Outcome-based Curriculum of
Master of Science in Physical Chemistry

Chemistry Discipline
Khulna University
2022

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PART-A

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

Program Overview	
Type of Program	Mixed Mode
Degree	Master of Science in Physical Chemistry
Abbreviated form of the Degree	MS in Physical 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 to 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

Mission	Description
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

Mission	Description
M1	To provide students with educational and research experience in a specialized branch in Chemistry
M2	To build talent in innovation, self-learning and career competitiveness
M3	To expertise students on experiment designing, execution, analysis and troubleshooting
M5	To contributes in scientific progress and environmental adaptation for socio-economic enhancement

*M = Mission of the Discipline/POE

08. Objectives of the Discipline/POE

Objective	Description
O1	To offer basic as well as 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 Physical Chemistry

10. Description of the Program

The Master of Science in Physical Chemistry program offered by Chemistry Discipline at Khulna University involves coursework to a minimum of 32 credits along with the research work of minimum 18 credits. The duration of the program will be one and half year of full-time study consisting of three terms each of 14 weeks. The student must complete 50 credits to earn his/her degree in Master of Science in Physical chemistry. Bangladesh National Qualifications Framework (BNQF) requires a Master of Science in Physical Chemistry program to complete general education (GEd) course(s) equivalent to at least 10% of the graduating credits, therefore, the students will have to complete one core/compulsory (01 credit) and one optional GEd course (04 credits), respectively. Besides, they will have to complete five departmental core/compulsory theory courses (20 credits), one optional theory course (04 credits), and one sessional course (01 credit). In addition, he/she must complete one In-plant Training or Industrial Tour and Field Visit course (02 credits). In-plant Training Program or Industrial Tour and Field Visit will be completed at any industry by the collaboration of Chemistry Discipline, Khulna University. Moreover, students must take Dissertation Part-I-M (03 credits in first year second term) and Dissertation Part-II-M (15 credits in second year first term) for the partial fulfillment of the dissertation. The detail of the program plan is described in the on-going sections.

11. Graduate Attributes

Attributes	Description	Domain
GA1	Demonstration of depth of specialised disciplinary knowledge and skills and be able to apply them in different contexts to solve problems.	Fundamental
GA2	Annexation of new contexts in selected field through the gathered knowledge and skills	Fundamental
GA3	Ability to apply critical and creative thinking to conceive innovative responses.	Thinking
GA4	Achieving professional behaviour and leadership to role the chosen occupations or careers.	Personal
GA5	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
GA6	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
GA7	Creation of new knowledge and understanding through research and inquiry.	Thinking

*GA = Graduate Attributes

12. Program Educational Objectives (PEOs)

Objectives	Description	Domain
PEO1	To produce graduates having depth knowledge in advanced aspects of physical chemistry and modern experimental techniques.	Fundamental
PEO2	To enable graduates contributing in economic and social impacts through knowledge and innovation	Social
PEO3	Students will be able develop theories about properties of materials, analyze them, and discover their potential use.	Personal
PEO4	The common goal is to discover, test, and understand the fundamental physical characteristics of a material.	Thinking
PEO5	To engage students in problem-solving activities that require analysis, synthesis, and evaluation as a means of testing and strengthening their developing knowledge	Thinking
PEO6	To make the students able to organize, evaluate, summarize, and communicate experimental data and scientific concepts in both written and oral formats.	Personal
PEO7	To develop critical thinking and collaborative skills which will be required in your future professional development.	Personal
PEO8	To prepare well-equipped for either future research within academia or for research and development in industry.	Thinking

*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	Gain theoretical knowledge and practical skills in advanced physical chemistry along with fundamentals of organic, inorganic, and general education
PLO2	Understand the properties of materials, analyze them, and discover their potential use.
PLO3	Comprehend electroanalytical chemistry principles
PLO4	Connect physical chemistry with the other branches of science
B. Social Skills	
PLO5	Participate in a variety of communities, both educational and professional, as well as social networks
PLO6	Spread the results of the investigation through a variety of social platforms
PLO7	Perform effectively in both oral and written forms of communication within their place of employment
C. Thinking Skills	
PLO8	Think critically and analytically, plan and formulate research problems, and independently carry out the necessary experiments and analyze as well as interpret the results.
PLO9	Analyse and provide constructive feedback on a wide range of scholarly publications
D. Personal Skills	
PLO10	Utilize a variety of scientific instruments and software programs for performing chemical analyses
PLO11	Analyse and provide context for experimental results
PLO12	Continuous academic/professional progress shows self-improvement

*PLO = Program Learning Outcome

14. Mapping Mission of the University with PEOs

Missions / **PEOs**	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		
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
First Year First Term												
0531 18 Chem 5101 Spectroscopic Techniques and Application	●		●	●				●	●		●	●
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 5121 Electrodes and Electrochemical Techniques	●	●	●	●					●	●		
0531 18 Chem 5123 Chemical Kinetics and Reaction Dynamics	●			●	●			●	●	●	●	
0531 18 Chem 5125 Surface Properties and Interfacial Contact	●		●	●				●	●	●	●	●
0531 18 Chem 5127 Material Chemistry	●		●					●	●		●	●

Course Code and Course Title	Fundamental Domain				Social Domain			Thinking Domain		Personal Domain		
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
First Year Second Term												
0531 18 Chem 5200 Dissertation Part-I-M: Research Design and Proposal Submission	●			●				●	●		●	●
0531 18 Chem 5221 Polymer Process and Engineering	●	●	●					●	●	●	●	●
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	One and half year having three 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/class/division of 2.50 or Second class.
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

g1) Area-wise Credit Distribution

Master of Science in Physical Chemistry				
Area	Course Type	Number of Courses	Credits	Total Credits
General Education (GEd) Core Courses**	Theory	1	1	13
	Sessional	0	0	
General Education (GEd) Optional Courses**	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**
**18.57% from GEd courses				

*** Thesis, project, internship etc. courses

g2) Category of Courses

Master of Science in Physical Chemistry			
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	-	-
Core/ Compulsory Courses	Theory	1. Polymer Process and Engineering 2. Electrodes and Electrochemical Techniques 3. Chemical Kinetics and Reaction Dynamics 4. Surface Properties and Interfacial Contact 5. Material Chemistry	20
	Sessional	1. In-Plant Training/Industrial Tour and Field Visit 2. Communication Skill Sessional	3
Optional/ Elective Courses	Theory	1. Chemical Analysis and Instrumental Techniques 2. Macromolecular Chemistry 3. Reaction Mechanism and Properties of Coordination Compounds 4. Spectroscopic Techniques and Applications	16
	Sessional	-	0
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 of Science in Physical 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	Optional	4.0	-	4.0	None
0531 18 Chem 5113	Reaction Mechanism and Properties of Coordination Compounds	Optional	4.0	-	4.0	None
0531 18 Chem 5121	Electrodes and Electrochemical Techniques	Core	4.0	-	4.0	None
0531 18 Chem 5123	Chemical Kinetics and Reaction Dynamics	Core	4.0	-	4.0	None
0531 18 Chem 5125	Surface Properties and Interfacial Contact	Core	4.0	-	4.0	None
0531 18 Chem 5127	Material Chemistry	Core	4.0		4.0	None
Total	Core courses:04, Optional courses: 04, Theory courses: 05, Sessional courses: 00		32.0	0	32.0	-
			32.0			

Master of Science in Physical Chemistry

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	-	6.0	3.0	None
0531 18 Chem 5221	Polymer Process and Engineering	Core	4.0	-	4.0	None
0531 18 Chem 5240	Communication Skill Sessional	Core	-	2.0	1.0	
0531 18 Chem 5242	In-Plant Training/Industrial Tour and Field Visit	Core	-	4.0	2.0	
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:04, Optional courses: 03, Theory courses: 02, Sessional courses: 03		17.0	12.0	23.0	
			29.0			
*At least one of these course must be taken to achieve the minimum GED credit limits of 5.0						
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 courses:01, Optional courses: 00, Theory courses: 00, Sessional courses: 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)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	Signify the UV-Visible, IR and Raman spectra	1,3,9
	CLO 2	Realize the importance of fingerprint region in IR	1,3,8
	CLO 3	Get idea about group frequencies	1,9
	CLO 4	Use IR in qualitative and quantitative purpose	3,8,11
	CLO 5	Criticize between IR and Raman spectroscopy	9,11
	CLO 6	Learn about resonance and masss spectroscopy	1,3,11
	CLO 7	Explain deeply about ^{13}C-NMR, ^{19}F-NMR and heteronuclear coupling	1,3
	CLO 8	Explain different terms associated with mass spectroscopy	1,12
	CLO 9	Characterize a compound by NMR, mass and DEPT	3,9,12
	CLO 10	Imply the spectroscopic knowledge in unknown structure elucidation	4,12

Course Contents		**CLOs**
Section A		
1	**UV-Visible Spectroscopy**: The basics, hyperchromic and hypochromic effect, bathochromic and hypsochromic 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–	1-5

	group frequencies, fingerprints, approach towards the analysis of an IR spectra, structural study of simple and complex organic compounds, qualitative and quantitative uses.	
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 based on 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, L. D., & Lampman, M. G., Introduction to Spectroscopy, 5th Edition, 2015. 2. Banwell, N. C., Fundamentals of molecular spectroscopy, 4th Edition, 1972. 3. Hollas, M. J., Modern Spectroscopy, 4th Edition, J. Wiley, 2004. 4. Mukamel, S., Principles of nonlinear optical spectroscopy, 1st Edition, Oxford University, 1995.

Supplementary Readings	1. Barone, V., Computational Strategies for Spectroscopy: from Small Molecules to Nano Systems. 1st Edition, Wiley, 2011.

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
	CLO 2	Make clear explanation about various properties of polymer and their reactions	1
	CLO 3	Analyze different types polymer	7, 10
	CLO 4	Estimate the practical uses of polymer	4, 6

	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), and 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	3

	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	
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. Elzagheid, & Mohamed. Macromolecular Chemistry: Natural and Synthetic Polymers, De Gruyter, 2021. 2. Sun, S. F., Physical chemistry of macromolecules: basic principles and issues. Edition 2nd, Wiley-Interscience, 2004.
Supplementary Readings	1. Gupta, L. A., Polymer Chemistry, Edition 5th, Pragani Publisher, 2014. 2. Davis, F., Polymer Chemistry, Oxford publisher, 2004.

Course Code: 0531 18 Chem 5111	**First Year**	**First Term**
Course Title: Chemical Analysis and Instrumental Techniques		
Course Status: Optional		
Credit: 4.0		
Prerequisite(s): None		
Rationale	Learning different techniques of analysis through various instruments is the basis of this course.	
Course Objectives:	• To comprehend 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 identify details about the absorption and emission spectroscopy

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	Conceptualize fundamentals of separation techniques in chemistry	1
	CLO 2	Explain the basic principles and applications of surface analytical technique	1,8
	CLO 3	Illustrate the importance and use of different types of Instruments	9
	CLO 4	Investigate thermal properties of a compound	4
	CLO 5	Distinguish between fluorescence and phosphorescence	3
	CLO 6	Criticize between different techniques	9
	CLO 7	Imply the spectroscopic knowledge to study various compounds	4,10,11

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	2,7

	(LEED), metastable atom electron spectroscopy (MAES), near edge x-ray absorption fine structure analysis (NEXAFS).	
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. Rouessac, Francis, Rouessac, Annick, Chemical analysis: modern instrumental methods and techniques, 2nd Edition, Wiley, 2007. 2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouc, Fundamentals of Analytical Chemistry, 9th Edition, Cengage learning, 2013. 3. Willard, Merritt, Dean and Settle, Instrumental Methods of Analysis, 6th Edition, Wadsworth publishing company, 1981.
Supplementary Readings	1. David H., Modern Analytical Chemistry, 1st Edition, McGraw-Hill, 1999. 2. Ahuj, S. & Jespersen, N., Modern Instrumental Analysis, Edition 1st, Elsevier Scicence, 2006.

Course Code: 0531 18 Chem 5113	**First Year**	**First Term**
Course Title: Reaction Mechanism and Properties of Coordination Compounds		
Course Status: Optional		
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.	2
	CLO 3	Specify the stabilities of coordination compounds	3
	CLO 4	Clarify the spectroscopic properties of coordination compounds.	3,10
	CLO 5	Illustrate the optical and magnetic properties of coordination compounds	3,6,9

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	2

	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.	
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. Prakash, Satya, Advance Inorganic Chemistry (v.1) S. Chand & Company Ltd. 2008. 2. Cotton, A. F, Wilkinson, G.S. Advanced inorganic chemistry, 6th Edition, John Wiley & Sons, 1999. 3. Guha, S. and Lee, J.D. Concise Inorganic Chemistry, 4th Edition, Wiley India Pvt. Ltd., 2019.

Supplementary Readings	1. Ellan, E. ET AL., Huheey, James, E. & Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, Pearson india, 2006. 2. Malik, Tuli, and Madan, Selected Topics in inorganic Chemistry, Schand, 2010.

Course Code: 0531 18 Chem 5121	**First Year**	**First Term**
Course Title: Electrodes and Electrochemical Techniques		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	Understanding and implementation of different electrochemical techniques	
Course Objectives:	• To understand the importance and instrumentation of electrochemical cells • To provide knowledge of reaction mechanism by different electrochemical techniques • To learn the chemical modification of sensors • To know the reactions of different electrochemical power sources	

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	conceptualize fundamentals of electroanalytical chemistry	1,9
	CLO 2	know about diffusion-controlled reactions, principles and applications of cyclic voltammetry	1
	CLO 3	explain the basic principles and applications of pulse voltammetry and amperometry	1,2
	CLO 4	illustrate the importance and use of different types of electrodes and sensors	4,10
	CLO 5	modify a sensor for the detection of different molecules	3,4
	CLO 6	explain working mechanism of Batteries and fuel cells	4,10

Course Contents		**CLOs**
Section A		
1	**Background:** Electroanalysis, faradaic processes, mass transport-controlled reactions: diffusion, convection, migration; potential step and potential sweep experiments, reactions controlled by the rate of electron transfer, activated complex theory, electrical double layer: solation, ion-pair, Debye-Huckel theory.	1,2
2	**Cyclic Voltammetry:** Cyclic Voltammogram, reversible, irreversible and quasi-reversible systems with single and multi-electron transfer; effects of pH, solvents, concentration and scan rate, solvent and	2

	supporting electrolytes; mechanism of complex reaction: EC, ECE, Randels-Sevsick equation.	
3	**Controlled Potential Techniques:** Pulse voltammetry, square wave and staircase voltammetry, flow analysis, stripping voltammetry.	1, 3
4	**Steady State Amperometry:** Chronoamperometry, current controlled by the kinetics of the redox reactions, electrodes with a diffusion layer of controlled thickness, current limited by kinetics and diffusion in reversible, irreversible and quasi-reversible systems.	2, 3
	Section B	
5	**Metal Electrodes:** Mercury electrodes; rotating-disk and ring-disk electrode; glassy carbon, carbon paste and carbon fiber electrodes; metal electrodes.	4
6	**Chemically Modified Electrodes and Micro Electrodes:** chemically modified electrodes: self-assembled monolayers, sol-gel encapsulation of reactive species, electrocatalytic modified electrode, pre-concentrating electrodes, pre-selective coatings, conducting polymers, microelectrodes: diffusion at microelectrodes, configurations of microelectrodes, composite electrodes.	4
7	**Biosensors (enzyme-based electrodes), Analytical Significance of Enzyme Electrodes:** glucose sensors, ethanol and urea electrodes, toxin (enzyme inhibition) biosensors, and tissue and bacteria electrodes. Affinity biosensors (immunosensors, DNA hybridization biosensors, and receptor-based sensors), gas sensors: carbon dioxide sensors, oxygen electrodes, solid-state devices: micro-fabrication of solid-state sensor assemblies, micro-fabrication techniques, sensor arrays.	4, 5
8	**Electrochemical Power Sources:** Chemical current-producing reactions in batteries, performance of batteries, electrochemical systems, primary batteries, storage batteries, lithium batteries, fuel cells.	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
CLO5	Problem-based Learning and Presentation	Assignment and Final Exam
CLO6	Lecture and Group Discussion	Quiz and Class Test

Learning Materials	
Recommended Readings	1. Brett, A.M.C. & Brett, O. M. A, Electrochemistry: Principles, Methods, and Applications, Oxford University Press Inc., New York, 1994. 2. Smite, M. G. Electroanalytical chemistry: new research, Nova Science Publishers, Inc., New York, 2008. 3. Bagotsky, S. V., Fundamentals of Electrochemistry, 2nd Edition,

	Wiley-Interscience, 2006. 4. Christensen, A. P. & Hamnet, A., Techniques and Mechanisms in Electrochemistry, 1st Edition, Blackie Academic & Professional, 1994.
Supplementary Readings	1. Bard, J. A., & Faulkner, R. L., Electrochemical methods: fundamentals and Applications, John Wiley & Sons, Inc., New York, 2001. 2. Perez, N., Electrochemistry and Corrosion Science, Kluwer Academic Publishers, 2004.

Course Code: 0531 18 Chem 5123	**First Year**	**First Term**
Course Title: Chemical Kinetics and Reaction Dynamics		
Course Status: Core		
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	1,8
	CLO 2	Analyze different techniques of kinetic study	4,11
	CLO 3	Explore various kinds of fast reactions	1,8
	CLO 4	Explore the surfactant based organized media.	
	CLO 5	Evaluate the catalytic activity of different substances.	1,9
	CLO 6	Determine a suitable catalyst for a specific reaction.	5,10

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 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.	5,6
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. Wright, R. M. Introduction to Chemical Kinetics, 1st Edition, Wiley-Interscience, 2004. 2. House, E. J. Principles of chemical kinetics, 2nd Edition, Academic Press, 2007. 3. Missen, W. R., Mims, A. C. and Saville, A. B. Introduction to chemical reaction engineering and kinetics, J. Wiley, 1999. 4. Bamford, C.H. and Tipper, C.F.H, Modern methods in kinetics, Elsevier Science & Technology, 1983.
Supplementary Readings	1. Adamson, W. A. and Gast, P. A., Physical chemistry of surface, 6th Edition, Wiley, 1997. 2. Glasstone, S. Textbook of physical chemistry, 2nd Edition, D. van nostrand company, inc, 1946.

Course Code: 0531 18 Chem 5125	**First Year**	**First Term**
Course Title: Surface Properties and Interfacial Contact		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge about surface chemistry, which will be useful for understand the fact finding on the basis of surface related problem and it's solution	
Course Objectives:	• To get details information about the surface chemistry. • Learn how to characterize a surface. • To understand the basic problems and solution related to surface. • Be acquainted with the techniques to find the composition of a surface.	

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	Compare between surface sensitivity and surface specificity	1,3,9
	CLO 2	Explain the importance of Ultra High Vacuum (UHV).	1,3,8
	CLO 3	Describe different adsorption isotherms.	1,9
	CLO 4	Apply the knowledge of statistical mechanics in adsorption.	3,8,11
	CLO 5	Learn different types of surface reactions	9,11
	CLO 6	Explain the importance of adsorption and way of surface modification	1,3,11
	CLO 7	Explain about Auger electron spectroscopy and its application.	1,3
	CLO 8	Realize the importance of XPS in characterization.	1,12
	CLO 9	Familiar with various forms of IR.	3,9,12
	CLO 10	Compare between different surface analytical techniques.	4,12
	CLO 11	Realize about some modern techniques, e.g., SEM & TEM	10
	CLO 12	Identify and quantify various components of a sample by depth profiling.	1, 8

Course Contents		CLOs
Section A		
1	**Surface Sensitivity and Surface Specificity:** General sensitivity problems, surface sensitive technique, Inelastic mean free path (IMFP) of electrons, UHV (Ultra High Vacuum (UHV), Effects of Gas Pressure.	1,2
2	**Adsorption of Molecules on Surfaces**: Kinetics of adsorption, Adsorption Isotherms, Langmuir, Freundlich, Hinshelwood, BET, Tempkin, Elley-Rideal etc. Adsorption with dissociation, Competitive adsorption, Non-ideal adsorption, thermodynamics and statistical mechanics of adsorption.	3,4,6
3	**Surface Reactions**: Unimolecular surface reactions, Inhibition and Activation. Bimolecular surface reactions, Reactions between two adsorbed molecules, Reaction between an adsorbed molecule and a gas molecule, Adsorption of two gases without mutual displacement, Inhibition, Activation Energies.	5
4	**Wetting and Dewetting Phenomena:** Surface energy, contact angle, hydrophilic and hydrophobic surface, super hydrophobicity, Young's law of contact angle, physical and chemical techniques of surface modification, measurement of surface tension.	6
Section B		
5	**Surface Properties**: Surface growth, role of defects in the growth of surface, surface composition.	5, 6
6	**Surface Analytical Techniques**: Auger Electron Spectroscopy (AES); Principle, instrumentation, application. X-ray Photoelectron Spectroscopy (XPS); Principle, instrumentation, application. Infra-red Spectroscopy; IR Spectroscopy of various forms, RAIRS, MIR, Electron Energy Loss Spectroscopy (EELS), Applications of Vibrational spectroscopy, LEED (low energy electron diffraction); principles and application, Near edge X-ray absorption fine structure analysis (NEXAFS); basic principle and application.	7,8,9,10
7	**Surface Imaging and Depth Profiling**: Basic Concepts in Imaging & Localised Spectroscopy, Electron Microscopy (SEM & TEM), Imaging XPS, SIMS Imaging & Depth Profiling, Auger Depth Profiling, Scanning Probe Microscopy (STM/AFM).	11,12

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
CLO 11	Problem-based Learning and Presentation	Assignment and Final Exam
CLO 12	Problem-based Learning and Presentation	Assignment and Final Exam

Learning Materials	
Recommended Readings	1. Butt, J. H. Graf, K. and Kappl, M. Physical and Chemistry of Interfaces, Wiley, 2003. 2. Somorjai, A. G. Introduction to Surface Chemistry and Catalysis, Wiley, 1994. 3. Erbil, Y. H. Surface Chemistry of Solid and Liquid Interfaces, Edition 1, Wiley-Blackwell, 2006. 4. Vabderah, A. T. Chemistry of superconductor Materials Preparation, Chemistry, Characterization and Theory, William Andrew, 1993.
Supplementary Readings	1. Brandon, G. D. and Kaplan, D. W. Microstructural Characterization of Materials, Wiley, 1999. 2. Barabasi, L. A. and Stanley, E. H. Fractal Concepts in Surface growth, Press Syndicate of the University of Cambridge, 1995. 3. Pecharsky, V. and Zavalij, P. Fundamentals of Powder Diffraction and Structural Characterization of Materials, Spinger, 2005.

Course Code: 0531 18 Chem 5127	**First Year**	**First Term**
Course Title: Material Chemistry		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge about material chemistry, which will be useful for understand the fact finding on the basis of crystal, crystal defect and characteristic properties of crystal related problem and it's solution	
Course Objectives:	• To get details information about the material chemistry. • Learn how to characterize crystalline materials. • To understand the basic problems and solution related to crystal properties. • Be acquainted with the techniques to find the composition of a crystal surface.	

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	Realize the general aspect of material science in chemistry	1,3,9
	CLO 2	Identify the characterization process of crystalline solid	1,3,8
	CLO 3	Describe the symmetry of the crystal elements	1,9
	CLO 4	Apply the knowledge about understanding the crystal defect of different crystalline elements	3,8,11
	CLO 5	Learn theoretical application of crystal	9,11
	CLO 6	Realize the importance of electronic and magnetic properties of solids	1,3,11
	CLO 7	Identify about microporous and mesoporous materials	1,3
	CLO 8	Realize the importance of ceramics and polymers.	1,12
	CLO 9	Familiar with semiconductor devices	3,9,12
	CLO 10	Recognize about Advanced materials including Biomaterials	1

Course Contents		**CLOs**
Section A		
1	**Review:** General aspect of material science in chemistry, microstructure of materials, development of microstructure in iron-carbon alloys, particle-reinforced polymer-matrix composites materials, advanced materials and its application.	1
2	**Materials Characterization:** Crystalline solids; crystal systems, Bravais lattices, coordination number , packing factors; cubic, hexagonal, diamond structures, lattice planes; miller indices, interplanar distances, directions, Types of bonding; lattice energy, Madelung constants, Born Haber cycle, cohesive energy. Symmetry elements; operations, translational symmetries , point groups , space groups, equivalent positions, close packed structures; voids important crystal structures, Paulings rules , defects in crystals, polymorphism and twinning.	2,3
3	**Crystal Defects**: Point defects-types of point defects-thermodynamics of point defects, geometry of dislocations, evidence of dislocations, grain boundaries-atomics structure of grain boundaries.	4
4	**Electronic and Magnetic Properties of Solids:** Free electron theory of metals, Drude theory, Wiedemann-Franz Law and Lorentz number; free electron statistics (Fermi-Dirac), density of states, Sommerfeld theory; concentration, chemical potential, Fermi energy and specific heat of free electrons, Boltzmann transport theory; electrical and thermal conductivity	5,6

	of electrons, small particle magnetism, magnetic anisotropy, magneto crystalline anisotropy, shape anisotropy, single domain particles, superparamagnetism, blocking temperature, effect of inter particle interaction and surface effects, spin polarized charge transport, giant magneto resistance, tunneling magneto resistance.	
Section B		
5	**Microporous and Mesoporous Materials:** Zeolites, metallosilicates, silicalites and related microporous materials: synthesis and characterizations, metallo phosphates/phosphonates, incorporation of heteroelements in microporous inorganic frameworks and their potential utilities, mesoporous silica, metal oxides and related functionalized mesoporous materials: synthesis, characterizations and support for metallic nanoparticles.	7
6	**Ceramics and Polymers**: Oxide ceramics; zirconia, alumina, silica, magnesia and, titania, mullite, carbide; vsilicon carbide, boron carbide, tungsten carbide, titanium carbide, nitride; silicon nitride, boron nitride, titanium nitride, borides, silicides, sialon, ceramic insulators and capacitors; ferroelectric ceramics; barium titanate, PZT, PLZT materials, magnetic ceramics, spinel ferrites, zinc ferrites, garnets, superconducting ceramics, varistors and fuel cells, polymer conformation and chain dimensions; freely oriented perpendicular chains, Gaussian model; amorphous state, glass transition temperature, the crystalline state, ordering of polymer chains, crystalline melting temperature, techniques to determine crystallinity, mechanical properties; introduction to viscoelasticity, dynamic mechanical analysis, mechanical models of viscoelastic behavior, Boltzmann superposition principle; introduction to rubber elasticity	6, 8
7	**Semiconductor Devices and Electronics**: Introduction physics of materials, confinement and quantization, Fermi-Dirac statistics energy bands in solids, the E-k diagram, density of states, bands: free electron and tight binding approximation occupation probability, carried concentration, fermi level and quasi-fermi levels, fermi energy, fermi surface semiconductor materials, bandgap modification, heterostructures, lattice matching, strained layer epitaxy and quantum well structures heterostructure p-n junction, schottky junction and ohmic contacts, physics of nano scale materials, metal-semiconductor contacts, ohmic contacts on semiconductors, fermi level pinning, schottky barrier diodes, causes of non-idealities-Schottky barrier diodes.	5,6,9
8	**Advanced Materials Including Biomaterials:** Composites, metal matrix composites; polymer matrix composites, ceramic matrix composites, reinforcements; whisker reinforced ceramics ; carbon-carbon composites; design of composite materials, hybrid composites, angled plied composites, unidirectional fiber composites, discontinuous fiber composites, applications of composites in electrical components and nuclear industry.	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	Assignment and Final Exam

	Presentation	
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. Dronskowski, R. Computional Chemistry of Solid State Materials, Edition 1st , Willey, 2005. 2. Theraja, B.L., Theraja, A.K. and Thrnekar, S.G. A Textbook of Electrical Technology Volume I, 1st Edition, S. Chand & Company LTD., 2005. 3. Askeland, D. R., Fulay, P.P and Wright, J.W. The Science and Engineering of Materials, 6th Edition, Cengage learning, 2010. 4. Mendes, G. and Editors, L. B. Strength of Materials, Nova Science Publishers, Inc., 2009. 5. Erbil, Y. H. Surface Chemistry of Solid and Liquid Interfaces, Edition 1, Wiley-Blackwell, 2006. 6. Vabderah, A. T. Chemistry of superconductor Materials Preparation, Chemistry, Characterization and Theory, William Andrew, 1993.
Supplementary Readings	1. Brandon, G. D. and Kaplan, D. W. Microstructural Characterization of Materials, Wiley, 1999. 2. Barabasi, L. A. and Stanley, E. H. Fractal Concepts in Surface growth, Press Syndicate of the University of Cambridge, 1995. 3. Pecharsky, V. and Zavalij, P. Fundamentals of Powder Diffraction and Structural Characterization of Materials, Spinger, 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: 08		
Prerequisite(s): None		
Rationale	Selection of convenient methods and tentative outcomes	
Course Objectives:	• Able to compare of various methods • Able to select the suitable method • Outcome of expected results	

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 of new methodology	1, 4, 12
	CLO 2	Analysis of the expected results	1, 8, 11
	CLO 3	Comparison of the results with other studies	8, 9

	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 Oral presentation	Literature review, Design of methodology

Learning Materials	
Recommended Readings	1. Fernandez, V. Fundamentals of Research Methodology, 1st Edition, OmniaScience, 2020 2. Shanti Bhushan Mishra, S.B. and Alok, S. Handbook of Research Methodology, 1st Edition, Educreation, 2017
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. Creswell, J.W. Research design: Qualitative, quantitative and mixed methods approach, 5th Edition, Thousand Oaks, CA: Sage, 2018.

Course Code: 0531 18 Chem 5221	**First Year**	**Second Term**
Course Title: Polymer Process and Engineering		
Course Status: Core		

Credit: 4.0	
Prerequisite(s): None	
Rationale	The course is designed to illustrate the practice of polymer processing
Course Objectives:	• To provide the basics of physical properties of polymer • To illustrate the polymer processing and reaction dynamics • To investigate the rheology of polymer chains

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	achieve the knowledge of physical properties of polymer	1,8
	CLO 2	realize and utilize the theories of polymer-processing operations	2,9
	CLO 3	exploit the rheological behavior of polymer material	10,11
	CLO 4	analyze and apply chemical kinetics in treating polymer-processing operations	3,8
	CLO 5	intelligently link between processing and polymer structural characteristics	12

	Course Contents	**CLOs**
	Section A	
1	**Introduction to Polymer:** Classification by processability, structural characteristics, molecular weight, effect of temperature, brunching, crosslinking, polarity, flexibility, crystalinity and orientation	2
2	**Chemical Reaction Kinetics in Polymer Systems:** Kinetics of condensation polymerization, free-radical addition polymerization, nonradical addition polymerization, copolymerization, mass transfer in polymer systems: diffusion and solution, diffusibility and solubility of gas in polymer	1
3	**Aspects of Polymerization Processes:** Bulk (batch reactor), bulk (continuous reactor), solution, suspension, emulsion, interfacial polycondensation, solid-state polycondensation	1,2
4	**Applied Polymer Rheology:** Fluid behavior, stress-strain curve, stress-shear rate curve, modulus, reynolds number, isothermal and non-isothermal flow of molten or thermally softened polymers in circular and non-circular condition, flow rates and pressure drops, factors affecting flow results	3,5
	Section B	
5	**Extrusion:** Basics principle, different types of extruders, solids-conveying section, melting, plasticating section, metering section, design and operating principles for extruders, twin and multiple screws, vented extruders	2
6	**Injection-Molding Systems:** Basic principle, the plastic flow path, injection-molding process analysis, injection-molding product problems, specialized injection molding processes, rotational molding, blow	5

	molding, transfer molding, compression molding operations	
7	**Some Processing Operations:** Calendering, thermoforming, and casting, synthetic fibers, fiber requirements and spinnability, role of transport phenomena, melt spinning, dry spinning, wet spinning, reaction spinning	2
8	**Interrelation of Polymer Processing, Structure and Properties:** Orientation, crystallinityin processing operations, chain flexibility, reinforcements, and blends	1,2,5

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. Hiemenz C. P. Polymer chemistry: the basic concept, illustrated edition, M. Dekker, 1984. 2. Ferrante, L. Handbook of applied polymer processing technology, 1st Edition, CRC press, 1996. 3. Denn, M. M. Polymer melt processing: Foundations in fluid mechanics and heat transfer, Cambridge University Press, 2008. 4. Gaspar-cunha, A. and Covas, A.J. Optimization in polymer processing, Nova Science Pub Inc, 2011. 5. Griskey, G. R., Polymer process engineering, 1st edition, Springer Netherlands, 1995.
Supplementary Readings	1. Dufresne, A., Thomas, S. Pothan, A. L., Grossman, F.R. and Nwabunma, D. Biopolymer nanocomposites: Processing, properties, and appliation, 1st Edition, Wiley, 2013. 2. Meyer, T. and Keurentjes, J. Handbook of polymer reaction engineering, 1st Edition, Wiley-VCH, 2005.

Course Code: 0531 18 Chem 5240	**First Year**	**Second Term**
Course Title: Communication Skill Sessional		
Course Status: Core		
Credit: 02		
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

	CLO 3	Improve himself or herself as a skilled person	12

	Course Contents	**CLOs**
	Scientific works presentation, group communication, 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

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)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	adapt with the industrial working environment	5
	CLO 2	maintain communication about multiple subjects and with multiple audiences	5,7
	CLO 3	operate different chemical instruments	1,3,10,11
	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	5,7,10
	CLO 7	monitor completion of allocated tasks	5,9
	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	12

		appropriate person, with possible causes	
	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 arrange in first year second term, which will be completed at any industry by the joint collaboration of Chemistry Discipline, Khulna University.	1-10

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	

Course Code: 0531 18 ChE 5251	**First Year**	**Second Term**
Course Title: Chemical Weapons Convention and Basics of Chemical Hazards 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)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	Realize 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	Realize how to control the hazardous materials and chemical accidents	6
	CLO 4	Learn how chemical weapon can be prohibited.	9

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.	2
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

Learning Materials	
Recommended Readings	1. Noyes, R. Chemical Weapons Destruction and Explosive Waste Unexploded Ordinance, William Andrew, 1997. 2. Robinson, J.P. Public Health Response to Biological and Chemical Weapons: WHO Guidance, 2nd Edition. World Health Organization, 2005. 3. Matousek, J. Kolodkin, V.M. and Ruck, W. Ecological Risks Associated with the Destruction of Chemical Weapons, 1st Edition. Springer Netherlands
Supplementary Readings	1. Mesilaakso, M. Chemical Weapons Convention Chemicals Analysis: Sample Collection, Preparation and Analytical Methods, 1st Edition. Wiley, 2005. 2. James, A. Romano, Jr., Lukey, J.B. and Salem, H. Chemical Warfare Agents, 2nd Edition. CRC Press, 2008.

	3. Crippin, B.J. Explosives and Chemical Weapons Identification, 1st Edition. CRC Press, 2005.

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)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	learn the scientific background of energy conversion, storage and consumption	1,9
	CLO 2	realize 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	1,8
	CLO 4	become intellectual in new developments of renewable energy studies	4,5
	CLO 5	attain knowledge in green energy technologies	10

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	2,3,5

	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	
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: Core		
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)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	Discuss about the types of waste and waste disposal methods	1, 2, 4
	CLO2	Develop different methods for updating solid waste collection, separation and control skills and know the current industrial environmental status.	4, 8
	CLO 3	Apply the principles of waste minimization, source reduction, material use and recovery in the design of solid and hazardous waste management systems.	3, 5, 6, 8, 9
	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, effect of modern agrotechnology, industrial pollution hazards in Bangladesh.	1,2
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,	1, 2

	biomedical waste, hazardous waste and health, hazardous waste in the geosphere, hydrosphere, atmosphere and biosphere, Nuclear waste.	
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: 0411 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)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		Mapping with PLOs
	CLO 1	Analyze and apply career concepts for the development of one's career in HR sector.	1, 7
	CLO 2	Analyze and evaluate applications of the career management model: a guide to career exploration, explain techniques for effective self-exploration programs.	5, 6, 7
	CLO 3	Explain applications of the career management model: goals, strategies, and appraisal.	5, 12
	CLO 4	Explain guidelines for effective occupational decision-making.	6, 12
	CLO 5	A workshop on career planning.	7
	CLO 6	Analyze organizational actions during mid-career, and apply organizational actions during late-career.	8
	CLO 7	Explain and evaluate sources and consequences of stress.	12
	CLO 8	Explain intersection of work and family roles: implications for career management, evaluate quality of life in two career families.	5, 7
	CLO 9	Develop and apply model of organizational fairness.	6
	CLO 10	Compare integration of career management	12

		with human resource system.	

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.
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-M: 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

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO 1	Generate of new idea for the synthesis of novel materials	1, 2, 3, 4, 8, 9
	CLO 2	Correlate the results with the demand of stakeholders	5
	CLO 3	Application of the for human welfare	6, 8, 11

	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, Report writing, Viva-voce

Learning Materials	
Recommended Readings	3. Fernandez, V. Fundamentals of Research Methodology, 1st Edition, OmniaScience, 2020 4. Shanti Bhushan Mishra, S.B. and Alok, S. Handbook of Research Methodology, 1st Edition, Educreation, 2017 5. Kate L. Turabian, K.L., Booth, W.C., Colomb, G.G. Joseph M. Williams, J.M., Bizup, J. and FitzGerald, W.T. A Manual for Writers of Research Papers, Theses, and Dissertations, 9th Edition, University of Chicago Press, 2018
Supplementary Readings	5. Davis, H.B. Tyson, J.F. Pechenik, J.A. A Short Guide to Writing about Chemistry, Addison-Wesley, Boston, MA, 2010. 6. Boudah, D.J. Conducting educational research: Guide to Completing a thesis, dissertation, or action research project, 2nd Edition, Thousand Oaks, CA: Sage, 2020. 7. Pan, M.L. Preparing literature reviews: qualitative and quantitative approaches, Pyrczak Publishing, 2013. 8. Creswell, J.W. Research design: Qualitative, quantitative and mixed methods approach, 5th Edition, Thousand Oaks, CA: Sage, 2018. 9. 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.

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(s) 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 in one Term for proposal development, and Dissertation Part-II in another term for completing the Dissertation. The total credit for the Dissertation will be between 15 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 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.

(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 01/02 credit(s) 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

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Economics Discipline 2016. Curriculum for BSS (Hons) in Economics Program, Economics Discipline, Khulna University. pp. 1-190.

FWT Discipline 2022. Outcome Based Curriculum for Bachelor of Science (Hon's.) in Forestry, Forestry and Wood Technology (FWT) Discipline, Khulna University

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KU 2022a. Ordinance for Undergraduate Examination, Khulna University. pp. 1-13.

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Law Discipline 2021. Program Specification and Curriculum of Bachelor of Laws (LLB Hons.), Law Discipline, Khulna University. pp. 1-120.

UGC 2020. Template of Outcome Based Education (OBE) Curriculum (Revised). pp. 1-8.

UGC 2021. Bangladesh National Qualifications Framework (BNQF) Part B: Higher Education (level 7-10). pp. 1-29.

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.