom electron spectroscopy (MAES), near edge x-ray absorption fine structure analysis (NEXAFS).	2,7
6	**Surface Imaging and Depth Profiling:** Scanning electron microscopy (SEM), transmission electron microscopy (TEM), depth profiling with laser microscope, scanning tunneling microscopy (STM), atomic force microscope (AFM).	2,7
7	**Bulk Analytical Technique:** Atomic absorption spectroscopy (AAS)**,** Inductively coupled plasma atomic emission spectroscopy **(**ICP-AES), Inductively coupled plasma mass spectrometry (ICP-MS), flame emission spectroscopy (FES), total organic carbon analysis (TOC)	3
8	**Photoluminescence Spectroscopy:** Theory of fluorescence and phosphorescence, relaxation by fluorescence and phosphorescence, fluorescent species: fluorescence and structure, effect of structural rigidity, temperature, solvent and concentration; excitation vs. emission spectra, instrumentation, and application.	5,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam
CLO6	Lecture and Group Discussion	Quiz and Class Test
CLO7	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Usharani, S. Analytical Chemistry: Techniques & Instrumentation, Trinity Press, India, 2019.

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

Course Code: 0531 18 Chem 5113	**First Year**	**First Term**
Course Title: Reaction Mechanism and Properties of Coordination Compounds		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is designed for obtaining deep knowledge with vast subfield of chemistry dealing with coordination compounds	
Course Objectives:	• Acquire knowledge on coordination compound, isomers of complexes. • To apply the knowledge of different reaction mechanism of coordination complexes and properties.	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	categorize coordination compounds and their isomers	1
	CLO 2	explain the stability of d-metal complexes, their reactivity, and the mechanisms of ligand substitution reactions and oxidation-reduction reactions	1, 2, 8, 11

	CLO 3	specify the stabilities of coordination compounds	1, 2
	CLO 4	clarify the spectroscopic properties of coordination compounds	3, 4, 9, 10
	CLO 5	illustrate the optical and magnetic properties of coordination compounds	1, 2

Course Contents		**CLOs**
Section A		
1	**Coordination Compounds:** Fundamental concepts about coordination compounds, nomenclature, low and high coordination number complexes, ligand classification, chelate effect and isomerism of complexes.	1
2	**Reactions and Mechanism of Complexes:** i. History and principles ii. Substitution reactions: Inert and labile compounds, mechanism of substitution. iii. Kinetic consequences of reaction pathways: Dissociation, interchange and association. iv. Experimental evidence in octahedral substitution: Dissociation, linear free energy relationships, associative mechanisms, the conjugate base mechanism, the kinetic chelate effect. v. Stereochemistry of reactions: Substitution in trans complexes, substitution in *cis* complexes, isomerization of chelate rings. vi. Substitution reactions of square planar complexes: kinetics and stereochemistry of square planar substitutions, evidence for associative reactions. vii. The trans effect: Explanation of the trans effect (sigma and pi bond effect). viii. Low spin and high spin complexes. ix. Oxidation-reduction reactions: Inner and outer sphere reactions, condition for low and high oxidation number. x. Reaction of coordinated ligands: Hydrolysis of esters, amides and peptides, template reactions, electrophilic substitutions.	2
Section B		
3	**Stability of Complexes in Aqueous Solution:** Classes of stability, relationship between thermodynamic and kinetic stability, labile and inert octahedral complexes according to VBT and CFT, factors affecting the lability of a complexes, factors affecting the stability of complexes- properties of central metal atom and ligands, experimental determination of stability constant and composition of a complex.	3

4	**Electronic Spectra of Coordination Compounds:** Absorption of light, Beer-Lambert absorption law, quantum numbers of multielectron atoms, spin orbit coupling, electronic spectra of coordination compounds, term symbols, selection rules, Tanabe-sugano diagram, applications of Tanabe-sugano diagrams, charge transfer spectra.	4
5	**Optical and Magnetic Properties of Complexes:** Fundamental concepts of various types of magnetism of complexes, magnetic susceptibility and effective magnetic moment, explanation of spectral and magnetic properties in terms of CFT concepts, colors of transition metal complexes with explanation, Color depends on oxidation State and ligand field.	5

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Malik, W.U. Tuli, G.D. Madan, R.D. Selected Topics in Inorganic Chemistry, S. Chand and Company Ltd, India, 1993. 2. Raj, G. Advanced Inorganic Chemistry, Volume-1, GOEL Publishing House, India. 3. Purcell, K.F. Kotz, J.C. Inorganic Chemistry, Cengage, 1980.
Supplementary Readings	1. Cotton, F.A. Wilkinson, G. Murillo, C.A. Bochmann, M. Advanced Inorganic Chemistry, 6th Edition, Wiley, 2007. 2. Huheey, J.E. Keiter, E.A. Inorganic Chemistry Principles of Structure and Reactivity", 16th Edition, Pearson Noida, 2013.

Course Code: 0531 18 Chem 5115	**First Year**	**First Term**
Course Title: Inorganic Polymers		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		

Rationale	Preparation, characterization and application of different kinds of inorganic polymers
Course Objectives:	• To provide students with broad and balanced foundation on inorganic polymer and macromolecules • The course is designed to apply the acquired knowledge of structure and function as well as external and internal applications of inorganic polymers and macromolecules in their practical life

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	Conceptualize fundamentals of inorganic polymer, their types, properties, structure and bonding	1
	CLO 2	Recognize and synthesize some inorganic polymer namely borazines, polyphosphazenes, polysilanes, polysiloxanes and flurocarbones	3, 4, 10
	CLO 3	Relate the applications of inorganic polymers in technology and practical life.	8
	CLO 4	Discuss about macromolecules, their types and importance	1, 6
	CLO 5	Describe the structure and function of hemovanadins, hemocyanins, ceruplasmin, chlorophyll, vitamin B_{12} and coenzyme B_{12}, carboxypeptidase and carbonic anhydrase	1, 6, 11

Course Contents		**CLOs**
	Section A	
1	**General Idea on Inorganic Polymer:** Introduction-inorganic polymer, types, properties, structure, bonding in polymers, lattice defects in polymers, importance of polymers	1
2	**Characterization of Inorganic Polymer:** Molecular weights, molecular weight distributions, other structural features, chain statistics, solubility considerations, crystallinity, mechanical properties	2
3	**Study on Some Typical Inorganic Polymeric Systems:** I. Borazines II. Polyphosphazenes III. Polysilanes IV. Polysiloxanes V. Flurocarbones	3

Section B		
5	**Macromolecules:** The chelate and macrocyclic system, types of macromolecule, macrocyclic ligands and conjugated system-Schiff base, importance of macromolecules	4
6	**Structure and Function of-** I. Hemovanadins II. Hemocyanins and Ceruloplasmin III. Chlorophyll IV. Vitamin B_{12} and Coenzyme B_{12} V. Carboxypeptidase and Carbonic anhydrase	5

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. James, E.M. Harry, R.A. and West, R. Inorganic Polymers, Oxford University Press, 2005. 2. Northolt, M.G. Decker, P. and Picken, S.J. Polymeric and Inorganic Fibre, 1st edition, Springer-Verlag Berlin Heidelberg, 2005.
Supplementary Readings	1. George, O. Principles of polymerization, John Wiley & Sons, Inc., Hoboken, New Jersey, 2015. 2. Odian, G. Principles of polymerization, 4th edition, John Wiley & Sons, UK, 2004.

Course Code:0531 18 Chem 5117	**First Year**	**First Term**
Course Title: Nanomaterials		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		

Rationale	**P**reparation, characterization and application of nanomaterials
Course Objectives:	• Conceptualize nanomaterials • Compare different methods for synthesis of nanomaterials • Acquire knowledge on their characterization and applications

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	conceptualize fundamentals of nanomaterials	1
	CLO 2	compare and design the synthetic routes of nanomaterials	2, 3, 11
	CLO 3	explain nanolithography and their applications	8
	CLO 4	discuss different techniques for characterizing nanomaterials	3, 4
	CLO 5	illustrate the properties of special nanomaterials	6, 9
	CLO 6	discuss the nanostructure of polymers	9
	CLO 7	application of nanomaterials in real life	6

Course Contents		**CLOs**
Section A		
1	**Basic Idea about Nanochemistry:** Concepts of nanoscale, nanoscience, nanotechnology and nanochemistry. Nanomaterials: classification of nanomaterials, natural nanomaterials. properties of nanomaterials: mechanical properties, thermal properties, electrical properties, optical properties, chemical properties, magnetic properties	1
2	**Approaches of Synthesis:** Vapor phase synthesis: gas vapor deposition, plasma-based synthesis, molecular beam epitaxy, inert gas condensation, flame pyrolysis, liquid phase synthesis: colloidal methods, solution precipitation, electrodeposition. sol-gel technique: sol-gel coating process, hydrothermal methods, template synthesis: hard template and soft template	2
3	**Nanolithography:** Basic steps, advantages and disadvantages of conventional lithography, photolithography, scanning lithography, electron beam lithography, x-ray lithography, dip pen nanolithography	3
4	**Characterization of Nanomaterials:** X-ray diffraction (XRD), small angle X-ray scattering (SAXS), electron microscopy: transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), scanning probe microscope (SPM): scanning tunneling microscope (STM), atomic force microscope (AFM), surface Analysis methods: auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), secondary ion mass spectroscopy (SIMS)	4

Section B		
5	**Special Nanomaterials:** Carbon fullerenes, fullerene-derived crystals, carbon nanotubes, graphen, silicon nanomaterials, micro and mesoporous materials-ordered and random mesoporous structures; crystalline microporous materials (zeolites), core-shell structures, metal-oxide structures, metal-polymer structures; oxide-polymer structures, organic/inorganic hybrids: class-i hybrids, class-ii hybrids, intercalation compounds, nanocomposites and nanograined materials	5
6	**Nanostructure Polymer:** Introduction, macromolecular structural control, polymer conformational control, morphology of block copolymers, nanostructures based on bulk phase separation, nanostructures based on lyotropicmesophases, core-crossliked systems, shell-crosslinked systems, nanoages, nanostructures from polymerized surfactant assemblies	6
7	**Applications of Nanomaterials:** Medicine: diagnosis, biosensor, imaging, therapy, regenerative medicine, environment: remediation and migration, pollution prevention, environment sensing, food packaging and monitoring, energy: solar energy, thermoelectricity, rechargeable batteries	7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Callister, W.D. Rethwisch, D.G. Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th edition, John Wiley & Sons, UK, 2012. 2. Askeland, D.R. Wright, W.J. Essentials of Materials Science and Engineering, 4th edition, Cengage Learning, USA, 2018. 3. Klabunde, K.J. Sergeev, G.B. Nanochemistry, 2nd edition, Elsevier Science, UK, 2013
Supplementary Readings	1. Poole J.R. Charles, P.O. Frank, J. Introduction to Nanotechnology, John Wiley and Sons, 2003.

	2. Rao, C.N.R. Muller, A. Cheetham, A.K. The Chemistry of Nanomaterials: Synthesis, Properties, Wiley VCH, 2004. 3. Rosoff, M. Nano-Surface Chemistry, CRC Press, 2019.

Course Code: 0531 18 Chem 5119	**First Year**	**First Term**
Course Title: Chemistry of Pollution		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	This course is to give students abroad view in different types of pollution and their management system.	
Course Objectives:	• To provide students with an extensive and balanced idea about different types of pollution • To study organic, inorganic and biological pollutants, their sources • To investigate the causes, effects, prevention and treatment process for sustainable environment	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	correlate the environment and ecological cycle	1
	CLO 2	understand the entrance of toxic elements and chemicals in the ecosystem	1, 4
	CLO 3	explain the sources and biochemical effects of heavy metals, organic and inorganic pollutants	8, 9
	CLO 4	elaborate the causes and associated health effects of thermal pollution	1, 8, 9
	CLO 5	discuss about the types of waste and waste disposal methods	1, 4,
	CLO 6	identify hazardous solid waste and their treatment options	3, 4
	CLO 7	explain the possible hazards, and causes of radioactive elements	1, 8
	CLO 8	measure noise level and health implications	4, 8
	CLO 9	find the possible solution for various environmental problems	5, 6, 7, 9

Course Contents	**CLOs**
Section A	

1	**Ecology and Environmental Pollution:** Ecosystem, types and components of ecosystem, biogeochemical cycles, scope of ecology, oxygen cycle, nitrogen cycle, hydrological cycle, carbon cycle, sulphur cycle, phosphorus cycle, origin of pollution, pollutants, classification of pollutants, types of pollution and their effects.	1
2	**Heavy Metal Pollution and Control:** Trace and heavy metals, pollution sources, biochemical and toxicological effects of arsenic, lead, mercury, cadmium, chromium, nickel, selenium and radon, control and treatment of heavy metal pollution, assessment of carcinogenic and non-carcinogenic health risk.	2, 3
3	**Organic, Inorganic and Biological Pollutants:** Hydrocarbons, pesticides and biodegradability, fertilizers, sediments, synthetic detergents and biodegradability, pathogens, accumulation of DDT in food chain, future strategy for pesticide use, effect of pollutants on ecosystem.	2, 3
4	**Thermal Pollution:** Definition, sources, thermal effects on human, marine life and bacteria, factors responsible for the thermal damage, control and measurement, ash-less coal, gasification of coal.	4, 9
Section B		
5	**Solid Waste and Management:** Introduction, sources and characteristics of different types of solid waste, materials flow in the society, objectives and methods of solid waste management, biomedical waste, recycling techniques.	5, 6
6	**Industrial Pollution and Treatment Options:** Nature and classification of industrial effluents, objectives of industrial effluent analysis, treatment option for textile, pulp and paper, cement, sugar, distillery and polymer industries, enhancing sustainable industrial development.	5, 6
7	**Radioactive Pollution:** Introduction, sources of radioactive pollution, the risks and benefits of radiation, general and biological effects of radioactive pollution, effect of X-rays, danger from nuclear power plants and nuclear reactors, protection and control from radiation.	7, 9
8	**Noise Pollution:** Definition, sources of noise pollution, noise level, measuring noise level, types of noise, equipment used for noise measurement, effects and control of noise pollution.	8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test

CLO5	Problem-based Learning and Presentation	Assignment and Final Exam
CLO6	Lecture and Group Discussion	Quiz and Class Test
CLO7	Lecture and Group Discussion	Quiz and Class Test
CLO8	Lecture and Team Teaching	Quiz and Class Test
CLO9	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Srivastava, M.M. Chemistry of Environment, 1st edition, Narosa Publishing House, New Delhi, 2005. 2. Manahan, S.E. Environmental Chemistry, 9th edition, CRC Press, Taylor & Francis group, New York, 2010. 3. Verma, R.M. Analytical Chemistry: Theory and Practice, 3rd edtion, CBS Publishers and Distributors, New Delhi, 2000. 4. De, A.K. Environmental Chemistry, 7th edition, New Age International (P) Ltd, New Delhi, 2010. 5. Kaur, H. Environmental Chemistry, 7th Edition, Progati Prakashan, New Delhi, 2012.
Supplementary Readings	3. Cunningham, W.P. Environmental Science: A Global Concern, 1st edition, McGraw-Hill, New York, 1990. 4. Dara, S.S. A Textbook of Environmental Chemistry and Pollution Control, 11th edition, S. Chand & Company Ltd, New Delhi, 2006. 5. Sodhi, G.S. Fundamental Concepts of Environmental Chemistry, 2nd edition, Narosa Publishing House, New Delhi, 2005.

Course Code: 0531 18 Chem 5123	**First Year**	**First Term**
Course Title: Chemical Kinetics and Reaction Dynamics		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is based on the theories of different reaction kinetics.	
Course Objectives:	• To understand the molecular basis of chemical reaction kinetics and diffusion processes • Identification of rate laws based on detailed reaction mechanisms in homogeneous and heterogeneous cases • To provide experimental and numerical methods used to obtain reaction mechanism. • To study the heterogeneous catalytic reactions	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		Mapping with PLOs
	CLO 1	learn the advanced theories of chemical kinetics in atomic scale	1, 3, 8
	CLO 2	analyze different techniques of kinetic study	4
	CLO 3	explore various kinds of fast reactions	1, 8, 11
	CLO 4	explore the surfactant based organized media	1, 2, 8, 11
	CLO 5	evaluate the catalytic activity of different substances	1, 2, 9
	CLO 6	determine a suitable catalyst for a specific reaction	2

Course Contents		**CLOs**
Section A		
1	**Kinetic Studies:** Methods of finding rate, rate constants and reaction order; autocatalysis; oscillating, complex and composite reactions, Flow method, Flash photolysis, Temperature Jump and Pressure Jump, Periodic potential method, Relative method, Production of free radicals and techniques	2, 3
2	**Collision Theory:** Single and double sphere collision, reaction rate constant, Arrhenius Equation- effect of temperature on reaction rates.	1
3	**Reaction Dynamics:** Potential-Energy Surfaces and its contour diagram, Transition-State Theory, thermodynamic formulation of TST, equilibrium hypothesis, statistical mechanics and chemical equilibrium, derivations of rate equation	1
4	**Data Evaluation:** Computer simulation and Kinetic data evaluation from rate equation	2
Section B		
5	**Homogeneous and Heterogeneous Catalysis:** general catalytic mechanisms, equilibrium treatment, steady-state treatment, activation energies of catalyzed reactions, catalysis by electron and group transfer in solution, acid-base catalysis-mechanism of acid-base catalysis, catalytic activity and acid-base strength, salt effects in acid-base catalysis; enzyme catalysis-influence of substrate concentration, influence of pH, influence of temperature; catalysis in chain reactions.	5,6
6	**Adsorption and Surface Reaction:** Reactions on surfaces and in the solid state-adsorption, ideal and non-ideal adsorption, thermodynamics and statistical mechanics of adsorption, Mechanisms of surface reactions-unimolecular surface reaction, bimolecular surface reaction; Some special types of reactions-parahydrogen conversion, combination and formation	5,6

	of atoms at surfaces, exchange reactions, addition of hydrogen to ethylene; Transition-state theory of surface reactions-rates of chemisorption, rates of desorption, unimolecular& bimolecular surface reactions, comparison of homogeneous and heterogeneous reaction rates.	
7	**Micellar Catalysis:** Surfactants, micelles, microemulsion, kinetic theories of micellar catalysis	4

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam
CLO6	Lecture and Group Discussion	Quiz and Class Test

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

Course Code:0531 18 Chem 5200	**First Year**	**Second Term**
Course Title: Dissertation Part-I-M: Research Design and Proposal Submission		
Course Status: Core		
Credit: 03		
Prerequisite(s): None		

Rationale	**Idea generation and proposal submission**
Course Objectives:	• Generation of new research • Overall an idea about the previous research • Literature survey

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	brief conceptualization about research thinking	8
	CLO 2	evaluation of research idea	2, 3, 4
	CLO 3	finalization of research proposal	5, 7

	Course Contents	**CLOs**
	Selection of Suitable Method for the Proposed Research	1, 2, 3

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and presentation	Literature review

Learning Materials	
Recommended Readings	1. Davis, H.B. Tyson, J.F. Pechenik, J.A. A Short Guide to Writing About Chemistry, Addison-Wesley, Boston, MA, 2010. 2. Boudah, D.J. Conducting Educational Research: Guide to Completing a Thesis, Dissertation, or Action Research Project, 2nd Edition, Thousand Oaks, CA: Sage, 2020. 3. Pan, M.L. Preparing Literature Reviews: Qualitative and Quantitative Approaches, Pyrczak Publishing, 2013.
Supplementary Readings	1. Islam, M.N. An Introduction to Research Methods, 4th Edition, Mullick and Brothers, Dhaka, 2018. 2. Creswell, J.W. Research Design: Qualitative, Quantitative and Mixed Methods Approach, 5th Edition, Thousand Oaks, CA: Sage, 2018. 3. Heppner, P.P. Heppner, M.J. Writing and Publishing Your Thesis, Dissertation, and Research: A Guide for Students in the Helping Professions. Belmont, CA: Brooks/Cole-Thomson Learning, 2004.

Course Code: 0531 18 Chem 5211	**First Year**	**Second Term**
Course Title: Advanced Concept of Chemical Bonding		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge about various chemical bonding in inorganic chemistry.	
Course Objectives:	• To familiarize with advanced ideas about atomic and molecular structure. • Develop skills to find geometry of a compound different chemical bond. • Learn about different bond parameter's	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	realize the difference between classical and modern theories of atomic structure	1, 9
	CLO2	understand the significance of wave function and implicate the quantum theory in chemistry	1, 2
	CLO 3	discuss different theories regarding ionic and covalent compounds	1, 2, 5, 9
	CLO 4	know advanced treatment of bonding in complex compounds	1, 2
	CLO 5	justify the importance of MOT over VBT	9, 12
	CLO 6	learn depth idea about metallic bonding	1

Course Contents		**CLOs**
	Section A	
1	**Atomic Structure:** Classical and modern theory of the structure of atom, wave equation, wave function, radial and angular functions, orbital and probability distribution, Effective nuclear charge and shielding, General implications of quantum theory in Chemistry.	1, 2
2	**Ionic Bonds:** Size of the ions and ionic structures, inter- atomic distances and their relationship with their structures of compounds and crystals, Stabilization of ions in crystals, The Born-Haber cycle.	3, 6
3	**Covalent Bonds:** Nature of covalent bonding, Wave mechanical principle, Hybridization, resonance, Valence bond theory (VBT), Lewis	3,4,5

	model and octet rule, expanded octet, Directional characteristics of covalent bonds, Shapes of molecule, Valence shell electron pair repulsion (VSEPR) theory, Structure of molecules containing lone pair of electrons.	
4	**Van der Waals' Forces:** Dipole-dipole interaction, Ion dipole interaction, Dipole-induced dipole interaction, London dispersion forces.	3,4
	Section B	
5	**Advanced Treatment of Bonding in Coordination Compounds:** The crystal field theory and Ligand field theory for octahedral complexes, Spectrochemical series, CFSE, Magnetic properties, Jahn-Teller Effect.	4
6	**Molecular Orbital Theory (MOT):** **(a)** Delocalized bond concept and molecular orbital theory, Comparison of VBT and MOT, Construction of molecular orbitals by LCAO method, Overlap criteria of bond formation, Bonding, Antibonding and Nonbonding Orbitals. **(b)** Moleculer Orbital theory of homo- and –hetero diatomic molecules, Poly atomic molecules, Delocalization of bonding electrons, HOMO and LUMO orbitals, Mixing of molecular orbitals and the correlation diagrams.	5
7	**Bonding in Metals:** Properties of metal, The band theory, Energy bands as a function of inter-nuclear distance, Cohesive energies of metals, Conductors, Semiconductors, and Insulators. Electron gas model, Free electron model (Sommerfield model).	6

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO 5	Lecture and Team Teaching	Quiz and Class Test
CL06	Lecture and Group Discussion	Final Exam

Learning Materials	
Recommended Readings	1. Purcell, K.F. and Kotz, J.C. Inorganic Chemistry, 1st edition, W.B. Saunders Company, 1977. 2. Malik, W.U. Tuli, G. D. and Madan, R.D. Selected Topics in Inorganic Chemistry, 1st edition, S. Chand & Company Ltd., New Delhi, 1976. 3. Lee, J.D. Concise Inorganic Chemistry, 4th edition, Chapman & Hall, New York, 1991.
Supplementary Readings	1. Cotton, F.A. Wilkinson, G. Advanced Inorganic Chemistry. A Comprehensive Text, 3rd edition, Interscience Publisher, New York, 1972.

	2. Haider, S.Z. Introduction to Modern Inorganic Chemistry, 6th edition, Noor Card Board Offset Press, Bangladesh, 2004. 3. Huheey, J.E. Keiter, E.A. and Keiter, R.L. Inorganic Chemistry, 4th edition, Herper Collins College Publishers, 1993.

Course Code:0531 18 Chem 5240		**First Year**	**Second Term**
Course Title: Communication Skill Sessional			
Course Status: Core			
Credit: 01			
Prerequisite(s): None			
Rationale	**Enhancement of personal and communication skill**		
Course Objectives:	Self-development through basic skills		

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	develop the communication skill with people	7
	CLO 2	cope with all types of ambiences	5, 6
	CLO 3	improve himself or herself as a skilled person	12

	Course Contents	**CLOs**
	Scientific Works Presentation, Group Discussion, Viva-voce	1, 2, 3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Communication, Presentation, Discussion	Presentation and viva-voce

Learning Materials	
Recommended Readings	1. Berlo, D.K. The Process of Communication: An Introduction to Theory and Practice, Holt, Rinehart and Winston, 1960. 2. Roger, G.Y and Agarwala, R. Communication in Organization, Free Press, 1976. 3. Vito, J.A.D. Communication: Concepts and Processes, Prentice-Hall, 2017. 4. Vito, J.A.D., Human Communication: The Basic Course, Hunter College of the City University, 2018.
Supplementary Readings	1. Cushman, D.P. Cahn, D.D. (Eds), Communication in Interpersonal Relationships, SUNY Press, 1985. 2. Hartley, P. Interpersonal Communication, Routledge, 2002.

	3. Hill, A. Watson, J. Rivers, D. Key Themes in Interpersonal Communication, McGraw-Hill Education, 2007. 4. Webb, R. Interpersonal Speech Communication: Principles and Practices, Prentice-Hall, 1975. 5. Weber, T. Handbook of Interpersonal Communication, Walter de Gruyter, 2008.

Course Code: 0531 18 Chem 5242	**First Year**	**Second Term**
Course Title: In-plant Training/ Industrial Tour and Field Visit		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	This course is designed to develop operating, trouble-shooting, communication, presentation, self-management, planning and organizing skills among the students.	
Course Objectives:	• To make the student adaptable easily in an industry • To provide hands on experience in using different instruments • To identify and assess the risks inherent in products handling, equipment use and operations. • To measure the possible consequences on safety, health and the environment. • To apply preventive measures recommended. • To adopt the most appropriate behavior to counter risks.	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	adapt with the industrial working environment	1, 5
	CLO 2	maintain communication about multiple subjects and with multiple audiences	2, 5, 7
	CLO 3	operate different chemical instruments	10
	CLO 4	collect technical and manufacturer's information	5,7
	CLO 5	use and contribute to workplace documentation	5,12
	CLO 6	identify and describe own role and role of other work within a team	5,7
	CLO 7	monitor completion of allocated tasks	5
	CLO 8	recognize and solve a problem or a potential problem in a plant unit, system or area	8, 10, 12

	CLO 9	refer problems outside area of responsibility to appropriate person, with possible causes	12
	CLO 10	operate within appropriate time constraints and work standards an own work requirement and assist others to plan theirs	12

Course Contents	**CLOs**
A training program or industrial field visit will be arranged in first year second Term, which will be completed at any industry by the joint collaboration of Chemistry Discipline, Khulna University.	1 to 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO 1	Visual observation, Hands on training, and Team work	Assigned task completion, Report writing, Oral Presentation and viva voce
CLO 2	Oral Presentation	
CLO 3	Survey	
CLO 4	Group work and discussion	
CLO 5	Work with employee	
CLO 6	Visual observation and documentation	
CLO 7	Problem-based Learning	
CLO 8	Problem-based Learning	
CLO 9	Oral Presentation and Tanning	
CLO 10	Oral Presentation and Tanning	
CLO 11	Oral Presentation and Tanning	

Learning Materials	
Recommended Readings	1. Sharma, B.K. Industrial Chemistry (Including Chemical Engineering), GOEL Publishing House, 2000. 2. Mark, A.B. Industrial Chemistry For Advanced Students, DeGruyter, 2019.
Supplementary Readings	1. Ali, M. Bassam A. Handbook of Industrial Chemistry: Organic Chemicals, 1st edition, McGraw-Hill Professional, 2004. 2. Trimm, H.H. Hunter, W. Industrial Chemistry: New Applications, Processes and Systems, Apple Academic Press, 2011.

Course Code:0711 18 ChE 5251	**First Year**	**Second Term**
Course Title: Chemical Weapons Convention and Basics of Chemical Hazard and Safety		
Course Status: Core		
Credit: 01		

Prerequisite(s): None	
Rationale	The course is designed for the safety concern of hazardous chemical and weaponry
Course Objectives:	To conceptualize the prohibition of chemical weapon To teach the control the hazardous materials To avoid chemical accidents

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	know the general concepts of chemical weapons	1
	CLO 2	get an idea about the role of various organizations for the prohibition of chemical weapons	5
	CLO 3	know how to control the hazardous materials and chemical accidents	2
	CLO 4	learn how chemical weapon can be prohibited	12

Course Contents		**CLOs**
Section A		
1	**Chemical Weapons:** Definition, classifications, Schedule chemicals and their effects, Harmful effects of CW, chemical weapons in international politics.	1
2	**Organization for the Prohibition of Chemical Weapons:** History of chemical weapons, Background for the formation of OPCW, Organization for the Prohibition of Chemical Weapons, their functions and role.	2
3	**Bangladesh National Authority for Chemical Weapons Convention (BNACWC):** History of BNACWC, background of formation, role of organizations in national and international level, national legislation on CWC in Bangladesh.	3
Section B		
4	**Introduction to Chemical Safety and Hazard Communication:** Loss prevention, hazard, risks, occupation and process safety, safety program, chemical safety and security, Hazard Communication Standard (HCS),	2
5	**Exposure, Evaluation and Health Risks of Chemical Exposure in Workplace:** Method of identifications of chemicals in work place, ways for the exposure of chemicals, method of control for chemical weapons in workplace, Health risks, effects, carcinogenic and non-carcinogenic risks in human body, long term effects,	3
6	**Chemical Safety Standards and Regulations:** Definition of chemical safety, measurable steps, rules and regulations for chemical safety in national and international level.	4

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Walters, D.B. Ho, P. Hardesty, J. Safety, Security and Dual-Use Chemicals, J. Chem. Health Safety, 2015; 1-14. **2.** Gilbert, S. Chemical Weapons, Toxipedia, 2014; 1-13. 3. Noyes, R. Chemical Weapons Destruction and Explosive Waste Unexploded Ordinance, William Andrew, 1997. 4. Robinson, J.P. Public Health Response to Biological and Chemical Weapons: WHO Guidance, 2nd Edition. World Health Organization, 2005.
Supplementary Readings	1. Chemical Weapons (Prohibition) Act-2006, Website of Bangladesh National Authority for Chemical Weapons Convention (BNACWC). 2. Loveland, W.D. Morrissey, D.J. and Seaborg, G.T. Modern Nuclear Chemistry, 1st ed., Wiley-Interscience, New York, 2001. 3. Choppin, G. Rydberg, J. Liljenzin, J.O. Radiochemistry and Nuclear Chemistry, 4th ed., Elsevier, 2013.

Course Code: 0533 18 Phy 5253	**First Year**	**Second Term**
Course Title: Sustainable Energy		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	Exploring different kinds of alternative energy sources	

Course Objectives:	• Understand the different types of non-conventional energy resources like solar, wind, biomass, ocean, tidal and wave sources • Learn their conversion techniques

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	learn the scientific background of energy conversion, storage and consumption	1, 9, 12
	CLO 2	understand the concept of various non-conventional energy resources	8, 12
	CLO 3	acquire in-depth knowledge on the conversion of non-conventional energy resources into electrical power	4
	CLO 4	become intellectual in new developments of renewable energy studies	4, 12
	CLO 5	attain knowledge in green energy technologies	4, 9

Course Contents		**CLOs**
Section A		
1	**Energy Resources and Their Utilization:** Renewable energy sources, world energy resources and consumption, energy planning, fossil fuels, renewable sources, environmental impacts of hydrogen-based energy systems, energy consuming and converting equipment, diesel generating sets (DG sets), motors, pumps, belt drives	1,2
2	**Solar Energy:** Solar radiations-introduction, interaction of the sun's radiation with the earth's atmosphere, terminology of radiation parameters, apparent motions of the sun, day length, solar energy reaching the earth's surface, rough estimates of the solar energy available at the earth's surface, earth–sun geometry, sun–earth geometry, radiation on inclined surfaces, mountain slopes; solar devices- introduction, solar panels, silicon wafers, solar cells	2,5
3	**Solar Photovoltaic Systems & Nanotechnology:** Solar photovoltaic cell, fabrication of photovoltaic cells, photovoltaic module performance ratings, reliability of photovoltaic systems, classification of photovoltaic systems, non-silicon-based photovoltaic systems, asphalt roads as solar power producers, conserve energy with nanotechnology solar panel, nanotechnology for energy extraction, drivers and barriers to innovation	1,2,5
4	**Wind Energy:** Energy from the wind, wind resources, conversion of wind energy, types and characteristics of windmill rotors, windmill performance, wind turbine, wind electricity basics, wind-electric system types, wind farm, environmental impact of wind power	2,3,5
Section B		

5	**Hydroelectric power:** Hydropower, power output from a dam, measurement of volume flow rate using a weir, water turbines, impact, economics and prospects of hydropower, how hydropower works, modern concepts and future role, benefits of hydropower, characteristics of hydropower, electrical system benefits, environmental issues and management for hydropower peaking operations	2,5
6	**Tide, Wave and Ocean Energy Geothermal Energy:** Tides, tidal power, power from a tidal barrage, tidal resonance, kinetic energy of tidal currents, generation of tidal energy, advantages and disadvantages of tidal energy, wave energy, ocean energy	2,5
7	**Geothermal Energy:** Geothermal fluid, design for geothermal power plants, conversion technologies, cooling types, structuring power plant to minimize impact, efficiency, non-traditional geothermal systems, new technology, direct use, environmental monitoring of geothermal power plants	2,3,5
8	**Biofuels:** Introduction, types of biomass, energy content of biomass, harvesting methods of biomass, conversion of biomass, thermo-chemical conversion of biomass, biodiesel production, bioethanol production	2,4

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Hanjalic, K. Krol, R. and Lekic, A. Sustainable Energy Technologies: Options and Prospects, 1st Edition. Springer, 2008. 2. Kilner, J. Skinner, S. Irvine, S. and Edwards, P. Functional materials for sustainable energy applications, 1st Edition. Woodhead Publishing Series in Energy, 2012.
Supplementary Readings	1. Xavier, M. and Munoz-Rojas, D. Materials for sustainable energy applications: Conversion, Storage, Transmission, and Consumption, Pan Stanford Publishing, CRC, 2016. 2. Dusastre, V. Materials for Sustainable Energy: A Collection of Peer-reviewed Research Papers and Review Articles from Nature Publishing Group, World Scientific Pub Co Inc, 2010.

	3. Eder, D. and Schlögl, R. Nanocarbon-Inorganic Hybrids: Next Generation Composites for Sustainable Energy Applications, 1st Edition. Walter de Gruyter, 2014.

Course Code: 0521 18 ES 5255	**First Year**	**Second Term**
Course Title: Industrial Hazards and Waste Management		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge about industrial hazards, waste treatment and management process	
Course Objectives:	• To learn general knowledge of chemical hazards • To gain knowledge of control of chemical plant hazards • To know the extensive and balanced foundation to recycling, reuse • To observe current industrial environmental status • To develop methods for improved solid waste collection, separation and control skill	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	discuss about the types of waste and waste disposal methods	1, 2, 8
	CLO2	develop different methods for updating solid waste collection, separation and control skills and know the current industrial environmental status	4
	CLO 3	apply the principles of waste minimization, source reduction, material use and recovery in the design of solid and hazardous waste management systems	2, 3,8
	CLO 4	develop technical knowledge and apply design skills related to solid waste generation, collection and disposal	4, 10

Course Contents		**CLOs**
Section A		
1	**General Idea of Chemical Hazards:** Chemical hazards, Industrial pollutants in the environment. Occupational diseases and their control,	1,2

	effect of modern agrotechnology, industrial pollution hazards in Bangladesh.	
2	**Control of Chemical Plant Hazards:** Industrial plant layout, Ventilation and lighting, storage, handling and transportation. Electrical system, fire hazards and prevention, personal protective device, laboratory safety, maintained procedure.	2
3	**Hazardous Waste:** Hazardous substances and waste, origin and amount of hazardous waste, identification of hazardous waste, biomedical waste, hazardous waste and health, hazardous waste in the geosphere, hydrosphere, atmosphere and biosphere, Nuclear waste.	1, 2
Section B		
4	**Industrial Wastes and Treatment Process:** Characteristics of industrial wastes, principal of industrial waste treatment process- physical, chemical and thermal treatment of industrial waste, treatment of waste with organic and inorganic impurities, the nature and treatment of waste from some chemical process industries-soap and detergents, alkali, pesticides and fertilizer industries.	3,4
5	**Current Industrial Environmental Status:** Concept of threshold limits value, methods of monitoring, exposure, active and passive sampling, and formulation of guidelines and discharge standards of various industries.	4
6	**Re-Use of Industrial Waste:** Construction material from waste, utilization of agricultural wastes- medicines, liquid fuels. Urban waste and bagasse for electricity, biomass into rural power, oil from plastic waste, plastic for heat and electricity generation, converting garbage into fuel, fertilizer and power.	3, 4

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Team Teaching	Quiz and Class Test
CLO2	Problem-based Learning and Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Final Exam
CLO4	Problem-based Learning and Presentation	Quiz and Class Test

Learning Materials	
Recommended Readings	1. Wang, L.K. Wang, M.S. Hung, Y.T. Shammas N.K. and Chen, J.P. Handbook of Advanced Industrial and Hazardous Wastes Management. CRC Press Taylor & Francis Group, 2018. 2. Saleh H.E.M. and Rahman R.A. Management of Hazardous Wastes. Intech Open, Croatia, 2016.

	3. Singh, P. Bassin, J. Rajkhowa, S. Hussain, S. and Oraon, R. Environmental Sustainability and Industries: Technologies for Solid Waste, Wastewater, and Air Treatment, 1st ed. Elsevier, 2022.
Supplementary Readings	1. Handbook of Pollution and Hazardous Materials Compliance: A Source book for Environmental Managers, CRC Press, 1996. 2. Woodside, G. Hazardous Materials and Hazardous Waste Management, 2nd ed. John Wiley and Sons, 1999. 3. Cheremisinoff, N.P. Hazardous Materials and Waste Management: A Guide for the Professional Hazards Manager. Elsevier Science, 1995. 4. Cheremisinoff, N.P. and Graffia, M.L. Environmental and Health and Safety Management: A Guide to Compliance. William Andrew, 1995. 5. Krishna, I.V.M. and Manickam, V. Environmental Management: Science and Engineering for Industry, 1st ed. Butterworth-Heinemann, 2017.

Course Code: 0413 18 HRM 5257	**First Year**	**Second Term**
Course Title: Career Planning and Development		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	This course provides students with an opportunity to explore the skills, Interests and values most likely to build up the career perfectly.	
Course Objectives:	• To conceptualize career along with the stages of career development. • To relate the theory of career management with practical scenario. • To discuss how to manage different stages of career. • To acquaint with job stress and how to manage it.	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	**CLO 1**	analyze and apply career concepts for the development of one's career in HR sector	8, 12
	CLO 2	analyze and evaluate applications of the career management model: a guide to career exploration, explain techniques for effective self-exploration programs	8, 12
	CLO 3	explain applications of the career management model: goals, strategies, and appraisal	5, 12

	CLO 4	explain guidelines for effective occupational decision making	5, 12
	CLO 5	a workshop on career planning	5, 7, 12
	CLO 6	analyze organizational actions during mid-career, and apply organizational actions during late-career	5, 12
	CLO 7	explain and evaluate sources and consequences of stress	5, 12
	CLO 8	explain intersection of work and family roles: implications for career management, evaluate quality of life in two career families	5, 12
	CLO 9	develop and apply model of organizational fairness	8, 12
	CLO 10	compare integration of career management with human resource system	8, 9, 12

Course Contents		**CLOs**
Section A		
1	**Introduction To the Study of Career:** Definition, the Changing Landscape of Work; Career Concepts; Need to Understand Career Management.	1
2	**Model of Career Management and its Applications:** Overview of The Career Management Model, Theory and Research on The Career Management Model, Career Management as an Ongoing Process, Indicators of Effective Career Management, Guidelines to Career Exploration, Types of Career Exploration, Techniques for Effective Self-Exploration Programs, Informal Self-Exploration, Career Goal Setting, Implications of Setting Goal for Organizations and Their Employees, Career Strategies, Career Appraisal, Career Management, A Blend of Formal And Informal Activities.	2, 3
3	**Career Development-An Overview:** Adult Life Development, Stages of Career Development, Difficulties in Applying a Career-Stage Perspective.	4, 5
4	**Occupational Choice, Preparation for Work, Organizational Entry, Early Career Establishment and Achievement:** Theories of Occupational Choice; Guidelines For Effective Occupational Decision Making, Establishment Period: Organizational Actions During Establishment; Individual Actions During Establishment; Achievement Period: Organizational Actions During Achievement; Individual Actions During Achievement.	5
Section B		
5	**Middle and Late Career Issues:** Middle Career: Remaining Productive Growth, Maintenance, or Stagnation; Organizational Actions During Mid-Career, And Individual Actions During Mid-Career, Late-Career; Organizational Actions During Late-Career; Individual Actions During Late Career.	6

6	**Job Stress and Intersection of Work and Family Roles: Implications for Career Management:** Job Stress; Sources and Consequences of Stress: Coping, Social Support, and Stress. Model of Work-Family Conflict; Work-Family Integration; Two-Career Family; Quality of Life in Two-Career Families; Organizational Responses to Work-Families Issues; Changing the Organization's Work-Family Culture; Career Management and the Quality of Life.	7, 8
7	**Entrepreneurial Careers:** Choosing an Entrepreneurial Career, Support for the Entrepreneurial Career, Characteristics and Experiences of Female and Minority Entrepreneurs, Selecting and Managing Entrepreneurial Career.	9
8	**Human Resource Support Systems:** Integration of Career Management With Human Resource Systems; Illustration of Career-Oriented Human Resource Systems.	10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Group Discussion	Quiz and Class Test
CLO2	Lecture, Problem-based Learning and Power Point Presentation	Assignment and Final Exam
CLO3	Lecture and Group Discussion	Brain storming and Final Exam
CLO4	Lecture and Power Point Presentation	Quiz and Class Test
CLO5	Lecture, Problem-based Learning and Power Point Presentation	Brain storming and Final Exam
CLO6	Lecture and Group Discussion	Quiz and Class Test
CLO7	Lecture and Group Discussion	Quiz and Class Test
CLO8	Problem-based Learning and Power Point Presentation	Brain storming and Final Exam
CLO9	Lecture and Group Discussion	Quiz and Class Test
CLO10	Problem-based Learning and Power Point Presentation	Quiz and Class Test

Learning Materials	
Recommended Readings	1. Greenhaus, J.H. Career Management, 4th ed. SAGE, 2009. 2. Garnesby, S. Career Planning and Development: The Path toward Your Dream Job. Create Space Independent Publishing Platform, 2013. 3. Jonathan, P. West: Career Planning, Development and Management, 1st Edition. Taylor & Francis Ltd, Routledge, London, 1983.
Supplementary Readings	1. West, J.P. Career Planning, Development and Management, 1st ed. Routledge, London, 2017.

	2. Rothwell, W.J. Jackson, R.D. Knight, S.C. Payne, T.D. Lindholm, J.E. Wang, W.A. Career Planning and Succession Management. Praeger Publishers, 2005. 3. Reardon, R.C. Lenz, J.G. Sampson, J.P. Peterson, G.W. Career Development and Planning: A Comprehensive Approach. Cengage Learning, 2008.

Course Code:0531 18 Chem 6100	**Second Year**	**First Term**
Course Title: Dissertation Part II: Research Outcome and Final Defense		
Course Status: Core		
Credit: 15.0		
Prerequisite(s): None		
Rationale	**Preparation of dissertation and critical discussion about the outcome**	
Course Objectives:	Evaluation of novel research	

Mapping Course Learning Outcomes (CLO) with Program Learning Objectives (PLO)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	**CLO 1**	generate of new idea for the synthesis of novel materials	1, 2, 3, 8,10
	CLO 2	correlate the results with the demand of stakeholders	5, 6, 9
	CLO 3	application of the research outcome for human welfare	2, 8, 10

	Course Contents	**CLOs**
	Preparation of Dissertation and final defense contents	1,2,3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Presentation of research findings	Oral presentation, Poster presentation

Learning Materials	
Recommended Readings	1. Anderson, J. Dursten B.H. Poole, M. Thesis and Assignment Writing, Wiley Eastern, 1977. 2. Rajamal, P. Devadoss, P. A Hand Book of Methodology of Research, R.M.M. Vidya Press, 1976

Supplementary Readings	1. Davis, H.B. Tyson, J.F. Pechenik, J.A. A Short Guide to Writing about Chemistry, Addison-Wesley, Boston, MA, 2010. 2. Boudah, D.J. Conducting Educational Research: Guide to Completing a Thesis, Dissertation, or Action Research Project, 2nd Edition, Thousand Oaks, CA: Sage, 2020. 3. Pan, M.L. Preparing Literature Reviews: Qualitative and Quantitative Approaches, Pyrczak Publishing, 2013. 4. Islam, M.N. An Introduction to Research Methods, 4th Edition, Mullick and Brothers, Dhaka, 2018. 5. Khulna University (KU) Ordinance for the Doctor of Philosophy, KU, 2022.

PART-D

20. Grading and Evaluation

20.1.1 Grading Scale

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

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

20.1.2 Cumulative Grade Point Average (CGPA)

GPA will be calculated as per the standard practices at the undergraduate level of Khulna University. A student's performance will be evaluated in terms of three indices, viz. Term Grade Point Average (TGPA), Yearly Grade Point Average (YGPA), and Cumulative Grade Point Average (CGPA). The TGPA is computed by dividing the total points earned in a Term by the number of credits taken in the Term. The YGPA is computed by dividing the total grade points earned in two Terms in a year by dividing the number of credits taken in that year. The CGPA is computed by dividing the total grade points accumulated up to date by the total completed credits. Thus a student who has earned 275 grade points in attempting 100 credits of courses would have an overall CGPA of 2.75. The students will be awarded the Degree with Distinction, if their CGPA is 3.75 or above.

20.1.3 Evaluation of Theory Courses

All theory courses will be evaluated out of 100 marks. The marks will be distributed as follows:

Attendance:	10 Marks
Continuous Assessments:	30-40 Marks
Term Final:	50-60 Marks
Total:	**100 Marks**

20.1.4 Evaluation of Sessional Courses

All sessional courses will be evaluated out of 100 marks. The marks will be distributed as follows:

Attendance:	10 Marks
Sessional Assessments:	60 Marks
Viva voce:	30 Marks
Total:	**100 Marks**

(a) For both theory and sessional courses, attendance shall carry 10 marks and the basis for awarding marks will be as follows:

Attendance (%)	Marks
≥ 90	10
85 to < 90	9
80 to < 85	8
75 to < 80	7
70 to < 75	6
65 to < 70	5
60 to < 65	4
< 60	0

(b) The continuous assessments (30 to 40 marks) for theory courses may be conducted in the form of written class examinations, assignments, home-works, presentations, quizzes, viva voce, mid-term, etc. For any theoretical course, there shall be at least four assessments. Section best (A & B) assessments shall be counted. A mid-term Examination may be taken if a Discipline/POE opts for it. The concerned Discipline will allocate marks for mid-term and continuous other evaluations in such a case. The course teachers must submit the continuous assessment and sessional assessment mark sheets to the Chair of the Examination Committee before the starting of the Term final examination.

(c) The remaining 50 to 60 marks will be allocated for the term final examination.

(d) A student who fails in any course(s) in the Term final examinations or who registered for the course(s) but did not sit for the examination, the concerned course(s) will be considered as retake course(s).

(e) A student retaking theory course(s) for clearing/passing or improvement must appear at the mid-term (if any) and Term final examinations. A student may attend continuous assessments also on the written approval of the Discipline Head; otherwise, the marks of continuous assessments will be maintained from the student's previous records. The marks of attendance will be carried forward from earlier Term. The obtained grade will be downgraded in case of retaking course(s).

(f) Examination procedure related other guidelines of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs, if not conflicting with this Ordinance.

20.1.5 Evaluation of Viva Voce

A Discipline may include Viva Voce of 01 credit at the end of each Term. The concerned Examination committee of that Term will conduct the viva and assess the students out of 100 marks.

20.1.6 Dissertation under Mixed-mode

i) There will be two components of the Dissertation, namely Dissertation Part-I-M in one Term for proposal development, and Dissertation Part-II-M in another term for completing the Dissertation. The total credit for the Dissertation will be between15 to 20 credits. The credit allocation for proposal development and dissertation parts will be 3-5 credits and 12-15 credits, respectively.

ii) A Dissertation (both proposal and Dissertation) will be evaluated out of 100 marks.

Marks distribution of Dissertation Part-I-M will be as follows:

a) Assessment of Supervisor 30 marks
b) Proposal Presentation 70 marks

Marks distribution for Dissertation Part-II-M will be as follows:

a) Assessment of Supervisor 20 marks
b) Dissertation Evaluation 50 marks
c) Defense (Oral examination) 30 marks

iii) Dissertation Part-I-M will usually commence in the Master's first-year second-term and Dissertation Part-II-M in the second-year first-term (final Term).

iv) The final evaluation of the Dissertation Part-II-M will be made at the end of the final Term. However, the evaluation of the Dissertation Part-I-M will be done in the corresponding Term.

v) A student registered for Dissertation will undertake research work under the guidance of a supervisor and a co-supervisor (if necessary).

vi) The research needs to be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

vii) There shall generally be one Supervisor for each student, but a co-supervisor may also be appointed if needed. A teacher not below the rank of Assistant Professor will act as supervisor/co-supervisor. However, a Lecturer with MPhil/ Master's by Research/ Ph.D. degree is eligible to supervise/co-supervise a student. Co-supervision may also be allowed from other Disciplines of Khulna University/other universities or research institutes.

viii) If a student has any grievance about a Supervisor, or if a Supervisor has any complaint against a student, s/he may inform the Discipline Head about the issue in writing. The Discipline will decide such matters.

ix) Pursuant to the leave rules of Khulna University, a Supervisor can remain absent from Khulna University (not more than six months) while continuing as a Supervisor. The online defense may be arranged in such cases if deemed necessary. Otherwise, the Co-supervisor (if any) or any other competent person will act as the Supervisor as per the guideline of the concerned Examination Committee. This will be applicable for projects and internships also.

x) Every student submitting a dissertation in partial fulfillment of the requirements of a degree will be required to appear at proposal presentation for Dissertation Part-I-M and defense board of Dissertation Part-II-M respectively on the dates fixed by the Discipline Head in consultation with the Supervisor(s). Such presentation and defense may be arranged online if deemed necessary to the concerned authority. A student must satisfy the examiners that s/he is capable of undertaking independent work and affording evidence of satisfactory knowledge related to the theory and techniques used in his/her research work.

xi) A student must submit the required number of printed and soft copies of Dissertation Part-II-M in the approved format through the Supervisors to the Discipline Head by a date to be fixed by the Discipline. The Dissertation will not usually be considered for evaluation if the plagiarism detection system yields a similarity index of more than 25% (excluding bibliography/references, quotes, and small sources with source exclusion threshold of ten word counts). This will be applicable to the dissertations written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

xii) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

xiii) If any change is required in the title/supervisor/co-supervisor/examiner/etc., the Discipline Head will send it to the BOAS through EC.

20.1.7 Project under Mixed-mode

(i) A student undertaking a project work will register 03-06 credits usually in the second-year first-term (final Term) under the guidance of a Supervisor. A teacher with MPhil/ Master's by Research/ Ph.D. degree can supervise a student. The project work should be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

(ii) A project will be evaluated out of 100 marks. Marks distribution of the project will be as follows:

Assessments of the Supervisor	20 marks
Project Report evaluation	50 marks
Defense (Oral examination)	30 marks

(iii) Final evaluation of the project report will usually be made at the end of the final Term for the student.

(iv) A student must submit the required number of printed and soft copies of the project report in the approved format through the supervisors to the Discipline Head by a date to be fixed by the Discipline. The project report will not usually be considered for evaluation if the plagiarism detection system yields more than 25% (excluding bibliography/references, quotes, and small sources with a source exclusion threshold of ten-word counts). This will be applicable to the reports written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

(v) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

20.1.8 Internship under Mixed-mode

(i) A student may be offered an internship usually in the second-year first-term (final Term). In such a case, the credit will be 03-06 Credits. There will be a Supervisor. A teacher with a post-graduate degree is capable of supervising an internship. The evaluation of the internship will be as follows:

a)	Continuation of the work (by Supervisor)	20 marks
b)	Report evaluation	50 marks
c)	Defense (Oral examination)	30 marks

(ii) A student must submit the required number of printed and soft copies of the internship report in the approved format through the supervisors to the Discipline Head by a date to be fixed by the Discipline. The report will not usually be considered for evaluation if the plagiarism detection system yields more than 25% (excluding bibliography/references, quotes, and small sources with a source exclusion threshold often-word counts). This will be applicable to the reports written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

(iii) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

20.1.9 Master's by Research Program

(i) The students under 'Master's by Research' program have to register for four parts of the Dissertation as follows:

Sl. No.	Course	Year	Term	Min. credit	Max. credit
1	Dissertation Part-I-R	1	1	8	10
2	Dissertation Part-II-R	1	2	10	15
3	Dissertation Part-III-R	2	1	12	15
4	Dissertation Part-IV-R	2	2	15	20

(ii) A Dissertation (Part I-IV-R) will be evaluated out of 100 marks. Marks distribution of Dissertation Part-I-R, II-R, and III-R will be as follows:

a) Assessment of Supervisor 30 marks
b) Presentation 70 marks

(iii) Marks distribution for Dissertation Part-IV-R will be as follows:

Assessment of Supervisor 20 marks
Dissertation Evaluation 50 marks
Defense (Oral examination) 30 marks

(iv) Usually research topic selection, title, rationale, objective, research question, literature review, sampling, research design, experiment, survey, data/information collection, analysis, result, discussion, policy implication, limitation, reference, annex, etc. related various issues will be covered (as applicable) under these four parts. The curriculum of the concerned program will provide a detailed description of coverage, objective, learning outcome, credit, etc., of these four parts.

(v) A student registered for Dissertation will undertake research under the guidance of a Supervisor and a Co-supervisor (if necessary).

(vi) The research needs to be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

(vii) There shall normally be one Supervisor for each student, but a co-supervisor may also be appointed if needed. A teacher not below the rank of Assistant Professor will act as Supervisor/Co-supervisor. However, a Lecturer with MPhil/ Master's by Research/ Ph.D. degree is eligible to supervise/co-supervise a student. Co-supervision may also be allowed from other Disciplines of Khulna University/other universities or research institutes.

(viii) If a student has any grievance about a Supervisor, or if a Supervisor has any complaint against a student, s/he may inform the Discipline Head about the issue in writing. The Discipline will decide such matters.

(ix) Pursuant to the leave rules of Khulna University, a Supervisor can remain absent from Khulna University (not more than six months) while continuing as a Supervisor. The online defense may be arranged in such cases if deemed necessary. Otherwise, the Co-supervisor (if any) or any other competent person will act as the Supervisor as per the guideline of the concerned Examination Committee.

(x) Final evaluation of the Dissertation Part-IV-R will be made at the end of the final Term. However, the Dissertation Part-I-R, II-R, and III-R will be evaluated in the corresponding terms.

(xi) Every student submitting a dissertation in partial fulfillment of the requirements of a degree will be required to appear at a seminar presentation for Dissertation Part-I-R, II-R, and III-R and defense board for Dissertation Part-IV-R respectively on the dates fixed by the Discipline Head in consultation with the Supervisor (s). Such seminar presentation and defense may be arranged online if deemed necessary to the concerned authority. A student must satisfy the examiners that s/he is capable of undertaking independent work and affording evidence of satisfactory knowledge related to the theory and techniques used in his/her research work.

(xii) After successfully completing the seminar and dissertation defense boards, the Chairman of the concerned boards shall arrange to send six-monthly progress reports for each student in each Term to the Dean for approval. Accordingly, the Dean will approve the progress reports and report to BOAS. Progress reports shall be submitted before the end of each Term, even if the Supervisor is on leave; otherwise, the student(s) shall not be allowed to register for the following Term.

(xiii) A student must publish (or at least accepted for publication) an article/paper in a peer-reviewed journal or a peer-reviewed conference paper in order to complete 'Master's by Research' Degree.

(xiv) A student must submit the required number of printed and soft copies of Dissertation Part-IV-R in the approved format through the supervisors to the Discipline Head by a date to be fixed by the Discipline. The Dissertation will not usually be considered for evaluation if the plagiarism detection system yields a similarity index of more than 25% (excluding bibliography/references, quotes, and small sources with source exclusion threshold of ten-word counts). This will be applicable to the dissertations written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

(xv) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

(xvi) If any change is required in the title/supervisor/co-supervisor/examiner/etc., the Discipline Head will send it to the BOAS through EC.

20.1.10 Credit Requirement and Duration of the Program

The required credits and duration for Master's Programs are mentioned below.

Program type	Credit Requirement				Program Duration			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Total (Min.)	Term (Min.)	Year (Min.)	Term (Max.)	Year (Max.)
Coursework	40	-	-	40	02	1.0	06	3.0
Mixed-mode (Dissertation)	20	15	20	40	03	1.5	06	3.0
Mixed-mode (Project)	20	3	6	40	03	1.5	06	3.0
Mixed-mode (Internship)	20	3	6	40	03	1.5	06	3.0
Research	-	45	60	45	04	2.0	06	3.0

The details of each Term Duration will be as follows:

Item	Duration
Teaching and continuous assessment/ Contact with Supervisor	14 weeks
Preparatory leave before: Final Examination/ Seminar/ Defense	02 weeks
Final Examination/ Seminar/ Defense	(Maximum) 04 weeks
Term Break	02 weeks
Total	**22 weeks**

20.1.11 Course Types

The courses included in the Master's curriculum may be divided into three groups as follows:

(i) **Core Courses:** Core courses are obligatory for a degree.

(ii) **Optional Courses:** Any other courses students may undertake to earn the Degree.

(iii) **Major Courses:** A Discipline may offer courses from one or more major areas (if any), and after completing a certain number of credits from that area (as reported in the following table), a student can achieve a Master's degree with a major in a specified field, and that will be mentioned in the Transcript, e.g., MS in Agrotechnology (Horticulture). The curriculum of the concerned program will provide a detailed description of such cases.

Credit Requirements for Offering Major

Program type	Min. credit requirement from major area*			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Min. from Major Area
Coursework	20	-	-	20
Mixed-mode (Dissertation)	9	15	20	20
Mixed-mode (Project)	15	3	6	20
Mixed-mode (Internship)	15	3	6	20
Research	-	45	60	45

***** For achieving a Master's degree with a major in a specified field under a mixed-mode or 'Master's by Research' scheme, the concerned dissertation must be directly linked with the 'major area' under consideration.

(iv) **Viva Voce:** A Discipline may include Viva Voce of 01 credit at the end of each Term. The concerned Examination committee of that Term will conduct the viva and assess the students out of 100 marks.

(v) **Assignment of Credit:**

Theory Courses: For theory courses, one-hour face-to-face learning (e.g., lecture, tutorial, seminar) per week will be equivalent to one credit.

Sessional Courses: For sessional courses, 1.5-hour face-to-face learning (e.g., lab work, studio, fieldwork, or clinical work) per week is equivalent to 1.0 credit. For industrial/ workplace learning, 2-hour learning per week is equivalent to 1.0 credit.

In addition to face-to-face and other means of learning, online teaching-learning might be exercised if deemed necessary to the Discipline/POE.

20.1.12 Course Registration

(i) Each student will get oneself registered with the University. S/he will fill in the course registration form in consultation with the Program Coordinator under the guidance of the Discipline Head. The Program Coordinator will verify the form and submit it to the Discipline Head for forwarding it to the Registrar's office. Such submission might be made online, when and where applicable. The Registrar's office will be responsible for its distribution to relevant authorities (Disciplines and the Controller of Examinations). Course registration will be permitted within five working days at the beginning of each Term. Late registration will be permitted up to the next five working days on payment of a late fee. Student(s) having outstanding dues to the University shall not be permitted to register.

(ii) A student has to register for the backlog/retake/re-retake core courses first followed by the fresh courses offered by the Discipline for the term s/he is going to enroll subject to the compliance with: (i) completion of prerequisite courses (if any) and (ii) maximum credit

registration limit per Term. However, s/he may not choose to register the optional backlog/retake/re-retake courses first.

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

(iv) A student retaking/re-retaking the course will be awarded the immediate lower grade he/she obtains, and this grade will be shown and maintained on the Transcript.

(v) A Discipline/POE will not continue an optional course if less than 30 percent of students (of total seats for that batch) register for that course within ten working days from the beginning of classes. The situation will be solved by dropping that optional course through applying article 10.3 of MS Ordinance by the next five working days. The Coordinator will maintain such records and act accordingly. However, the concerned Discipline/POE might relax this clause for only final term/year optional courses if it is deemed necessary (for example, the studentship will be toward termination or the student will have to wait for additional term/year if the considered optional course(s) are not offered).

20.1.13 Limits on the Credits to be taken in a Term

Discipline Head may allow a student to register up to a maximum of 25 credits if recommended by the Program Coordinator. However, there is no minimum credit limit per Term in Master's level study.

20.1.14 Course Adjustment Procedure

A student will have the option to add or drop course(s) from his/her registration list within fifteen working days from the beginning of classes. This can be done with the advice of the concerned Program Coordinator and consent of the Discipline Head. Adjustment of initially registered courses in any Term can be made by duly filling in the Adjustment Form. The Registrar's office will do the needful.

20.1.15 Withdrawal from a Term

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

20.1.16 Absence in a Term

A student may be absent from continuous assessments (quizzes/class test/field works, etc.) during the Term. Such absences will naturally reduce points/marks, which count towards the final grade. Absence in the Mid Term (if any) and the Term Final Examination will result in 'F' grade. A student who has been absent for short periods, up to a maximum of three weeks due to illness, should request the Course Teacher or Program Coordinator to makeup continuous assessments immediately on returning to the class. A medical certificate should support such request from the Chief Medical Officer of Khulna University. The medical certificate issued by registered medical practitioners (with the registration number shown explicitly on the certificates) and endorsed by the Chief Medical officer of the University will also be acceptable only in those cases where the student has valid reasons for his absence from the University.

20.1.17 Special Term

Students having any retake/re-retake course(s) may apply for a special Term to complete the total required course (maximum 09 credits) in that Term. The special Term will be offered for the final term students who have retake/re-retake courses. The examination will start four (04) weeks after publication of the result and will continue not more than 2 (two) weeks. The marks of both attendance and continuous assessments will be carried over from the previous record.

20.1.18 Registration for Improvement

If any student gets a 'D' to 'C+' grade in any course, s/he may be allowed to repeat that course to improve the grade. The previous grade will be replaced from the grade sheet in such a case.

20.1.19 Backlog

If a student obtains an 'F' grade in any Core course in any term, this 'F' grade will not be counted for Grade Point Average (GPA) but will be shown on the grade sheet, and in such case, he/she will have to retake the course to complete the Degree. If a student does not register for an offered Theory or Sessional course in his/her applicable Term (for example, '0541 12 Math 5101' course in his/her Master's first year first term, '0541 12 Math 5203' course in his/her Master's first year second term, '0541 12 Math 6104' course in his/her Master's second year first term), that course will be considered as a 'Backlog' course for that student in the subsequent terms. If a student gets an 'F' grade in an Optional course, he/she may, subject to availability, choose to take an optional substitute course. In such a case, that substitute course will be deemed as a fresh course. In case of registering for a Backlog Theory or Sessional course, a student has to face/appear/attend 100 marks evaluation, like a fresh course.

20.1.20 Credit Transfer/ Credit Waiver

This ordinance permits credit transfer to facilitate educational mobility. That transfer of credit(s) may be inward or outward. In the case of outward credit transfer, a student of Khulna University has to apply to the Registrar through the Head of the Discipline/POE for

getting a credit transfer certificate. The application must be supported by necessary documents, including a copy of the grade sheet(s). Accordingly, the Registrar will issue a credit transfer certificate mentioning the number of credits already completed at Khulna University.

In case of inward credit transfer, students from other Universities/ Institutions may apply to the Registrar of Khulna University for credit transfer. The application must be supported by necessary documents, including a copy of grade sheet(s) and curriculum. The Registrar's office will forward the application to the concerned Discipline/POE. A three-member committee headed by the Discipline Head and two senior most teachers will assess the application and recommend for approval to the Registrar. The maximum limit of credit transfer from other Universities/ Institutions will be less than or equal to 50 percent of the total credits required to complete the concerned Degree. The final transcript of such students will show only the number of credits transferred.

The same process may be applied for handling the credit waiver related applications. However, the maximum limit of inward credit waiver from other Universities/ Institutions should be less than or equal to 20 percent of the total credits required to complete the concerned Degree.

20.2 Grades

Grade related issues are reported in section 20.1.

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

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

$GPA = \sum CiGi/\sum Ci$

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

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

Then his/her GPA for the term will be computed as follows:

GPA= 3(4.0) + 3(3.0) + 3(3.75) + 2(3.25) + 1(3.5) / (3 + 3 + 3 + 2 + 1) = 3.52

c) A student's performance will be evaluated in terms of three indices- Term Grade Point Average (TGPA), Yearly Grade Point Average (YGPA), and Cumulative Grade Point Average

(CGPA). The TGPA is computed by dividing the total points earned in a Term by the number of credits taken in the Term. The YGPA is computed by dividing the total grade points earned in two Terms in a year by dividing the number of credits taken in that year. The CGPA is computed by dividing the total grade points accumulated till date by the total completed credits. Thus a student who has earned 275 grad points in attempting 100 credits of courses would have an overall CGPA of 2.75.

20.4 Course Withdrawal

a) 'W' is the corresponding grade for withdrawn of a course, as mentioned in section 20.1.1.

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

20.5 Incomplete (I) Courses

'I' is the corresponding grade for an incomplete course, as mentioned in section 20.1.1.

20.6 Retake

Retake related issues are reported in section 20.1.

20.7 Grade Improvement

Grade improvement related issues are reported in section 20.1.

20.8 Dropout/Cancellation of Studentship

Dropout/Studentship cancellation related guidelines of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs, if not conflicting with this Ordinance.

20.9 Publication of Results

(i) The Controller of Examinations will publish the result and preserve all the records for one year after the Degree is awarded. The result will be published subject to completing the required number of credits and fulfilling other requirements (for example, article/paper for 'Master's by Research' mode students) within the stipulated time limit, as applicable.

(ii) A student can have his/her results re-examined by applying to the Controller of Examinations within 30 working days from the date of publication of results. However, s/he has to pay a re-examination fee fixed by the concerned authorities. The Controller of Examinations will take necessary measures regarding the matter in consultation with the Chairman of the Examination Committee. Answer script re-scrutiny and result re-

examination related rules of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs also.

20.10 Subsequent Ordinances

For related/relevant issues, which are not covered (or not cleared) here, provisions of the latest 'Ordinance for Undergraduate Program' and 'Ordinance for Undergraduate Examination' of Khulna University may be consulted and applied, if not conflicting with this Ordinance

References

1. BAC 2021. Bangladesh Accreditation Council (BAC) Standards for Accreditation of Academic Program, BAC, Dhaka.
2. Economics Discipline 2016. Curriculum for BSS (Hons) in Economics Program, Economics Discipline, Khulna University.
3. FWT Discipline 2022. Outcome Based Curriculum for Bachelor of Science (Hon's.) in Forestry, Forestry and Wood Technology (FWT) Discipline, Khulna University
4. IQAC 2022. Template of Outcome-based Curriculum, Institutional Quality Assurance Cell (IQAC), Khulna University.
5. KU 2022a. Ordinance for Undergraduate Examination, Khulna University.
6. KU 2022b. Ordinance for Undergraduate Program, Khulna University.
7. Law Discipline 2021. Program Specification and Curriculum of Bachelor of Laws (LLB Hons.), Law Discipline, Khulna University.
8. UGC 2020. Template of Outcome Based Education (OBE) Curriculum (Revised).
9. UGC 2021. Bangladesh National Qualifications Framework (BNQF) Part B: Higher Education (level 7-10).

Acknowledgement

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

17.	Professor M. Nazrul Islam Department of Chemistry, University of Rajshahi	Expert Member	

List of the concerned stakeholders		
Serial No.	**Name**	**Designation**
1.	Prof. Dr. Mahmood Hossain	Vice chancellor
2.	Prof. Dr. Mosummath Hosna Ara	Pro-Vice chancellor
3.	Prof. Dr. Afroza Parvin	Dean, Science, Engineering and Technology School
4.	Professor Mohammed Ziaul Haider, Ph.D	Director, IQAC
5.	Professor Dr. Md. Matiul Islam	Additional Director, IQAC
6.	Professor Dr. Jagadish Chandra Joardar	Additional Director, IQAC
7.	Md. Mostafizur Rahman	Additional Director, IQAC
8.	Prof. Dr. Md. Rezaul Haque	Member Discipline Curriculum Committee
9.	Dr. Kaykobad Md. Rezaul Karim	Convener, Discipline Curriculum Committee
10.	Dr. Md. Mahiuddin	Member, Discipline Curriculum Committee
11.	Dr. Jamil Ahmed	Member, Discipline Curriculum Committee
12.	Dr. Muhammad Shamim Al Mamun	Member, Discipline Curriculum Committee
13.	Palash Kumar Dhar	Member, Discipline Curriculum Committee
14.	Sumon Chakrabarty	Member Secretary, Discipline Curriculum Committee
15.	Shishir Kumar Dey	Member, Discipline Curriculum Committee
16.	Rumpa Kundu	Member, Discipline Curriculum Committee
17.	Jannatul Naime	Member, Discipline Curriculum Committee
18.	Prianka Saha	Member, Discipline Curriculum Committee
19.	Dr. Md. Ahsan Habib	Member, Discipline Curriculum Committee
20.	Sagar Kumar Dutta	Member, Discipline Curriculum Committee
21.	Md. Abu Rayhan Khan	Member, Discipline Curriculum Committee
22.	Professor Dr. Md. Ahsan Habib	Expert Member, Discipline Curriculum Committee

23.	Professor M. Nazrul Islam	Expert Member, Discipline Curriculum Committee
24.	Md. Habibur Rahman	Employer Office, QC, Essential drugs Company Limited, Gopalganj
25.	Md. Noman Hossain	Employer Vice-Principal, Imperial College of Engineering, Khulna
26.	Md. Mahabubur Rahman	Alumni and craft Instructor, Civil Department, Khulna Polytechnic institute.
27.	Md. Saiful Islam	Alumni and craft Instructor, CMI Department, Khulna Polytechnic institute.
28.	Rokeya Khatun	Alumni and craft Instructor, Civil Department, Khulna Polytechnic institute.
29.	Md. Shakil Anwar	Alumni
30.	Pronoy Gosh	Alumni
31.	Yeasin Arafat Tarek	Alumni and Research Fellow, BCSIR, Dhaka
32.	Uttam Kumar	Alumni
33.	Md. Mahadi Hasan	Alumni
34.	Hasan Md. Ashekul Islam	Alumni and craft Instructor, CST Department, Khulna Polytechnic institute.