Act/Charter of the University allowing to offer a program

(Attached as annexure-I)

Approval of the University statutory body to start/launch program

(Attached as annexure-II)

Curriculum of program in line with the HEC guidelines

(Attached as annexure-III)

Annexure III

MS Chemistry Curriculum

Course work Credit Hours for MS students

	Number of courses	Credit Hours (CH)
Core courses	4	12
Elective Courses	4	12
Thesis research (2 semesters)		12 (6 CH per semester)
Communication Skills	1	1

Core Courses (CC)

1.	CY 501	Atomic Spectroscopy	3 CH
2.	CY 502	Chemistry of Synthetic Polymers	3 CH
3.	CY 590	Advanced Physical Chemistry	3 CH
4.	CY 591	Topics in Inorganic Chemistry	3 CH

Elective Courses (4 courses to be chosen among below elective courses)

S. No.	Code	Titles	CH	Pre-Requisite
1.	CY 503	Advanced Chemistry Laboratory	3	CY 501
2.	CY 504	Chemistry of Nuclear Fuel Cycle	3	Nil
3.	CY 505	Radiation and Chemical Safety	3	Nil
4.	CY 506	Electrochemistry	3	CY 590
5.	CY 507	Separation Techniques	3	CY 590
6.	CY 601	Chemistry of Energetic Materials	3	CY 590
7.	CY 602	Synthetic Chemistry	3	CY 590 or 591
8.	CY 603	Membrane Science and Technology	3	CY502
9.	CY 604	Polymer Additives and Blends	3	CY502
10.	CY 605	Chemosensors and Biosensors	3	CY 506
11.	CY 606	Surface Chemistry and Catalysis	3	CY 590
12.	CY 607	Special Topics in Chemistry	3	IC
13.	CY 608	Advanced Topics in Chemistry	3	IC
14.	MME 623	Polymer Matrix Composites	3	CY 502
15.	MME 507	Characterization of Materials	3	CY 501
	CY 609	Thesis Project	12	

MS Chemistry

(Semester Wise Plan)

First Semester

1.	Atomic Spectroscopy	3 CH
2.	Chemistry of Synthetic Polymers	3 CH
3.	Advanced Physical Chemistry	3 CH
4.	Topics in Inorganic Chemistry	3 CH

Second Semester

1.	Elective Course – 1	3 CH
2.	Elective Course – 2	3 CH
3.	Elective Course – 3	3 CH
4.	Elective Course – 4	3 CH
5.	Communication Skills	1 CH

Third and Fourth Semester

	Thesis Research (6 CH per semester)	12 CH

Details of Courses

CY 501 Atomic Spectroscopy

Status	Core Course
Credits	3
Pre-requisites	Nil

Spectrometric methods of analysis, optical atomic spectrometry, Components of the instruments, Atomic absorption and atomic fluorescence spectrometry (flame, flameless, hydride generation), Atomic emission spectrometry (arc, spark, ICP, DCP), Atomic mass spectrometry, Mossbaur spectroscopy, Atomic X-ray spectrometry (WDXRF and EDXRF); Instrumentation, interferences and applications; X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS).

Recommended Books

1. Skoog, D. A., Holler, F. J., Crouch, S. R., Principles of Instrumental Analysis, 7th edition, Thomson Brooks/Cole, 2017.
2. Margui, E., Grieken, R. V., X-ray Fluorescence Spectrometry and related techniques, Momentum Press, 2013.
3. Dean, J. R., Practical Inductively Coupled Plasma Spectroscopy, John Wiley, 2005.
4. Hollas, J. M., Modern Spectroscopy, 4th edition, Wiley, 2004.
5. Welz, B., Sperling, M., Atomic Absorption Spectrometry, 3rd edition, John Wiley and Sons, 2002.

CY 502 Chemistry of Synthetic Polymers

Status	Core Course
Credits	3
Pre-requisites	Nil

Types of synthetic polymers, synthesis processes i.e. step growth polymerization, chain polymerization, ionic polymerization, radical polymerization, copolymerization, coordination polymerization and ring-opening polymerization, Kinetics and mechanism of each of the technique. Conditions of polymerization processes i.e. bulk, solution, emulsion, suspension, gas phase, and batch vs. continuous fluidized bed. Structure and properties relationship of linear chain, branched, Cross-linked, networked polymers with examples from PE, PVC, Polyesters,

Polyurethane, Polyimides, Polyamides, epoxies, etc. Controlling parameters to modify properties (such as molecular weights, branching, crosslinking, and crystallinity), rheological and viscoelastic behavior of polymers and controlling parameters.

Recommended Books

1. Akay, M., Introduction to Polymer Science and Technology, Bookboon, 2013.
2. G. Odian, Principles of Polymerization, 4th edition, John Wiley, 2004.
3. Davis, F. J., Polymer Chemistry, Oxford University press, 2004.
4. Carraher, C. E., Seymour/Carraher's Polymer Chemistry, 6th Edition, Monticello, 2003.
5. Ebewele, R. O., Polymer Science and Technology, 1st edition, CRC press, 2000.

CY 503 Advanced Chemistry Laboratory

Status	Strategic requirement / Optional
Credits	3
Pre-requisites	CY 501

S. No.	Technique	Title of Experiment
1.	Complexometry	Determination of hardness of different water samples.
2.	UV-Vis Spectrophotometry	Spectrophotometric determination of iron, manganese and chromium in industrial effluent.
3.	Flame Photometer	Determination of sodium and potassium in blood sample by flame photometry.
4.	Atomic Absorption Spectrometer	Determination of zinc and copper in brass by atomic absorption spectrometry.
5.	Potentiometery	Potentiometric titration of chloride and iodide in a mixture using a silver electrode.
6.	Dissolved Oxygen Meter	Calibration of DO meter and determination of dissolved oxygen in lake water.
7.	Gas Chromatography	Separation of a mixture of aromatic hydrocarbons (BTX) by GC
8.	High Performance Liquid Chromatography	Determination of caffeine in a commercial soft drink/coffee by HPLC chromatography.

9.	Liquid Scintillation Counter	Measurement of the efficiency of liquid scintillation counter (LSC) and determination of tritium activity in a water sample by LSC.
10.	Gamma Spectrometer	Gamma spectroscopy using NaI(Tl) and HPGe detectors.
11.	Fourier Transform Infrared Spectrometer	Identification of organic compounds and polymers by using transmission and attenuated total reflectance (ATR) modes on FTIR spectrometer.
12.	Thermogravimetric analysis	Measurement of thermal stability and other thermal properties of polymer composite by Thermogravimetric analyzer.
13.	Differential Scanning Calorimetry	Curing studies of epoxies on Differential Scanning Calorimeter
14.	Melt Processing	Study of effects of additives on Melt processing parameters of thermoplastics

Recommended Books

1 Christian, G. D., Purnendu, K., Dasgupta, S., Schug, K. A., Analytical Chemistry, 7th edition, John Wiley & Sons, Inc., 2014.

2 Garland, C., Nibler, J., Shoemaker, D., Experiments in Physical Chemistry, 8th edition, Science Engineering & Math, 2011.

3 Mohring, J. R, Hammond, C. N., Schatz, P. F., Techniques in Organic Chemistry, 3rd edition, W. H. Freeman and Company, 2010.

4 Mendham, J., Denny, R. C., Barnes, J. D., Thomas, M., Sivasankar, B., Vogel's Textbook of Quantitative Chemical Analysis, 6th edition, Pearson, 2009.

5 Skoog, D. A., West, D. M., Holler, F. J., Crouch, S. R., Analytical Chemistry An Introduction, 7th edition, Saunders College Publishing, 2000.

CY 504 Chemistry of Nuclear Fuel Cycle

Status	Strategic Requirement / Optional
Credits	3
Pre-requisites	Nil

Chemistry of uranium: Leaching chemistry, Leaching processes for oxides, hydroxides, sulfides, disulfides, phosphates and silicates, Chemistry of refining processes, solution purification, chemical precipitation, cementation, crystallization, ion-exchange, Uranium enriched processes (gas centrifugation, laser separation, etc.), Production and analysis of

auxiliary materials (H_2SO_4, HF, F_2, Ca, Mg etc.), metals (Al, Cu, Ni, Zn, Co, Au, etc.) recovery through electrolysis and precipitation.

Recommended Books

1. ZeevKarpas, Analytical Chemistry of Uranium, CRC Press, Taylor & Francis Group, Bocan Raton, London, New York, 2014.
2. *Nash, K. L. and Lumetta, G. J.,* Advanced Separation Techniques for Nuclear Fuel Reprocessing and Radioactive Waste Treatment, Woodhead Publishing Limited, 2011.
3. Büchel, K. H., Moretto, H. H., Woditsch, P., Industrial Inorganic Chemistry, Second Edition, WILEY-VCH Verlag GmbH, 2007.
4. Quality System Implementation for Nuclear Analytical Techniques, Training Courses Series No. 24, International Atomic Energy Agency, Vienna, 2004.
5. Choppin, G. R., Liljenzin, J., and Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd Edition, Elsevier, 2002.

CY 505 Radiations and Chemical Safety

Status	Strategic requirement / Optional
Credits	3
Pre-requisites	Nil

Radiation sources; biological effects of radiation; Radiation interaction and detection; Standards of radiation protection; Calculation of exposure and dose.Principles, working and selection of Instruments for personal dosimetry and environmental surveillance; Attenuation coefficients and build-up factors. Gamma rays; Shielding of sources with different geometrical shapes; Shields with internal sources; Multilayered Concept of removal cross -sections; Removal - attenuation and removal diffusion calculations; Principles of shielding. General safety rules, Waste Disposal, Chemical Hazards, Materials Safety Data Sheets (MSDS) and their use, Health & Physical Hazards, hazards identification, human exposure assessment, Communication & Labels, Protective Equipment, Handling & Storage, Chemical Management, Chemical Inventory, Incompatible chemicals, Emergency Procedures.

Recommended Books

1. Hill, R. H., Finister, D. C., Laboratory Safety for Chemistry Students, 2nd edition, John Wiley, 2016.

2. Christian, G. D., Purnendu, K., Dasgupta, S., Schug, K. A., Analytical Chemistry, 7th edition, John Wiley & Sons, Inc., 2014.
3. Johnson, T. E., Birky, B. K., Health Physics and Radiological Health, Lippincott Williams & Wilkins, 2011.
4. Cember, H., Johnson, T., Introduction to Health Physics, 4th Ed., McGraw Hill, 2008.
5. Turner, J. E., Atoms, Radiations and Radiation Protection, Willey-VCH, 2004.

CY 506 Electrochemistry

Status	Strategic requirement / Optional
Credits	3
Pre-requisites	CY 590

Electrodes, Electrode-electrolyte interface, Descriptions of double layer, Kinetics of electrode processes, Polarization (ohmic, activation and concentration) and depolarization, Faraday's law, Nernst equation, Electrochemical cells, Electrolysis, Primary and secondary cells (batteries), Corrosion, types of corrosion and corrosion's control. Principles of electroanalytical chemistry: Stationary and rotating electrodes, Potentiometry (potentiometric electrodes, pH measurement, membrane and ion-selective electrodes, potentiometric titrations), Voltammetry (polarography, linear sweep voltammetry, cyclic voltammetry), Coulometry and Conductometry; AC impedance spectroscopy, Electrochemical data interpretation, Construction of equivalent circuits; Butler–Volmer equation, Tafel plot.

Recommended Books

1. Skoog, D. A., Holler, F. J., Crouch, S. R., Principles of Instrumental Analysis, 7th edition, Thomson Brooks/Cole, 2017.
2. Callister, W. D., Materials Science and Engineering, 7th edition, John Wiley & Sons, Inc., 2007.
3. Monk, P. M. S., Fundamentals of Electroanalytical Chemistry, John Wiley & Sons, 2002.
4. Wang, J. Analytical Electrochemistry, 2nd edition, John Wiley & Sons, 2001.
5. Bard, A. J., Faulkner, L. R., Electrochemical Methods: Fundamentals and Applications, 2nd edition, John Wiley & Sons, 2001.

CY 507 Separation Techniques

Status	Optional
Credits	3
Pre-requisites	CY 590

Physical and chemical principles of separations; Theory, Principles, Instrumentation and applications of gas, liquid, and supercritical fluid chromatography: Van Deemter equation, Column chromatography, Ion-exchange chromatography, Size-exclusion chromatography; Physical processes, modern instrumentation, and response characteristics of chromatography detectors; Hyphenated techniques; Miscellaneous separation techniques: Electrophoresis, Solvent extraction, and Membrane separation; fundamentals of membrane separation, membrane preparation and characterizations, theories of membrane transportation, and membrane applications.

Recommended Books

1. Skoog, D. A., Holler, F.J., Crouch, S. R., Principles of Instrumental Analysis, 7th edition, Thomson Brooks/Cole, 2017.
2. Baker, R. W., Membrane Technology and Applications, 3rd edition, John Wiley & Sons, 2012.
3. Mohring, J. R, Hammond, C. N., Schatz, P. F., Techniques in Organic Chemistry, 3rd edition, W. H. Freeman and Company, 2010.
4. Skoog, D. A., Holler, F. J., Crouch, S. R., Fundamentals of Analytical Chemistry, 8thedition, Thomson, 2004.
5. Fifield, F. W., Kealey, D., Principles and Practice on Analytical Chemistry, 5th edition, Blackwell Science Ltd., 2000.

CY 590 Advanced Physical Chemistry

Status	Core Course
Credits	3
Pre-requisites	Nil

Models in ideal and non-ideal solutions, Theories of liquid mixtures, Deby-Huckel theory and its implications, Thermodynamics of mixing, Factors influencing rate of a reaction, Mechanism of complex reactions. Equilibrium approximation, Steady state approximation, Product study, Stoichiometry, Exner plot, Nature of reaction series and selectivity, Arrhenius equation, Activated complex theory, Chain reaction (Photo Chemical and thermal reactions), Chain initiation process, Hydrogen–

halogen reaction, Branching chain reaction, Gas phase combustion, H_2O_2 reaction, Explosive reactions. Molecular Spectroscopy: qualitative and quantitative aspects, Infrared Spectroscopy, Raman spectroscopy, Nuclear magnetic resonance spectroscopy, Mass spectrometry, (ionization techniques, mass analyzers, ion detectors, quantitative analysis).

Recommended Books

1. Silverstein, R. M., Webster, F. X., Kiemle, D. J., Bryce, D. L., Spectrometric Identification of Organic Compounds, 8th edition, Wiley, 2014.
2. Atkins, P. W., Physical Chemistry, Volume 1 & 2, 9th edition, 2010.
3. Metiu, H., Physical Chemistry – Kinetics, Taylor & Francis, 2006.
4. Glasstone, S., Thermodynamics for Chemists, East-West Press Ltd., 2002.
5. Levine, I. N., Physical Chemistry, 5th edition, McGraw Hill, 2001.

CY 591 Topics in Advanced Inorganic Chemistry

Status	Core Course
Credits	3
Pre-requisites	Nil

Chemistry of f-block elements, Separation of lanthanides, Chemistry of nuclear fuel cycle, Water chemistry of PWR. Production of radionuclides with reactors, Accelerators and isotopic generators, Radio-pharmaceuticals and methods of radio-labeling, Radio-analytical chemistry, Isotopic dilution analyses, Principles of activation analysis, (instrumental and radiochemical), Organometallic compounds.

Recommended Books

1. Skoog, D. A., Holler, F.J., Crouch, S. R., Principles of Instrumental Analysis, 7th edition, Thomson Brooks/Cole, 2017.
2. Saha, G. B., Fundamentals of Nuclear Pharmacy, 6th edition, Springer, 2010.
3. Alberts, D. S., Hess, L. M., Fundamentals in Nuclear Physics: From Nuclear Structure to Cosmology, Springer Science, 2005.
4. Choppin, G. R., Liljenzin J. O., Rydberg, J., Radiochemistry and Nuclear Chemistry, 3rd edition, Butterworth-Heinemann Publishers, 2002.
5. Malik, W. U., Tuli, G. D., Madan, R. D., Selected Topics in Inorganic Chemistry, 7th edition, S. Chand & Company Ltd., 2001.

CY 601 Chemistry of Energetic Materials

Status	Strategic Requirement / Optional
Credits	3
Pre-requisites	CY 590

Energetic materials and their selection criteria, Structural investigation of energetic materials, Method for preparing energetic compounds, polycyclic amines chemistry, Nitration with nitronium salts. Selection of binders, oxidizers, Catalysts and processing aids, Combustion chemistry, Types of igniters, Thermal decomposition studies of model compounds, Solid propellants, Solid propellant grain design, Safety characteristics of solid propellants, Composite propellants, Thermal insulations, Liners and inhibitors.

Recommended Books

1. Olah, G. A., Chemistry of Energetic Materials, Academic Press, 2012.
2. Teipel, U., Energetic Materials: Particle Processing and Characterization, WILEY-VCH Verlag GmbH & Co., 2005.
3. Teipel, U., Energetic Materials: Particle Processing and Characterization, 1st edition, John Wiley & Sons, 2004.
4. Politzer, P., Murray, J. S., Energetic Materials: Part 1 – Decomposition, Crystal Growth and Molecular Properties, Elsevier, 2003.
5. Politzer, P., Murray, J. S., Energetic Materials: Part 2 – Detonation and Combustion, Elsevier, 2003.

CY 602 Synthetic Chemistry

Status	Optional
Credits	3
Pre-requisites	CY 590 and CY 591

Techniques for purification, drying and transfer of reagents/products for air and moisture sensitive chemical reactions. Synthesis of coordination compounds, metallocene. Organic synthesis: Synthesis using alkylation, halogenation, sulfonation, amination and oxidation and reduction etc., Chemical Industry, Homo and heterogeneous catalysis.

Recommended Books

1. Leonard, J. L., Procter, B. G., Advanced Practical Organic Chemistry, 3rd edition, CRC Press, 2013.

2. Schubert, U., Hüsing, N., Synthesis of Inorganic Materials, 3rd edition, Wiley VCH, 2012.
3. Weissermel, K., Arpe, A. J., Industrial Organic Chemistry, 3rd Edition, Wiley, 2008.
4. Nuffield Foundation, Chemical Engineering Students' Book: Nuffield Advanced Chemistry Special Study, The Nuffield Trust, 2004.
5. Groggins, P. H., Unit processes in Organic Synthesis, 5th edition, Tata MC Graw-Hill Company Limited, 2004.

CY 603 Membrane Science and Technology

Status	Optional
Credits	3
Pre-requisites	CY 502

Membranes, Membrane module and design, Membrane materials, processing and characterizations, Transport in membranes, Thermodynamics of membrane preparation and separation, Fouling and concentration polarizations. Membrane applications: Liquid-liquid separation, Gas separation, etc. Water treatment technologies: e.g., Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF) and Reverse osmosis (RO). Membranes applications in nuclear industry: Separation of Boric acid, liquid radioactive waste treatment and Nuclear fuel reprocessing. Emergent membrane technologies: e.g, Electro-dialysis, Forward osmosis, Pressure retarded osmosis. Membranes for energy productions and storage: Membrane contactors, Membrane reactors, Batteries and Fuel cells.

Recommended Books

1. Singh, R., Hankins, N., Emerging Membrane Technology for Sustainable Water Treatment, 1st edition, Elsevier Science, 2016.
2. Baker, R. W., Membrane Technology and Applications, 3rd edition, John Wiley & Sons, 2012.
3. Basile, A., Gallucci, F., Membranes for Membrane Reactors: Preparation, Optimization and Selection, 1st edition, John Wiley & Sons, 2011.
4. Basile, A., Nune, S. P., Advanced Membrane Science and Technology for Sustainable Energy and Environmental Applications, 1st edition, Woodhead Publishing, 2011.
5. Peinemann, K. V., Nunes, S. P., Membranes for Energy Conversion, Volume 2, Wiley VCH, 2008.

CY 604 Polymer Additives and Blends

Status	Optional
Credit	3
Prerequisite	CY 502

Types of additives; Chemistry and mechanisms of antioxidants; Heat stabilizer; crosslinking agents; Plasticizer; Fillers; Impact modifier; Lubricant; Coupling agents; flame retardant and colorants in polymers; Chemical; Physical and toxicological requirements for additives; Safety issues; Polymer blending; Theory and methods of blending; Methods of compatibilisation; Role of compatibilser and Compatibilising mechanism; Processing of blends and their effects on morphology; characterization of blends; Current developments in polymer blends

Recommended Books

1. Kresta, J. E., Polymer Additives (Polymer Science and Technology Series), Springer, 2013.
2. Mikitaev, A. K., Ligidov, M. K., Zaikov, G. E, Polymers, Polymer Blends, Polymer Composites and Filled Polymers: Synthesis, Properties, and Applications, 1st edition, Nova, 2006.
3. Bart, J. C. J., Additives in Polymers: Industrial Analysis and Applications, John Wiley Interscience, 1st edition, 2005.
4. Utracki, L. A., Polymer Blends, Volume 11, Rapra Publishing, 2000.
5. Paul, D. R., Bucknall, C. B., Polymer Blends: Formulation, John Wiley Interscience, 2000.

CY 605 Chemosensors and Biosensors

Status	Optional
Credits	3
Pre-requisites	CY 506

Requirement and Applications; Forces governing exchangeable interactions; Molecular recognition and transduction; signal acquisition; Modification of sensor surfaces and immobilization techniques; Label free bio sensing. Physical sensors, Electrochemical sensors, Optical sensors, Surface Plasmon Resonance (SPR), Silicon Field effect transistor sensors, Piezoelectric resonators, cantilevers etc, Recent developments in commercial biosensors, Sensitivity and accuracy for detection of blood constituents (e.g., glucose, urea, creatinine) and disease biomarkers.

Recommended Books

1. Karunakaran, C.,Bhargava, K., Biosensors and Bioelectronics, 1st edition, Elsevier, 2015.
2. Banica, F. G., Chemical Sensors and Biosensors: Fundamentals and Applications, 1st edition, Wiley-Blackwell, 2012.
3. Wang, B., Anslyn, E. V., Chemosensors: Principles, Strategies, and Applications, John Wiley & Sons, Inc., 2011.
4. Eggins, B. R., Chemical Sensors and Biosensors, 1st edition, John Wiley & Sons, 2009.
5. Cooper, M. A., Label-Free Biosensors: Techniques and applications, Cambridge University Press, 2009.

CY 606 Surface Chemistry and Catalysis

Status	Strategic Requirement / Optional
Credits	3
Pre-requisites	CY 590

Structure of solid surfaces, Physisorption and chemisorption , adsorption isotherms, Adsorbateoverlayers, Brunauer-Emmett-Teller (BET) surface area analysis, physical and electronic properties of surfaces, Kinetics and Thermodynamic aspects of surfaces, adsorption and catalysis on surfaces, surface science approach to heterogeneous catalysis, Heterogenous catalysis - Role of surface in catalysis, Mechanism of Heterogenous catalysis-Langmuir-Hinshelwood mechanism of bimolecular reaction - Langmuir Rideal mechanism of bimolecular reaction, electrocatalysis, photocatalysis, nanocatalysts, cluster science and sensors.

Recommended Books

1. Levine, K. L., Thermodynamics and physical chemistry of surface, Create Space Independent Publishing Platform, 2017.
2. Simonet, J., Electro-Catalysis at Chemically Modified Solid Surfaces, World Scientific Publishing Company, 2017.
3. Konsolakis, M., Surface Chemistry and Catalysis, MDPI AG, 2016.
4. Barrow, G. M., Physical Chemistry, Tata-McGraw Hill, 5th edition, 2003.
5. Carley, A. F., Davies P. R., Hutchings, G. J., Spencer M. S., Surface Chemistry and Catalysis, Springer, 2002.

MME 507 Characterization of Materials

Status	Optional
Credits	3
Pre-requisites	CY 501

Production, detection and properties of X-rays, X-ray diffraction: Braggs law, Laues equations, diffraction methods, Structure factor calculations, Phase identification, Indexing patterns of cubic and noncubic crystals, Effect of cell distortion on powder pattern, determination of atom positions and number of atoms in a unit cell, Electron specimen interactions, electron diffraction, Design and functions of Scanning Electron Microscope (SEM) subsystems, Topographic, compositional and other contrast mechanisms, Design of a Transmission Electron Microscope (TEM) and sample preparation, Contrast mechanisms in TEM, Scanning transmission electron microscopy, Quantitative and qualitative chemical analysis in SEM and TEM using Energy Dispersive and Wavelength Dispersive spectrometers.

Recommended Books

1. Skoog, D. A., Holler, F. J., Crouch, S. R., Principles of Instrumental Analysis, 7th edition, Thomson Brooks/Cole, 2017.
2. Williams, D. B., Carter, C. B., Transmission Electron Microscopy, A Textbook for Materials Science, Springer, 2009.
3. Goldstein, J., Newbury, D. E., Joy, D. C, Lyman, C. E., Echlin, P., Lifshin, E., Sawyer, L. C., Michael, J. R., Scanning Electron Microscopy and X-ray Microanalysis, Springer, 3rd edition, 2003.
4. Cullity, B. D., Stock S. R., Elements of X-ray Diffraction, Prentice Hall, 3rd edition, 2001.
5. Goodhew, P. J., Humphreys F. J., Beanland R., Electron Microscopy and Analysis, Taylor and Francis, 3rd edition, 2001.

MME 623 Polymer Matrix Composites

Status	Optional
Credits	3
Pre-requisites	CY 502

Definition and classification, natural composites, property enhancement by reinforcement and orientation, matrix interface, synthetic fibers, properties and processing of composites with polymeric matrix, interface

reactions. Hybrid composite materials, Principles for developing organic-fiber-reinforced polymers for aerospace engineering, mechanical and thermal properties, stress relaxation and creep studies, dynamical mechanical properties, toughening mechanism and mechanical failure in polymeric composites.

Recommended Books

1. Advani, S. G., Hsiao, K. T., Manufacturing techniques for polymer matrix composites, edition 1st, Woodhead Publishing, 2012.
2. Wang, R. M., Zheng, S. R., Zheng, Y., Polymer Matrix Composites and Technology, Woodhead Publishing, 1st edition, 2011.
3. Mikitaev, A. K., Ligidov, M. K., Zaikov, G. E, Polymers, Polymer Blends, Polymer Composites and Filled Polymers: Synthesis, Properties, and Applications, 1st edition, Nova, 2006.
4. Matthews, F. L., Rawlings, R. W., Composite Materials: Engineering and Science, RC Press, 2006.
5. Talreja, R., Manson, J.-A, E., Polymer Matrix Composites, Elsevier, 2001.

CY 609 Thesis Project

Status	Compulsory
Credits	12 (6 + 6)
Pre-requisites	Supervisor's Consent

Each student will be required to select a research topic at the end of Semester – III (Fall) in consultation with his/her potential supervisor from the list of available research projects. The purpose of the research project will be to acquaint the students with research methodologies and techniques in chemistry with particular emphasis on developing a problem solving ability, interpreting and evaluating data, and deducing conclusions.

Exact title of the program that will appear on the degree

Master of Science (MS) Chemistry

Brief introduction of the program and Date of Commencement

PIEAS has been expanding its MS and PhD programs since its inception to cater for the national and strategic needs of Pakistan. PIEAS programs primarily emphasize on focused studies with significant component of research and development (R&D) work associated with the strategic needs, ensuring high level of quality and meeting the international standards. So far, students with the chemistry background have been offered admissions in MS in Materials Engineering, Chemical Engineering, and Nuclear Engineering at PIEAS. It has been, however, realized that the Post Graduate Programs in Chemistry would be highly beneficial for chemistry students to cater for the expertise and training required to perform much better in the higher education institutions, Industries, and R & D organizations as well as pursue higher studies and research in chemistry and its related research areas. In addition to the sufficient knowledge of chemistry, our country needs require graduates having in depth knowledge of strategic materials and techniques, radiation and fire-retardant polymers, polymeric composites, energy-related materials, and biomedical materials with an ability of ongoing adjustments based on the feedbacks and the emerging needs of the country.

In addition, other sciences and engineering departments at PIEAS will also be benefited from this program as well by utilizing the advanced knowledge in the emerging multidisciplinary areas in the field of chemistry, nanomaterials, biomaterials, nanotechnology, microfabrication, nanofabrication, energy and environment related materials, etc. This program will play a key role to improve the overall ranking of the University nationally and internationally as well as the students and faculty research capabilities. Our infrastructure includes high tech labs with state-of-the-art equipment and highly qualified full-time faculty (8 PhDs). This is high time to take a step forward and launch post graduate program in chemistry at PIEAS.

Date of Commencement: January, 2019

Objectives of the program

- Train manpower for industrial, academia, and research organizations
- Equip students with the research areas in the field of chemistry and its related research areas
- Impart in-depth knowledge of chemistry in specific areas of national interest
- Transfer knowledge of analytical and creative nature through extensive hands-on trainings on all major analytical equipment
- Groom a chemist so that he/she may be able to carry out the interdisciplinary research works and developmental projects
- Train chemists to cater for the specific national needs

Scope regarding market, social, and employment prospective of the program

Presently, the chemists graduated from PIEAS have been inducted in different strategic organizations. After graduating from the Department of Chemistry (PIEAS), these MS students will most likely be inducted in the following domains:

- ➢ Educational institutions such as, colleges, universities, and professional schools
- ➢ Federal and Provincial Government-funded research institutes and departments
- ➢ Pharmaceutical, biomedical, and forensic laboratories
- ➢ Chemistry-related industries
- ➢ CPEC and one-belt-one-road related industrial zones and projects

The chemists trained from PIEAS will have following unique abilities for the job market:

- Develop new materials to be used in the research areas in various fields including but not limited to: nanotechnology, energy and environment related fields, biomaterials, pesticides, and health-related materials.
- Develop and design experimental techniques useful for the emerging multidiscilinary research areas in the fields of science & technology
- Apply experimental chemistry tools to solve practical problems in forensic, chemical industries, engineering, sciences, and other fields
- Perform interdisciplinary research work where expertise in chemistry will be required along with the understanding of other subjects of applied nature

Entry/admission requirement of program

Regular Fee Basis

In order to be eligible for admission MS degree programs as regular students, first division is preferably required throughout the academic career provided they meet the pre-requisite course requirements of the degree program. However, one-second division is allowed at any stage in the academic career from Matriculation to final degree. Applicants having third division in academic career are not eligible. However, the Rector, PIEAS only in case of nominees from foreign government/agencies, may relax this condition. There is no age limit for regular students.

PAEC Fellowship

For fellowship in the MS degree programs, first division is preferably required throughout the academic career. However, one-second division is allowed in academic career at any stage except the final degree. Maximum age limit is 27 years for admission in the MS program. The candidates having BS (4 years)/Master degree in Chemistry must have studied Physics and Mathematics at the undergraduate level.

Postgraduate Program	Physical Sciences	Remark
MS in Chemistry	BS in Chemistry, Applied Chemistry, Biochemistry, Forensic Chemistry, Polymer Chemistry, and Materials Chemistry or M.Sc in Chemistry, Applied Chemistry, Biochemistry, Forensic Chemistry, Polymer Chemistry, and Materials Chemistry (16 years of education)	Both national & international applicants fulfilling the admission requirements are eligible to apply

The admission criteria laid down by PIEAS, from time to time, will be followed

Duration of the program and semester-wise breakup

The duration of MS program is two years. This includes 4 regular semesters of 16 weeks teaching followed by two weeks for terminal examinations. The regular semesters (semester 1 and 2) are primarily devoted to the core and elective courses. Terminal examinations are conducted at the end of each semester while tests; quizzes and assignments are regular part of the sessional assessment during a semester. The overall grades are based upon the sessional examinations, assessment, and the terminal examinations. In the question papers, no choice is allowed and students are expected to attempt all the questions. Semester 3 and 4 are devoted to full time work on a research project , which starts during at the beginning of the 3rd semester.

Semester-wise Breakup of the Program

Semester number	Workload	Minimum credit hours
I	Course Work	12
II	Course Work	13
III	Research Work	6
IV	Research Work	6

Full-time faculty

Name	Designation	M. Sc	MS	PhD	
				Degree/Department	SPECIALAIZATION
Dr. Tariq Yasin	Professor	Chemistry	-	Polymer Chemistry	Polymer Chemistry
Dr. Gul Bali Shah	DCS	Applied Chemistry	-	Chemistry & Applied Chemistry	Applied Chemistry
Dr Muhammad Mansha Chaudhry	Professor	Chemistry	-	Chemistry	Analytical
Dr. Shaukat Saeed	Professor	Chemistry	MS in Nuclear Engineering	Materials Engineering	Polymer Chemistry
Dr. Asif Mahmood	Associate Professor	Applied Chemistry	MS. In Process Engineering	Green Chemistry & Environmental Biotechnology	Green Chemistry
Dr. Muhammad Shafiq	Assistant Professor	Applied Chemistry	MS in Materials Engineering	Biomedical Engineering	Polymeric Biomaterials
Dr. Asma Khurshid	Assistant Professor (IPFP)	Organic Chemistry	M.Phil in Organic Chemistry	Chemistry	Organic Chemistry
Dr. Nazish Urooj Tanoli	Assistant Professor (IPFP)	Chemistry	-	Organic Chemistry	Organic Chemistry

The following details of the Ph.D. faculty are attached as annexure-V

(i) Appointment order/notification
(ii) Joining report along with the current status of employment
(iii) CV along with one passport-sized photograph
(iv) Copy of PhD and MS/M.Phil/Equivalent degree and their translations in English (if required)
(v) Copy of Transcript of PhD and MS/M.Phil/Equivalent program
(vi) Abstract of theses of PhD and MS/MPhil/Equivalent program
(vii) Equivalence certificate in case of a foreign degree
(viii) Area of specialization in PhD
(ix) Copy of CNIC