

Department of Chemistry

Phone: 041-9203038

Email: chemistry@gcuf.edu.pk



Programs Offered

1. BS Chemistry
2. MPhil (Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry)
3. PhD Chemistry

Chairman: Prof. Dr. Khalid Mahmood Zia



Vision

To promote quality research in various branches of Chemistry. To promote industrially viable research to strengthen university-industry linkages. To provide students a healthy environment based on curricular and co-curricular activities. To provide well-groomed and highly trained individuals to the society.

Mission

Chemists are the pioneers of modern age. The mission of the Department of Chemistry is to be a benchmark in the "Knowledge Based Study & Value-Added Research". The faculty of the department enthusiastically endorses the slogan of the university "Striving for the excellence". The department aims to stimulate high quality academic and research culture to enrich the society with top class teachers, researchers, entrepreneurs and above all the civilized citizens. The Department of Chemistry is deeply engaged to produce highly qualified and skilled chemists to establish liaison between the academia and industry. We foresee a bright future of our chemists in all areas of life where they deem fit to perform.

Introduction

The modern chemistry boomed and flourished in the era of 20th century. It is renowned markedly as an era of modern chemistry. The significant number of chemists (188) have consecrated with the title of "Nobel laureates" all over the world. Their contribution towards chemistry is deemed as "the greatest benefit to humankind" since 1901 to present. Now days, chemistry is dominating in each component of our

lifestyle. The Department of Chemistry was established in 2002 with the emergence of Government College University Faisalabad. It is located in Sir Syed block at New Campus. A wide and attractive piece of landscape with spacious, ventilated, lecture rooms and theater halls beaming with the natural light. It is glorified with well-equipped general laboratories for all the specializations offered by the department. More than 900 students of undergraduate, postgraduate and doctorate studies are enrolled in the department. The curriculum of all offered degrees is coherent under the guidelines of Higher Education Commission (HEC), Pakistan. New courses are being developed and offered persistently in order to acquaint our students with the recent developments in the subject. The department aims to launch our students to meet the national and international challenges in the field of chemistry. Our graduates are catering the requirements of industry, public and private research sectors. They have been recognized as successful entrepreneurs. The research activities are also flourishing in the department with the large number of ongoing research projects funded by the national and international funding agencies. Faculty of department has won more than 25 competitive research projects worth 80 million PKR on their credit.

Faculty

Prof. Dr. Khalid Mahmood Zia

Professor / Chairman

PhD (Pakistan), BIMS (Australia)

Specialization: Physical Chemistry, Polymer Chemistry, Textile Chemistry, Bionanocomposites

Prof. Dr. Muhammad Kaleem Khan Khosa

Professor
PhD (Pakistan), Post Doc. (UK)
Specialization: Material Chemistry, Organo Transition Metal Chemistry

Prof. Dr. Abdullah Ijaz Hussain

Professor
PhD (Pakistan), Post Doc. (Malaysia)
Specialization: Analytical Chemistry, Pharmaceuticals & Nutraceuticals

Prof. Dr. Ameer Fawad Zahoor

Professor (Tenured)
PhD (Germany)
Specialization: Organic Synthesis, Drug Discovery

Prof. Dr. Nasir Rasool

Professor (Tenured)
PhD (Germany)
Specialization: Synthesis of Natural Products, Medicinal Chemistry, Homogeneous Catalysis

Prof. Dr. Syed Ali Raza Naqvi

Professor (Tenured)
PhD (Pakistan)
Specialization: Bio-Analytica, Nuclear Medicine Chemistry

Prof. Dr. Matloob Ahmad

Professor (Tenured)
PhD (Pakistan)
Specialization: Organic Chemistry, Synthetic Organic chemistry, Heterocyclic Compounds

Prof. Dr. Muhammad Asghar Jamal

Professor
PhD (Pakistan)
Specialization: Physical Chemistry, Solution Chemistry

Prof. Dr. Muhammad Zubair

Professor
PhD (Pakistan), Post Doc. (Canada)
Specialization: Organic Chemistry

Prof. Dr. Muhammad Ramzan Saeed Ashraf Janjua

Professor
PhD (China), Post Doc. (Portugal), MBA (PIMSAT)
Specialization: Physical Chemistry, Computational Chemistry

Prof. Dr. Shahzad Ali Shahid Chatha

Professor
PhD (Pakistan), Post Doc. (Canada)
Specialization: Analytical Chemistry / Natural Products / Environmental / Material Chemistry

Prof. Dr. Asim Mansha

Professor (Tenured)
PhD (Austria), Post Doc. (Austria)
Specialization: Physical Chemistry / Computational Chemistry

Prof. Dr. Tanveer Hussain Bokhari

Professor (Tenured)
PhD (Pakistan), Post Doc. (USA)
Specialization: Inorganic Chemistry / Radiochemistry

Dr. Zulfiqar Ali Khan

Associate Professor (Tenured)
PhD (UK), Post Doc. (Canada)
Specialization: Organic Chemistry

Dr. Muhammad Usman

Associate Professor (Tenured)
PhD (Pakistan)
Specialization: Physical Chemistry

Dr. Majid Muneer

Associate Professor (Tenured)
PhD (Pakistan), Post Doc (KSA)
Specialization: Physical Chemistry, Radiation Chemistry

Dr. Muhammad Saeed

Associate Professor (Tenured)
PhD (Pakistan)
Specialization: Physical Chemistry (Heterogeneous Catalysis)

Dr. Atta ul Haq

Associate Professor (Tenured)
PhD (Pakistan)
Specialization: Analytical Chemistry

Dr. Shazia Tabassum

Associate Professor
PhD (Pakistan)
Specialization: Organic Chemistry

Dr. Kulsoom Ghulam Ali

Associate Professor
PhD (Pakistan)
Specialization: Inorganic Chemistry

Dr. Kiran Aftab

Associate Professor
PhD (Pakistan)
Specialization: Analytical Chemistry

Dr. Saima Rehman

Associate Professor
PhD (Pakistan)
Specialization: Physical Chemistry

Dr. Samreen Gul Khan

Associate Professor (TTS)
PhD (Pakistan)
Specialization: Analytical Chemistry

Dr. Fozia Anjum

Assistant Professor (TTS)
PhD (Pakistan)
Specialization: Analytical Chemistry

Dr. Nadia Akram

Assistant Professor (TTS)
PhD (Pakistan)
Specialization: Physical Chemistry (Polymer / Composite materials / Soft matter)

Dr. Tahir Maqbool

Assistant Professor
PhD (Pakistan)
Specialization: Organic Chemistry

Dr. Bushra Parveen

Assistant Professor
PhD (Pakistan)
Specialization: Inorganic Chemistry

Dr. Akber Ali

Assistant Professor (TTS)
PhD (Brazil)
Specialization: Synthetic Organic Chemistry

Dr. Zumaira Siddique

Assistant Professor (OPS)
PhD (Pakistan)
Specialization: Physical Chemistry

Dr. Faiz Ahmed

Assistant Professor (OPS)
PhD (Pakistan)
Specialization: Organic Chemistry

**Dr. Ayesha Malik**

Assistant Professor (OPS)

PhD (Pakistan)

Specialization: Organic Chemistry

Ms. Javeria Rehman

Lecturer (On study Leave)

M.Phil (Pakistan)

Specialization: Analytical Chemistry

Scheme of Studies BS Chemistry

Semester 1		
CHM-301	Principles of Inorganic Chemistry	4(3 - 1)
ENG-321	Functional English	3(3 - 0)
ICT-321	Applications of Information & Communication Technologies	3(3 - 0)
MTH321/ BOT-303	Algebra and Trigonometry/ Functional Biology-I	3(3 - 0) 3(3 - 0)
ISL-321 / ETH-322	Islamic Studies / Ethics *	2(2 - 0)
QTR-421	Quantitative Reasoning-I	3(3-0)
UHQ-I	Understanding of Holy Quran-I	1(0-1)
Students with pre-engineering background will take Functional Biology-I and students with premedical will take Algebra and Trigonometry		
Semester 2		
CHM-302	Principles of Organic Chemistry	4(3 - 1)
ENG-322	Expository Writing	3(3 - 0)
ICP-321	Ideology and Constitution of Pakistan	2(2 - 0)
MTH-322 ZOL-307	Introduction to Calculus / Functional Biology-II	3(3 - 0) 3(2 - 1)
CHM-303	Introduction to Nanochemistry	2(2-0)
CCE-421	Civics and Community Engagement	2(2-0)
PST-321	Pakistan Studies	2(2 - 0)
Students with pre-engineering background will take functional Biology-II and students with premedical will take Introduction to Calculus		
Semester 3		
CHM-401	Principles of Physical Chemistry	4(3 - 1)
QTR-422	Quantitative Reasoning-II	3(3-0)
IRS-515	Introduction to International Relations	2(2-0)

CHM-403	Principles of Environmental Chemistry	3(3 - 0)
CHM-405	Cheminformatics and Chemometrics	3(3-0)
PHY-322	Fundamentals of Electricity and Magnetism	3(2-1)
UHQ-II	Understanding of Holy Quran-II	1(0-1)
Semester 4		
CHM-402	Principles of Analytical Chemistry	4(3 - 1)
GSC-321	The Science of Global Challenges	3(2-1)
BCH-303	Essentials of Biochemistry-I	3(3-0)
CHM-404	Principles of Industrial Chemistry	3(3 - 0)
CHM-406	Principles of Green Chemistry	3(3-0)
ENT-422	Entrepreneurship	2(2-0)
Semester 5		
CHM-501	Inorganic Chemistry - I	4(3 - 1)
CHM-503	Organic Chemistry - I	4(3 - 1)
CHM-505	Physical Chemistry - I	4(3 - 1)
CHM-507	Analytical Chemistry - I	4(3 - 1)
Semester 6		
CHM-502	Inorganic Chemistry - II	4(3 - 1)
CHM-504	Organic Chemistry - II	4(3 - 1)
CHM-506	Physical Chemistry - II	4(3 - 1)
CHM-508	Analytical Chemistry - II	4(3 - 1)
Semester 7		
Specialization in Analytical Chemistry		
INT-631	Internship/ Field Experience	3(0-3)
CHM-601	Electroanalytical Techniques	4(3-1)
CHM-603	Advanced Separation Techniques	4(3-1)
CHM-605	Advanced Atomic Spectroscopy	4(3-1)
Specialization in Inorganic Chemistry		
INT-631	Internship/ Field Experience	3(0-3)
CHM-611	Main Group Organometallic and Organic Reagents	4(3-1)
CHM-613	Spectroscopic Methods in Inorganic Chemistry	4(3-1)
CHM-615	Organo-Transition Metal Compounds	4(3-1)
Specialization in Organic Chemistry		
INT-631	Internship/ Field Experience	3(0-3)
CHM-621	Spectroscopic Methods in Organic Chemistry	4(3-1)
CHM-623	Rearrangements and Pericyclic Reactions	4(3-1)

CHM-625	Pharmaceutical Chemistry	4(3-1)
Specialization in Physical Chemistry		
INT-631	Internship/ Field Experience	3(0-3)
CHM-631	Advanced Reactions Kinetics	4(3-1)
CHM-633	Advanced Spectroscopy in Physical Chemistry	4(3-1)
CHM-635	Material Chemistry	4(3-1)
Semester 8		
Specialization in Analytical Chemistry		
CHM-602	Thermal Methods of Analysis	3(3 - 0)
CHM-604	Nuclear Analytical Techniques	3(3 - 0)
CHM-606	Food and Drug Analysis	3(3 - 0)
CHM-608	Molecular Spectroscopy	3(3 - 0)
CHM-610	Advanced Analytical Chemistry Lab	2(0 - 2)
CAP-630	Capstone Project	3(0-3)
Specialization in Inorganic Chemistry		
CHM-612	X-ray Spectroscopy	3(3 - 0)
CHM-614	Homogeneous Catalysis	3(3 - 0)
CHM-616	Radioactivity and Nuclear Chemistry	3(3 - 0)
CHM-618	Magneto Chemistry	3(3 - 0)
CHM-620	Advanced Inorganic Chemistry Lab	2(0 - 2)
CAP-630	Capstone Project	3(0-3)
Specialization in Organic Chemistry		
CHM-622	Organic Polymers	3(3 - 0)
CHM-624	Reactive Intermediates and Photochemistry	3(3 - 0)
CHM-626	Disconnection Approach	3(3 - 0)
CHM-628	Organic Catalyst and Protective Group	3(3 - 0)
CHM-632	Advanced Organic Chemistry Lab	2(0 - 2)
CAP -630	Capstone Project	3(0-3)
Specialization in Physical Chemistry		
CHM-634	Group Theory and Solution Chemistry	3(3 - 0)
CHM-636	Statistical and Quantum Mechanics	3(3 - 0)
CHM-638	Nuclear and Radiation Chemistry	3(3 - 0)
CHM-640	Electrochemical Aspects of Solutions	3(3 - 0)
CHM-642	Advanced Physical Chemistry Lab	2(0 - 2)
CAP -630	Capstone Project	3(0-3)

*Religious Education / Ethics in lieu of Islamic Studies

Deficiency Courses For Bridging Zero Semester

CHM-421	Basic Analytical Chemistry	3(2 – 1)
*MTH-321 BOT-303	Algebra and Trigonometry OR Functional Biology-I	3(3 – 0)
CHM-406	Industrial Chemistry	3(3 – 0)
CHM-403	Basic Environmental Chemistry	3(3-0)
CSI-422	Computer Applications and Web-II	3(3 – 0)
BCH-303	Essentials of Biochemistry-I	3(3-0)
*Students with botany and zoology combination will take Algebra and Trigonometry and students with combination of Physics and Mathematics will take functional Biology		

MPhil / PhD Chemistry

Inorganic Chemistry		
CHM-701	Solid State Chemistry	3(3 – 0)
CHM-702	Photochemical Reactions of Transition Metals	3(3 – 0)
CHM-703	Applied Transition Metal Catalytic Chemistry	3(3 – 0)
CHM-704	Chemistry of Organometallic Compounds	3(3 – 0)
CHM-705	Inorganic Electronic Spectroscopy	3(3 – 0)
CHM-706	Kinetics and Mechanism of Inorganic Reactions	3(3 – 0)
CHM-707	Bio-Inorganic Chemistry	3(3 – 0)
CHM-708	Advanced Nano Chemistry	3(3 – 0)
CHM-709	Applied Spectroscopy	3(3 – 0)
CHM-710	Extractive Metallurgy	3(3 – 0)
CHM-711	Metal Based Drugs	3(3 – 0)
CHM-712	Medicinal Inorganic Chemistry	3(3 – 0)
CHM-713	Advanced Thermal Analysis	3(3 – 0)
CHM-714	Metal Complexes in Cancer Chemotherapy	3(3 – 0)
CHM-715	Inorganic Cage Compounds	3(3 – 0)
CHM-716	Inorganic Polymers	3(3 – 0)
CHM-717	Radiochemistry	3(3 – 0)
CHM-718	Chemistry of Advanced Materials	3(3 – 0)
CHM-719	Diffraction Method of Analysis	3(3 – 0)
CHM-720	Advanced Atmospheric Chemistry	3(3 – 0)
CHM-721	Modern Surface Catalysis & Kinetics	3(3 – 0)
Analytical Chemistry		
CHM-731	Advanced Research Methodology	3(3 – 0)
CHM-732	Advanced Gas Chromatography	3(3 – 0)

CHM-733	Advanced Liquid Chromatography	3(3 – 0)
CHM-734	Smart Structures: Analysis and Design	3(3 – 0)
CHM-735	Mass Spectrometric Analysis	3(3 – 0)
CHM-736	Advanced Emission Spectroscopy	3(3 – 0)
CHM-737	Laser and Luminescence Spectroscopy	3(3 – 0)
CHM-738	Analytical Aspects of NMR Spectroscopy	3(3 – 0)
CHM-739	Radiopharmaceutical Analysis	3(3 – 0)
CHM-740	Radio-Analytical Methods of Analysis	3(3 – 0)
CHM-741	Modern Extraction Techniques	3(3 – 0)
CHM-742	Surfaces and Thin film Analysis	3(3 – 0)
CHM-743	Modern Analysis for Process Industries	3(3 – 0)
CHM-744	Techniques for Polymer Analysis	3(3 – 0)
CHM-745	Environmental Impact of Chemical Industries	3(3 – 0)
CHM-746	X-Rays Methods of Analysis	3(3 – 0)
CHM-747	Advanced Electrochemical Techniques	3(3 – 0)
CHM-748	Advanced Electrophoretic Techniques	3(3 – 0)
CHM-749	Forensic Chemistry	3(3 – 0)
CHM-750	Automated Methods of Analysis	3(3 – 0)
Organic Chemistry		
CHM-751	Modern Trends in Organic Synthesis	3(3 – 0)
CHM-752	Advanced Stereochemistry	3(3 – 0)
CHM-753	Physico-organic Chemistry and Reaction Mechanism	3(3 – 0)
CHM-754	Advanced Heterocycles-I	3(3 – 0)
CHM-755	Chemistry of Glycosides	3(3 – 0)
CHM-756	Biosynthesis of Natural Products	3(3 – 0)
CHM-757	Advanced Nuclear Magnetic Resonance	3(3 – 0)
CHM-761	Protective Groups in Organic Synthesis	3(3 – 0)
CHM-762	Advanced Heterocycles -II	3(3 – 0)
CHM-763	Advanced Molecular Rearrangements	3(3 – 0)
CHM-764	Chemistry of Nitrogenous Compounds	3(3 – 0)
CHM-765	Advanced Mass Spectrometry	3(3 – 0)
CHM-766	Supramolecular Chemistry	3(3 – 0)
CHM-767	Chemistry of Drugs	3(3 – 0)
CHM-768	Chelated Enolates in Organic Synthesis	3(3 – 0)
CHM-769	Cross Coupling Reactions	3(3 – 0)
CHM-770	Multi-component Reactions	3(3 – 0)
CHM-771	Green Synthesis	3(3 – 0)

CHM-772	Symmetry Controlled Reactions	3(3 – 0)
CHM-773	Classics in Total Synthesis	3(3 – 0)
CHM-774	Advanced Techniques for Polymerization	3(3 – 0)
Physical Chemistry		
CHM-776	Nanostructures and Nanomaterials	3(3 – 0)
CHM-777	Advanced Functional Materials	3(3 – 0)
CHM-778	Renewable Resources - Chemistry and Technology	3(3 – 0)
CHM-779	Photovoltaic Materials and Solar Cells	3(3 – 0)
CHM-780	Polymer Mechanochemistry	3(3 – 0)
CHM-781	Physical Chemistry of High Polymers	3(3 – 0)
CHM-782	Complex Extension of Quantum Chemistry	3(3 – 0)
CHM-783	Electrode Processes	3(3 – 0)
CHM-784	Magnetic Spin Dynamics	3(3 – 0)
CHM-785	Principles of Molecular Spectroscopy	3(3 – 0)
CHM-786	Photochemistry	3(3 – 0)
CHM-787	Solution Chemistry	3(3 – 0)
CHM-788	Colloids and Surfactants	3(3 – 0)
CHM-789	Theoretical and Computational Chemistry	3(3 – 0)
CHM-790	Advanced Composite Materials	3(3 – 0)
CHM-791	Heterogeneous Catalysis	3(3 – 0)
CHM-792	Modern Aspects of Chemical Kinetics	3(3 – 0)
CHM-793	Environmental Chemistry and Energy Conversions	3(3 – 0)
CHM-794	Surface Chemistry	3(3 – 0)
CHM-795	Solid State and Semiconductors	3(3 – 0)
CHM-796	Thermodynamics and Statistical Mechanics	3(3 – 0)
CHM-797	Environmental Applications of High Energy Radiations	3(3 – 0)
CHM-798	Instrumental Physical Chemistry	3(3 – 0)
CHM-799	Modern Trends in Symmetry and Group Theory	3(3 – 0)
Mandatory Requirements for MPhil		
UHQ-I	Understanding of Holy Quran-I	1(0-1)
UHQ-II	Understanding of Holy Quran-II	1(0-1)
STA-795	Statistics for Research	3(2-1)
CHM-728	Seminar (General)	1(0 – 1)
CHM-729	Seminar (Research)	1(0 – 1)
CHM-730	Thesis	6(0 – 6)



Mandatory Requirements for PhD		
UHQ-I	Understanding of Holy Quran-I	1(0-1)
UHQ-II	Understanding of Holy Quran-II	1(0-1)
*STA-795	Statistics for Research	3(2-1)
CHM-758	Seminar (General)	1(0-1)
CHM-759	Seminar (Research)	1(0-1)
CHM-760	Thesis	

*Ph.D students who have not studied the course "Statistics for Research" in M.Phil will have to take this course as audit course as mandatory requirement.
 †Audit Course





SCHEME OF STUDIES
FOR
BS DEGREE IN CHEMISTRY (SESSION 2025-2029)

Semester 1

Course Code	Course Title	Credit Hours
CHM-301	Principles of Inorganic Chemistry	4(3 - 1)
ENG-321	Functional English	3(3 – 0)
ICT-321	Applications of Information & Communication Technologies	3(2– 1)
*MTH-321/ *BOT-303	Algebra and Trigonometry/ Or Functional Biology-I	3(3 – 0)/ 3(3 – 0)
ISL-321 or /ETH-322	Islamic Studies or / Ethics	2(2 – 0)
QTR-421	Quantitative Reasoning-I	3(3-0)
UHQ-I	Understanding of Holy Quran-I	1(0-1)
	Total	18
Students with Pre-Engineering background will take BOT-303 <u>Functional Biology-I</u> and students with Premedical will take MTH-321 <u>Algebra and Trigonometry</u>		

BS Chemistry

Semester 1

CHM-301 Principles of Inorganic Chemistry 4(3-1)

The periodic Law and Periodicity

Development of periodic table; Classification of elements based on s, p, d, and f orbitals, group trends and periodic properties in s, p, d and f block elements i.e., atomic radii, ionic radii, ionization potentials. Electron affinities, electronegativities and redox potential.

Chemical Bonding in Main Block Elements

Nature and types of chemical bonding, Lewis concepts, ionic, covalent, coordinate covalent bond; Valence bond theory (VBT), Molecular orbital theory (MOT). Interpretation of shapes of inorganic molecules on the basis of valence shell electron pair repulsion (VSEPR) theory and hybridization.

Acid and Bases

Concepts of acids and bases including soft and hard acid base concepts. Relative strengths of acids and bases, significance of pH, pKa, pKb and buffers solutions. Theories of indicators; (acid base, redox, adsorption). Solubility, solubility product, common ion effect and their industrial applications.

Chemistry of the p-block Elements

General characteristics of the following group of p-block elements with reference to the aspects given against each

Carbon and Silicon:

Group anomalies. Allotropic forms of carbon, fullerenes and their applications. Production of pure silicon for solar energy and silicon chips, silicates and silicones and industrial applications.

Nitrogen and Phosphorus

Group anomalies. Preparation, structures, properties and the environmental role of oxides of nitrogen. Industrial superphosphate fertilizers. Causes of fog and smog.

Oxygen and Sulfur

Group anomalies. Preparation, structure, properties and environmental role of oxides and oxyacids of sulphur, manufacturing of sulphuric acid and its reactions. Thionic acids and use of hypo in industry.

The Halogens

Anomalous behavior of fluorine. Industrial preparation of chlorine. Preparation, structures, properties and uses of oxides, oxyacids of chlorine, interhalogens and pseudohalogens.

The Noble Gases

Preparation, properties, structures and uses of xenon fluorides; commercial uses of noble gases.

Practicals: Laboratory Ethics and Safety Measures:

Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe

laboratory operations.

Qualitative Analysis

Analysis of four ions (two cations and two anions) from mixture of salts.

Preparation and standardization of normal and molar solutions of HCl, NaOH and KMnO_4 .

Quantitative analysis

- Determination of total hardness of water using EDTA.
- Estimation of magnesium using EDTA.
- Estimation of copper (iodometrically).
- Determination of ferricyanide using KI solution
- Determination of chloride by Volhard and Mohr methods.
- Estimation of chloride/bromide ions using adsorption (fluorescein) indicator.
- Percentage determination of ferric ions in ferric alum using KMnO_4 solution.
- Determination of purity of commercial potassium oxalate using KMnO_4 solution
- Estimation of ferrous / ferric ions using $\text{K}_2\text{Cr}_2\text{O}_7$ solution.
- Percentage determination of barium in barium nitrate by gravimetric method.
- Gravimetric determination of nickel.

Recommended Books

1. J. William, "Inorganic Chemistry, Theoretical and Practical: A Manual for Students in advanced Classes", Legare Street Press (2023).
2. J. E. House Inorganic Chemistry 2nd edition (2012).
3. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bockmann, "Basic Inorganic Chemistry" 2nd Ed, John Wiley & Sons, USA (1987).
4. B. Douglas, D. McDaniel, J. Alexander, "Concepts and Models of Inorganic Chemistry" 3rd Ed, John Wiley & Sons, Inc. (1994).
5. J. W. Hill, R. H. Petrucci, "General Chemistry" 8th Ed, Prentice-Hall, Inc. (1996).
6. J. E. Huheey, "Inorganic Chemistry Principles of Structure and Reactivity" 2nd Ed, Harper and Row Publishers (1978).
7. J. D. Lee, "Concise Inorganic Chemistry" 5th Ed, Chapman and Hall (1996).
8. G. L. Miessler, A. T. Donald, "Inorganic Chemistry" 2nd Ed., Prentice-Hall International, Inc. (1991).
9. B. Moody, "Comparative Inorganic Chemistry" 3rd Ed, Routledge, Chapman and Hall, Inc. (1991).
10. D. F. Shriver, P.W. Atkins, C. H. Langford, "Inorganic Chemistry" Oxford University Press USA (1994).



ہائیر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION
Government of Pakistan, Islamabad
(Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 8-9 August 2023 in the Higher Education Commission, Lahore (Regional Office) to design courses of "Functional English" and "Expository Writing" each of three (03) credits, as part of the general education component of the HEC Undergraduate Education Policy (V 1.1).

Following members of the committee attended the meeting and developed the draft of the two courses:

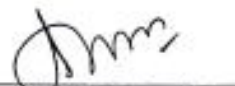
1. Dr. Muhammad Khan Sangi, Professor & Dean, Faculty of Arts, University of Sindh, Jamshoro
2. Dr. Nasir Abbas, Professor & Dean, Faculty of Languages and Literature, Lasbela University of Agriculture, Water & Marine Sciences, Uthal, Lasbela
3. Dr. Rizwan Akhtar, Professor, Institute of English Studies, University of the Punjab, Lahore
4. Dr. Sajjad Ali Khan, Professor & Chairman, Government College University, Lahore (for the course of Functional English only)
5. Dr. Zulfiqar Ali Shah, Professor & Director, Institute of English Language & Literature, Shah Abdul Latif University, Khairpur
6. Dr. Aamna Khalid, Associate Professor, Mushtaq Ahmad Gurmani School of Humanities and Social Sciences, Lahore University of Management Sciences, Lahore
7. Dr. Umaira Kamran, Associate Professor and Chairperson, Department of English, Quaid-i-Azam University, Islamabad
8. Dr. Arshad Mehmood Raja, Assistant Professor and In-charge, Department of English, International Islamic University, Islamabad
9. Dr. Azhar Pervaiz, Assistant Professor, Department of English, University of Sargodha, Sargodha
10. Dr. Muhammad Akbar Sajid, Assistant Professor and Head, Department of English, National University of Modern Languages, Multan Campus
11. Dr. Saima Jabeen, Assistant Professor, Department of English Language and Literature, Government College University, Lahore (for the course of Expository Writing only)
12. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

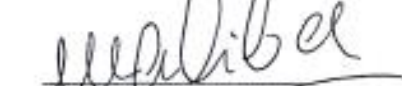
Following members of the committee could not attend the meeting due to official / other commitments:

1. Dr. Farhana Wazir Khan, Professor, Department of English, University of Karachi, Karachi
2. Dr. Faria Saeed Khan, Professor, Department of English Literature, University of Balochistan, Quetta
3. Dr. Fatima Syeda, Professor & Chairperson, Department of English, Forman Christian College, Lahore
4. Dr. Humaira Aslam, Associate Professor, Department of English, University of Peshawar, Peshawar

That after consultation and endorsement of the committee, the final drafts of the courses are hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.


Dr. Aamna Khalid
(Convener)


Dr. Azhar Pervaiz
(Co-Convener)


Mr. Muhammad Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

FUNCTIONAL ENGLISH

UGE Policy V 1.1 : General Education Course

Credits:	03
Pre-Requisite:	Nil
Offering:	Undergraduate Degrees (including Associate Degrees)
Placement:	1 - 3 Semesters
Type:	General Education
Fields:	All

DESCRIPTION

This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and analytical skills in listening and reading. Moreover, the course encompasses a range of practical communication aspects including professional writing, public speaking, and everyday conversation, ensuring that students are equipped for both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with ease and efficacy, making a positive impact in their functional interactions.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Apply enhanced English communication skills through effective use of word choices, grammar and sentence structure.
2. Comprehend a variety of literary / non-literary written and spoken texts in English.
3. Effectively express information, ideas and opinions in written and spoken English.
4. Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

SYLLABUS

1. **Foundations of Functional English:**
 - Vocabulary building (contextual usage, synonyms, antonyms and idiomatic expressions)
 - Communicative grammar (subject-verb-agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes, etc.)
 - Word formation (affixation, compounding, clipping, back formation, etc.)
 - Sentence structure (simple, compound, complex and compound-complex)
 - Sound production and pronunciation
2. **Comprehension and Analysis:**
 - Understanding purpose, audience and context
 - Contextual interpretation (tones, biases, stereotypes, assumptions, inferences, etc.)
 - Reading strategies (skimming, scanning, SQ4R, critical reading, etc.)
 - Active listening (overcoming listening barriers, focused listening, etc.)
3. **Effective Communication:**
 - Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.)
 - Structuring documents (introduction, body, conclusion and formatting)

- Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.)
- Public speaking (overcoming stage fright, voice modulation and body language)
- Presentation skills (organization content, visual aids and engaging the audience)
- Informal communication (small talk, networking and conversational skills)
- Professional writing (business e-mails, memos, reports, formal letters, etc.)

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

As part of the overall learning requirements, students will also be exposed to relevant simulations, role-plays and real-life scenarios and will be required to apply skills acquired throughout the course in the form of a final project.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "Understanding and Using English Grammar" by Betty Schramper Azar.
2. "English Grammar in Use" by Raymond Murphy.
3. "The Blue Book of Grammar and Punctuation" by Jane Straus.
4. "English for Specific Purposes: A Learning-Centered Approach" by Tom Hutchinson and Alan Waters.
5. "Cambridge English for Job-hunting" by Colm Downes.
6. "Practical English Usage" by Michael Swan.
7. "Reading Literature and Writing Argument" by Missy James and Alan P. Merickel.
8. "Improving Reading: Strategies, Resources, and Common Core Connections" by Jerry Johns and Susan Lenski.
9. "Comprehension: A Paradigm for Cognition" by Walter Kintsch.
10. "Communication Skills for Business Professionals" by J.P. Verma and Meenakshi Raman.



ہائیر ایجوکیشن کمیشن

HIGHER EDUCATION COMMISSION
Government of Pakistan, Islamabad
(Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 10 August 2023 in the Higher Education Commission, Lahore (Regional Office) to design a three-credits course of "Applications of Information and Communication Technologies" as part of the general education component of the HEC Undergraduate Education Policy (V 1.1).

Following members of the committee attended the meeting and developed the draft of the course:

1. Dr. Aasia Khanum, Professor, Department of Computer Science, Forman Christian College, Lahore
2. Dr. Faisal Riaz, Professor, Department of Computer Science & Information Technology, Mirpur University of Science & Technology, Mirpur
3. Dr. Humaira Afzal, Professor, Department of Computer Science, Bahauddin Zakariya University, Multan
4. Dr. Samina Rajper, Professor, Institute of Computer Science, Shah Abdul Latif University, Khairpur
5. Dr. Shahzad Sarwar, Professor & Chairperson, Department of Computer Science, University of the Punjab, Lahore
6. Dr. Huma Javed, Associate Professor, Department of Computer Science, University of Peshawar, Peshawar
7. Dr. Muhammad Rafi, Associate Professor & Head, Department of Artificial Intelligence and Data Science, National University of Computer and Emerging Sciences, Karachi
8. Dr. Munam Ali Shah, Associate Professor, Department of Computer Science, COMSATS University Islamabad
9. Dr. Nadeem Mahmood, Associate Professor & Chairperson, Department of Computer Science, University of Karachi, Karachi
10. Dr. Seemab Latif, Associate Professor, School of Electrical Engineering and Computer Science, National University of Sciences & Technology, Islamabad
11. Dr. Shahid Hussain, Associate Professor & Chairperson, Department of Computer Science, Institute of Business Administration, Karachi
12. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

Following members of the committee could not attend the meeting due to official / other commitments:

1. Dr. Muddasir Shabbir, Associate Professor & Chairperson, Department of Computer Science, Information Technology University, Lahore
2. Dr. Syed Sajjad Hussain Rizvi, Associate Professor & Head, Robotics and Artificial Intelligence, Shaheed Zulfiqar Ali Bhutto Institute of Science & Technology, Karachi
3. Dr. Bushra Naeem, Associate Professor & Chairperson, Balochistan University of Information Technology, Engineering and Management Sciences, Quetta
4. Dr. Muhammad Hamad Alizai, Associate Professor, Syed Bahar Ali School of Science and Engineering, Lahore University of Management Sciences, Lahore

That after consultation and endorsement of the committee, the final draft of the course is hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.

Dr. Shahzad Sarwar
(Convener)

Dr. Muhammad Ali Baig
(Co-Convener)

Mr. Muhammad Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

APPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES

UGE Policy V 1.1 : General Education Course

Credits: 03 (Class Credits: 02; Lab Credits: 01)
Pre-Requisite: Nil
Offering: Undergraduate Degrees (including Associate Degrees)
Placement: 1 - 4 Semesters
Type: General Education
Fields: All

DESCRIPTION

This course is designed to provide students with an exploration of the practical applications of Information and Communication Technologies (ICT) and software tools in various domains. Students will gain hands-on experience with a range of software applications, learning how to leverage ICT to solve daily life problems, enhance productivity and innovate in different fields. Through individual and interactive exercises and discussions, students will develop proficiency in utilizing software for communication, creativity, and more.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Explain the fundamental concepts, components, and scope of Information and Communication Technologies (ICT)
2. Identify uses of various ICT platforms and tools for different purposes.
3. Apply ICT platforms and tools for different purposes to address basic needs in different domains of daily, academic, and professional life.
4. Understand the ethical and legal considerations in use of ICT platforms and tools.

SYLLABUS

1. **Introduction to Information and Communication Technologies:**
 - Components of Information and Communication Technologies (basics of hardware, software, ICT platforms, networks, local and cloud data storage etc.).
 - Scope of Information and Communication Technologies (use of ICT in education, business, governance, healthcare, digital media and entertainment, etc.).
 - Emerging technologies and future trends.
2. **Basic ICT Productivity Tools:**
 - Effective use of popular search engines (e.g., Google, Bing, etc.) to explore World Wide Web.
 - Formal communication tools and etiquettes (Gmail, Microsoft Outlook, etc.).
 - Microsoft Office Suites (Word, Excel, PowerPoint)
 - Google Workspace (Google Docs, Sheets, Slides).
 - Dropbox (Cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft Office integration).
 - Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas).
 - Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.).
 - Social media applications (LinkedIn, Facebook, Instagram, etc.).
3. **ICT in Education:**
 - Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.).
 - Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.).
 - Interactive multimedia and virtual classrooms.

Dahmad

4. ICT in Health and Well-being:

- Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkeeper, etc.).
- Telemedicine and online health consultations (OLADOC, Sehat Kahani, Marham, etc.).

5. ICT in Personal Finance and Shopping:

- Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, ILLINK and MNET, Keem Wallet, etc.).
- E-commerce platforms (Daraz.pk, Telemart, Shophive, etc.)

6. Digital Citizenship and Online Etiquette:

- Digital identity and online reputation.
- Netiquette and respectful online communication.
- Cyberbullying and online harassment.

7. Ethical Considerations in Use of ICT Platforms and Tools:

- Intellectual property and copyright issues.
- Ensuring originality in content creation by avoiding plagiarism and unauthorized use of information sources.
- Content accuracy and integrity (ensuring that the content shared through ICT platforms is free from misinformation, fake news, and manipulation).

PRACTICAL REQUIREMENTS

As part of the overall learning requirements, the course will include:

1. Guided tutorials and exercises to ensure that students are proficient in commonly used software applications such as word processing software (e.g., Microsoft Word), presentation software (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools. Students may be assigned practical tasks that require them to create documents, presentations, and spreadsheets etc.
2. Assigning of tasks that involve creating, managing, and organizing files and folders on both local and cloud storage systems. Students will practice file naming conventions, creating directories, and using cloud storage solutions (e.g., Google Drive, OneDrive).
3. The use of online learning management systems (LMS) where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with the practical experience with online platforms commonly used in education and the workplace.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. "Discovering Computers" by Vermaat, Shaffer, and Freund.
2. "GO! with Microsoft Office" Series by Gaskin, Vargas, and McLellan.
3. "Exploring Microsoft Office" Series by Grauer and Poatsy.
4. "Computing Essentials" by Morley and Parker.
5. "Technology in Action" by Evans, Martin, and Poatsy.

Dr. Ahmad

(Signature)

MTH-321 Algebra and Trigonometry**3(3-0)**

(For Medical Students)

MTH-321 Algebra and Trigonometry 3(3-0)

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule. Quadratic Equations: Solution of quadratic equations, nature of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations. Sequences and Series: Arithmetic progression, geometric progression, harmonic progression. Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices. Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Recommended books:

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, Algebra 2 and Trigonometry, 1978, Houghton & Mifflin,
2. Boston (suggested text) Kaufmann JE, College Algebra and Trigonometry, 1987, PWSKent Company, Boston
3. Swokowski EW, Fundamentals of Algebra and Trigonometry (6th edition), 1986, PWS-Kent Company, Boston.
4. N. Khalid Mathematics-I Algebra and Trigonometry, Discover Mathematics Series, 3rd Edition, 2021.

OR**BOT-303 Functional Biology-I 3(3-0)**

(For Non-medical Students)

BOT-303 Functional Biology-I 3(3-0)

(For Non-medical Students) Biological Methods; Principles of Cellular Life, Chemical Basis, Structure and Function, Principles of Metabolism, Energy Acquisition, Principles of Inheritance, Mitosis and Meiosis, Chromosomes, Observable Inheritance Patterns, DNA Structure and Function, RNA and Proteins, Genes Genetic Engineering and Biotechnology, Biodiversity, Fundamental Concept of Biodiversity, One or two examples of each of the following from commonly found organism, Prions, Viruses, Bacteria, Protistans, Algae, Fungi, Plants, Crops, Animals, Invertebrates, Vertebrates

Books Recommended

1. Roberts, M.M., Reiss and G.Monger. 2000. Advanced Biology, Nelson.
2. Starr, C, and R, Taggart, 2001. Biology: The Unity and Diversity of Life Brooks and Cole.
3. Campbell, N.A., J.B, Reece, L.G. Mitchell, M.R, Taylor. 2001. Biology: Concepts and Connections. Prentice-Hall.



ہی اے سی اے کیجیو کیشن کمیشن
HIGHER EDUCATION COMMISSION
 Government of Pakistan, Islamabad
 (Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 11 August 2023 in the Higher Education Commission, Lahore (Regional Office) to design a two credits course of "Islamic Studies" as part of the general education component of the HEC Undergraduate Education Policy (V 1.1).

Following members of the committee attended the meeting and developed the draft of the course:

1. Dr. Qibla Ayaz, Chairman, Council of Islamic Ideology, Islamabad
2. Dr. Fareed Ud Din Tariq, Professor, Department of Islamic Studies, University of Azad Jammu and Kashmir, Muzaffargarh
3. Dr. Muhammad Abdullah, Professor and Director, Shaikh Zayed Islamic Center, University of the Punjab, Lahore
4. Dr. Zahid Ali Zahidi, Professor and Dean, Faculty of Islamic Studies, University of Karachi, Karachi
5. Dr. Zia-ur-Rehman, Professor and Chairman, Department of Quranic Studies, Islamia University of Bahawalpur, Bahawalpur
6. Dr. Hafiz Abdul Ghani, Associate Professor and Chairperson, Department of Religious Studies, Forman Christian College, Lahore
7. Dr. Hafiz Muhammad Sajjad, Associate Professor, Department of Interfaith Studies, Faculty of Arabic and Islamic Studies, Allama Iqbal Open University, Islamabad
8. Dr. Hassan Shakeel Shah, Associate Professor and Chairperson, Department of Islamic Thought and Civilization, University of Management and Technology, Lahore
9. Dr. Zaimul Abidin Arjo, Associate Professor, Institute of Islamic Studies, Shah Abdul Latif University, Khairpur
10. Dr. Aurangzeb Haneef, Assistant Professor, Muztag Ahmad Gurnani School of Humanities and Social Sciences, Lahore University of Management Sciences, Lahore
11. Dr. Muhammad Feroz-ud-Din Shah, Assistant Professor, Department of Islamic Studies, University of Sargodha, Sargodha
12. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

Following members of the committee could not attend the meeting due to official / other commitments:

1. Dr. Muhammad Saleem Hawed, Professor and Dean, Faculty of Islamic and Oriental Studies, University of Peshawar, Peshawar
2. Dr. Sahbzada Baz Mohammad, Professor and Chairperson, Department of Islamic Studies, University of Balochistan, Quetta
3. Dr. Hafiz Taj Afsar, Associate Professor and Deputy Dean, Faculty of Usuluddin, International Islamic University, Islamabad
4. Dr. Muhammad Farooq Haider, Associate Professor and Chairperson, Department of Islamic Studies, Government College University, Lahore

Thus after consultation and endorsement of the committee, the final draft of the course is hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.

Dr. Qibla Ayaz
(Convener)

Dr. Zahid Ali Zahidi
(Co-Convener)

Mr. Muhammad-Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

ISLAMIC STUDIES

UGE Policy V 1.1 : General Education Course

Credits:	02
Pre-Requisite:	Nil
Offering:	Undergraduate Degrees (including Associate Degrees)
Placement:	1 - 4 Semesters
Type:	General Education
Fields:	All

DESCRIPTION

This course is designed to provide students with a comprehensive overview of the fundamental aspects of Islam, its beliefs, practices, history and influence on society. It will further familiarize the students with a solid foundation in understanding Islam from an academic and cultural perspective. Through this course, students will have an enhanced understanding of Islam's multifaceted dimensions which will enable them to navigate complex discussions about Islam's historical and contemporary role, fostering empathy, respect, and informed dialogue.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Demonstrate enhanced knowledge of Islamic foundational beliefs, practices, historical development, spiritual values and ethical principles.
2. Describe basic sources of Islamic law and their application in daily life.
3. Identify and discuss contemporary issues being faced by the Muslim world including social challenges, gender roles and interfaith interactions.

SYLLABUS

1. **Introduction to Islam:**
 - Definition of Islam and its core beliefs.
 - The Holy Quran (introduction, revelation and compilation).
 - Hadith and Sunnah (compilation, classification, and significance).
 - Key theological concepts and themes (Tawhid, Prophethood, Akhirah etc.).
2. **Sirah of the Holy Prophet (Peace Be Upon Him) as Uswa-i-Hasana:**
 - Life and legacy of the Holy Prophet PBUH.
 - Diverse roles of the Holy Prophet PBUH (as an individual, educator, peace maker, leader etc.).
3. **Islamic History and Civilization:**
 - World before Islam.
 - The Rashidun Caliphate and expansion of Islamic rule.
 - Contribution of Muslim scientists and philosophers in shaping world civilization.
4. **Islamic Jurisprudence (Fiqh):**
 - Fundamental sources of Islamic jurisprudence.
 - Pillars of Islam and their significance.
 - Major schools of Islamic jurisprudence.
 - Significance and principles of Ijtihad.
5. **Family and Society in Islam:**
 - Status and rights of women in Islamic teachings.
 - Marriage, family, and gender roles in Muslim society.
 - Family structure and values in Muslim society.
6. **Islam and the Modern World:**
 - Relevance of Islam in the modern world (globalization, challenges and prospects).



- Islamophobia, interfaith dialogue, and multiculturalism.
- Islamic viewpoint towards socio-cultural and technological changes.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "The Five Pillars of Islam: A Journey Through the Divine Acts of Worship" by Muhammad Mustafa Al-Azami.
2. "The Five Pillars of Islam: A Framework for Islamic Values and Character Building" by Musharraf Hussain.
3. "Towards Understanding Islam" by Abul A' la Mawdudi.
4. "Islami Nazriya e Hayat" by Khurshid Ahmad.
5. "An Introduction to Islamic Theology" by John Renard.
6. "Islamic Civilization Foundations Belief & Principles" by Abul A' la Mawdudi.
7. "Women and Social Justice: An Islamic Paradigm" by Dr. Anis Ahmad.
8. "Islam: Its Meaning and Message" by Khurshid Ahmad.

Note: This course is compulsory for Muslim and optional for non-Muslim undergraduate students. Non-Muslim students can opt for any course of at least the same or more credits in subjects such as religious studies, ethics, theology, comparative religion, Christian ethics, etc.

Two handwritten signatures in blue ink are present. The signature on the left is a large, stylized, circular scribble. The signature on the right is a more linear, angular scribble.



ہائیر ایجوکیشن کمیشن

HIGHER EDUCATION COMMISSION

Government of Pakistan, Islamabad
(Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 20-21 July 2023 in the Higher Education Commission, Lahore (Regional Office) to design courses of "Quantitative Reasoning (I)" and "Quantitative Reasoning (II)" each of three (03) credits, as part of the general education component of the HEC Undergraduate Education Policy (V.1.1).

Following members of the committee attended the meeting and developed the draft of the two courses:

1. Dr. Asif Ali Shaikh, Professor & Chairman, Department of Basic Sciences and Related Studies, Mehran University of Engineering & Technology, Jamshoro
2. Dr. Muhammad Zubair Khan, Professor & Associate Dean, Faculty of Basic Sciences, Balochistan University of Information Technology, Engineering & Management Sciences, Quetta
3. Dr. Akbar Zada, Associate Professor, Department of Mathematics, University of Peshawar, Peshawar
4. Dr. Asad Ullah, Associate Professor & Chairman, Department of Mathematical Sciences, Karakoram International University, Gilgit
5. Dr. Jamal Abdul Nasir, Associate Professor & Chairman, Department of Statistics, Government College University, Lahore
6. Dr. Kalim Ul-Haq Tariq, Associate Professor, Department of Mathematics, Mirpur University of Science & Technology, Mirpur
7. Dr. Naveed Ahmad, Associate Professor, School of Mathematics and Computer Science, Institute of Business Administration, Karachi
8. Dr. Rizwan Ul Haq, Associate Professor, Department of Mathematics, School of Natural Sciences, National University of Sciences & Technology, Islamabad
9. Dr. Saima Altaf, Associate Professor, Department of Statistics, Bahauddin Zakariya University, Multan
10. Dr. Shaheen Nazir, Associate Professor, Department of Mathematics, Syed Babar Ali School of Science and Engineering, Lahore University of Management Sciences, Lahore
11. Dr. Shakila Bashir, Associate Professor, Department of Statistics, Forman Christian College University, Lahore
12. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

Following members of the committee could not attend the meeting due to official / other engagements:

1. Dr. Muhammad Akram, Professor & Chairman, Department of Mathematics, University of the Punjab, Lahore
2. Dr. Nasir Ali, Associate Professor & Chairman, Department of Mathematics & Statistics, International Islamic University, Islamabad
3. Dr. Nargis Aslam Khan, Associate Professor, Department of Mathematics, Islamia University of Bahawalpur, Bahawalpur

That after consultation and endorsement of the committee, the final drafts of the courses are hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.

Dr. Naveed Ahmad
(Convener)

Dr. Jamal Abdul Nasir
(Co-Convener)

Mr. Muhammad Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

QUANTITATIVE REASONING (I)

UGE Policy V 1.1 : General Education Course

Credits:	03
Pre-Requisite:	Nil
Offering:	Undergraduate Degrees (including Associate Degrees)
Placement:	1 - 4 Semesters
Type:	Mandatory
Fields:	All

DESCRIPTION

Quantitative Reasoning (I) is an introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concepts and analysis. The course is designed to familiarize students with the basic concepts of mathematics and statistics and to develop students' abilities to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises, this course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expanding their academic horizon and breadth of knowledge of their specific major / field of study.

COURSE LEARNING OUTCOMES

By the end of this course, students shall have:

1. Fundamental numerical literacy to enable them work with numbers, understand their meaning and present data accurately;
2. Understanding of fundamental mathematical and statistical concepts;
3. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

SYLLABUS

1. **Numerical Literacy**
 - Number systems and basic arithmetic operations;
 - Units and their conversions, dimensions, area, perimeter and volume;
 - Rates, ratios, proportions and percentages;
 - Types and sources of data;
 - Measurement scales;
 - Tabular and graphical presentation of data;
 - Quantitative reasoning exercises using number knowledge.
2. **Fundamental Mathematical Concepts**
 - Basics of geometry (lines, angles, circles, polygons etc.);
 - Sets and their operations;
 - Relations, functions, and their graphs;
 - Exponents, factoring and simplifying algebraic expressions;
 - Algebraic and graphical solutions of linear and quadratic equations and inequalities;
 - Quantitative reasoning exercises using fundamental mathematical concepts.
3. **Fundamental Statistical Concepts**
 - Population and sample;
 - Measures of central tendency, dispersion and data interpretation;
 - Rules of counting (multiplicative, permutation and combination);
 - Basic probability theory;
 - Introduction to random variables and their probability distributions;
 - Quantitative reasoning exercises using fundamental statistical concepts.

Asifa Yousaf

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "Quantitative Reasoning: Tools for Today's Informed Citizen" by Bernard L. Madison, Lynn and Arthur Steen.
2. "Quantitative Reasoning for the Information Age" by Bernard L. Madison and David M. Bressoud.
3. "Fundamentals of Mathematics" by Wade Ellis.
4. "Quantitative Reasoning: Thinking in Numbers" by Eric Zaslow.
5. "Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis" by Ethan Bueno de Mesquita and Anthony Fowler.
6. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
7. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
8. "Statistics for Technology: A Course in Applied Statistics" by Chatfield, C.
9. "Statistics: Unlocking the Power of Data" by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

H.L.2

James S.

DIRECTORATE OF ACADEMICS
GOVERNMENT COLLEGE UNIVERSITY, FAISALABAD



Email: diracad@gcuf.edu.pk
923006627246
GCUF/DACAD/25/1080

Allama Iqbal Road,
38000-Faisalabad, Pakistan

Dated: 02/10/2025

NOTIFICATION

through discussion with Dean Islamic and Oriental Learning it was decided that the courses Understanding of Holy Quran will be coded as:

- UHQ-301 UNDERSTANDING OF HOLY QURAN-I
- UHQ-401 UNDERSTANDING OF HOLY QURAN-II

In case of BS these courses will be offered in first & third semesters as per Scheme of Studies approved from respective statutory bodies of the departments.

In case of MPhil and PhD these courses will be offered in first two semesters.

Salma Sultana
(PROF. DR. SALMA SULTANA)
Director Academics

Dr. Salma Sultana
Director Academics
GCU, Faisalabad

to Vice Chancellor
Vice Chancellor
Deans/ Chairpersons/ Teacher Incharge

Seen & Circulate
6/10/2025

Semester 2

Course Code	Course Title	Credit Hours
CHM-302	Principles of Organic Chemistry	4(3 – 1)
ENG-322	Expository Writing	3(3 – 0)
ICP-321	Ideology and Constitution of Pakistan	2(2 – 0)
MTH-322/ ZOL-307	Introduction to Calculus / Or Functional Biology-II	3(3 – 0)/ 3(2 – 1)
CHM-303	Introduction to Nanochemistry	2(2-0)
CCE-421	Civics and Community Engagement	2(2-0)
PST-321	Pakistan Studies	2(2-0)
	Total	18

Students with Pre-Engineering background will take **ZOL-307 Functional Biology-II** and students with Premedical will take **MTH-322 Introduction to Calculus**

Semester 2

CHM-302 Principles of Organic Chemistry 4(3-1)

Basic concepts in chemical bonding

Localized and delocalized bonding. Concept of hybridization leading to bond angles, bond energies and geometry of simple organic molecules; dipole moment; inductive effect; resonance, resonance energy, rules of resonance, resonance effect, steric inhibition of resonance; hyperconjugation; tautomerism; hydrogen bonding.

Nomenclature of organic compounds

Common and trivial name of organic compounds; and introduction to the systematic nomenclature of mono and bi-functional organic compounds by IUPAC rules.

Aromatic Hydrocarbons

Aromatic Compounds Structure of benzene, aromaticity, electrophilic substitution including orientation and reactivity, addition and oxidation reactions, preparation and reactivity of naphthalene.

Isomerism

Geometrical isomerism Determination of configuration of geometrical isomers, Z, E convention and

cis- and trans- isomerism in compound containing two double bonds; Optical isomerism, optical activity, chirality and optical activity, racemization and resolution of racemic mixture, R, S notation, diastereoisomers. Conformational isomerism A brief introduction to conformation of ethane, n-butane and cyclohexane.

Chemistry of the Hydroxyl Group and Ethers

Brief review of the physical properties, preparation and reactions of alcohols. Phenols acidity, preparation and reactions, Ethers preparation, properties and reactions.

Chemistry of Carboxylic Acids and Their Derivatives

Physical properties of carboxylic acids, effect of substitution and structure on the strengths of acidity of carboxylic acids. Preparation, properties and reactions of carboxylic acids and their derivatives i.e. ester, amides, acid halides and acid anhydrides.

Practicals

Sixteen experiments shall be conducted based on the following techniques:

a. Melting and boiling point determination, Distillation, solvent extraction, crystallization.

b. Qualitative Organic Analysis

Systematic identification of organic compound (1 Compounds)

c. Preparation of Organic Compounds

Preparation of simple organic compound like iodoform, aspirin, acetanilide etc

Recommended Books

1. David R. Klein, Organic Chemistry as a Second Language: First Semester Topics, 6th Edition, John Wiley & Sons, Inc. (2024).
2. G. M. Loudon, "Organic Chemistry", 7th Ed., W.H. Freeman (2021).
3. G. R. Chatwal, "Reaction Mechanism and Reagents in Organic Chemistry", 5th Ed., Himalaya Publishing House (2019).
4. Jonathan Clayden, Nick Greeves, Stuart Warren "Organic Chemistry", 2nd edition, OUP Oxford, (2012).
5. J. March, "Advanced Organic Chemistry Reactions, Mechanisms and Structure" 6th Ed, John Wiley & Sons (2007).
6. J. McMurry, "Organic Chemistry" 5th Ed, Thomson Asia Ltd; Singapore (2000).
7. S. H. Pine, J. B. Hendrickson, G. S. Hammond, "Organic Chemistry" 4th Ed, McGraw-Hill, Inc; (1992).

ENG-322 Expository Writing 3(3-0)



ہائیر ایجوکیشن کمیشن

HIGHER EDUCATION COMMISSION Government of Pakistan, Islamabad (Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 8-9 August 2023 in the Higher Education Commission, Lahore (Regional Office) to design courses of "Functional English" and "Expository Writing" each of three (03) credits, as part of the general education component of the HEC Undergraduate Education Policy (V 1.1).

Following members of the committee attended the meeting and developed the draft of the two courses:

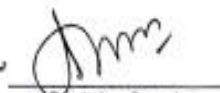
1. Dr. Muhammad Khan Sangi, Professor & Dean, Faculty of Arts, University of Sindh, Jamshoro
2. Dr. Nasir Abbas, Professor & Dean, Faculty of Languages and Literature, Lasbela University of Agriculture, Water & Marine Sciences, Uthal, Lasbela
3. Dr. Rizwan Akhtar, Professor, Institute of English Studies, University of the Punjab, Lahore
4. Dr. Sajjad Ali Khan, Professor & Chairman, Government College University, Lahore (for the course of Functional English only)
5. Dr. Zulfiqar Ali Shah, Professor & Director, Institute of English Language & Literature, Shah Abdul Latif University, Khairpur
6. Dr. Aamna Khalid, Associate Professor, Mushtaq Ahmad Gurmani School of Humanities and Social Sciences, Lahore University of Management Sciences, Lahore
7. Dr. Umaima Kamran, Associate Professor and Chairperson, Department of English, Quaid-i-Azam University, Islamabad
8. Dr. Arshad Mehmood Raja, Assistant Professor and in-charge, Department of English, International Islamic University, Islamabad
9. Dr. Azhar Pervaiz, Assistant Professor, Department of English, University of Sargodha, Sargodha
10. Dr. Muhammad Akbar Sajid, Assistant Professor and Head, Department of English, National University of Modern Languages, Multan Campus
11. Dr. Saima Jabeen, Assistant Professor, Department of English Language and Literature, Government College University, Lahore (for the course of Expository Writing only)
12. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

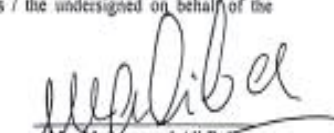
Following members of the committee could not attend the meeting due to official / other commitments:

1. Dr. Farhana Wazir Khan, Professor, Department of English, University of Karachi, Karachi
2. Dr. Faria Saeed Khan, Professor, Department of English Literature, University of Balochistan, Quetta
3. Dr. Fatima Syeda, Professor & Chairperson, Department of English, Forman Christian College, Lahore
4. Dr. Humaira Aslam, Associate Professor, Department of English, University of Peshawar, Peshawar

That after consultation and endorsement of the committee, the final drafts of the courses are hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.


Dr. Aamna Khalid
(Convener)


Dr. Azhar Pervaiz
(Co-Convener)


Mr. Muhammad Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

EXPOSITORY WRITING

UGE Policy V 1.1 : General Education Course

Credits:	03
Pre-Requisite:	Functional English
Offering:	Undergraduate Degrees (including Associate Degrees)
Placement:	2 - 4 Semesters
Type:	General Education
Fields:	All

DESCRIPTION

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation of the pre-requisite course, Functional English, this course will enhance students' abilities of producing clear, concise and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Understand the essentials of the writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.
2. Demonstrate mastery of diverse expository types to address different purposes and audiences.
3. Uphold ethical practices to maintain originality in expository writing.

SYLLABUS

1. **Introduction to Expository Writing:**
 - Understanding expository writing (definition, types, purpose and applications)
 - Characteristics of effective expository writing (clarity, coherence and organization)
 - Introduction to paragraph writing
2. **The Writing Process:**
 - Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.)
 - Drafting (three stage process of drafting techniques)
 - Revising and editing (ensuring correct grammar, clarity, coherence, conciseness etc.)
 - Proof reading (fine-tuning of the draft)
 - Peer review and feedback (providing and receiving critique)
3. **Essay Organization and Structure:**
 - Introduction and hook (engaging readers and introducing the topic)
 - Thesis statement (crafting a clear and focused central idea)
 - Body Paragraphs (topic sentences, supporting evidence and transitional devices)
 - Conclusion (types of concluding paragraphs and leaving an impact)
 - Ensuring cohesion and coherence (creating seamless connections between paragraphs)
4. **Different Types of Expository Writing:**
 - Description

- Illustration
 - Classification
 - Cause and effect (exploring causal relationships and outcomes)
 - Process analysis (explaining step-by-step procedures)
 - Comparative analysis (analyzing similarities and differences)
5. **Writing for Specific Purposes and Audiences:**
- Different types of purposes (to inform, to analyze, to persuade, to entertain etc.)
 - Writing for academic audiences (formality, objectivity, and academic conventions)
 - Writing for public audiences (engaging, informative and persuasive language)
 - Different tones and styles for specific purposes and audiences
6. **Ethical Considerations:**
- Ensuring original writing (finding credible sources, evaluating information etc.)
 - Proper citation and referencing (APA, MLA, or other citation styles)
 - Integrating quotes and evidences (quoting, paraphrasing, and summarizing)
 - Avoiding plagiarism (ethical considerations and best practices)

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

As part of the overall learning requirements, students will be required to build a writing portfolio having a variety of expository texts and present the same at the end of the course showcasing proficiency in expository writing.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "The St. Martin's Guide to Writing" by Rise B. Axelrod and Charles R. Cooper.
2. "They Say / I Say: The Moves That Matter in Academic Writing" by Gerald Graff and Cathy Birkenstein.
3. "Writing Analytically" by David Rosenwasser and Jill Stephen.
4. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup.
5. "The Elements of Style" by William Strunk Jr. and E.B. White.
6. "Good Reasons with Contemporary Arguments" by Lester Faigley and Jack Selzer.
7. "Writing to Learn: How to Write - and Think - Clearly About Any Subject at All" by William Zinsser.
8. "The Norton Field Guide to Writing" by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg.
9. "The Art of Styling Sentences" by Ann Longknife and K.D. Sullivan.
10. "Writing Today" by Richard Johnson-Sheehan and Charles Paine.

ICP-321 Ideology and Constitution of Pakistan 2(2-0)



بانیبر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION
Government of Pakistan, Islamabad
(Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 18 August 2023 in the Higher Education Commission, Islamabad to design a two-credits course of "Ideology and Constitution of Pakistan" as part of the general education component of the HEC Undergraduate Education Policy (V 1.1).


Following members of the committee attended the meeting and developed the draft of the course:

1. Dr. Anis Ahmad, Vice Chancellor, Riphah International University, Islamabad
2. Dr. Qibla Ayaz, Chairman, Council of Islamic Ideology, Islamabad
3. Dr. Mahboob Hussain, Professor & Chairperson, Department of History and Pakistan Studies, University of the Punjab, Lahore
4. Dr. Navoed Ahmed, Professor, University Law College, University of the Punjab, Lahore
5. Dr. Altaf Qadir, Associate Professor, Department of History, University of Peshawar, Peshawar
6. Dr. Muhammad Shoaib Malik, Associate Professor and Head, Department of Pakistan Studies, National University of Modern Languages, Islamabad
7. Dr. Sami Raza, Associate Professor, Department of International Relations, University of Peshawar, Peshawar
8. Dr. Siraj Ahmed Soomro, Associate Professor & Chairperson, Department of Pakistan Studies, Shah Abdul Latif University, Khairpur
9. Dr. Shakila Noor Sindhu, Assistant Professor & Chairperson, Department of Political Science, Forman Christian College, Lahore
10. Dr. Erum Muzaffar, Assistant Professor & In-charge, Pakistan Study Center, University of Karachi, Karachi
11. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

That after consultation and endorsement of the committee, the final draft of the course is hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.


Dr. Anis Ahmad
(Convener)


Dr. Mahboob Hussain
(Co-Convener)


Mr. Muhammad Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

IDEOLOGY AND CONSTITUTION OF PAKISTAN

UGE Policy V 1.1 : General Education Course

Credits: 02
Pre-Requisite: Nil
Offering: Undergraduate Degrees (including Associate Degrees)
Placement: 1 - 4 Semesters
Type: General Education
Fields: All

DESCRIPTION

This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistani citizens to enable them function in a socially responsible manner.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
2. Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
3. Explain about the guiding principles on rights and responsibilities of Pakistani citizens as enshrined in the Constitution of Pakistan 1973.

SYLLABUS

1. **Introduction to the Ideology of Pakistan:**
 - Definition and significance of ideology.
 - Historical context of the creation of Pakistan (with emphasis on socio-political, religious, and cultural dynamics of British India between 1857 till 1947).
 - Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah., etc.
 - Contributions of women and students in the freedom movement for separate homeland for Muslims of British India.
2. **Two-Nation Theory:**
 - Evolution of the Two-Nation Theory (Urdu-Hindi controversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940).
 - Role of communalism and religious differences.
3. **Introduction to the Constitution of Pakistan:**
 - Definition and importance of a constitution.
 - Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949).
 - Overview of constitutional developments in Pakistan.
4. **Constitution and State Structure:**
 - Structure of Government (executive, legislature, and judiciary).
 - Distribution of powers between federal and provincial governments.
 - 18th Amendment and its impact on federalism.



5. Fundamental Rights, Principles of Policy and Responsibilities:

- Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
- Overview of Principles of Policy (Articles 29-40).
- Responsibilities of the Pakistani citizens (Article 5).

6. Constitutional Amendments:

- Procedures for amending the Constitution.
- Notable constitutional amendments and their implications.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "The Idea of Pakistan" by Stephen P. Cohen.
2. "Ideology of Pakistan" by Javed Iqbal.
3. "The Struggle for Pakistan" by I.H. Qureshi.
4. "Pakistan the Formative Phase" by Khalid Bin Sayeed.
5. "Pakistan: Political Roots and Development" by Safdar Mahmood.
6. "Ideology of Pakistan" by Sharif-ul-Mujahid.
7. "The Struggle for Pakistan: A Muslim Homeland and Global Politics" by Ayesha Jalal.
8. "Jinnah, Pakistan and Islamic Identity: The Search for Saladin" by Akbar S. Ahmed.
9. "The Making of Pakistan: A Study in Nationalism" by K.K. Aziz.
10. "Pakistan: A New History" by Ian Talbot.
11. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring.
12. "The Constitution of Pakistan 1973", Original.
13. "Constitutional and Political Development of Pakistan" by Hamid Khan.
14. "The Parliament of Pakistan" by Mahboob Hussain.
15. "Constitutional Development in Pakistan" by G.W. Choudhury.
16. "Constitution-Making in Pakistan: The Dynamics of Political Order" by G.W. Choudhury.



MTH-322 Introduction to Calculus 3(3-0)

(For Medical Students)

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities. Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions. Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives. Integration and Indefinite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts.

RECOMMENDED BOOKS

1. Anton H, Bevens I, Davis S, Calculus: A New Horizon (8th edition), 2005, John Wiley, New York.
2. Stewart J, Calculus (3rd edition), 1995, Brooks/Cole (suggested text).
3. Swokowski EW, Calculus and Analytic Geometry, 1983, PWS-Kent Company.
4. Boston Thomas GB, Finney AR, Calculus (11th edition), 2005, Addison-Wesley, Reading, Ma, USA.
5. N. Khalid, M.K. Iqbal, Mathematics-II Introduction to Calculus, Discover Mathematics Series, 2nd Edition, 2021.

OR

ZOL-307 Functional Biology-II 3(2-1)

(For Non-medical Students)

Aims and Objectives

The Objectives of the courses are:

1. To teach about animals' diversity adapted in different strategies' for performance of their similar functions through modifications in body parts in past and present times.
2. To impart understanding of diverse strategic structural adaptations in each of the functions of integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory and respiratory systems for effective survival in their specific conditions.
3. To understand the organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body.
4. To embrace the phenomena in basic structure of each system that determines its particular function.

Course Learning Outcomes:

1. Acquire the concept that for the performance of a function for example exchange of respiratory gases the different forms are adapted in t environments e.g. gills in aquatic and lungs in terrestrial environment.

2. Understand that diverse forms adapted to perform the same functions are because of the different past and present conditions.

3. Solve of emergence of diversity of forms for the performance of similar function.

4. Analyze the requirements of diverse forms for the performance of similar function in their past and present needs.

5. Evaluate the adaptations in forms for its efficiency in managing the function in differing situations in the past and present times.

6. Demonstrate that a form is successfully adapted to perform a function adequately and successfully.

Course Contents

1. Nutrition and Digestion

Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion; animal strategies for getting and using food, diversity in digestive structures of invertebrates and vertebrates; the mammalian digestive system:

2. Temperature and Body Fluid Regulation

Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Temperature Regulation in Invertebrates, Invertebrate and Vertebrate Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions.

3. Reproduction and Development

Asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction; sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes.

4. Protection, Support, and Movement

Protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates.

5. Communication

Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells. Sensory reception of invertebrates and vertebrates. Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; Hormones with principal function of invertebrates and vertebrates.

6. Circulation, Immunity and Gas Exchange

Internal transport and circulatory systems in invertebrates and transport systems in vertebrates;

Immunity: nonspecific defenses, the immune response; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.

Practical's

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection and Model).
3. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).
4. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (performance/Model).
5. Model study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
6. Study and notes of skeleton of Labeo, Rana tigrina, Varanus, fowl and rabbit alongwith models.
7. Study of nervous system of earthworm and a fish.
8. Study of endocrine system in an insect and a rabbit.
9. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Books Recommended

1. Miller, S.A. and Harley, J.B. ZOOLOGY, 10th Edition (International), 2016. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 17th Edition (International), 2017. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

CHM-303 Introduction to Nanochemistry 2(2-0)

Nanochemistry, Current trends in micro to nanoscale analysis, Classification of nanomaterials, Fundamental physical and chemical properties of nanomaterials, Methods for synthesis and characterization (XRD, SEM, TEM, EDX, Electro-optical characterization etc.). Green nanomaterials and nanotechnology, Fabrication and applications of nanomaterials, nanocomposites, separation science, catalysis, nano-optics and electronics, drug discovery and delivery.

Recommended Books

1. Al-Noor, T. & H. Rhayma, Mazin & Hussein, Khairy. (2017). Introduction to Nano-chemistry and Nano-materials. ISBN: 978-620-2-34432-6, Noor Publishing, Mauritius.
2. The Physics and Chemistry of NanoSolids by Frank J. Owens and Charles P. Poole Jr, Wiley- Interscience, 2008.
3. Roduner, E. (2006) Nanoscopic Materials: Size Dependent Phenomena, Royal Society of Chemistry
4. Rajangam, K., Behanna, H. A., Hui, M. J., Han, X. Q., Hulvat, J. F., Lomasney, J. W., Stupp, S. I. (2006) Nano Lett., 6 (9), 2086–90.
5. Mnyusiwalla, A., Daar, A. S., Singer, P. A. (2003) Nanotechnology, 14 (3), R9–R13.



ہائیر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION
Government of Pakistan, Islamabad
(Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 5 September 2023 in the Higher Education Commission, Regional Office, Lahore to design a two-credits course of "Civics and Community Engagement" as part of the general education component of the HEC Undergraduate Education Policy (V.1.1).

Following members of the committee attended the meeting and developed the draft of the course:

1. Dr. Asif Naveed Ranjha, Professor & Chairperson, Department of Social Work, The Islamia University of Bahawalpur, Bahawalpur
2. Dr. Mumtaz Ali Baloch, Professor, Department of Social Work, University of Balochistan, Quetta
3. Dr. Naveed Ahmed, Professor, University Law College, University of the Punjab, Lahore
4. Dr. Asmat Ara, Associate Professor & Chairperson, Department of Mass Communication, University of Karachi, Karachi
5. Dr. Farasat Rasool, Associate Professor, School of Media & Mass Communication, Beaconhouse National University, Lahore
6. Dr. Farhan Hanif Siddiqi, Associate Professor, School of Politics & International Relations, Quaid-i-Azam University, Islamabad
7. Dr. Fouzia Ghani, Associate Professor & Chairperson, Department of Political Science, Government College University, Lahore
8. Dr. Naila Usman Siddiqui, Associate Professor & Chairperson, Department of Sociology, University of Karachi, Karachi
9. Dr. Shakool Ahmed, Associate Professor & Head, Department of Social Work, University of Peshawar, Peshawar
10. Dr. Une Laila, Associate Professor, Department of Government & Public Policy, National University of Sciences and Technology, Islamabad
11. Dr. Amen Jaffer, Assistant Professor, Mushtaq Ahmad Gurnani School of Humanities and Social Sciences, Lahore University of Management Sciences, Lahore
12. Dr. Natasha Kiran, Assistant Professor, Department of Philosophy & Interdisciplinary Studies, Bahauddin Zakariya University, Multan
13. Dr. Qurah-ul-Ain, Assistant Professor & Chairperson, Department of Public Administration, University of Kotli Azad Jammu & Kashmir, Kotli
14. Dr. Shakila Noor Sindhu, Assistant Professor & Chairperson, Department of Political Science, Forman Christian College, Lahore
15. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad

That after consultation and endorsement of the committee, the final draft of the course is hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by us / the undersigned on behalf of the committee for consideration of HEC.


Dr. Shakila Noor Sindhu
(Convener)


Dr. Farhan Hanif Siddiqi
(Co-Convener)


Mr. Muhammad Ali Baig
(Secretary)

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

CIVICS AND COMMUNITY ENGAGEMENT

UGE Policy V 1.1 : General Education Course

Credits:	02
Pre-Requisite:	Nil
Offering:	Undergraduate Degrees (including Associate Degrees)
Placement:	1 - 4 Semesters
Type:	General Education
Fields:	All

DESCRIPTION

This course is designed to provide students with fundamental knowledge about civics, citizenship, and community engagement. In this course, the students will learn about the essentials of civil society, government, civic responsibilities, inclusivity, and effective ways to participate in shaping the society which will help them apply theoretical knowledge to the real-world situations to make a positive impact on their communities.

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Demonstrate fundamental understanding of civics, government, citizenship and civil society.
2. Understand the concept of community and recognize the significance of community engagement for individuals and groups.
3. Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.

SYLLABUS

1. **Civics and Citizenship:**
 - Concepts of civics, citizenship, and civic engagement.
 - Foundations of modern society and citizenship.
 - Types of citizenship: active, participatory, digital, etc.
2. **State, Government and Civil Society:**
 - Structure and functions of government in Pakistan.
 - The relationship between democracy and civil society.
 - Right to vote and importance of political participation and representation.
3. **Rights and Responsibilities:**
 - Overview of fundamental rights and liberties of citizens under Constitution of Pakistan 1973.
 - Civic responsibilities and duties.
 - Ethical considerations in civic engagement (accountability, non-violence, peaceful dialogue, civility, etc.)
4. **Community Engagement:**
 - Concept, nature and characteristics of community.
 - Community development and social cohesion.
 - Approaches to effective community engagement.
 - Case studies of successful community driven initiatives.
5. **Advocacy and Activism:**
 - Public discourse and public opinion.
 - Role of advocacy in addressing social issues.
 - Social action movements.
6. **Digital Citizenship and Technology:**
 - The use of digital platforms for civic engagement.
 - Cyber ethics and responsible use of social media.

PST-321 Pakistan Studies 2(2-0)

PAKISTAN STUDIES

UG POLICY V I.I : GENERAL EDUCATION COURSE

Credits: 02
Pre-Requisite: Nil
Offering: Undergraduate Degrees
Placement: 1 - 8 Semesters
Type: General Education
Fields: All

DESCRIPTION

This course is designed to provide students with a comprehensive exploration of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over time including democratic transitions and military interventions. The aim of this course is to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

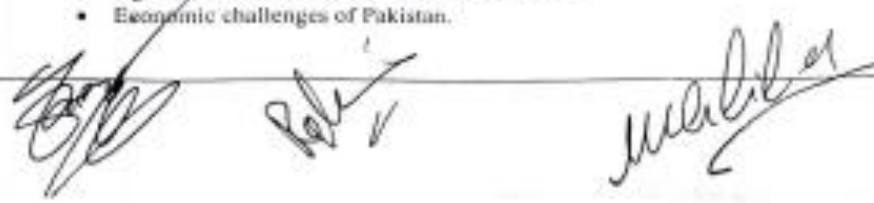
COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
2. Understand the society and culture of Pakistan.
3. Understand and explain the socio-economic developments in Pakistan.
4. Explore contemporary issues and challenges faced by Pakistan and their implications for the future.

SYLLABUS

1. Introduction to Pakistan:
 - Geographical location and significance.
 - Historical background: Ancient civilizations in the region.
 - Factors leading to the creation of Pakistan.
2. Political History of Pakistan:
 - Formative phase.
 - Military interventions and democratic transitions.
3. Geography of Pakistan:
 - Physiography: Mountains, plains, plateaus, deserts, valleys and coastal areas.
 - River systems: Indus River and its tributaries.
 - Climatic regions of Pakistan.
4. Society and Culture of Pakistan:
 - Socio-cultural diversity.
 - Languages and literature of Pakistan.
5. Economic Development of Pakistan:
 - Agriculture and industrial sectors of Pakistan.
 - Economic challenges of Pakistan.



6. Contemporary Issues:

- Foreign relations of Pakistan.
- Security challenges: terrorism, extremism, and regional conflicts.
- Environmental problems and sustainable development (SDGs).
- Media and social change.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan" by Ayesha Jalal
3. "The struggle for Pakistan" by Ishtiaq Husain Qureshi
4. "Pakistan, the Formative Phase, 1857-1948" by Khalid B. Sayeed
5. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
6. "Constitutional and Political History of Pakistan" by Hamid Khan
7. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
8. "Pakistan: A Modern History" by Ian Talbot
9. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
10. "Physical Geography of Pakistan" by Umar Jahangir
11. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan
12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke
13. "Separatism in East Pakistan" by Rizwan Ullah Kokab
14. "Being Pakistani: Society, Culture and the Arts" by Raza Rumi
15. "Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects" edited by Abdul Jabbar Khan
16. "Language and Politics in Pakistan" by Tariq Rahman
17. "Sociology" by Horton and Hunt
18. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring
19. "Economic Development of Pakistan" by Ishrat Husain
20. "Issues in Pakistan's Economy" by S. Zaidi



- Digital divides and disparities (access, usage, socioeconomic, geographic, etc.) and their impacts on citizenship.
7. **Diversity, Inclusion and Social Justice:**
- Understanding diversity in society (ethnic, cultural, economic, political etc.).
 - Youth, women and minorities' engagement in social development.
 - Addressing social inequalities and injustices in Pakistan.
 - Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

As part of the overall learning requirements, the course may have one or a combination of the following practical activities:

1. **Community Storytelling:** Students can collect and share stories from community members. This could be done through oral histories, interviews, or multimedia presentations that capture the lived experiences and perspectives of diverse individuals.
2. **Community Event Planning:** Students can organize a community event or workshop that addresses a specific issue or fosters community interaction. This could be a health fair, environmental cleanup, cultural festival, or educational workshop.
3. **Service-Learning:** Students can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time and skills to address a particular community need, such as tutoring, mentoring, or supporting vulnerable populations.
4. **Cultural Exchange Activities:** Students can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances, and presentations that promote cross-cultural understanding.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education.
2. "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman.
3. "Engaging Youth in Civic Life" by James Youniss and Peter Levine.
4. "Digital Citizenship in Action: Empowering Students to Engage in Online Communities" by Kristen Mattson.
5. "Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby.
6. "Community Engagement: Principles, Strategies, and Practices" by Becky J. Feldpausch and Susan M. Omilian.
7. "Creating Social Change: A Blueprint for a Better World" by Matthew Clarke and Marie-Monique Steckel.

Semester 3

Course Code	Course Title	Credit Hours
CHM-401	Principles of Physical Chemistry	4(3 - 1)
QTR-422	Quantitative Reasoning-II	3(3-0)
IRS-515	Introduction to International Relations	2(2-0)
CHM-403	Principles of Environmental Chemistry	3(3 - 0)
CHM-405	Cheminformatics and Chemometrics	3(3-0)
PHY-322	Fundamentals of Electricity and Magnetism	3(2 - 1)
UHQ-II	Understanding of Holy Quran-II	1(0-1)
	Total	18

Semester 3

CHM-401 Principles of Physical Chemistry 4(3-1)

Chemical Thermodynamics

Laws of thermodynamics and their applications, thermochemistry, calorimetry, heat capacities and their dependence on temperature, pressure and volume, reversible and non-reversible processes, spontaneous and non-spontaneous processes, relations of entropy and Gibbs free energy with equilibrium constant, Gibbs Helmholtz equation, Clausius-Clapeyron equation, van't Hoff equation.

Solutions

Physical properties of liquids, surface tension, viscosity refractive index, dipole moment etc. and their applications, brief account of interactions among the molecules in liquids, ideal and non-ideal solutions, Raoult's law and its applications, lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, vapor pressure of non-ideal solutions and Henry's law.

Chemical Kinetics

The rates of reactions, zero, first and second reactions with same and different initial concentrations, half-lives of reactions, experiment techniques for rate determination and methods for determination of order of reaction (integration, half-life, initial rate and graphical methods), Arrhenius equation.

CHM-401 Lab

1. Determination of viscosity and parachor values of liquids.
2. Determination of percent composition of liquid solutions by viscometer.
3. Determination of refractive index and molar refractivity.
4. Determination of percent composition of liquid solutions by refractive index measurement.
5. Determination of molecular weight of a compound by elevation of boiling point (ebullioscopic method)
6. Determination of molecular weight of a compound by lowering of freezing point (cryoscopic method).
7. Determination of heat of solution by solubility method.
8. Determination of heat of neutralization of an acid with a base.
9. Determination of strength of NaOH by titrating against HCl.
10. Determination of association factor of benzoic acid.

Recommended Books

1. Peter Atkins, Julio De Paula and James Keeler, "Atkin"s Physical Chemistry" 12th edition, Oxford University Press, 2023.
2. Robert J. Silbey, Robert A. Alberty, George A. Papadantonakis, Mounqi G. Bawendi, "Physical Chemistry" 5th edition, 2022, Wiley publisher.
3. Andreas Hofmann, "Physical Chemistry Essentials" 1st edition, Springer, 2018.
4. Kaith J. Laidler, John H. Meiser, Bryan C. Sanctuary "Physical Chemistry" 4th edition, Brooks Cole publisher, 2006.
5. Ira N. Levine, "Physical Chemistry" 6th edition, Mc Graw Hill, 2009.
6. Ananya Ganguly, "Fundamentals of Physical Chemistry" Pearson Education India, 2011.
7. Barrow, M. G. "Physical Chemistry" 6th edition, Mc Graw Hill, 2000.
5. Thomas Engel, Philip Reid, Physical Chemistry, 3rd Edition, 2012, Pearson, publisher.

QTR-422 Qualitative Reasoning-II 3(3-0)

QUANTITATIVE REASONING (II)

UGE Policy V 1.1 : General Education Course

Credits: 03
Pre-Requisite: Quantitative Reasoning (I)
Offering: Undergraduate Degrees (including Associate Degrees)
Placement: 2 - 4 Semesters
Type: Mandatory
Fields: All

DESCRIPTION

Quantitative Reasoning (II) is a sequential undergraduate course that focuses on logical reasoning supported with mathematical and statistical concepts and modeling / analysis techniques to equip students with analytical skills and critical thinking abilities necessary to navigate the complexities of the modern world. The course is designed to familiarize students with the quantitative concepts and techniques required to interpret and analyze numerical data and to inculcate an ability in students the logical reasoning to construct and evaluate arguments, identify fallacies, and think systematically. Keeping the pre-requisite course of Quantitative Reasoning (I) as its base, this course will enable students further their quantitative, logical and critical reasoning abilities to complement their specific major / field of study.

COURSE LEARNING OUTCOMES

By the end of this course, students shall have:

1. Understanding of logic and logical reasoning;
2. Understanding of basic quantitative modeling and analyses;
3. Logical reasoning skills and abilities to apply them to solve quantitative problems and evaluate arguments;
4. Ability to critically evaluate quantitative information to make evidence based decisions through appropriate computational tools.

SYLLABUS

1. **Logic, Logical and Critical Reasoning**
 - Introduction and importance of logic;
 - Inductive, deductive and abductive approaches of reasoning;
 - Propositions, arguments (valid, invalid), logical connectives, truth tables and propositional equivalences;
 - Logical fallacies;
 - Venn Diagrams;
 - Predicates and quantifiers;
 - Quantitative reasoning exercises using logical reasoning concepts and techniques.
2. **Mathematical Modeling and Analyses**
 - Introduction to deterministic models;
 - Use of linear functions for modeling in real-world situations;
 - Modeling with the system of linear equations and their solutions;
 - Elementary introduction to derivatives in mathematical modeling;
 - Linear and exponential growth and decay models;
 - Quantitative reasoning exercises using mathematical modeling.
3. **Statistical Modeling and Analyses**
 - Introduction to probabilistic models;
 - Bivariate analysis, scatter plots;

At 2 Jan 2017

- Simple linear regression model and correlation analysis;
- Basics of estimation and confidence interval;
- Testing of hypothesis (z-test; t-test);
- Statistical inference in decision making;
- Quantitative reasoning exercises using statistical modeling.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
2. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
3. "Discrete Mathematics with Applications" by Susanna S. Epp.
4. "Applied Mathematics for Business, Economics and Social Sciences" by Frank S Budnick.
5. "Elementary Statistics: A Step by Step Approach" by Allan Bluman.
6. "Introductory Statistics" by Prem S. Mann.
7. "Applied Statistical Modeling" by Salvatore Babones.
8. "Barron's SAT" by Sharvon Weiner Green, M.A and Ira K. Wolf.

Alz
January

IRS- 515 Introduction to International Relations 2(2-0)

Subject: Principles of International Relations

Course Code: IRS-515

Credit Hours: 2(2-0)

Course Objectives:

The course aims:

- To highlight the significance and introduce the fundamentals of the
- Discipline of International Relations to the students.
- To help understand the nature of the discipline.
- To highlight the scope of International Relations as an independent
- discipline.

Course Learning Outcomes:

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

- Acquire the basic knowledge of international relations and understand
- the concepts of basic methodologies to interpret international events.
- Solve, analyze and evaluate the problems using critical thinking while
- observing different multi-view political phenomenon.

Course Contents:

1. Meaning, Scope and significance of International Relations
2. Evolution and Development of International Relations
3. Theoretical Basis of International Relations
 - Realism
 - Liberalism
4. National Interest
5. Foreign Policy
6. Concept of Power and Balance of Power
7. Globalization and International Relations
8. Importance of Non- State Actors in International Relations
9. The Concept of War and Peace in International Relations

Recommended Books:

- Karen A. Mingst, and McKibben, Essentials of International Relations (London: Oxford Publishers, 2016)
- Richard Devetak and Jim George, An Introduction to International Relations (Cambridge: Cambridge University Press, 2017)
- Joshua Goldstine, International Relation (Washington DC: Pearson Education, 2020)
- Kaufman, J. P. (2022). Introduction to International Relations: Theory and Practice. United States: Rowman & Littlefield Publishers.
- Martin Griffiths, and Terry O'. Callaghan, International Relations: The Key Concepts (London, Rutledge, 2018)
- Paul Wilkinson, International Relations: A Very Short Introduction (Oxford: Oxford University Press, 2020)

CHM-405 Cheminformatics and Chemometrics 3(3-0)

1. Cheminformatics: (1 Credit Hours weight)

Scope of computer in Chemistry, MS Office (word, excel, power point), Chemistry-based calculations and plotting graphs and curves, Internet browsing for literature survey using different search engines, applications and practice of software/programs CHEMDRAW, MATHTYPE, MENDELEY and ENDNOTE to be used for chemistry research and manuscript writing

2. Chemometrics (2 Credit Hours weight)

Basic Chemical Data Operation:

Basic concept and scope of Statistics in chemical sciences, Descriptive and Inferential Statistics, Population, Sample, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant figures, Rounding of data (Numbers), Sources of data, Collection of primary and secondary data, Editing of Data.

Sampling and Sampling Distributions of Chemical Process:

Sample design and sampling frame, Bias, Sampling and non-sampling errors, Sampling with and without replacement, Probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions.

Hypothesis Testing for Chemical Analysis:

Statistical Data Treatment and Evaluation Hypothesis Testing, Statistical problem, Statistical Aids to hypothesis testing, Null and alternative hypothesis, Confidence interval and range, Levels of significance, Acceptance and rejection regions, General procedure for testing of hypothesis.

Recommended Books

1. Matthias Otto, 2017, **Chemometrics: Statistics and Computer Application in Analytical Chemistry**, 3rd Eds. Wiley-VCH Verlag GmbH & Co.
2. Robert de Levie, 2004, **How to use Excel in Analytical Chemistry and in General Scientific Data Analysis**, Cambridge University Press, UK.
3. Chaudhary, S.M., 2000, **Introduction to Statistical Theory: Part-I** Ilmi Kitab Khana Lahore.
4. Chaudhary, S.M., 2000, **Introduction to Statistical Theory: Part-II** Ilmi Kitab Khana Lahore.
5. Xiaoli Chu, Yue Huang, Yong-Huan Yun, Xihui Bian, 2022, **Chemometric Methods in Analytical Spectroscopy Technology**, Springer Nature.
6. Richard G. Brereton, 2018, **Chemometrics: Data Driven Extraction for Science**, Wiley & Sons.
7. Matthias Otto, 2017. **Chemometrics: Statistics and Computer Application in Analytical Chemistry**, 3rd Eds. Wiley-VCH Verlag GmbH & Co.
8. Robert de Levie, 2004, **How to use Excel in Analytical Chemistry and in General Scientific**

Data Analysis, Cambridge University Press, UK.

9. Johann Gasreiger, Thomas Engel, 2003, Cheminformatics: A Text book, John Wiley & Sons.
10. Thomas Engel, John Gasteiger, 2018, Cheminformatics: Basic Concept and Method, John Wiley & Sons.
11. Thomas Engel, John Gasteiger, 2018, Applied Cheminformatics: Achievements and Future Opportunities, John Wiley & Sons.
12. Leonard J. Ledger, 2023, Microsoft Office 365 for Beginners, Computers.
13. Abha Agrawal, Majid Rasouli, 2019, EndNote 1-2-3 Easy, Springer.
14. Jacques Raubenheimer, 2014, Mendely: Crowd-Sourced Reference and Citation Management in the Information Era, True Insight Publisher.

CHM-403 Principles of Environmental Chemistry 3(3-0)

Course Objectives

Students will be able to acquire knowledge and develop understanding about the fundamental principles of environmental chemistry and different types of pollutions. Such information will be useful in studying and solving pollution related issues and experiments in the laboratory.

Course Contents

Atmospheric Pollution: The atmosphere, composition, temperature and pressure profile, role of free radicals in the atmosphere, temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, atmospheric aerosols, acid-rain major sources, mechanism, control measures and effects on buildings and vegetation, global warming, major greenhouse gases, mechanism, control measures and global impact, stratospheric ozone, ozone hole, CFCs, ozone protection, biological consequences of ozone depletion. Water pollution source and their treatment, eutrophication, detergents and phosphates in water, water quality criteria, water purification: primary, secondary and advanced treatment. Heavy metals contamination of soil, bio-accumulation of heavy metals, organic matter in soil, macro and micronutrients in soil, ion- exchange in soil, soil pH and nutrients availability.

Recommended Books

1. Baird, C. and Cann, M., Environmental Chemistry, 5 th ed., W. H. Freeman & Company, (2012).
2. Dara, S. S. and Mihsra, D. D., A Text Book of Environmental Chemistry and Pollution Control, 9th ed., S. Chand & Co. Ltd., (2004).
3. Singhi, R. and Singh, V., Green Chemistry for Environmental Remediation, John-Wiley & Sons, Inc., (2011).

4. Holloway, A. M. and Wayne, R. P., Atmospheric Chemistry, 1 st ed., Royal Society of Chemistry, (2010).
 5. Vaclavikova, M., Vitale, K., Gallios, G. P. and Ivanicova, L. Water Treatment Technologies for Removal of High Toxicity Pollutants, Springer link, UK, (2010).
 6. Manahan, S. E., Environmental Chemistry, 9 th ed., CRC press, Taylor & Francis group, USA, (2009).
 7. Girard, J. E., Principles of Environmental Chemistry, 2 nd ed., Jones and Bartlett publishers, (2010).
- Harrison, R. M., Monks, P., Farmer, J. G., Graham, M. C., Mora, S. J., Pulford, I. and Hulsal, C., Principles of Environmental Chemistry, 1 st ed., Royal Society of Chemistry, (2007).
9. Matalack, A., Introduction to Green Chemistry, 2 nd ed., CRC press, Taylor & Francis group, USA, (2010).
 10. Wright, J., Environmental Chemistry, Routledge Taylor & Francis group, (2003).

PHY-322 Fundamentals of Electricity and Magnetism 3(2-1)

Electric charges, Conductor, Insulators, Coulomb's law, Electric field, Electric field intensity, Flux of electric field, Gauss's law and applications, Potential energy, Electric potential energy, Electric potential, Capacitor, Capacitance, Capacitors in series and parallel, Energy storage in an electric field, Electric current, Electromotive force, Motion of charge particles in electrical and magnetic fields, Analysis of circuits, Resistors in series and parallel, Energy transferred in an electric circuit, Magnetic force on a moving charge, Magnetic force on a current carrying wire, Ampere's law, Faraday law of induction, Lenz's law, Motional emf, Generator and motors, Induced electric fields, Visible light, Speed of light, Reflection and refraction of light waves, Double refraction, Polarization by scattering, Total internal reflection, Diffraction, Single slit diffraction, Diffraction grating, X-ray diffraction, Polarization, Types of polarization,

1. To study the behavior of RLC series circuit and determination of its resonance frequency.
2. To study the behavior of RLC Parallel circuit and determination of its resonance frequency.
3. Calibration of a voltmeter by a potentiometer.
4. Calibration of an ammeter by a potentiometer.
5. To determine the high resistance by Neon flash lamp and a capacitor.

Recommended Books:

1. Halliday, Resnick and Walker, 2011, Fundamental Physics, 9th Ed. Ed, John Wiley and Sons Inc. New York.
2. *Young and Freedman*, 2010 *University Physics* 12th edition.

3. Halliday, Resnick and Krane, 2002. Physics Vol. I & II, 5th Ed, John Wiley and Sons Inc. New York.

4. Sears, Zemansky and Young, 2000, University Physics, 8th Ed, Addison-Wesley. Reading (MA) USA.

UHQ-II Understanding of Holy Quran-II 1(0-1)

DIRECTORATE OF ACADEMICS
GOVERNMENT COLLEGE UNIVERSITY, FAISALABAD

Email: diracad@gcuf.edu.pk
923006627246
GCUF/DACAD/25/1080

Allama Iqbal Road,
38000-Faisalabad, Pakistan

Dated: 02/10/2025



NOTIFICATION

Through discussion with Dean Islamic and Oriental Learning it was decided that the courses Understanding of Holy Quran will be coded as:

UHQ-301 UNDERSTANDING OF HOLY QURAN-I
UHQ-401 UNDERSTANDING OF HOLY QURAN-II


In case of BS these courses will be offered in first & third semesters as per Scheme of Studies approved from respective statutory bodies of the departments.

In case of MPhil and PhD these courses will be offered in first two semesters.

Salma Sultana
(PROF. DR. SALMA SULTANA) ^{2-11/25}
Director Academics

Dr. Salma Sultana
Director Academics
GC, University, Faisalabad

cc Vice Chancellor
Vice Chancellor
Deans/ Chairpersons/ Teacher Incharge

Seen & Circulate
in 
6/10/2025

Semester 4

Course Code	Course Title	Credit Hours
CHM-402	Principles of Analytical Chemistry	4(3 – 1)
GSC-321	The Science of Global Challenges	3(2-1)
BCH-303	Essentials of Biochemistry-I	3(3-0)
CHM-404	Principles of Industrial Chemistry	3(3 – 0)
CHM-406	Principles of Green Chemistry	3(3-0)
ENT-422	Entrepreneurship	2(2-0)
	Total	18

Semester 4

CHM-402 Principles of Analytical Chemistry 4(3-1)

Introduction: Analytical chemistry and analysis, Application of analytical chemistry in other disciplines of sciences, Qualitative and quantitative analysis, Classification of analytical techniques, Steps of a typical chemical analysis.

Data handling/Statistical Analysis: Analytical concepts of errors, precision, accuracy (sources, control and applications), arithmetic mean, median, mode, absolute error, relative errors, relative accuracy, standard deviation, coefficient of variation and variance, confidence limits, confidence interval, student t-test, F-test and Q test.

Laboratory Tools: Specification, applications and handling of various glassware used in analytical laboratory, Specifications and grades of chemicals and reagents, Expression of quantities and concentrations.

Good Laboratory Practice/Quality Assurance and Quality Control: Concept of good laboratory practice, quality assurance, quality control and quality assessment and their elaboration with examples and application; Validation of analytical method; Laboratory accreditation, electronic record and electronic signatures.

Solvent Extraction:

Principle, distribution coefficient (K_d) and distribution ratio (D), factors affecting the extraction efficiency, types, and practical applications of solvent extraction in chemical analysis.

Practicals

1. Laboratory materials, reagents, and safety measures,
2. Calibration of volumetric glassware,
3. Preparation and standardization of reagents and solutions,
4. Solvent extraction of organic compounds
5. Single step and multiple batch solvent extraction and comparison of efficiency

Books Recommended:

1. Gary D. Christian, Purnendu H Dasgupta & Hevin A Achug, 2021. Analytical Chemistry. 7 th Eds. John Wiley and Sons, New York.
2. Douglas A. Skoog, Donald M. West, F. James Holler & Stanley R. Crouch, 2022. Fundamentals of Analytical Chemistry. 10 th Eds. Harcourt College Publishers.
3. Harvey, D., 2000. Modern Analytical Chemistry, 1 st Eds. McGraw-Hill, USA.
4. F.W. Fifield & D. Kealey, 2000. Principles and Practice of Analytical Chemistry, 5 th Eds. Blackwell Science Ltd. UK.
5. Douglas A. Skoog, F. James Holler & Stanley R. Crouch, 2022. Principles of instrumental Analysis, 5 th Eds. Harcourt College Publishers.
6. Daniel C. Harris, 2021. Quantitative Chemical Analysis, 9th Eds. W. H. Freeman & Company.
7. Reilley, C. 1993. Laboratory Manual of Analytical Chemistry. Allyn & Bacon, London.



Higher Education
Commission

The Science of Global Challenges

(Model Course)

Copyright © 2021 @ Higher Education Commission.
All Right Reserved.

COURSE DESCRIPTION:

Our world has seen a massive transformation in the past 200 years. The progress that we see around ourselves is largely owed to the advancement in Scientific knowledge that has enabled us to harness Nature's resources in a multitude of ways. This progress however has come at a great cost, including a threat to our own existence. Through this course, we will discuss some of the core challenges mankind is facing, the scientific reasoning behind all these challenges and the actions that must be taken to create a future free of these problems. The three main areas we will focus on include Climate Change, The Energy Crisis and the survival of humanity in the wake of deadly viruses and infectious diseases.

Towards the end the students will get to see the complex relationship between Science, Technology and our Society and some future directions that promise a safer future for all of us.

COURSE OUTCOMES:

Through successful completion of this course, students will be able to:

1. Explain the scientific principles that help understand the key challenges we are facing today
2. Describe natural systems modulating the Earth's climate, articulate causes and consequences of anthropogenic climate change, and discuss measures to curb global greenhouse gas emissions.
3. Differentiate between renewable and nonrenewable systems
4. Explain the working principles of various renewable systems and devices including solar photovoltaics, wind mills, hydro power, geo thermal and bio energy
5. Explain the working principle of key biological ideas including viruses and diseases, evolution by natural and artificial selection
6. Demonstrate an understanding of the deep connection between science, technology and society

COURSE OUTLINE/WEEKLY BREAKDOWN

Module Name	Time (weeks)	Goal	Topics
Overview and Framing of the course	1	Overview of the course and the key challenges that will be tackled.	Introduction to some key advancements we have made in the last 200 years and the associated challenges that are manifesting themselves in the form of Climate Crisis, the over reliance on fossil fuels and mass extinction of various species.
Challenge 1: Climate Change	4	The goal of this module is for students to understand how several different natural processes interact to produce the dynamic system that is the Earth's climate. It will discuss how human actions have disturbed these natural systems which is resulting in rapid climatic change globally. The module ends with a focus on how we build and use models to predict future changes in climate at various spatial and temporal scales	<ul style="list-style-type: none"> • Intro and Framing • What's the greenhouse effect? • Challenges and risks of climate change • Geologic History and Planetary Processes • Oceans: How do ocean currents regulate global climate • Atmosphere: How do large scale wind patterns affect global climate • Ecosystems: Climate constrain ecosystems and ecosystems impact global climate • Projections of future climate • Measuring anthropogenic climate change • What are GCMs? Carbon emission scenarios • Sustainability
Challenge 2: Energy	3	This module will introduce various methods of harnessing energy through renewable systems. Working of various renewable systems including Solar Photovoltaics, Wind Mills, Hydro Power, Bio Energy, Geo Thermal Energy and Tidal and Wave Energy will be introduced. A contextual study of renewables for Pakistan will also be studies to see the future of Energy in this region	<ul style="list-style-type: none"> • Science of Energy: Forms of Energy, Energy Conversion • Sustainability of Energy Systems • Working of renewable devices. How do solar cells operate? Photoelectric effect, intro to semiconductors and band gaps, Wind energy, Wind mills, Physics of a generator • Energy quantification - Energy needs, available resources, renewable vs nonrenewable, challenges of current practices. • Future of Energy

<p>Challenge 3: Human survival and infectious disease</p>	<p>4</p>	<p>Understanding how infection originate and how human body responds to them, what happens if the body fails to fight them</p>	<ul style="list-style-type: none"> • What are infectious diseases. • Types of infectious diseases • History of Germs, Vaccines and Diseases • Evolution by Natural and Artificial Selection • Why are viruses crossing species barrier? • Anti-biotic resistance • Human physiological limits • Changing interactions and new diseases
<p>Science, Technology, and Society</p>	<p>2</p>	<p>An introduction to how Science, Technology and Society intersect</p>	<ul style="list-style-type: none"> • Complex web of science, politics and social systems • Development of Science in certain areas, Role of Wars • Scientific Funding • Technological Progress and Ethical Constraints • Human experiences as Data
<p>The Future of Science: Nanotechnology & Biotechnology</p>	<p>1</p>	<p>A discussion of some emerging technologies which are seen as a revolution in the field of science including nano-technology and bio-technology</p>	<ul style="list-style-type: none"> • Nanotechnology and its future applications in Medicine, Food, Computational Systems, Energy • Biotechnology • Future of foods: Agricultural production, consumption and nutrition • Genetic Modification: CRISPR, Gene Therapy • Exobiology – Life and humans outside of Earth

Course Objective:

This course will provide:

- Fundamental postulates in Biochemistry
- Understanding of classification, structures, characteristics, and biological functions of vital macromolecules

Learning Outcome:

After studying the course, the students will be able to:

- Understand the scope of biochemistry
- Understand biochemical basis of life
- Acquire basic knowledge of biomolecules

Course outlines:

- A general introduction to the science of Biochemistry, Importance, scope, and history of Biochemistry
- Review of the diversity and ecology of the living world
- Structure, functions, and brief classification of prokaryotes, Cellular architecture of prokaryotes and eukaryotes
- Physical properties, structure and importance of H₂O, pH, and buffer
- Distinctive properties of carbon and other elements found in biomolecules
- Classification, structure, characterization, and biological functions of following vital macromolecules

Carbohydrates:

Definition and classification, chemistry, physical and chemical properties of various classes of carbohydrates. Biological structure and function of homo- and hetero polysaccharides, function of starch, glycogen, and cell wall polysaccharides.

Lipids:

Definition and classification of lipids. Chemistry and biological important fatty acids, waxes, glycerides, phospholipids, sphingolipids, glycolipids, sterols, and prostaglandins
Significance of lipids in biological membranes and transport mechanism

Proteins:

Chemistry and classification of Amino acids, Physical and chemical properties of amino acids. Biological significance of amino acids, peptides. Proteins; their classification, properties and biological significance, primary, secondary, tertiary, and quaternary structure of proteins. Denaturation of proteins.

Nucleic Acids:

Chemical composition of nucleic acids. Structure and biological significance of nucleic acids. Chemical synthesis of oligonucleotides. Nucleic acids hydrolysis. Isolation and separation of nucleic acids. Introduction to recombinant DNA technology.

Enzymes:

Introduction to enzymes, Nomenclature and classification, Isoenzymes, coenzymes and role of cofactors, Structure of enzyme; active site and regulatory sites, Enzyme Inhibition and types of inhibition.

Recommended Books:

- Lehninger, David L. Nelson; Michael M, "Principles of Biochemistry", Worth Publisher, New York, (2021).
- Lippincott Illustrated Reviews: "Biochemistry 8th edition", Emine Ercikan Abali, Susan D. Cline (2021).
- Harper's Biochemistry, 30th Ed, (2018).
- Textbook of Biochemistry with Clinical Correlations, 7th Ed, (2010).
- Voet, D. and Voet J.G., "Biochemistry", John Willey & Sons, New York, 4th Ed (2010).

CHM-404 Principles of Industrial Chemistry 3(3-0)

Fundamentals of Chemical Industry

Basic principles and parameters for industrial plant unit operations and unit processes.

Chemical Industries

Raw materials, flow sheet diagrams and unit operations and unit processes of sulphuric acid, oxalic acid, caustic soda and washing soda, fertilizer industry, sugar industry, cement industry, textile, polymer and petroleum processes, copper and iron metallurgy.

Recommended Books

1. Sharma, J., Ndi., Applied Industrial Chemistry, Arise publishers & Distributors, (2012).
2. Vermani, O. P. and Narula, A. K., Applied Chemistry; Theory and Practice, New Age International Pvt. Ltd. Publishers, (2008).
3. Hede, P. D., Bier. S.P., Inorganic and Applied Chemistry, Ventus publishing app., (2007).
4. Kent, J. A., Riegel's Handbook of Industrial Chemistry, 10th ed., Kluwer Academic/Plenum Publishers (2003).
5. Heaton, A., An introduction to Industrial Chemistry, 3rd Ed., Chapman & Hall (1996).

CHM-406 Principles of Green Chemistry 3(3-0)

Course Overview

Green chemistry is the utilization of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. This course will introduce the principles and fundamental concepts of green chemistry and provide examples of commercial applications of green Chemistry.

Outlines

Introduction of green Chemistry, principles and environmental impact of green Chemistry. Overview of periodic table for the relative abundance and toxicity of elements. Chemical hazards and safety. Balancing equations, stoichiometry and classes of reactions to understand high and low atom economy and energy-efficient reactions. Energy sources and fuels from biomass including the replacement of fossil fuels with renewable wind and solar energy. Examples of traditional synthesis verses green synthesis.

Recommended Books

1. A Textbook of Green Chemistry, 2021, Edition: First, Techno World, ISBN: 978-93-92145-03-03-
2. Green Chemistry, Fundamentals and Applications, Hard ISBN: 9781926895437, Paperback ISBN: 978-1-77463-269-7, E-Book ISBN: 9781466578265, Pages: 396pp.
3. Lancaster, M. *Green Chemistry: An Introductory Text*, Third Edition; RSC Publishing; 2016. ISBN: 978-1-78262-294-9
4. Anastas, P. T.; Warner, J. C. *Green Chemistry: Theory and Practice*, Oxford University Press, Oxford; 1998. ISBN: 0-19-850234-6.
5. Baird, C.; Cann, M. *Environmental Chemistry*, Fifth Edition; W. H. Freeman and Company, New York; 2012. ISBN-13: 978-1-4292-7704-4. (Toxicology, Chapters 13-1.
6. Manahan, S. E. *Environmental Chemistry*, Eighth Edition; CRC Press, 2005. ISBN: 1-56670-633-5. (Toxicology, Chapters 22-23).

ENT-422 Entrepreneurship 2(2-0)



ہائیر ایجوکیشن کمیشن

HIGHER EDUCATION COMMISSION

Government of Pakistan, Islamabad
(Curriculum Division)

ENDORSEMENT OF THE COURSE DESIGN COMMITTEE

A meeting of a course design committee was held on 15 June 2023 in the Higher Education Commission, Islamabad to design a two-credit course on "Entrepreneurship".

Following members of the committee attended the meeting in person and developed the first draft of the course:

1. Dr. Hamid Rafiq Khattak, CEO, MANTECH&ARC, Islamabad (Convener)
2. Dr. Shahid Mansoor Hashmi, Sr. Joint Director Instructional Design, National Institute of Banking & Finance, Islamabad (Member)
3. Mr. Owais Anjum, CEO, Emumba, Islamabad (Member)
4. Dr. Muhammad Shujaat Mubarak, Dean (CBM), Institute of Business Management, Karachi (Member)
5. Dr. Farah Naz Baig, Chairperson Department of Marketing, Institute of Business Administration, Karachi (Member)
6. Dr. Saleem Gul, IMSciences, Peshawar (Member)
7. Dr. Tasneem Fatima, Associate Professor, Department of Business Administration, International Islamic University, Islamabad (Member)
8. Dr. Saad Hassan, Assistant Professor (AUSOM), Air University, Islamabad (Member)
9. Mr. Muhammad Ali Baig, Deputy Director, Higher Education Commission, Islamabad (Secretary)

Following members of the committee, in addition to the above, attended the subsequent online meetings to review and revise the draft of the course:

1. Dr. Sara Saeed Khurram, CEO, Sehat Kahani, Karachi (Member)
2. Mr. Ayub Zakoori, CEO, Zakoori Group, Peshawar (Member)
3. Mr. Mansoor Lashari, CEO, Barqbox, Lahore (Member)
4. Dr. Faiza Ali, Associate Professor (SDSB), Lahore University of Management Sciences, Lahore (Member)

That after consultation and endorsement of the committee, the final draft of the course is hereby submitted to the office of the Director Curriculum Division, HEC, Islamabad by the undersigned being convener of the committee and on its behalf for consideration.


Dr. Hamid Rafiq Khattak
(Convener)

Dated: 20-06-2023

PLEASE NOTE:

1. The Curriculum Division, HEC may conduct an internal review of the draft submitted by the committee and make necessary amendments as and when needed, with or without sharing reasons of the same with the committee.
2. The Curriculum Division, HEC may refer the draft submitted by the committee to other experts or a new committee for review who may propose revisions / additional recommendations in the said draft.

ENTREPRENEURSHIP

UGE Policy V 1.1 : General Education Course

Credits:	02
Offering:	Undergraduate Degrees (including Associate Degrees)
Placement:	1 - 4 Semesters
Type:	Mandatory
Fields:	All

DESCRIPTION

This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills, abilities, enabling them to seize the identified opportunities for initiating ventures and successfully navigating the challenges that come with starting a business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business, market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation.

COURSE LEARNING OUTCOMES

By the end of this course, students shall have:

1. Knowledge of fundamental entrepreneurial concepts, skills and process.
2. Understanding on different personal, social and financial aspects associated with entrepreneurial activities.
3. Basic understanding of regulatory requirements to set up an enterprise in Pakistan, with special emphasis on export businesses;
4. Ability to apply knowledge, skills and competencies acquired in the course to develop a feasible business plan.

SYLLABUS

1. **Introduction to Entrepreneurship:**
 - Definition and concept of entrepreneurship.
 - Why to become an entrepreneur?
 - Entrepreneurial process.
 - Role of entrepreneurship in economic development.
2. **Entrepreneurial Skills:**
 - Characteristics and qualities of successful entrepreneurs (including stories of successes and failures).
 - Areas of essential entrepreneurial skill and ability such as creative and critical thinking, innovation and risk taking abilities etc.
3. **Opportunity Recognition and Idea Generation:**
 - Opportunity identification, evaluation and exploitation;
 - Innovative idea generation techniques for entrepreneurial ventures.
4. **Marketing and Sales**
 - Target market identification and segmentation;
 - Four P's of Marketing.
 - Developing a marketing strategy.
 - Branding.

5. Financial Literacy:

- Basic concepts of income, savings and investments.
- Basic concepts of assets, liabilities and equity.
- Basic concepts of revenue and expenses.
- Overview of cash-flows.
- Overview of banking products including Islamic modes of financing.
- Sources of funding for startups (angel financing, debt financing, equity financing etc.).

6. Team Building for Startups:

- Characteristics and features of effective teams.
- Team building and effective leadership for startups.

7. Regulatory Requirements to Establish Enterprises in Pakistan:

- Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.).
- Intellectual property rights and protection.
- Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms.
- Taxation and financial reporting obligations.

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

As part of the overall learning requirements, students shall be tasked with creating and presenting a comprehensive business plan at the end of the course for a hypothetical or real business idea. This practical exercise shall allow them to apply the knowledge, skills and competencies acquired in the course to develop a feasible business plan.

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. "Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland.
2. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko.
3. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffrey A. Timmons, Stephen Spinelli Jr., and Rob Adams.
4. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.
5. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.
6. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valérie Ohlsson.

Semester 5

Course Code	Course Title	Credit Hours
CHM-501	Inorganic Chemistry - I	4(3 – 1)
CHM-503	Organic Chemistry - I	4(3 – 1)
CHM-505	Physical Chemistry - I	4(3 – 1)
CHM-507	Analytical Chemistry - I	4(3 – 1)
	Total	16

CHM-501 Inorganic Chemistry-I 4(3-1)

1. BONDING MODELS FOR NON TRANSITION ELEMENTS

(a) Covalent bond. VSEPR model followed by VBT for prediction of geometries of molecules and ions containing sigma bonds as well as pi bonds. MOT for homonuclear and heteronuclear diatomic molecules.

(b) Metallic bond. Band theory to describe conductors, insulators and semiconductors.

(c) 3 center 4 electrons bond, 3 center 2 electrons bond, bent bond, H bonding.

2. CHEMISTRY OF COORDINATION COMPOUNDS

Nomenclature, theories of bonding (Werners theory, Sigwick theory, Chain theory, VBT, CFT, LFT). Stereochemistry of coordination compounds, Coordination geometries (CN 2 – 6). Preparation of coordination compounds Stability of coordination compounds. Spectrochemical series. Application of coordination compounds in Chemistry, life and industry.

3. LANTHANIDES AND ACTINIDES

Historical survey, occurrence, separation and preparation. Oxidation states, magnetic properties of Lanthanides and Actinides. Lanthanides contraction. Applications and uses of elements and their compounds.

CHM-501 Practicals

1. Separation of cations by paper chromatography: (Pb²⁺, Cd²⁺, Cu²⁺, Co²⁺, Ni²⁺, Ag¹⁺)

2. Preparation And Characterisation of Complex Compounds:

(i) Sodium Cobaltinitrate (ii) Potassium trioxalato aluminate (iii) Ammonium Nickel II Sulphate (iv) Hexa aqua Chromium III chloride).

3. Complexometric Titration (Any four) Cu²⁺/ Ni²⁺; Ca²⁺ /Ba²⁺; Au²⁺ /Pb²⁺; Cd²⁺/Zn²⁺; Ni²⁺ /Mg²⁺; Ca²⁺ /Zn²⁺

Recommended Books

1. G. J. Leigh, N. Winterton, "Modern Coordination Chemistry" The Royal Society of Chemistry (2021).
2. Birgit Weber, "Coordination Chemistry Basics and Current Trends" Springer spectrum (2023).
3. E. Disha, "Chemical Bonding" 2nd Edition, American Chemical Society, (2019).
4. P. Atkins, L. Jones, "Chemical Principles" 2nd Ed, Freeman and Company (2002).
5. J. E. Brady, J. R. Holm, "Chemistry-The Study of Matter and Its Changes" 3rd Ed, John Wiley and Sons, Inc. (2000).
6. G. L. Miessler, A. T. Donald, "Inorganic Chemistry" 2nd Ed, Prentice-Hall International, Inc. (1991).
7. D. F. Shriver, P.W. Atkins, C. H. Langford, "Inorganic Chemistry". 2nd Ed, Oxford University Press. USA (1994).

CHM-503 Organic Chemistry-I 4(31)

Acids and Bases

Concepts of acids and bases; scale of acidity and basicity; pKa values; predicting acids/basis reactions from pKa values; the effect of structure on the strengths of acids and bases, field effects, resonance effects, steric effects, hydrogen bonding effects and hybridization effects, the effect of the medium on the strengths of acids and bases; the Hammett and Tafts equations, applications and limitations.

Stereochemistry

Introduction; optical isomerism; optical activity, chirality, symmetry elements and optical inactivity, relative and absolute configuration, R, S notation, methods of determining configuration. Racemic mixtures and their resolution, asymmetric synthesis, optical activity in biphenyls, alkenes and spiro compounds, stereospecific and stereoselective reactions; Geometrical isomerism. Determination of configuration of geometrical isomers, Z, E, conventions cis-and trans-isomerism in cyclic systems; Conformational isomerism conformational analysis of monosubstituted cyclohexanes, disubstituted cyclohexanes and decalin systems.

Oxidation Reduction Reactions:

a)Oxidation: Introduction. Oxidation of saturated, olefinic and aromatic compounds. System containing oxygen and nitrogen compounds.

b) Reduction: Introduction. Reduction of cycloalkanes, olefins, alkynes and aromatic rings. Hydrogenolysis. Reduction of systems containing oxygen and nitrogen compounds.

CHM-503 Practicals

Purification Techniques: Fractional distillation, fractional distillation under reduced pressure and fractional crystallization

Mixture Analysis: Analysis of two component mixture.

Books Recommended:

1. David R. Klein, Organic Chemistry as a Second Language: First Semester Topics, 6th Edition, John Wiley & Sons, Inc. (2024)
2. Felix A. Carroll, Perspectives on Structure and Mechanism in Organic Chemistry, 3rd Edition, John Wiley & Sons, Inc. (2023).
3. Christine K. F., Hermann, T. C. Morrill, R. L. Shriner, R. C. Fuson, The Systematic Identification of Organic Compounds, Set, 9th Edition, John Wiley & Sons, Inc. (2023).
4. P. Sykes, "A Guide Book to Mechanism in Organic Chemistry", Creative Media Partners, LLC (2021).
5. G. M. Loudon, "Organic Chemistry", 7th Ed., W.H. Freeman (2021).
6. P. Y. Bruice, Organic Chemistry, 8th Edition, Pearson. (2016).

7. Jonathan Clayden, Nick Greeves, Stuart Warren "Organic Chemistry", 2nd edition, OUP Oxford, (2012).
8. A. L. Vogel, "Elementary Practical Organic Chemistry Part III: Quantitative Organic Analysis", 2nd Ed., Longman Group Ltd (2011).

CHM-505 Physical Chemistry-I 4(3-1)

Quantum Chemistry

Black body radiation, photoelectric effect, wave and particle nature of matter, de Broglie's equation, Heisenberg's uncertainty principle, wave functions, Eigen functions and eigenvalues, Hamiltonian operator, Schrödinger wave equation, Particle in one dimensional box, Particle in three dimensional box, Quantum numbers, wave functions for hydrogen-like atomic orbitals.

Kinetic molecular theory of Gases

Postulates of Kinetic Molecular theory of gases, Equation of states, ideal and real gases, the virial equation and the van der Waals equation for real gases, critical phenomena and critical constants, Maxwell distribution of molecular speeds, average speeds, calculation of molecular speeds, binary collisions, effusion and mean free paths, Maxwell- Boltzmann's law of energy distribution.

Chemical and Phase Equilibrium

General equilibrium expressions, reaction quotients, examples of equilibrium reactions in solid, liquid and gas phases, extent of reactions and equilibrium constants, effect of temperature and pressure on the equilibrium constants/compositions, Le-Chatelier's principle.

Gibbs phase rule, Phase diagrams of one component and two component systems, Gibbs energy and the phase diagram of a substance, location of phase boundaries, binary phase diagrams and lever rule.

CHM-505 Lab

1. Equilibrium constant of the $KI + I_2 = KI_3$ reaction
2. Kinetics of saponification of ethyl acetate
3. Acid catalyzed hydrolysis of sucrose
4. Determination of heat of solution by solubility method
5. Study of the charge transfer complex formation between iodine and benzene
6. Determination of activation energy for the acid catalyzed hydrolysis of ethyl acetate
7. Determination of partial molar volumes
8. Determination of partition coefficient of a substance in two immiscible liquids
9. Determination of molecular formula of copper-ammonia complex by partition coefficient method
10. Dissociation of trichloroacetic acid-Kinetics method

Recommended Books

1. Silbey, R. J., Alberty, R. A., Papadantonakis, G. A., & Bawendi, M. G. (2022). *Physical Chemistry*. John Wiley & Sons.
2. Atkins, P. W., De Paula, J., & Keeler, J. 12th edition, (2023). *Atkins' Physical Chemistry*. Oxford University press.
3. Mortimer, R. G., & Blinder, S. M. (2023). *Mathematics for Physical Chemistry*. Elsevier.
4. Atkins, P. (2024). *Concepts in Physical Chemistry*. Royal Society of Chemistry.
5. Jang, S. J. (2023). *Quantum Mechanics for Chemistry*. Springer.
6. Garland, C. W., Nibler, J. W., & Shoemaker, D. P. (2009). *Experiments in Physical Chemistry*.
7. Castner Jr, E. W. (2005). *Modern Spectroscopy*, (J. Michael hollas).
8. D. W. Ball, "Physical Chemistry" 1 st Ed, Brooks/Cole Co. Inc. (Latest Edition).
- B. R. Stephen, S. A. Rice, J. Ross, "Physical Chemistry" 2nd Ed., Oxford University Press, USA (2000).

CHM-507 Analytical Chemistry-I 4(3-1)

Analytical processes: Accuracy of analytical processes such as weighing, volume measurements, precipitation, washing, filtration, and ignition. **Sample and Sampling:** Samples and their types, Sampling plan, Sampling of solid, liquid and gases.

Ionic Equilibria in Solutions: Activity and activity coefficients, Hydrogen ion activity and pH for weak acids and bases, Determination of pK_a and pK_b value, common ion effect and its industrial applications. Buffer its composition and mechanism and buffer capacity. Stability and formation constants of complexes, methods for their determination.

Separation Techniques:

Introduction and principle of chromatographic separations, classification and nomenclature of chromatographic techniques, Principle, theory and applications of column chromatography and planer chromatography (paper, thin-layer, and ion-exchange chromatography).

Practicals

1. Practical elaboration of weighing, precipitation, washing, filtration, and ignition through experiments
2. Separation and identification of metal ions and biomolecules by paper chromatography, thin layer chromatography (TLC) and instant TLC etc.
3. Separation of mixture of organic and inorganic compounds by chromatography methods

Books Recommended

1. Gary D. Christian, Purnendu H Dasgupta & Hevin A Achug, 2021. Analytical Chemistry. 7 th Eds. John Wiley and Sons, New York
2. Douglas A. Skoog, Donald M. West, F. James Holler & Stanley R. Crouch, 2022. Fundamentals of Analytical Chemistry. 10 th Eds. Harcourt College Publishers.
3. Harvey, D., 2000. Modern Analytical Chemistry, 1 st Eds. McGraw-Hill, USA.
4. F.W. Fifield & D. Kealey, 2000. Principles and Practice of Analytical Chemistry, 5 th Eds. Blackwell Science Ltd. UK.
5. Douglas A. Skoog, F. James Holler & Stanley R. Crouch, 2022. Principles of Instrumental Analysis, 5 th Eds. Harcourt College Publishers.
6. Daniel C. Harris, 2021. Quantitative Chemical Analysis, 9 th Eds. W. H. Freeman & Company.
8. Reilley, C. 1993. Laboratory Manual of Analytical Chemistry. Allyn & Bacon, London.

Semester 6

Course Code	Course Title	Credit Hours
CHM-502	Inorganic Chemistry - II	4(3 – 1)
CHM-504	Organic Chemistry - II	4(3 – 1)
CHM-506	Physical Chemistry – II	4(3 – 1)
CHM-508	Analytical Chemistry - II	4(3 – 1)
	Total	16

Semester 6

CHM-502 Inorganic Chemistry-II 4(3-1)

1. Chemistry of Non-Aqueous Solvents

Classification of solvents. Type of reactions in non-aqueous solvents. Physical and chemical properties of solvents. Study of reactions in liquid NH_3 , HF , SO_2 , BrF_3 , CH_3COOH and HCN . Reactions in molten salt system.

2. Pi-Acceptor Ligands

Class of ligands. Metal carbonyls, molecular structure, localized bonding (EAN rule, 18 electron rule). Delocalized bonding, spectroscopic evidence of bonding situation. Chemical properties of metal-carbonyls (carbonylate anions, carbonyl hydrides and carbonyl halides). Metal nitrosyls and their derivatives. Applications of metal carbonyls and their derivatives to catalysis and organic synthesis.

3. Kinetics and mechanism of inorganic reactions

Rate law, Stationary state approximation, Labile and inert complexes. Mechanism of substitution reactions in octahedral complexes (hydrolysis reactions, anation reactions, reactions of substituted ligand and redox reactions). Thermodynamic and kinetic stability. Half life.

CHM- 502 Practicals

1. Estimation of Anions (Any four)

Chloride/Phosphate; Chloride/Nitrate; Bromide/Nitrate; Iodide/Nitrate; Borate/
Acetate; Oxalate/ Chloride; Sulphate/Phosphate

2. KIO_3 Titrations (Any two)

3. Gravimetric Estimations:

Estimations of Ba^{2+} ; Oxalate ions.

Books Recommended:

1. A. K.Thakur, Dr. K. Jha. & Dr. K. K. Jha, "Inorganic Chemistry", Books clinic Publishing (2023).
2. R. D. Madan, "Satya Prakash's Modern Inorganic Chemistry" S Chand & Company Limited (2019).
3. P. J. Dyson, J. S. Mcindoe, "Transition Metal Carbonyl Cluster Chemistry", CRC Press (2019).
4. M. Dalal, "A Textbook of Inorganic Chemistry", 1st Edition, Dalal Institute, Haryana, India (2017).
5. V.E. Rudi, D.H. Colin, "Inorganic Reaction Mechanisms: Advances in Inorganic Chemistry" Elsevier Science (2017).
6. A. K. Holliday, A. G. Massey, R. Robert, H. M. N. H. Irving and L. A. K. Staveley "Non Aqueous Solvents in Inorganic Chemistry", Elsevier Science (2013).
7. A. Smiljko, "Chemical Kinetics and Inorganic Reaction Mechanisms", 2nd Edition, Springer New York, NY (2012).
8. Y.Mido, S.Taguchi, Chemistry in Aqueous and Non-aqueous Solvents, Discovery Publishing House (2001).
9. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bockhmann, "Advanced Inorganic Chemistry" 6th Ed, John Wiley & Sons, Inc.USA (1999).

CHM-504 Organic Chemistry-II 4(3-1)

Aliphatic nucleophilic substitution and Elimination reactions

Aliphatic nucleophilic substitution reactions Mechanisms and study of S_N1, S_N2, S_N1, S_N2, mechanism; neighbouring group participation, intra molecular displacement by neighbouring oxygen, nitrogen, sulphur and halogen; The effects of the substrate structure, entering group, leaving group and reaction medium on the mechanisms and rates of substitution reactions.

Elimination Reactions. Mechanisms study of E1, E1cB and E2 mechanisms; attacking base, leaving group and the reaction medium on the rates and mechanisms of elimination reactions; competition between elimination and substitution reactions.

Aromatic Substitution reactions

Electrophilic substitution Aromaticity; mechanisms of substitution; orientation sulfonation, Friedel-Crafts reactions, diazo-coupling, formylation and carboxylation.

Nucleophilic substitution. Mechanisms-Study of S_NAr, S_N1 and benzyne mechanisms; The effects of substrate structure, leaving group and the attacking nucleophile on the rates of substitution reactions.

Named Organic Reactions

Cannizzaro reaction, Perkin reaction, Michael reaction, Claisen-Schmidt reaction, Darzens Glycidic Ester reaction, Stobbe reaction, Mannich reaction, Wittig reaction, Ene reaction and Reformatsky reaction, Diels-Alder reaction.

CHM-504 Practicals

Organic Synthesis at least four experiments involving two step synthesis

Estimation of Amide and Carboxyl groups, Phenol and other functional groups.

Determination of Saponification value and acid value in oil.

Recommended Books

1. David R. Klein, Organic Chemistry as a Second Language: First Semester Topics, 6th Edition, John Wiley & Sons, Inc. (2024).
2. Felix A. Carroll, Perspectives on Structure and Mechanism in Organic Chemistry, 3rd Edition, John Wiley & Sons, Inc. (2023).
3. J. March, "Advanced Organic Chemistry Reactions, Mechanisms and Structure", 8th Ed, John Wiley & Sons, Inc; USA (2019).
4. K. S. Tewari and N. K. Vishnoi, A Textbook of Organic Chemistry, 5th edition, Vikas (2017)
5. P. Y. Bruice, Organic Chemistry, 8th Edition, Pearson. (2016).
6. Christine K. F., Hermann, T. C. Morrill, R. L. Shriner, R. C. Fuson, The Systematic Identification of Organic Compounds, Set, 9th Edition, John Wiley & Sons, Inc. (2023)
7. A. L. Vogel, "Elementary Practical Organic Chemistry Part III: Quantitative Organic Analysis", 2nd Ed., Longman Group Ltd (2011).

CHM-506 Physical Chemistry II 4(3-1)

Electrochemistry

Ions in solution, measurement of conductance and Kohlrausch's law, mobility of ions and transport number, activity and activity coefficient, ionic strength, Debye-Hückel theory, Redox reactions, spontaneous reactions, electrochemical cells, standard electrode potentials, liquid junction potential, electrochemical series, Nernst's equation, thermodynamic of redox reactions, measurement of pH and pKa, electrolytic cells, potentiometry, reference and indicator electrodes, voltammetry, fuel cells, corrosion and its prevention.

Surface Chemistry

Interfaces, Gibbs surface excess, capillary action, adsorption and adsorption isotherms, Freundlich and Langmuir adsorption isotherms, catalysis, colloids, emulsions and their industrial applications.

Nuclear Chemistry

Atomic nucleus, nuclides, nuclear stability, modes of decay, nuclear energetics, nuclear models (shell and liquid drop model), fusion and fission, non - spontaneous nuclear processes, nuclear reactors.

Practicals

1. Determination of molecular weight of a polymer by viscosity method
2. Precipitation value of electrolytes
3. Measurement of IR spectra of simple compound and their interpretation
4. Measurement of cyclic voltammogram of an organic compound and its interpretation
5. Determination of dipole moment of an organic liquid
6. Study of the adsorption isotherms of acetic acid charcoal system
7. Verification of Beer-Lambert Law

8. Determination of percentage composition of KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$ or any other colored compound in a given solution by spectroscopy
9. Stoichiometry of a complex in solution by jobs method
10. Evaluation of pKa value of indicator by spectrometric method.

Recommended Books

1. Atkins, P. Paula, J. D. and James Keeler. Atkin's Physical Chemistry, 11th ed., Oxford University Press, (2018).
2. Somorjai, G. A. and Li, Y., Introduction to Surface Chemistry and Catalysis, 2nd ed., John-Wiley & Sons, Inc., (2010).
3. Vertes, A., Nagy, S., Klencsar, Z. Lovas G. R. and Rosch F, Handbook of Nuclear Chemistry. Volume 1: Basics of Nuclear Science, 2nd ed., Springer, (2010).
4. Loveland, W., Morrisey, D. J. and Seaborg, G. T., Modern Nuclear Chemistry, John-Wiley & Sons, Inc., (2006).
5. J. Albery, "Electrode Kinetics", 2nd Ed, Clarendon, Oxford, (2001).
6. H. Yidirim Erbil, Surface Chemistry of Solid and Liquid Interfaces, 1st Edition, Blackwell publishing (2006).
7. O. M. J. Bockris, A. K. N. Reddy, "Modern Electrochemistry" 2nd Ed, Vol. I and 2, Plenum Press, New York, USA (2002).

CHM-508 Analytical Chemistry-II 4(3-1)

Electromagnetic Radiations: Basic concept and classification parameters/characteristics (energy, frequency, wavelength and wave number) of electromagnetic radiation and their interaction with matter, Nature of electromagnetic radiation (Wave theory and Quantum theory).

Spectroscopy: Introduction to spectroscopy, Classification of spectroscopic techniques based on different parameters (Atomic & molecular and absorption & emissions spectroscopic techniques), Principals of spectroscopic techniques, Lambert-Beer's Law and its applications and limitations, Common instrumental components and nomenclature of instruments.

UV/Vis Spectroscopy: Basic concept, Molecular energy levels and transitions, Characteristics of absorption (position and intensity of absorption) and effects of solvent and conjugation, auxochrome, chromophore along with the nomenclature of spectral shifts. Instrumentation: Sources of light (lamp and lasers), monochromators, photomultiplier tubes, diode array detectors, signal processor (charged coupled devices) and readout devices and Single and double beam spectrophotometers, Applications of UV/Vis spectroscopy in science and daily life.

Photometry: Atomic energy levels and electronic transitions, Emission spectrum, Absorption spectrum, Principle of Photometry, Flame sources and prospects in analysis, Instrumentation of Flame Photometer, Salient interferences and corrections, Calibration, Sample preparation and analysis, Applications of Flame Photometry in science and daily life.

Practicals:

1. Determination of λ_{max} of different colored solutions (Potassium permanganate, Iron sulfate etc.) UV/Visible Spectroscopy.
2. Identification of different organic compounds using UV/Visible Spectroscopy
3. Determination of unknown sample concentration using calibration graphs by UV/Visible Spectroscopy
4. Determination of iron (II) by in food samples using UV/Visible Spectroscopy
5. Determination of minerals (Sodium/Potassium) in tap water and food samples using Flame photometer
6. Determination of Calcium in chalk sample using Flame photometer
7. Visit of Hi-Tech Lab and practical demonstration of available spectroscopic techniques

Reference Books

1. Christian, G.D. Analytical Chemistry, 7th Eds., John-Wiley & Sons, New York (2014).
2. Harris, D.C. Quantitative Chemical Analysis, 8th Eds., W. H. Freeman and Company, New York, (2011).
3. Skoog, D. A., West, P.M., Holler, F.J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 9th Eds., Cengage Learning, (2013).
4. Braun, R.D. Introduction to Instrumental Analysis, International student Edition, (1985).
5. Harvey, D. Modern Analytical Chemistry, Revised Eds. The McGraw Hill Companies, Inc. USA (2008).

Summer Semester (after 6th semester)

Supervisors will be allocated to the students, who will then commence **INT-630 – Internship/Field Experience** (to be enrolled in the 7th semester) and **CAP-630 – Capstone Project** (to be enrolled in the 8th semester). The students will complete their internship during the summer semester, and the viva voce will be conducted in Semester 7; therefore, the course enrollment for the internship will take place in Semester 7. Accordingly, the **CAP-630 – Capstone Project** will be enrolled in the 8th semester.

Course Code	Course Title	Credit Hours	To be enrolled in
INT-631	Internship/ Field Experience	3(0-3)	7 th
CAP-630	Capstone Project	3(0-3)	8 th

Semester 7 (Specialization in Analytical Chemistry)

Course Code	Course Title	Credit Hours
INT-631	Internship/ Field Experience	3(0-3)
CHM-601	Electroanalytical Techniques	4(3 – 1)
CHM-603	Advanced Separation Techniques	4(3 – 1)
CHM-605	Advanced Atomic Spectroscopy	4(3 – 1)
	Total	15

Semester 7
Specialization in Analytical Chemistry
<p>INT-631 Internship/ Field Experience 3(0-3) (to be completed in Summer Semester)</p>
<p>CHM-601 Electroanalytical Techniques 4(3-1) Introduction: Electrochemistry, Electrochemical cells, Standard cell potential, Indicator electrode, Reference electrodes, Classification of electroanalytical methods, Bulk method, Interfacial methods, static methods, dynamic methods Potentiometric method of analysis: Potentiometric measurements, Indicator electrodes, Metallic indicator electrode, Membrane indicator electrode, working of potentiometer and its application including pH measurements, ion selective electrode systems, ion exchange membrane electrode, solid state membrane electrodes and bio-membrane electrodes, potentiometric titrations. Application of potentiometric methods in automations. Coulometry and Electrogravimetry: Basic electrochemistry, principle, instrumentation of coulometry, principle, instrumentation of electrogravimetry, consequences of electrogravimetry, Ohmic drop, activation over potential, concentration and gas polarization, basic difference and merits/demerits of coulometry and electrogravimetry. Practical's: Determine the pKa values for given samples of weak acids/amino acids by potentiometric method. Determine the quality of given sample of water through conductometric titrations. Determine the unknown soda ash through pH titration. Determination of Total Dissolved Solids in a given water sample through electrical conductivity measurement Determination of minerals contents of fruits juices by measuring specific conductance. Potentiometric Titration of Ferrous Ions With Standard Potassium Dichromate Solution. Reference Books: 1. Bard, Allen J. (Editor). "Electroanalytical Chemistry: A Series of Advances: Volume 30." CRC Press, 2022. 2. Bard, Allen J., Faulkner, Larry R., and Zoski, Cynthia G. "Electrochemical Methods: Fundamentals and Applications." 3rd Edition, Wiley, 2018.</p>

3. Zhong, Ziyi, and Huang, Chuanjing (Editors). "Modern Electroanalytical Techniques." Springer, 2021. Christian, G.D. Analytical Chemistry, 6th ed., John-Wiley & Sons, New York, (2004).
4. Harris, D.C. Quantitative Chemical Analysis, 8th ed., W. H. Freeman and Company, New York, (2011).
5. Skoog, D. A., West, P.M., Holler, F.J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 9th ed., Cengage Learning, (2013).
6. Christian, G.D. Analytical Chemistry, 6th ed., John-Wiley & Sons, New York, (2004).
7. Singla, N., Kaur, N., Kohil, K. Practical Manual of Analytical Chemistry, BSP Books. ISSN 9789389974072 (2020).
8. Hanif, M.A. Hussain, A.I. (2022). Chemistry in the Lab. International Scientific Organization. ISBN: 978-969-23074-1-3.

CHM-603 Advanced Separation techniques 4(3-1)

Theoretical consideration: Distribution ratio and separation, retention and equilibrium, efficiency of separation, band broadening, Van-Deemter equation and its significance in evaluating column efficiency. Classifications of column chromatography.

Gas Chromatography (GC): Principle, instrumentation (sample injection modes, columns, choices of stationary phases, detectors), sample preparations, separation process, temperature programming, identification and quantification (normalization of peak areas) and its applications.

Liquid Chromatography (LC): Principle and theory of LC, modes of LC, High performance LC (HPLC), instrumentation, solvent delivery systems, injectors (sample loading procedures), columns with choice of stationary phases, detectors) sample preparation, method development, applications with emphasis on pharmaceutical and petrochemical industry.

Supercritical Fluid Chromatography (SFC): Principle, supercritical fluids, instrumentation, separation process, applications in industrial Sectors.

Electrophoresis: Theory and principle of Electrophoresis, Types of Electrophoresis (Paper & Gel Electrophoresis), Capillary Electrophoresis (CE), Separation Procedure (mobility, electro-osmotic flow separation), Instrumentation and applications.

Practicals

1. Separation of dyes using column/paper/thin layer chromatography.
2. Separation of sugars using paper chromatography.
3. Separation of amino acids using paper/ thin layer chromatography.
4. Separation of phytochemicals of plant sample using 2D thin layer chromatography
5. Separation of hydrocarbons using GC/HPLC.
6. Determination of charge on different pharmaceutical and biological samples using electrophoresis
7. Separation of protein components from biological sample using gel electrophoresis

Reference Books:

1. Christian, G.D. Analytical Chemistry, 7th Ed., John-Wiley & Sons, New York, (2014). Edited by Jack Cazes by Ewing's Analytical Instrumentation Handbook. Marcel Dekker, Inc., Cimarron Road, Monticello, New York 12701, U.S.A. (2005).
2. Mikkelsen, S. R. and Corton, E. Bioanalytical Chemistry, 2nd ed. Wiley, Inc., Hoboken, New Jersey, USA (2016).
3. Harvey, D. Modern Analytical Chemistry, 1st Ed, McGraw-Hill, USA, (2000).
4. Skoog, D. A., West, P.M., Holler, F.J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 10th ed., Cengage Learning, (2021).
5. Patnaik, P. Dean's Analytical Chemistry Handbook, 2nd Ed. McGraw-Hill, USA.
6. F. W. Fifield, David Kealey. Principles and Practice of Analytical Chemistry, 5th Edition (2000), USA, Wiley.

7. Hanif, M.A. Hussain, A.I. (2022). Chemistry in the Lab. International Scientific Organization. ISBN: 978-969-23074-1-3.
8. Leo M. L. Nollet. Handbook of Food Analysis: Physical characterization and nutrient analysis. CRC Press, Technology & Engineering, New York USA, 2004.

CHM-605 Advanced Atomic Spectroscopy 4(3-1)

Atomic Absorption Spectrophotometry: principle of atomic absorption spectrophotometry, concentration dependence of absorption, quantitative methodology, instrumentation for atomic absorption spectrophotometry, radiation sources, atomizers, flames, graphite furnaces and electrochemical atomizers, wavelength selectors, detectors, handling background absorption, interferences in atomic absorption spectrophotometry, sample handling in atomic absorption spectrophotometry, applications of atomic absorption spectrophotometry.

Atomic Emission Spectrophotometry: Introduction, principle of atomic emission spectrometry, atomic emission spectrometry using plasma sources, plasma and its characteristics, inductively plasma, direct current plasma, microwave induced plasma, choice of argon as plasma gas, instrumentation for ICP-MS.

Atomic Fluorescence Spectrometry: Origin of atomic fluorescence, atomic fluorescence spectrum, types of atomic fluorescence transitions, principle of atomic fluorescence spectrometry, fluorescence intensity and analyte concentration, instrumentation for atomic fluorescence spectrometry, applications of atomic absorption spectrophotometry, interferences, merits and limitations.

Practicals

- 1 Determination of lithium/sodium/potassium/calcium ions in the given solution by flame photometer using calibration curve method.
2. Determination of calcium in tap water/milk/chalk sample using flame photometer.
3. Determination of heavy metals (Pb, Ca, Fe, Cd) in tap water/food sample using atomic absorption photometer.
4. Determination of lead in sewage sludge/plant leaves by atomic absorption spectrophotometric method.
5. Sample preparation for flame photometric and atomic absorption spectrophotometric analyses.
6. Quantitative estimation of zinc (Zn) and iron (Fe) in multivitamin tablets by atomic absorption spectroscopy.
7. Quantification of phosphorus (P) and sulfur (S) in fertilizers by atomic emission spectroscopy.
8. Detection of magnesium (Mg), iron (Fe) and copper (Cu) in biological fluids using inductively coupled plasma-atomic emission spectroscopy.

Reference Books:

1. Christian, G.D. Analytical Chemistry, 6th ed., John-Wiley & Sons, New York, (2004).
2. Harris, D.C. Quantitative Chemical Analysis, 8th ed., W. H. Freeman and Company, New York, (2011).
3. Skoog, D. A., West, P.M., Holler, F.J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 9th ed., Cengage Learning, (2013).
4. Braun, R.D. Introduction to instrumental Analysis, International student Edition, (1985).
5. De Loos-Vollebregt, Margaretha T.C., and De Galan, Louis. "Atomic and Molecular Spectroscopy: Basic Concepts and Applications." CRC Press, 2019.
6. Hieftje, Gary M., and Rindfleisch, James A. "Atomic Spectroscopy: Introduction to the Theory of Hyperfine Structure." Academic Press, 2021.
7. Sneddon, Jocelyn. "Atomic Spectroscopy: An Introduction to the Theory of Hyperfine Structure." CRC Press, 2023.
8. West, Philip W. "Atomic Spectroscopy: Principles and Applications." Oxford University Press, 2020.

9. Jackson, Ronald S. "Atomic Absorption and Atomic Fluorescence Spectrometry." Wiley, 2018.
10. Hanif, M.A. Hussain, A.I. (2022). Chemistry in the Lab. International Scientific Organization.
11. Reddy, A.V.R., Swain, K.K. Venkatesh, K. Association of Environmental Analytical Chemistry of India. *Analytical Division*, Bhabha Atomic Research Centre, Mumbai (2021), ISBN: 978-969-23074-1-3.
12. David E. Newton, Forensic Chemistry, United States of America, (2007).

Semester 7 (Specialization in Inorganic Chemistry)

Course Code	Course Title	Credit Hours
INT-631	Internship/ Field Experience	3(0-3)
CHM-611	Main Group Organometallic and Organic Reagents	4(3-1)
CHM-613	Spectroscopic Methods in Inorganic Chemistry	4(3-1)
CHM-615	Organo-Transition Metal Compounds	4(3-1)
	Total	15

Semester 7
Specialization in Inorganic Chemistry
INT-631 Internship/ Field Experience 3(0-3) (to be completed in Summer Semester)
CHM-611 Main Group Organometallic and Organic Reagents 4(3 - 1)
<p>Main Group Organometallic Reagents Introduction, Preparation, classes of nucleophilic organometallic reagents organo-Li, S, Sc, Si, B, Sn, Sb and Zn in organic synthesis, control side reaction (Enolization vs. nucleophilic addition, substitution vs. elimination, selectively among functional groups via organometallic reagents)</p> <p>Organic reagents in inorganic Analysis Type of reagents, their specific nature and methods of applications with specific examples, Complexometric and gravimetric methods involving various reagents, chelates and chelate effect.</p> <p>Practicals</p> <ul style="list-style-type: none"> • 8-Hydroxyquinoline Al (III) and Fe (III) • Salicylaldehyde: Ni (II) in the presence of Cu (II) • Anthranilic acid: Co (II) and Zn (II) • Micro determination of Cr(III) by Di-phenylcarbazide. • Determination of Fe (II) by 1-10 Phenanthroline. • Determination of nitrites by complexometry • Determination of percentage composition of copper, zinc and nickel in alloy. <p>Recommended Books:</p> <ol style="list-style-type: none"> 1. R. D. Madan, "Satya Prakash's Modern Inorganic Chemistry" S Chand & Company Limited (2019). 2. B. L. Shaw & N. I. Tucker, "Organo-Transition Metal compounds and Related Aspects of Homogeneous Catalysis", Pergamon Press (2016). 3. J. E. Huheey, "Inorganic Chemistry Principles of Structure and Reactivity" 2nd Ed., Harper and Row Publishers (1978). 4. Zavis Holzbecher, Martin Kral, L. Divis, Handbook of Organic Reagents in Inorganic Analysis (Series in Analytical Chemistry) (1976).

5. C. R. Dillard, D. E. Goldberg, "Chemistry, Reactions, Structure and Properties" Colliers-Macmillan Limited, London, UK (1971).
6. A. K. Holliday, A. G. Massey, "Inorganic Chemistry in Non-Aqueous Solvents", 6th Ed., Pergamon Press. (1985).
7. M. P. Frederick, "Practical Methods of Inorganic Chemistry", Creative Media Partners, LLC (2015).
8. G. Svehla, B. Sivasankar, "Vogels Qualitative Inorganic Analysis", 7th Edition, Pearson Education, India (2012).
9. J. Mendham, R.C. Denney, J.D. Barnes, and M. Thomas, *Vogel's Textbook of Quantitative chemical Analysis*, 6th ed., Pearson Education Ltd. (2000).

CHM-613 Spectroscopic Methods in Inorganic Chemistry 4(3-1)

Physical methods of analysis in Inorganic Chemistry, NMR, IR, UV Spectroscopy, Basic Principles, Instrumentation and Applications.

UV Spectroscopy: Origin of UV-Visible spectroscopy, electronic transitions and nature of electronic spectrum, probability of interaction, allowed transition and forbidden transition, transitions involving d or f electrons, charge transfer transitions, chromophore and auxochrome instrumentation and applications

IR Spectroscopy: Infra red absorption process, Bond properties and absorption trends, modes of vibrations, instrumentation, examining infrared spectra of inorganic and organic compounds.

NMR Spectroscopy: Nuclear spin states, Nuclear magnetic moments, absorption of energy, chemical environment and chemical shift, tetramethyl silane reference, instrumentation, spectrum and application using spin active nuclei ¹H, ¹³C, ¹⁹F and ³¹P. **Practicals**

- Spectrophotometric determination of Pb²⁺ using solvent extraction.
- Spectrophotometric determination of NO₃¹⁻ in water.
- Spectrophotometric determination of aspirin, phenacetin and caffeine (APC) tablets using solvent extraction.
- Spectrophotometric determination transition metal complexes.
- Water quality evaluation by measurement of physicochemical parameters in drinking water.
- Determination of strength of NaCl given solution by AgNO₃ using Fluorescein as indicator.
- Determination of % age purity of KBr using Fluorescein as indicator.
- Determination of % composition of mixture of KI & KNO₃ using Eoscein as indicator.

Recommended Books:

1. A.K. Bhuyan, Fundamental concepts of molecular Spectroscopy, 1st edition (2023).
2. W.H. Rankin, Norbert Mitzel, Carole Morrison, "Structural Methods in molecular inorganic Chemistry" Wiley (2013).
3. C.N.R. Rao, John R. Ferraro "Spectroscopy in inorganic Chemistry, Volume-II (2012).
4. Alan K. Brisdon, Inorganic Spectroscopic Methods (Oxford Chemistry Primers), 1st edition (1998).
5. E.A.V. Ebsworth, David W. H. Rankin, Stephen Cradock, Structural Methods in Inorganic Chemistry, Second Edition 2nd Edition (1991).
6. A. Douglas, F. Skoog, J. Holler, A. T. Neuman "Principles of Instrumental Analysis", 5th Ed, Saunders College Publishing, New York, USA (1997).
7. E. A. V. Ebsworth, D. W. H. Rankin, S. Cradock, "Structural Methods in Inorganic Chemistry," 2nd Ed., Blackwell, (1987).
8. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley (2003).
9. G. Raj, *Advanced Practical Inorganic Chemistry*, 7th edition, Krishna Parkashan Media (P) Ltd. (2005). Bassette, J., Denney, G.H. and Mendham, J., *Vogel's Textbook of Quantitative Inorganic*

Analysis Including Elementary Instrumental Analysis” English Language Book Society, 4th Edition. 1981.

CHM-615 Organo-Transition Metal Compounds 4(3-1)

Introduction, Cluster Compounds: Nomenclature and Structural Patterns, Metal Carbonyl Type Clusters, Anionic, Hydrido, Larger and Superlarge Carbonyl Clusters, Non-Carbonyl Clusters, Heteroatom in Clusters, Electron Counting Rules (TEC, Wades rule, Capping). Metal to Carbon Single, Double and Triple bonds; Acyls, Alkylidene and Alkylidyne Complexes, Bonding to Olefins, Polyolefins, Allyl, Alkyne and Arene Complexes.

Practicals

- Preparation and characterization of chrome alum and chrome red.
- Preparation and analysis of ferric ammonium sulphate $\text{Fe}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 24\text{H}_2\text{O}$
- Synthesis and characterization of inorganic compounds $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$, $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- Preparation and estimation of, dipyridine (I) nitrate $[(\text{C}_5\text{H}_5\text{N})_2\text{I}]^+\text{NO}_3^-$.
- Preparation of inorganic compounds and characterization of $[\text{Cobalttrisethylenediamine}]\text{I}_3$.
- Titration of strong acid and weak acid with a strong base.
- Precipitation titration involving AgNO_3 and KCl .
- Determination of K_1 , K_2 and K_3 for H_3PO_4
- Determination of chloride in the presence of iodide and evaluation of AgI and AgCl
- Estimation of available chlorine in bleaching powder.

Recommended Books

1. G. J. Leigh, N. Winterton, “Modern Coordination Chemistry” The Royal Society of Chemistry (2021).
2. S. G. Davies, “Organotransition Metal Chemistry Applications to Organic Synthesis” Pergamon Press (2016).
3. R. H. Crabtree, “The Organometallic Chemistry of the Transition Metal”, John Wiley & Sons, Inc. (2014).
4. G. L. Miessler, A. T. Donald, “Inorganic Chemistry”, 5th Ed., Prentice Hall International, USA (2013).
5. G. R. Chatwal, “Organotransition Metal Chemistry”, Himalaya Publishing House (2010).
6. B. Douglas, D. McDaniel, J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edition, John Wiley and Sons (2006).
7. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, “Advanced Inorganic Chemistry”, 6th Edition, John Wiley and Sons (2003).
8. M. Schlosser, “Organometallics in Synthesis: A Manual”, John Wiley & Sons, Inc. (2001).
9. W. W. Porterfield, Inorganic Chemistry, A Unified Approach, 2nd Edition, Elsevier (1993).

10. Vogel, A. I., ‘‘A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis’’ Longman Green & Co. 1995.
11. Fritz, J. S. and Schenk, G. H., ‘‘Quantitative Analytical Chemistry’’, Allyn and Bacon Inc., 4th Edition, 1979.
12. Pass. G and Sutcliffe H., ‘‘Practical Inorganic Chemistry’’. Van Nostrand Reinhold Company. 1972.
13. J. William, ‘‘Inorganic Chemistry, Theoretical and Practical: A Manual for Students in Advanced Classes’’, Legare Street Press (2023).

Semester 7 (Specialization in Organic Chemistry)

Course Code	Course Title	Credit Hours
INT-631	Internship/ Field Experience	3(0-3)
CHM-621	Spectroscopic Methods in Organic Chemistry	4(3-1)
CHM-623	Rearrangements and Pericyclic Reactions	4(3-1)
CHM-625	Pharmaceutical Chemistry	4(3-1)
	Total	15

Semester 7**Specialization in Organic Chemistry**

INT-631 Internship/ Field Experience 3(0-3)
(to be completed in Summer Semester)

CHM-621 Spectroscopic Methods in Organic Chemistry 4(3 - 1)

(a) Introduction

Electromagnetic radiations. Wavelength, frequency, wave number and energy of electromagnetic radiations and their interconversion. Electromagnetic spectrum. Interaction transitions and spectral regions. Relaxation of the excited molecules.

(b) Ultraviolet/Visible Spectroscopy:

Introduction, Electronic transitions and absorption of electromagnetic radiations, Intensities of absorption, Beer-Lambert Law and its applications, Instrumentation and sample handling, The chromophore, Absorption by conjugated systems, Woodward fieser rules for conjugated dienes and unsaturated carbonyl systems, Absorption by aromatic compounds, Application of UV/Vis spectroscopy.

(c) Infrared Spectroscopy:

Introduction, Vibrational modes and absorption frequencies, Hooks Law, Instrumentation and sample handling, Interpretation of Infrared spectra, Characteristic absorptions frequencies of some common functional groups, Applications of Infrared spectroscopy.

(d) Nuclear Magnetic Resonance:

Introduction, Spin flipping Nuclear Precession and absorption of electromagnetic radiation, Spin relaxation, The Chemical shift and integration curve, Molecular structure and chemical shifts, Instrumentation and Sample handling, Spin splitting and coupling constants. Interpretation of NMR spectra.

(e) Mass spectrometry:

Introduction, Basic Principle, Instrumentation (theory and operation) The mass spectrum, Modes of Fragmentation of various organic molecules. Applications of mass spectrometry determination of molecular weight, molecular formula and molecular structure. Interpretation of mass spectra.

Practicals:

- Spectral interpretation (UV, FT-IR, ¹H -NMR, ¹³C-NMR, MS) of:
 1. Benzoic Acid
 2. Ethyl Benzoate
 3. Diethyl Ether
 4. Benzamide
 5. Dibenzal acetone

6. Acetanilide
7. Acetyl Salicylic acid
8. 4-amino benzaldehyde.

Recommended Books:

- George S. Zweifel, Michael H. Nantz, Peter Somfai, Modern Organic Synthesis: An Introduction, 2nd Edition, John Wiley and Sons, (2017).
- K. L. Ivanov (Editor), P. K. Madhu (Editor), G. Rajalakshmi (Editor), Two-Dimensional (2D) NMR Methods, John Wiley & Sons, Inc. (2023)
- S. A. Richards, J. C. Hollerton, Essential Practical NMR for Organic Chemistry, 2nd Edition, John Wiley & Sons, Inc. (2022)
- Atta-ur-Rahman, M. I. Choudhary, Atia-tul-Wahab, Solving Problems with NMR Spectroscopy, 2nd Edition, Elsevier Inc. (2016)
- J. W. Akitt, B. E. Mann, Nmr And Chemistry – An Introduction To Modern Nmr Spectroscopy (4th Ed.). Taylor and Francis group. (2017)
- H. E. Duckworth, R. C. Barber, V.S. Barber, V.S. Venkatasubramanian “Mass Spectroscopy”, 2nd Ed., Cambridge University Press, London, UK (1996)
- W. Kemp, “Organic Spectroscopy”, 3rd Ed., Macmillan, London, USA (1991)
- B. S. Fumiss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell “Vogel’s Practical Organic Chemistry”, 5th Ed, Addition Wesley Longman, Harlow, England (1989).

CHM-623 Rearrangements and Pericyclic Reactions 4(3 – 1)

Classification of rearrangement, Pinacol Pinacolone rearrangement, Benzil benzilic acid rearrangement, R.A involving Diazomethane, Favorski R.A, Hofman R.A. Schmidt R.A, Lossen R.A, Bayer Villiger, R.A, benzidine R.A, Fries R.A. Sigma tropic R.A.

Migration of carbon, Cope rearrangement, Claisen rearrangement benzidine rearrangement. [1,3] H, [1,5], [1,7] H, [1,9] H migration.

Pericyclic Reactions

Conrotatory and Disrotatory motion of orbital, electrocyclic reactions, thermal cyclization, Photochemical cyclization, Hofman rule, Fukui Theory of Frontier orbitals.

Introduction to cycloaddition reactions. Suprafacial and Antarafacial addition Woodward Hofman Rule. Frontier theory and mobius huckle theory for (2 + 2) and (2 + 4) thermal and photochemical cycloaddition reaction.

Practicals:

- Synthesis of benzoic acid from benzil
- Synthesis of phenyl – azo – β-naphthol
- Preparation of benzylated compound (Benzylation of Phenol)
- Synthesis of anthranilic acid
- Synthesis of Methyl Orange
- Synthesis of di-benzal acetone
- Preparation of Benzilidene Aniline
- Synthesis of isoamyl benzoate

Recommended Books

- Paul H. Schudder, Electron Flow in Organic Chemistry: A Decision-Based Guide to Organic Mechanisms, 3rd Edition, John Wiley and Sons, (2023).
- J. Clayden, N. Greeve, S. Warren, P. Wothers, “Organic Chemistry”, 2nd Ed., Oxford University Press, USA (2012).
- F. L. Ansari, R. Qureshi and M. L. Qureshi “Electrocyclic Reactions – from Fundamentals to Research”, 1st Ed., John Wiley and Sons, (1999).
- R. O. C. Norman “Principles of Organic Synthesis”, Blackie Academic & Professional, 3rd Ed. (1993).
- Laurie S. Starkey, Introduction to Strategies for Organic Synthesis, 2nd Edition, John Wiley and Sons, (2018).

- George S. Zweifel, Michael H. Nantz, Peter Somfai, Modern Organic Synthesis: An Introduction, 2nd Edition, John Wiley and Sons, (2017).

CHM-625 Pharmaceutical Chemistry 4(3 – 1)

Alkaloids

Introduction, occurrence, function of alkaloids in plants, Classification, Nomenclature, Pharmaceutical Applications, Isolation, Qualitative Test and General Properties, General Method of Structure Determination. Morphines, Nicotine, Quinine.

Drugs

Introduction, Sources, Route of administration, Metabolites and mechanism of drug action. Sulfonamide, antipyretics, analgesic, barbiturates, antibiotics, their general synthesis and structure activity relationship.

Practicals:

- Synthesis of Aspirin
- Synthesis of Paracetamol
- Synthesis of Caffeine
- Isolation of Nicotine
- Synthesis of Methyl Salicylate
- Isolation of i-buprufen from commercially available tablets
- Synthesis of benzene sulfonamides
- Synthesis of isoamyl benzoate

Recommended Books

1. V. Alagarsamy, Pharmaceutical Organic Chemistry, BSP Books (2020)
2. C. Rostron and J. Barber, Pharmaceutical Chemistry 2nd Edition, Oxford (2021)
3. D. Cairns, Essentials of Pharmaceutical Chemistry 4th Edition, Pharmaceutical Press (2012)
4. D. Kumar and A. K. Jangra, Pharmaceutical Chemistry, V. M. BOOKS (2022)
5. K. G. Bothara and S. Y. Gabhe, Pharmaceutical Organic Chemistry, Nirali Prakashan (2019).
6. D. G. Watson, Pharmaceutical Chemistry 1st Edition, Churchill Livingstone (2011).
7. D. W. Mayo, R.M. Pike, D. C. Forbes, Microscale Organic Laboratory: With Multistep and Multiscale Syntheses, 7th Edition. John Wiley and Sons, (2023).
8. Stéphane Caron (Editor), Practical Synthetic Organic Chemistry: Reactions, Principles, and Techniques, 2nd Edition, John Wiley and Sons, (2020).

Semester 7 (Specialization in Physical Chemistry)

Course Code	Course Title	Credit Hours
INT-631	Internship/ Field Experience	3(0-3)
CHM-631	Advanced Reactions Kinetics	4(3-1)
CHM-633	Advanced Spectroscopy in Physical Chemistry	4(3-1)
CHM-635	Material Chemistry	4(3-1)
	Total	15

Semester 7**Specialization in Physical Chemistry**

INT-631 Internship/ Field Experience 3(0-3)
(to be completed in Summer Semester)

CHM-631 Advanced Reactions Kinetics 4(3-1)

Chemical Reactions

Third order reactions with same and different initial concentration of reactants, Advanced theories of unimolecular reactions, Chain and non-chain complex reactions, opposing reactions, parallel reactions, consecutive reactions, Fast reactions, Experimental techniques for measurement of fast reaction kinetics.

Photochemical Reactions

Laws of photochemistry, photochemical reactions in gas phase and in solutions, quantum yields, flash photolysis, photosensitization, radiative and non-radiative photophysical processes, photoluminescence and quenching, photochemical reaction kinetics.

Interfacial Phenomena

Thermodynamics of adsorption, adsorption at liquid surfaces or solutions, surface tension and surfactants, catalytic reactions of gases on solid phase, interfacial kinetics, Langmuir Hinshelwood mechanism, Eiley-Rideal Mechanism, kinetics of enzyme catalyzed reactions.

Practicals

1. Kinetic study of enzyme catalysed reactions.
2. Determination of energy of activation for acid hydrolysis of ethyl acetate.
3. Determination of kinetics of saponification of ethyl acetate with sodium hydroxide.
4. Acid catalyzed hydrolysis of sucrose for determination of rate constant for first order reaction.
5. Determination of rate constant and order of reaction between hydrogen peroxide and hydroiodic acid.
6. Determination of adsorption parameters using Langmuir adsorption isotherm of acetic acid on charcoal.
7. Determination of adsorption of oxalic acid on charcoal and prove the validity of Freundlich adsorption isotherm.
8. Investigation of the order of reaction and velocity constant for the inversion of cane sugar in the presence of an acid by polarimetry.
9. Preparation of Buffer solutions of required pH.

Recommended Books:

1. S. Asperger, "Chemical Kinetics and Inorganic Reaction Mechanisms" 3rd Ed., Springer Verlag (2012).
2. J. H. Espenson, "Chemical Kinetics and Reaction Mechanism" 2nd Ed., McGraw Hill London, UK (2002).
3. D. C. Neckers, G. von, B. Unau, W. S. Jenks, "Advances in Photochemistry", Vol. 27, John Wiley & Sons,

Inc. USA (2002).

4. Peter Atkins, Julio De Paula and James Keeler, "Atkin's Physical Chemistry" 12th edition, Oxford University Press, 2023.

5. K. J. Laidler, John. Meiser, Bryanc. Sanctuary "Physical Chemistry" 4th Ed., Brooks Cole Publisher (2006).

6. Garland, C. W., Nibler, J. W., & Shoemaker, D. P. (2009). Experiments in physical chemistry.

7. C.W. Garland, J.W. Nibler and DP Shoemaker, Experiments in Physiacl Chemistry, Mc Grawhill, 7th edition (1996).

CHM-633 Advanced Spectroscopy in Physical Chemistry 4(3-1)

Molecular Spectroscopy

Interactions of electromagnetic radiations with matter, Jablonski diagram, UV-Visible spectroscopy, microwave and infrared spectroscopy, rotational, rotational and vibrational spectra of diatomic and polyatomic molecules, Raman spectroscopy

Spin Resonance Spectroscopy

Principles of magnetic resonance. Nuclear magnetic resonance (NMR) spectroscopy. Coupling phenomenon in simple (AX_n) and complex systems. Relaxation mechanisms and their applications. Dynamic NMR. Applications in structure elucidation. Electron spin resonance spectroscopy (ESR). Principles and applications of ESR.

Practicals

1. Verify Beer's Lambert's Law for the given solution.
2. Determination of percentage composition of KMnO₄ / K₂Cr₂O₇ in a given solution by spectroscopy.
3. Evaluation of pKa value of indicator by spectrometric method
4. Interpretation of IR and NMR spectra.
5. Measurement of IR spectra of simple compound and their interpretation
6. Interpretation of Raman spectra
7. NMR spectra of simple compound and their interpretation.

Recommended Books:

1. Peter F. Bernath, Spectra of Atoms and Molecules, 4th Edition, Oxford University Press (2020).
2. Raul SanMartin, Maria Teresa Herrero, Structure Determination By Spectroscopic Methods A Practical Approach. 1st Ed. Taylor and Fracis group. (2021).
3. J. D. Graybal, "Molecular Spectroscopy," McGraw-Hill, New York, USA (1988).
4. C.N. Banwell, "Molecular Spectroscopy" 4th edition Tata-Mc Gra Hill Publishing Company, USA, 1994.
5. G. M. Barrow, "Introduction to Molecular Spectroscopy," 2nd Ed, McGraw-Hill, New York, USA (1962).
6. Pavia, D.L., Lampman, G. M., Kriz, G.S., & Vyvyan. J/ A. (2014). Introduction to spectroscopy. Fourth Edition (Cengage Learning).
7. A. Findly's Practical Physical Chemistry, Longmann, London (1972).
8. LP Gold, L. Gold, Physical Chemistry Laboratory, Primis Publishers (1997) ISBN: 0072902698.
9. Garland, C. W., Nibler, J. W., & Shoemaker, D. P. (2009). Experiments in Physical Chemistry.

CHM-635 Material Chemistry 4(3-1)

Physical Chemistry of Macromolecules

Introduction, Molecular forces and chemical bonding in macromolecules, configurations and conformation of polymer chains, theories of polymer solutions, spectroscopic analysis, thermal and mechanical analysis, polymer rheology.

Solid State

Introduction, Attractive forces, properties of solids, crystal structure, crystal defects, crystallography, theories of bonding, packing of atoms in metals.

Modern Materials

Composite materials, advance printing materials, AI assisted material design, bio sensors, chromogenic materials, ultralight materials, superconductors, conducting polymers, Bullet proof polymers, edible plastics, smart materials, nano materials.

Note: At least 06 experiments are to be performed.

1. Synthesis of Nanomaterials by precipitation method.
2. Green Synthesis of Nanomaterials by appropriate method.
3. Fabrication of polymers by approaching modern techniques.
4. Determination of molecular weight of given sample of polymer viscometrically.

5. Phase determination of polymers and crystalline solids through XRD.
6. Determination of particle size by employing Debye Scherrer equation on X-ray diffractogram.
7. Evaluation of thermal stability of polymers by TGA (Polyethylene, Poly vinyl chloride, Poly vinyl alcohol etc.
8. Experimental verification of thermosetting of plastics.
9. Evaluation of Mechanical behavior of macromolecules by DMA (thin films)
10. Experimental verification of Hildebrand theory of solubility of polymers.

Recommended Books:

1. West, A. R. (2022). *Solid state chemistry and its applications*. John Wiley & Sons.
2. Hofmann, P. (2022). *Solid state physics: an introduction*. John Wiley & Sons.
3. Holgate, S. A. (2021). *Understanding solid state physics*. cRc Press.
4. Snoke, D. W. (2020). *Solid state physics: Essential concepts*. Cambridge University Press.
5. Anthony West “Basic Solid-State Chemistry” John Wiley and sons, 1988, USA.
6. Robert J. Young, “Introduction to polymers” Capmann and Hall, 1981, USA.
7. Joel R. Fried “Polymer Science and Technology” Prentice Hall PTR. 1995. USA.
8. Fred W. Billmeyer “Text of Polymer Science” Wiley Interscience Publications, John Wiley and sons, 1984, USA.
9. Peter Atkins, Physical chemistry, 12th edition, Oxford University Press, 2022.
10. Harry R. Allcock, “Introduction to Materials Chemistry”, 2nd Edition, Wiley, 2019
11. Bradley D. Fahlman, Materials Chemistry, 3rd Edition, Springer, 2018.
12. T P Radhakrishnan, “Core Concepts for a Course on Materials Chemistry” RSC London, 2022.
13. Garland, C. W., Nibler, J. W., & Shoemaker, D. P. (2009). *Experiments in Physical Chemistry*.
14. James, A. M., Prichard, F. E., *Practical Physical Chemistry*, 3rd ed., Longman Group Limited, New York, (1974).
15. A. Findly’s *Practical Physical Chemistry*, Longmann, London (1972).
16. Viswanathan, B., P.S. Raghava, *Practical Physical Chemistry*, (2005), Viva books Private Limited. New Delhi.
17. S. K. Sharma, *Handbook of Materials Characterization*, Springer International Publishing AG, part of Springer Nature (2018).

Semester 8 (Specialization in Analytical Chemistry)

Course Code	Course Title	Credit Hours
CHM-602	Thermal Methods of Analysis	3(3 – 0)
CHM-604	Nuclear Analytical Techniques	3(3 – 0)
CHM-606	Food and Drug Analysis	3(3 – 0)
CHM-608	Molecular Spectroscopy	3(3 – 0)
CHM-610	Advanced Analytical Chemistry Lab	2(0 – 2)
CAP-630	Capstone Project	3(0-3)
	Total	17

Semester 8
Specialization in Analytical Chemistry
<p>CHM-602 Thermal Methods of Analysis 3(3-0)</p> <p>Introduction to thermal methods Historical development, definitions, classification, computer and thermal methods, factors affecting thermal analysis results, simultaneous and complementary techniques.</p> <p>Thermogravimetry (TG): introduction, historical background, instrumentation, kinetics of reactions, controlled rate TGA and high resolution TGA, applications.</p> <p>Differential thermal analysis (DTA) and differential scanning calorimetry (DSC): introduction, definitions, instrumentation, classification of DSC, heat flux DSC, power compensated DSC, specialist DSC systems i.e. pressure DSC, photo-calorimetric DSC, modulated DSC, applications.</p> <p>Thermomechanical, dynamic mechanical and associated methods: introduction, principles, Thermomechanical analysis: definition, instrumentation, applications, Dynamic mechanical analysis: definition, instrumentation, applications, Dielectric thermal analysis: definition, instrumentation, applications. Thermally stimulated current analysis and relaxation map analysis: definition, instrumentation, applications.</p> <p>Simultaneous techniques and product analysis: introduction, principles, instrumentations, simultaneous TG-DTA and TG-DSC, Evolved gas analysis, detection and identification of evolved gases, infrared and simultaneous TA-infrared, infrared product analysis, thermomicroscopy, applications.</p> <p>Reference Books</p> <ol style="list-style-type: none">1. Peter J. Haines, Thermal Methods of Analysis Principles, Applications and Problems, First Edition, Springer Science + Business Media Dordrecht.2. Michael E. Brown, Introduction to Thermal Analysis Techniques and Applications, Kluwer Academic Publishers New York, Boston, Dordrecht, London, Moscow.

3. Patrick K. Gallagher (Series editor) and Stephen Z.D. Cheng (edited), Handbook of Thermal Analysis and Calorimetry, Volume 3, Applications to Polymers and Plastics, Elsevier Science B.V. The Netherlands.
4. Wesley WM. Wendandt, Thermal Analysis, third edition, A Wiley-Interscience Publication, John Wiley & Sons
5. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis, Seventh Edition, Cengage Learning 20 Channel Center Street Boston, MA 02210 USA.

CHM-604 Nuclear Analytical Techniques 3(3-0)

Introduction to Nuclear Science, Stability of Nucleus, Binding Energy, Mode of Radionuclide decay, Production of nuclear radiation and its characteristics. Nuclear Analytical Techniques, Classification, Radiation Detection and Measurement Instruments (Gas filled and Scintillation detectors), Neutron Activation Analysis (Types & Applications), Radiochemical Method of Analysis (RMA) including Radiometric Titration and Isotope Dilution Methods of Analysis (IDMA), Radiation Safety, Applications of Radioisotope Detecting Instruments in Medical, Environment, Agriculture and Industries.

Reference Books

1. Saha, G. B. Fundamentals of Nuclear Pharmacy, 6th Ed. Springer New York Heidelberg, Dordrecht London, (2010).
2. F. W. Fifield, David Kealey. Principles and Practice of Analytical Chemistry, 5th Edition (2000), USA, Wiley.
3. J. Tölgyessy, T. Braun, M. Kyrš and H. Freiser by Isotope Dilution Analysis: International Series of Monographs in Analytical Chemistry, 1st ed, Elsevier Science, USA, (2013).
4. V.S. Ramachandran, J.J. Beaudoin Handbook of Analytical Techniques in Concrete Science and Technology, Principle, Technique and Applications. William Andrew Publishing. Norwich, New Yourk, USA, 2001.
5. Brune, D.; Forkman, B.; Persson, B. Nuclear analytical chemistry, Chartwell-BrattLtd., Bromley, England, United States, 1984.
6. R Cornelis, J Caruso, H Crews, K Heumann Handbook of elemental speciation II: species in the environment, food, medicine and occupational Health. Wiley Online Library, England, 2005.

CHM-606 Food and Drug Analysis 3(3-0)

Introduction to food analysis, food gradients and nutritional values, sampling of food, general methods of analysis. Analysis of Food Contaminants, Residues, and Chemical Constituents of Concern, Analysis of milk, butter, wheat flour, meat, beverages, tea, coca, honey and soft drinks.

Pharmaceuticals: Classification of drugs, Test for analysis of different pharmaceuticals, Toxicology and Drug Testing: Alcohol and the Human Body, Testing for Blood Alcohol Concentration, Testing for Drugs, Testing for Poisons,

Forensics: History and scope of forensic Science, forensic ethics, forensic toxicology. Classification and analysis of narcotics & dangerous drugs, examination of crime scene evidences, fingerprinting, skeletal material to provide scientific opinion for legal.

Reference Books:

1. Yolanda Picó, Chemical Analysis of Food: Techniques and Applications Academic Press, ELSEVIER, Spain, 2012.
2. Leo M. L. Nollet. Handbook of Food Analysis: Physical characterization and nutrient analysis. CRC Press, Technology & Engineering, New Yourk USA, 2004.
3. David E. Newton, Forensic Chemistry, United States of America, (2007).
4. Houck, Max M., and Siegel, Jay A. "Fundamentals of Forensic Science." Academic Press, 2020.

5. Bell, Suzanne. "Forensic Chemistry." Wiley, 2021.
6. Strano-Rossi, Sabina, and Mastroianni, Marco. "Forensic Chemistry: Fundamentals and Applications." Springer, 2019.
7. Nielsen, S. Suzanne. "Food Analysis." Springer, 2021.
8. Belitz, H.-D., W. Grosch, and P. Schieberle. "Food Chemistry." Springer, 2013.
9. Jackson, Ronald S. "Modern Food Analysis." Academic Press, 2019.

CHM- 608 Molecular Spectroscopy 3(3-0)

Introduction: Basics of Molecular Spectroscopy and Mass Spectrometry, Rotational Spectroscopy and Transition Rules

IR Spectroscopy: Principles, basic theory of IR spectroscopy, sample preparations, instrumentation (Sources of radiations, signal processors and detectors), Dispersive and nondispersive IR spectroscopy.

Raman Spectroscopy: Basic theory, Selection rule and comparison with IR, Raman Instrumentation. Applications of IR and Raman spectroscopy in research & development and quality control processes.

Nuclear Magnetic Resonance Spectroscopy, Overview of the Physical Basis of NMR Spectroscopy, Theory of NMR, Instrumentation, Magnet Systems, NMR Probes, RF Generation and Signal Detection, Magnetic Field Gradients, Computer Systems, General Experimental Aspects associated with Obtaining and Analysing Spectra, Data Analysis and Interpretation, Spectral Processing, Manual Data Interpretation, Analytical Applications

Mass Spectrometry: Basic Theory and Instrumentation, Classification and Types of Ionization Methods, Types of Mass Analyzers (e.g. Quadrupole, Time-of-Flight, Ion-Trap Mass Spectrometer etc), Method Development and Interpretation of Mass Spectrum, Fragmentations and Identification Peaks, Nitrogen Rule, Rule of 13 etc. Analytical Applications of MS.

Reference Books:

1. Roger S. Macomber, (2018) "A Complete Introduction of Modern NMR Spectroscopy" A Wiley Interscience Publication, ISBN 0-471-15736-8.
2. Jack Cazes. "The Analytical Instrumentation Handbook". (2005). 3rd Edition, Marcel Dekker, U.S.A.
3. Frank Settle. "Handbook of Instrumental Techniques for Analytical Chemistry". (1997). A Simon and Schuster Company, Prentice-Hall, Inc. NJ (USA).
4. Douglas A. Skoog, Donald M. West, F. James Holler & Stanley R. Crouch, 2022. Fundamentals of Analytical Chemistry. 10 th Eds. Harcourt College Publishers.
5. Harvey, D., 2000. Modern Analytical Chemistry, 1 st Eds. McGraw-Hill, USA. 4. F.W. Fifield & D. Kealey, 2000. Principles and Practice of Analytical Chemistry, 5 th Eds.

CHM- 610 Advanced Analytical Chemistry Lab 2(0 - 2)

The experiments may be set making use of the following instruments depending upon their availability. The instructor should consult the "Journal of Chemical Education" for the innovative designing of experiments. Special experiments may also be designed for which a specimen list of instruments/techniques is given below.

Column chromatography, Gas Chromatography, HPLC, Capillary Electrophoresis. IR and MS, Thermogravimetry, Differential Thermal Analyzer, Differential Scanning Calorimetry, Differential Photo-Calorimetry, Evolved Gas Analyzer, Thermo-mechanical Analyzer.

Experiments

- Separation of hydrocarbons using GC/HPLC.
- Analysis of Fatty acid methyl esters using GC
- Analysis of phenolic acids using HPLC
- Spectrophotometric determination of Iron in soil.

IR analysis and identification of human body stones

To record and characterization of IR spectra of at least one organic compounds.

Mass spectrometry of mineral oil samples.

Determination of iron in foods products spectrophotometrically.

Qualitative and Quantitative Analysis of Fruit juices for Vitamin C using HPLC.

Enzymatic determination of Glucose in Blood.

Separation of dyes using column chromatography.

Identification of fingerprints by chemical test.

Analysis of Analgesics using HPLC.

Test for analysis of drugs.

To determine lead in sewage sludge by atomic absorption spectrophotometer.

Identification of fingerprints by powder test.

To record and characterization of IR spectra of at least 1organic compounds.

Gas Chromatographic analysis of drugs and poison.

Analysis of milk, beverages, and meat.

Analysis of polymer samples on TGA

Analysis of sample on XRD

Reference Books:

1. Yolanda Picó, Chemical Analysis of Food: Techniques and Applications Academic Press, ELSEVIER, Spain, 2012.
2. Leo M. L. Nollet. Handbook of Food Analysis: Physical characterization and nutrient analysis. CRC Press, Technology & Engineering, New York USA, 2004.
3. David E. Newton, Forensic Chemistry, United States of America, (2007).

CHM-630 Capstone Project 3(0-3)
As per HEC Guidelines

Semester 8 (Specialization in Inorganic Chemistry)

Course Code	Course Title	Credit Hours
CHM-612	X-ray Spectroscopy	3(3 – 0)
CHM-614	Homogeneous Catalysis	3(3 – 0)
CHM-616	Radioactivity and Nuclear Chemistry	3(3 – 0)
CHM-618	Magneto Chemistry	3(3 – 0)
CHM-620	Advanced Inorganic Chemistry Lab	2(0 – 2)
CAP-630	Capstone Project	3(0-3)
	Total	17

Semester 8		
Specialization in Inorganic Chemistry		
CHM-612	X-ray Spectroscopy	3(3-0)
Introduction, Lattice and unit cell, geometry of crystals, crystal systems, primitive and non primitive cells, Lattice direction and planes crystal shapes Dimensional relationship, Braggs equation, reciprocal lattice, experimental methods of single & multicrystal (power) analysis, diffraction and diffractometer, identification and applications.		
Recommended Books:		
1. Cosmiso Bambi, Jiachen Jiang, “High-Resolution X-ray Spectroscopy, Instrumentation, Data Analysis, and Science, Springer (2023).		
2. Jun Kawai, “X-Ray Spectroscopy for Chemical State Analysis” 1st ed. Springer, (2023).		
3. Stephen P Cramer, X-Ray Synchrotron Radiations: Fundamental and Applications”, Springer International Publishing 1 st Ed. (2020).		
4. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, “Advanced Inorganic Chemistry” Vol.I (1997).		
CHM-614	Homogenous Catalysis	3(3-0)
Reaction of CO and hydrogen Hydroformylation, reductive carbonylation, reduction of CO by hydrogen, synthesis of water gas and shift reactions. Carbonylation reaction Synthesis of methanol and methyl acetate, adipic ester, other carbonylation and decarbonylation reactions. Catalytic addition of molecules to C-C multiple bonds Homogeneous hydrogenation, and hydrocylation and hydrocyanation.		
Recommended Books:		

1. L. Gonsalvi, "Homogenous Catalysis and Mechanisms in Water and Biphasic Media", MDPI Switzerland (2019)
2. B. L. Shaw & N. I. Tucker, "Organo-Transition Metal compounds and Related Aspects of Homogeneous Catalysis", Pergamon Press (2016).
3. S. Bhaduri, M. Doble, "Homogeneous Catalysis: Mechanisms and Industrial Applications", 2nd Edition, Wiley (2014)
4. M. Christopher, "Homogenous Transition-Metal Catalysis: A General Art", Springer Netherlands (2012)
5. L. Kollar, "Modern Carbonylation Methods", Wiley-VCH Verlag GmbH & Co. KGaA (2008)
6. P. W. N. M. van Leeuwen & P. W. N. M. Leeuwen, "Homogeneous catalysis" Kluwer Academic Publishers (2004)
7. G. L. Miessler, D. A. Tarr, "Inorganic chemistry" 2nd Ed., Prentice Hall International, USA (1998).
8. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, "Advanced Inorganic Chemistry" 6th Ed, John Wiley & Sons, Inc. USA (1999).

CHM-616 Radioactivity and Nuclear Chemistry 3(3-0)

Fundamentals and applied aspects of Radioactivity and nuclear chemistry. Trans-Uranium elements; Natural and artificial radioactivity, methods for isotope production, nuclear reactions; mass spectrograph, astam mass spectrograph, The structure of the nucleus; nuclear stability and radioactive decay; types, characteristics and detection of radioactive Particles; laws of radioactive decay; the interaction of radiation with matter including radiological health hazards; processing of the nuclear materials. accelerators of charged particles, applications of radioisotopes.

Recommended Books

1. F. Rosch, Nuclear and Radiochemistry, Volume I & II (2023).
2. A. Vértes, S. Nagy, Z. Klencsár, Rezso György Lovas, Frank Rösch, Handbook of Nuclear Chemistry: Vol. 1: Basics of Nuclear 2nd Edition, Springer (2010).
3. J. Hofstader, Nuclear Chemistry, published by Larsen and Keller Education (2022).
4. G. Choppin, Jan R., J. Liljenzin Radiochemistry and Nuclear Chemistry, 3rd edition (2002).
5. G. R. Choppin, J. Rydber, "Theory and Applications", 1st Ed., Pergamon (1980).
6. H. J. Arnikan, "Essentials of Nuclear Chemistry", 4th Ed, (1990).
7. B. G. Harvey, "Nuclear Physics and Chemistry", Prentice-Hall Inc., (1990).
8. I. I. Naqvi, "Radiochemistry", McGraw Hill, USA (1990).

CHM-618 Magneto Chemistry 3(3-0)

Theory of magnetism, diamagnetism, paramagnetism, ferro-, ferri- and antiferromagnetism, magnetic susceptibility, magnetic moments, Faraday's & Gouy's methods, orbital contribution to magnetic moment, Russell-Sanders coupling scheme, derivation of term symbols of for $p^1 - p^6$ and $d^1 - d^{10}$ systems, pigeon holes diagram, effect of temperature on magnetic properties of complexes. Magnetic moment of lengthanise.

Recommended Books:

1. Pöttgen, Rainer, Jüstel, Thomas and Strassert, Cristian A. Applied Inorganic Chemistry Volume 1-3, De Gruyter, (2022).
2. B. Douglas, D. McDaniel, J. Alexander, "Concepts of Models of Inorganic Chemistry", 3rd Ed, John Wiley & Sons Inc., (.1994).
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, "Inorganic Chemistry: Principles of Structure and Reactivity", 4th Ed., Harper & Row, New York, USA (2001).

4. K. M. Mackay, R. A. Mackay, W. Henderson, "Introduction to Modern Inorganic Chemistry", 5th Ed, Stanley Thomas Publisher Ltd. (1996).

5. G. L. Miessler, A. T. Donald, "Inorganic Chemistry", 2nd Ed., Prentice Hall International, 1991.

CHM-620 Advanced Inorganic Chemistry Lab 2(0-2)

Preparation of at least six compounds/organometallic compounds and characterization by IR and UV spectrophotometer to the subject of availability of facilities, Spectroscopic determination of some metal ions, Estimation of different metals in food, tap water and brass etc. By atomic absorption spectrometer/flame photometer/UV/Visible spectrophotometer, subject to the availability of facilities.

Recommended books:

1. J. William, "Inorganic Chemistry, Theoretical and Practical: A Manual for Students in Advanced Classes", Legare Street Press (2023)
2. Bassette, J., Denney, G.H. and Mendham, J., Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis " English Language Book Society, 4th Edition .1981.
3. Vogel, A. I., "A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis " Longman Green & Co. 1995.
4. Fritz, J. S. and Schenk, G. H., "Quantitative Analytical Chemistry", Allyn and Bacon Inc., 4th Edition, 1979.
5. Pass. G and Sutcliffe. H., "Practical Inorganic Chemistry ". Van Nostrand Reinhold Company. 1972.

CHM-630 Capstone Project 3(0-3)

As per HEC guidelines

Semester 8 (Specialization in Organic Chemistry)

Course Code	Course Title	Credit Hours
CHM-622	Organic Polymers	3(3 – 0)
CHM-624	Reactive Intermediates and Photochemistry	3(3 – 0)
CHM-626	Disconnection Approach	3(3 – 0)
CHM-628	Organic Catalyst and Protective Group	3(3 – 0)
CHM-632	Advanced Organic Chemistry Lab	2(0 – 2)
CAP-630	Capstone Project	3(0-3)
	Total	17

Semester 8		
Specialization in Organic Chemistry		
CHM-622	Organic Polymers	3(3 – 0)
<p>Introduction to polymer chemistry. Step-growth polymerization, free radical addition polymerization, ionic polymerization; stereochemistry polymers; polymerization using Ziegler-Ziegler-Niegler-Natta catalyst. Stereo-regulation and conformation of polymers. Molecular weight determination. Structure property relation. Reactions of synthetic polymers; polymers degradation and stability with special emphasis on thermal and photo-degradation.</p> <p>Recommended Books:</p> <ol style="list-style-type: none"> Sodagudi Francis Xavier (Editor), Thermoplastic Polymer Composites: Processing, Properties, Performance, Applications and Recyclability, Johan Wiley & Sons, (2022). A. Gandini, T.M. Lacerda, Furan Polymers and their Reactions, Johan Wiley & Sons, (2023). J. R. Fried “Polymer Science & Technology”, Prentice Hall, Inc. (1995). W. Fred, B. Meyer “Text Book of Polymer Science”, 3rd Ed. Johan Wiley & Sons, (1992). Joel R. Fried “Polymer Science & Technology”, Prentice Hall, Inc. (1995). L. H Sperling “Introduction to Physical Polymer Sciences”, 2nd Ed., John Wiley & Sons, USA (1990). 		
CHM-624	Reactive Intermediates and Photochemistry	3(3 – 0)
<p>Nomenclature, Preparation, Reaction of Carbene. Nitrene: Nomenclature, Preparation, Reactions, Preparation, Reaction. Arynes: Preparation, Reactions.</p> <p>Photochemistry:</p> <p>Introduction, Principles, Difference between thermal and photochemical reaction, laws of photochemistry,</p>		

quantum yield, inter system crossing, Jablonski diagram, Photofragmentation, Norrish type I and II reaction. Photoreduction, Paterno-Büchi Reaction. Reactivity of ketone, photochemistry of olefins. Pinnerization reaction.

Recommended Books:

1. Felix A. Carroll, Perspectives on Structure and Mechanism in Organic Chemistry, 3rd Edition, John Wiley & Sons, Inc. (2023).
2. P. Sykes, "A Guide Book to Mechanism in Organic Chemistry", Creative Media Partners, LLC (2021).
3. Maya Shankar Singh, Reactive Intermediates in Organic Chemistry: Structure, Mechanism, and Reactions, John Wiley & Sons, Inc. (2014).
4. P. Y. Bruice, Organic Chemistry, 8th Edition, Pearson. (2016).
5. Jonathan Clayden, Nick Greeves, Stuart Warren "Organic Chemistry", 2nd edition, OUP Oxford, (2012).
6. A. L. Vogel, "Elementary Practical Organic Chemistry Part III: Quantitative Organic Analysis", 2nd Ed., Longman Group Ltd (2011).

CHM – 626 Disconnection Approach 3(3 – 0)

The Disconnection Approach

Basic Principles: Synthesis of Aromatic Compounds, One Group: C – X Disconnections, Strategy II: Chemoselectivity, Two Group C – X Disconnections, Strategy V: Stereoselectivity A, One Group C – C Disconnections II: Carbonyl Compounds, Strategy VI: Regioselectivity, Two Group Disconnections II: 1,3-Difunctionalized Compounds and α,β -unsaturated Carbonyl Compounds, Two Group Disconnections III: 1,5-Difunctionalized Compounds, Michael Addition and Robinson Annulation, Two Group Disconnections IV: 1,2-Difunctionalized Compounds, Strategy XIII: Introduction to Ring Synthesis. Saturated Heterocycles, Three Membered Rings, Strategy XV: Use of Ketenes in Synthesis, Six-membered Rings

Recommended Books:

1. David R. Klein, Organic Chemistry as a Second Language: First Semester Topics, 6th Edition, John Wiley & Sons, Inc. (2024).
2. Felix A. Carroll, Perspectives on Structure and Mechanism in Organic Chemistry, 3rd Edition, John Wiley & Sons, Inc. (2023)
3. P. Sykes, "A Guide Book to Mechanism in Organic Chemistry", Creative Media Partners, LLC (2021).
4. G. M. Loudon, "Organic Chemistry", 7th Ed., W.H. Freeman (2021).
5. P. Y. Bruice, Organic Chemistry, 8th Edition, Pearson. (2016).
6. Jonathan Clayden, Nick Greeves, Stuart Warren "Organic Chemistry", 2nd edition, OUP Oxford, (2012).
7. A. L. Vogel, "Elementary Practical Organic Chemistry Part III: Quantitative Organic Analysis", 2nd Ed., Longman Group Ltd (2011).

CHM-628 Organic Catalyst and Protective Group 3(3-0)

Homogeneous and heterogeneous catalysis, Acid Catalysis, Base Catalysis, Metal ion catalysis, Hydrogenation, Asymmetric hydrogenation, Hydroboration and Hydrocyanation of olefins, Transformation of alkenes and alkynes i.e. polymerization, metathesis, dimerization and oligomerization and olefin isomerization, oxidation of olefins using catalysts, Metal complexes and Quaternary ammonium compounds in organic synthesis. Protecting Groups for alcohols, aldehydes, carboxylic acid and amines

Recommended Books:

1. David R. Klein, Organic Chemistry as a Second Language: First Semester Topics, 6th Edition, John Wiley & Sons, Inc. (2024).
2. Felix A. Carroll, Perspectives on Structure and Mechanism in Organic Chemistry, 3rd Edition, John Wiley & Sons, Inc. (2023).
3. P. Sykes, "A Guide Book to Mechanism in Organic Chemistry", Creative Media Partners, LLC (2021).
4. G. M. Loudon, "Organic Chemistry", 7th Ed., W.H. Freeman (2021).
5. P. Y. Bruice, Organic Chemistry, 8th Edition, Pearson. (2016).
6. Jonathan Clayden, Nick Greeves, Stuart Warren "Organic Chemistry", 2nd edition, OUP Oxford, (2012).
7. A. L. Vogel, "Elementary Practical Organic Chemistry Part III: Quantitative Organic Analysis", 2nd Ed., Longman Group Ltd (2011).

CHM-632 Advanced Organic Chemistry Lab 2(0-2)

The experiments may be arranged as per choice/requirement of instructor but should be designed from following categories;

Synthesis of the organic compounds involving multi step synthesis using various synthetic methods. Synthesis of five or six membered heterocyclic compounds. Synthesis of targeted molecules; Anthranilic Acid. Benzilic acid, p-nitro aniline, Phenacetin and Acridon.

Recommended Books:

- 1- D. W. Mayo, R.M. Pike, D. C. Forbes, Microscale Organic Laboratory: With Multistep and Multiscale Syntheses, 7th Edition. John Wiley and Sons, (2023).
- 2- Stéphane Caron (Editor), Practical Synthetic Organic Chemistry: Reactions, Principles, and Techniques, 2nd Edition, John Wiley and Sons, (2020).
- 3- Laurie S. Starkey, Introduction to Strategies for Organic Synthesis, 2nd Edition, John Wiley and Sons, (2018).
- 4- George S. Zweifel, Michael H. Nantz, Peter Somfai, Modern Organic Synthesis: An Introduction, 2nd Edition, John Wiley and Sons, (2017).
- 5- B. S. Fumiss, A. J. Iannaford, P.W.G. Smith, A. R. Tatchell "Vogel's Practical Organic Chemistry", 5th Ed, Addition Wesley Longman, Harlow, England (1989).

CHM-630 Capstone Project 3(0-3)

As per HEC guidelines

Semester 8 (Physical Chemistry)

Course Code	Course Title	Credit Hours
CHM-634	Group Theory and Solution Chemistry	3(3 – 0)
CHM-636	Statistical and Quantum Mechanics	3(3 – 0)
CHM-638	Nuclear and Radiation Chemistry	3(3 – 0)
CHM-640	Electrochemical Aspects of Solutions	3(3 – 0)
CHM-642	Advanced Physical Chemistry Lab	2(0 – 2)
CAP-630	Capstone Project	3(0-3)
	Total	17

Semester 8
Specialization in Physical Chemistry
CHM-634 Group Theory and Solution Chemistry 3(3-0) Symmetry and Group Theory Symmetry operations, symmetry elements, Classes of symmetry, Group Algebra. Point groups. Character table and representation, Group theory application in Chemistry Chemistry of Solution Physicochemical characteristics of solvents. Solute-solvent interaction, solvation of ions, preferential solvation. Thermodynamic methods for study of solutions Biophysical Chemistry Principles of biophysical chemistry; thermodynamic aspect of simple molecules, macromolecules, lipids and biological membranes; nucleic acids and proteins; enzyme kinetics and catalysis; experimental techniques to study biophysical phenomenon. Recommended Books 1. F. A. Cotton, “Chemical Applications of Groups Theory”, Wiley India Publishers (2003). 2. A. Mohammad, “Application of Symmetry and Group Theory in Chemistry” University Grants Commission, Islamabad, (1984). 3. Alan Vincent “Molecular Symmetry and Group Theory” John Wiley & sons, (2001). 4. Robert J. S., Alberty, R. A., Robert J. S. and Mounji G. B. “Physical Chemistry”. 5 th Edition, John Wiley and Sons, (2022). 5. P. W. Atkins, “Physical Chemistry” 11 th Ed, W. H. Freeman and co. New York, (2018). 6. K. J. Laidler, Johnh. Meiser, Bryanc. Sanctuary “Physical Chemistry” 4 th Ed., Brooks Cole Publisher

(2006).

7. Robert G. Mortimer. "Physical Chemistry" 3rd Edition, Elsevier Academic Press, UK (2008).

CHM-636 Statistical and Quantum Mechanics 3(3-0)

Quantum Chemistry

Particle in three dimensional box, Degeneracy, Quantum Tunneling, The variation Method, The perturbation method, Solution of hydrogen atom by variation method, solution of helium atom by variation and perturbation method, Slater type Orbitals, Electronic configurations and spectroscopic states, Vibrating systems, Quantum mechanical harmonic Oscillators

Statistical Mechanics

The Boltzmann distribution law, Maxwell velocity and Barometric distribution as special case of Boltzmann distribution law, The partition function and statistical thermodynamics, The translational, vibrational and rotational partition functions, The law of equipartition energies, Partition function with the excited electronic states, Thermodynamic preliminaries, The equilibrium constant from the partition constant

Computational Chemistry

Concept of potential energy surface, Born-Oppenheimer approximation, Geometry optimization, Stationary points, Transition states, Calculation of force field, Introduction to molecular mechanics, Ab initio calculations, Semi-empirical methods, Density Functional Calculations.

Recommended Books

1. John P. Lowe, Kirk A Peterson, "Quantum Chemistry" 3rd Ed., Elsevier (2005).
 2. James E. House, "Fundamentals of Quantum Chemistry" 2nd Ed., Elsevier (2004).
 3. Ira N. Levine, "Quantum Chemistry" 7th Ed., Pearson (2014).
 4. Saegjoo J. Jang, "Quantum Mechanics for Chemistry" 1st Ed, Springer (2023).
 5. Benjamin Widom, "Statistical Mechanics A concise introduction for chemists" 1st Ed., Cambridge University Press (2002).
 6. Biman Bagchi, "Statistical Mechanics for Chemistry and Material Science" 1st Ed., Routledge Taylor & Francis Group. (2019).
 7. Errol G. Lewars, "Computational Chemistry, Introduction to the Theory and Applications of Molecular and Quantum Mechanics" 1st Ed., Springer, (2003).
- Jerry Harvey, "Computational Chemistry" 1st Ed. Oxford University Press (2018).

CHM-638 Nuclear and Radiation Chemistry 3(3-0)

Nuclear Chemistry

Nuclear systematic, sources of nuclear instability, nuclear energetics, nuclear fission and fusion. Nuclear reactors, applications of nuclear reactions.

Nuclear Techniques

Nuclear track detectors, Etchings, Kinetics and mechanism of track etching. Nuclear materials.

Radiation Chemistry

Tracers. Radiation Chemistry, theoretical aspects. Various models. Kinetic studies of radiolytic processes. Dosimetry (physical and chemical). Radiation chemical yields. Dose and dose rate effects on primary and secondary products. Steady state and pulse radiolysis techniques. Radiolytic studies of gaseous, water, aqueous and organic systems. Radiology.

Recommended Books:

1. G-Chopin, J. Redberg and C. Ekberg. "Radiochemistry and Nuclear Chemistry". 4th edition. Academic Press USA. (2013)

2. W. D. Loveland, D.J. Morrossery and G. T. Deaborg. "Modern Nuclear Chemistry". 3rd Edition. Willey Interscience USA. (2020).
3. G. Friedlander, J. W. Kennedy, "Nuclear and Radiochemistry", 3rd Ed. John Wiley & Sons, New York, USA (1981).
4. G. R. Choppin, J. Rayberg "Nuclear Chemistry Theory and Applications", 1st Ed., Pergaman Press, Oxford, USA (1998).
5. F. Aziz, M. A. J. Rodgers, "Radiation Chemistry Principles and Application" Ed., VCH Publishers, Inc, (1987).
6. R. Gregory, Choppin, J. Rayberg "Nuclear Chemistry Theory and Applications" 1st Ed., Pergaman Press, Oxford, USA (1998).
7. R. J. Wood & J. W. T. Spinks. "Introduction to Radiation Chemistry" 3rd Edition. Wiley-Interscience (1990).

CHM-640 Electrochemical Aspects of Solutions 3(3-0)

Electrochemistry of Solution

Interconversion of concentration units, Thermodynamics of solution formation, Molar and equivalent conductance, ionic strength, Theories of electrolytes (Farady's laws of electrolytes, Arrhenius theory of electrolytes, Kohlrausch law, Ostwald dilution law, Debye Huckel Theory) Fugacity, activity, activity coefficient, Debye Huckel limiting law, Nernst equation, Ion association, Effect of ion association on pH of acids, pH of strong and weak acids, pH of polyprotic acids, Degree of dissociation of electrolytes in solution, Abnormal colligative properties of electrolytes, Transport Properties, interfacial phenomena, electrode kinetics, mechanism of electrode reactions, Butler Volmer equation, cyclic voltammetry and its applications

Colloidal Solution

Colloids, classification, preparation of colloidal solution, coagulation, flocculation, peptisation, Dialysis, Electrophoresis, Zeta potential, Solutions of Surfactants.

Recommended Books

1. Arrhenius, S. (2023). Theories of solution. In *Scientific and Medical Knowledge Production, 1796-1918* (pp. 190-192). Routledge.
2. Steed, J. W., & Atwood, J. L. (2022). *Supramolecular chemistry*. John Wiley & Sons.
3. Bard, A. J., Faulkner, L. R., & White, H. S. (2022). *Electrochemical methods: fundamentals and applications*. John Wiley & Sons.
4. Newman, J., & Balsara, N. P. (2021). *Electrochemical systems*. John Wiley & Sons.
5. Safety, L. B. (2022). *Electrochemical Power Sources: Fundamentals, Systems, and Applications*.
6. Orest Popovyich & Reginald Tomkins, *Non Aqueous Solution chemistry*, John Wiley, 1981, USA.
7. Keith J. Laidler, John H. Meiser, Bryan C. Sanctuary, *Physical Chemistry*, Boston: Houghton Mifflin, c2003.

Rosen, M. J. *Surfactants and Interfacial Phenomenon*, 4th edition, 2012, Wiley Interscience, USA.

CHM-642 Advanced Physical Chemistry Lab 2(0-2)

NB: At least eight experiments should be performed from following list subjected to availability of apparatus and chemicals.

1. Determination of Equivalent and molar conductance of aqueous and non-aqueous solutions of different electrolytes.
2. Determination of partial molar volumes and excess molar volumes for binary and ternary systems.

3. Purification of the given commercial solvent using pertinent methods of separation (distillation, fractional distillation, reflux).
4. Verification of Kohlraush's law.
5. Verification of Ostwald's Dilution law.
6. Verification of Debye-Huckel Limiting law.
7. Determination of heat of solutions of selected compounds by solubility methods in aqueous and non-aqueous media.
8. Determination of critical micelle concentration of selected surfactants in aqueous and non-aqueous media by surface tension and conductivity.
9. Determination of free energy of micellization of selected surfactants in aqueous and non-aqueous media by surface tension and conductivity.
10. Determination of equivalence point of acid-base titration by electrical conductivity.
11. Determination of degree of dissociation of weak electrolytes.
12. Determination of pK_a values of acids and indicators.
13. Preparation of colloidal solution and determination of precipitation value of colloidal solution by using monovalent, bivalent and trivalent cations
14. Determination of apparent molar volume of different sample solutions
15. Calculation of partial molar volume by graphical method.

Recommended Books

1. Garland, C. W., Nibler, J. W., & Shoemaker, D. P. (2009). Experiments in physical chemistry.
2. James, A. M., Prichard, F. E., *Practical Physical Chemistry*, 3rd ed., Longman Group Limited, New York, (1974).
3. A. Findly's Practical Physical Chemistry, Longmann, London (1972).
4. L.P Gold, L. Gold, Physical Chemistry Laboratory, Primis Publishers (1997) ISB: 0072902698.
5. B. Viswanathan, P.S. Raghava, Practical Physical Chemistry, (2005), Viva books Private Limited. New Dehli.
6. C.W. Garland, J.W. Nibler and DP Shoemaker, Experiments in Physical Chemistry, Mc Grawhill, 7th edition (1996).

CHM-630 Capstone Project 3(0-3)

As per HEC guidelines