CHEMISTRY

Our chemistry department is doing some of the most impactful research at the university and around the world. The department's 21 regular research faculty comprise one of the highest external research grant-generating departments at S&T. Our emphasis on excellence in research and creativity has moved our programs to the forefront of science. The department supports a broad range of research performed by internationally recognized faculty competing at the leading edge of technological research.

The department provides programs in analytical, inorganic, organic, physical, and biochemistry, as well as in more specialized areas including polymer and coatings, electrochemistry, bioanalytical chemistry, cancer biology, colloids, corrosion, environmental chemistry, kinetics, organometallic chemistry, reaction mechanisms, atmospheric sciences, solid state chemistry, chemical instrumentation design and development, spectroscopy and theoretical chemistry. A number of our faculty are involved in efforts which have been organized into several centers or institutes including the Missouri S&T Coatings Institute, the Materials Research Center, the Cloud and Aerosol Sciences Laboratory and the Center for Single Nanoparticle, Single Cell, and Single Molecule Monitoring. Financial support is available from research grants for advanced students.

The department of chemistry, along with the department of biological sciences, is housed in the recently renovated Schrenk Hall and features modern teaching and computer laboratories and research facilities. The department has a number of technical support personnel to provide assistance with laboratory instrumentation, hardware, and computers. Departmental instrumentation and instrument training are available to the entire campus community (https://chem.mst.edu/research/depart-instr/instr-training (https://chem.mst.edu/research/depart-instr/instr-training/)).

The department's Shared Instrument Lab (https://chem.mst.edu/research/depart-instr/shared-instr (https://chem.mst.edu/research/depart-instr/shared-instr/)) holds a suite of state-of-the-art research instrumentation, incuding a Thermo Nicolet iS50 FTIR with built-in ATR, Magritek Spinsolve Carbon benchtop NMR, Shimadzu QP-2020 GCMS, Edinburgh Instruments FS5 fluorescence spectrometer with lifetime measurement capability, Agilent Cary 5000 and Varian Carey 50 UV-visible spectrophotometers, Thermo Vanquish HPLC with diode array detector, TA Instruments Q2000 differential scanning calorimeter, TA Instruments Q500 thermogravimetric analyzer, Varian CP-3800 GC, Jasco P-2000 digital polarimeter, Exeter CE-440 elemental (CHN) analyzer, Electrothermal Engineering M-2341 melting point apparatus, Sartorius ME-5 Series Ultramicro balance, Dymax Model 5000 UV curing oven, and CEM MDS-2000 microwave reactor oven.

Specialized instruments (https://chem.mst.edu/research/depart-instr/specialized-dept-instruments (https://chem.mst.edu/research/depart-instr/specialized-dept-instruments/)) available elsewhere in the department include a Bruker-AXS D8 single-crystal X-ray diffractometer, Bruker Dimension Icon atomic force microscope, Renishaw inVia Raman microscope, Nikon A1R/Ti2E confocal microscope, WissEl Model W302 low-temperature Mössbauer spectrometer, and Amnis CellStream flow cytometer. The department also houses an extensive collection of additional instrumentation in the various research groups.

The departmental Institute for Applied NMR Spectroscopy (https://chem.mst.ed/research/nmr-institute/) houses a Bruker 400 MHz Avance III HD Liquid State NMR with multinuclear liquid, diffusion, and variable-temperature capabilities, a Bruker 400 MHz Avance III Wide-bore Solid State NMR, and a Bruker 200 MHz Avance DRX Wide-bore NMR with multinuclear liquid and toroidal cavity capabilities.

Research groups have free access to the campus centralized computing facility which includes new high-performance computing hardware (https://itrss.mst.edu/cluster/foundry (https://itrss.mst.edu/cluster/foundry/)). Neutron diffraction is on hand at the Missouri S&T High Flux Reactor (https://nuclear.mst.edu/research/reactor (https://nuclear.mst.edu/research/reactor/)). Facilities for studying very fast combustions and explosions, as well as a variety of new and innovative techniques for characterizing high-energy materials, are provided in the Rock Mechanics and Explosives Research Center (https://explosives.mst.edu).

Amitava Choudhury, Associate Professor
PHD Indian Institute of Science, Bangalore, India
Solid state chemistry; Synthesis of polyanion-based materials, complex chalcogenides, porous materials (MOFs, organically templated solids, and zeolites); X-ray crystallography including single-crystal and powder X-ray diffraction (laboratory and synchrotron); Solid state electrochemistry (lithium- and sodium-ion batteries, solid electrolytes); Magnetic, electronic and thermoelectric properties.

Richard Dawes, Adjunct Professor
PHD University of Manitoba, Canada
Spectroscopy and dynamics of small molecules primarily of interest to combustion and atmospheric chemistry.

Nuran Ercal, Professor
PHD Hacettepe University, Turkey
Vitek Chair of Biochemistry. Effects of N-acetylcysteineamide (NACA) in various oxidative stress related conditions, including metal toxicity, radiation, medicinal drug- induced toxicity, and degenerative eye disorders; Developing NACA eye drops as an alternative to surgery for oxidative stress-induced eye disorders; Developing HPLC techniques for thiol-containing compounds in biological samples.

Rainer Glaser, Professor and Interim Vice Provost for Graduate Education
PHD University of California, Berkeley, CA
CO2 capture from air: Rubisco-inspired oligopeptide-based reversible CO2 capture systems; Oscillating chemical reactions: Video-based kinetic analysis and complete simulation of complex reaction systems; Organic crystalline ferroelectric materials for nonlinear optics; Ethical science: Peer review ethics, science communication, cross-disciplinary science education, and globalization.

Garry Smitty Grubbs II, Associate Professor
PHD University of North Texas, Denton, TX
Physical chemistry in the area of molecular rotational spectroscopy and gas phase chemistry; Development of spectroscopic tools for the detection of chirality, structural determination of van der Waals complexes, observation and molecular determination of actinide-containing species, and as a basis for determination of molecules in the interstellar medium; Chemistry education research aimed at delivering undergraduate level physical chemistry teaching laboratories that integrate thermodynamics, statistical mechanics, kinetics, and quantum chemistry on a budget.

Vadym Mochalin, Associate Professor
PHD L. M. Litvinenko Institute of Physical Organic and Coal Chemistry of the National Academy of Sciences of Ukraine
Fundamental chemistry and physics, synthesis, characterization, purification, chemical modification, computational modeling, and development of low-dimensional (0D materials, 2D materials, nanodiamond, MXenes, nanoonions, nanocarbons, and other materials) for applications in composites, energy storage and harvesting, biology and medicine, optoelectronics, sensing, and extreme environments.

Paul Ki-souk Nam, Associate Professor
PHD University of Missouri-Columbia
Biofuel and bioproduct development; Microalgae and agricultural product utilization; Environmental monitoring and remediation: endocrine disruptors, emerging contaminants, aerosol/particulate matter, carbon sequestration; Supercritical fluid reaction, extraction and chromatography; Explosive and chemical agent detection and neutralization; Synthesis and characterization of enantio-enriched peptides and oligomers; Thermal treatment for material characterization and recycling.

Manashi Nath, Associate Professor
PHD Indian Institute of Science, Bangalore, India
Growth of functional nanowires and nanotubes of inorganic materials for energy conversion and storage, biosensor, and superconducting applications; Developing protocols for device fabrication with functional nanowire and nanotube arrays.

Thomas Schuman, Professor
PHD University of Alabama-Huntsville
Interface control; Non-chrome, corrosion inhibitors for aluminum alloys and steel; Adhesion promotion to plastic substrates; Organometallic nanocomposites; Development of industrial agricultural products/ materials; Polymer gels for EOR applications; Transportation-infrastructure sustainability materials.

Honglan Shi, Research Professor Emeritus and Adjunct Professor
PHD Missouri S&T
Environmental analysis and bioanalytical techniques, including emerging water contaminants, soil contaminants; Bioanalytical analysis, analytical instrument and test kits designs; Analytical methods development for state-of-the-art instruments including LC-MS, GC-MS, ICP-MS, ICP-OES, HPCE, HPLC, GC, and IC.

Chariklia Sotiriou-Leventis, Professor
PHD Michigan State University, East Lansing, MI
Synthesis of nanomaterials based on aerogels: polyisocyanurate aerogels as shape memory polymers for deployable panels and biomimetic applications; Microporous carbons from phenolic aerogels as sorbent materials with exceptionally high CO2 adsorption; Nanoporous metals, carbides, nitrides, borides; Supramolecular chemistry.

Pericles Stavropoulos, Associate Professor
PHD Imperial College, London, UK
Development of transition-metal catalysts for applications in C–H bond activation and atom/group-transfer chemistry.

Jay A. Switzer, Chancellor's Professor and Curators' Distinguished Professor Emeritus
PHD Wayne State University, Detroit, MI
Inorganic materials chemistry; Electrochemistry; Photoelectrochemistry; Electrocatalysis; Chiral surfaces; Epitaxial growth of thin films and nanostructures; Energy conversion and storage.

Risheng Wang, Associate Professor
PHD New York University, New York City, NY
Biochemistry; Structural DNA nanotechnology; Nanomaterials; Fabrication and characterization of nanostructures; DNA based biomedical and electronic applications.

Philip D. Whitefield, Professor Emeritus
PHD University of London, London, UK
Aerospace emissions; Chemical and physical characterization of aerosols; Aerosols generated by aerospace and other civilian and military activities; Environmental problems presented by aerosol production (e.g. local air quality at airports, rocket impact on stratospheric ozone) and their impact on power plant efficiency (e.g. evaluation of fuel additives).

Jeffrey G. Winiarz, Associate Professor and Associate Chair for Undergraduate Education
PHD SUNY at Buffalo
Development of polymeric photonic materials and devices using photosensitization by way of the inclusion of surface-passivated semiconductor nanocrystals.

Klaus Woelk, Associate Professor
PHD University of Bonn, Germany
In situ high-temperature and high-pressure NMR spectroscopy to study the chemistry of thermoplastics upcycling and the hydrothermal degradation of lignocellulosic biomass; NMR relaxometry and diffusiometry to investigate fluid mobility in inhomogeneous and porous materials; Spin-spin (T2) and spin-lattice (T1) relaxation of hyperpolarized NMR spin states, toroid-cavity rotating-frame NMR microscopy.

CHEM 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Prerequisite: Preceded or accompanied by Chem 1100 or an equivalent training program approved by S&T. Consent of instructor required.

CHEM 5001 Special Topics (LAB 2.0 and LEC 1.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CHEM 5099 Master Research (IND 0.0-6.0)
Master level research with the intent to lead to the preparation of a master degree thesis. Not more than six (6) credit hours allowed for graduate credit. Subject and credit to be arranged with the instructor. Preparation of a written, detailed report culminating in a thesis is required of the student. Prerequisite: Must meet departmental training requirements for laboratory safety. Consent of instructor required.

CHEM 5100 Laboratory Safety & Hazardous Materials (LEC 1.0)
A systematic study of safe laboratory operations and pertinent regulations of state and federal agencies. Prerequisites: Graduate standing.

CHEM 5210 Fundamentals of Synthetic Organic Reactions (LEC 3.0)
Fundamental organic reactions are discussed based on reaction mechanisms and synthetic applications emphasizing the synthon approach. Graduate students are required to demonstrate a higher level of learning on assessments. Prerequisite: Chem 2220.

CHEM 5220 Physical Organic Chemistry (LEC 3.0)
Mechanisms of organic reactions and the tools used for their elucidation including kinetic isotope effects, linear-free energy relationships, MO theory and more advanced electronic structure methods, non-covalent interactions and other fundamental topics. Graduate students are expected to demonstrate a higher level of proficiency during assessments. Prerequisites: Chem 2220.

CHEM 5310 Introduction to Inorganic Chemistry (LEC 3.0)
A study of inorganic chemistry with emphasis on physical methods. General subjects covered include: molecular structure, bonding, complexes, spectroscopy, and reaction rates. Graduate students are required to demonstrate a higher level of proficiency during assessments.

CHEM 5410 Advanced Chemical Thermodynamics (LEC 3.0)
A study of the laws of thermodynamics with application to chemical systems. Emphasis is placed on partial molal functions. Credit will not given for both Chem 5410 and Chem 4410. Prerequisites: Chem 3420.

CHEM 5420 Elemental Quantum Chemistry (LEC 3.0)
A study of molecular structures and spectroscopy, statistical thermodynamics, kinetic theory, chemical kinetics, crystals, and liquids. Prerequisites: Math 2222; Physics 2135 or Physics 2111.

CHEM 5430 Advanced Chemical Kinetics (LEC 3.0)
Introductory graduate treatment of special topics of physical chemistry including statistical mechanics and kinetics. Prerequisites: Chem 3430.

CHEM 5460 Molecular Engineering of Materials (LEC 3.0)
This course focuses on the fundamentals of molecular engineering with an emphasis on their applications including renewable/clean energy solutions, energy storage, air/water cleaning, and optoelectronics. Topics include principles of modern physics, carbon chemistry, macromolecules, metal(covalent)-organic frameworks sol-gel processing and crystal growth. Prerequisites: Senior Standing or consent of instructor. (Co-listed with MS&E 5460).

CHEM 5510 Introduction to Chemical Analysis (LAB 1.0 and LEC 3.0)
Principles and analytical applications of molecular spectroscopy, chromatographic separations, mass spectrometry, and radiochemistry. A brief overview of instrument electronics, signal generation and processing, and automated analysis is also provided. Graduate students are expected to achieve a higher level of proficiency on application and assessments compared to Chem 4510 students. Prerequisites: Chem 1100, Chem 2510, Chem 2220, Chem 3430.

CHEM 5610 Biochemistry (LEC 3.0)
A resume of the important aspects of quantitative and physical chemistry in biochemical processes. General subjects covered include: proteins, nucleic acids, enzymes, carbohydrates and lipids. Credit may not be given for both Chem 5610 and Chem 4610. Prerequisite: Chem 2220.

CHEM 5619 Biochemistry Laboratory (LAB 2.0)
Experiments are integrated with the lectures and cover the chemical and physical properties of proteins, enzymes, nucleic acids, carbohydrates and lipids. Credit may not be given for both Chem 5619 and Chem 4619. Prerequisites: Preceded or accompanied by Chem 5610 and Chem 1100 or an equivalent training program approved by S&T.

CHEM 5620 Biochemical Metabolism (LEC 3.0)
A continuation of Chem 5610. Catabolism and anabolism of carbohydrates, lipids, proteins, and nucleic acids. Photosynthesis, oxidative phosphorylation and membranes. Credit may not be given for both Chem 5620 and Chem 4620. Prerequisite: Chem 4610 or 5610.

CHEM 5630 Biochemical Nanotechnology (LEC 3.0)
This course will educate on the interdisciplinary areas of bio-nanotechnology. Student will investigate the potential of nanoscience in advanced applications including DNA/protein nanotechnology, drug delivery, environmental biosensor and emerging biotechnology industries. Credit may not be given for both Chem 5630 and Chem 4630. Prerequisite: At least junior standing.

CHEM 5650 Introduction to Medicinal Chemistry (LEC 3.0)
A survey of the important aspects of analytical, organic, and physical chemistry as they relate to drug development, metabolism, and mechanism of action. A deeper understanding about drug design and molecular mechanisms by which drugs work in the body will be covered. Prerequisite: Chem 2220.

CHEM 5710 Environmental Monitoring (LEC 3.0)
This course provides an overview of environmental monitoring methodologies. Discussion covers thermodynamic and kinetic processes that affect chemical transport and fate in the environment. Federal environmental regulations and remediation technologies are also covered with specific examples. Credit may not be given for both Chem 5710 and Chem 4710. Prerequisites: Chem 2210, Physics 2111.

CHEM 5810 Introduction to Polymeric Materials (LEC 3.0)
A basic study of the organic chemistry of natural and synthetic high polymers, their inherent properties and their uses in plastic, fiber, rubber, resin, food, paper and soap industries. Credit may not be given for both Chem 5810 and Chem 4810. Prerequisite: Chem 1320. (Co-listed with MS&E 5810 and Chem Eng 5810).

CHEM 5819 Polymer Synthesis and Characterization Lab (LAB 1.0)
Laboratory experiments dealing with polymerization syntheses and solution, bulk and solid properties will be presented. Each student will prepare polymers and carry out all characterization experiments on actual samples. Credit may not be given for both Chem 5819 and Chem 4819. Prerequisite: Chem 4810 or MS&E 4810 or Chem 5810 or MS&E 5810 or Chem Eng 5310, preceded or accompanied by Chem 1100 or Chem 5100 or an equivalent training program approved by S&T. (Co-listed with MS&E 5819).

CHEM 5850 Introduction to Coating Chemistry (LEC 3.0)
Study of the basic principles of protective coatings with particular reference to the paint and varnish industry. Classifications, manufacture, properties and uses of protective coatings. Credit may not be given for both Chem 5850 and Chem 4850. Prerequisite: Chem 1320 or Met Eng 1210. (Co-listed with MS&E 5850).

CHEM 6000 Special Problems (IND 0.0-6.0)
Problems or reading on specific subjects or projects in the department. Consent of instructor required.

CHEM 6001 Special Topics (IND 0.0 and LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CHEM 6010 Seminar (RSD 1.0)
Discussion of current topics.

CHEM 6040 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

CHEM 6050 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

CHEM 6099 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Prerequisite: Must meet departmental requirements for instruction in laboratory safety. Consent of instructor required.

CHEM 6101 Introduction to Chemistry Research (LEC 1.0)
An introduction to chemical research topics of interest to the department presented by different faculty members. Special emphasis will also be placed on a discussion of ethics, plagiarism, codes of conduct, research notebooks, publishing, and presentations. Prerequisite: Graduate Student Status.

CHEM 6220 Advanced Synthetic Organic Chemistry (LEC 3.0)
A discussion of a large numer of synthetically useful reactions involving enolates and enamines; nucleophilic additions to carbonyl compounds; functional group interconversions, thermal pericyclic reactions; organometallic compounds; carbocations, carbenes and free radicals as reactive intermediates; aromatic substitutions; and multistep synthesis. Prerequisite: Chem 4210 or Chem 4220.

CHEM 6240 Physical Organic Chemistry (LEC 3.0)
An advanced course in theoretical organic chemistry treating molecular orbital theory, free energy relationships, transition state theory, and other fundamental topics. Prerequisite: Chem 4210.

CHEM 6250 Spectrometric Identification of Organic Compounds (LEC 3.0)
Overview of MS and IR techniques in the characterization of organic compounds; CD/ORD; 1H, 13C, and heteronuclear NMR spectroscopy in the structural analysis; applications of APT, DEPT, 1H-1H COSY, HETCOR, HMQC, HMBC, INADEQUATE, TOCSY, NOE AND NOESY, and dynamic NMR. Prerequisite: Chem 2220.

CHEM 6320 Solid State Chemistry (LEC 3.0)
The aim of this course is to build a comprehensive understanding of the chemistry of solids and its application to the materials world. Emphasis will be given on the synthesis, crystal structure and various properties of solids including electrical, optical and magnetic. Students will gain knowledge about how to correlate a property with structure. Prerequisites: Chem 2310, Chem 2320, and Chem 3410.

CHEM 6330 Nanomaterials Synthesis, Properties and Applications (LEC 3.0)
Chemistry of nanomaterials. Understanding the fundamentals of nanoscience and technology. Studying the different synthesis strategies for nanomaterials and their characterization. Understanding the properties of nanomaterials and their possible applications. Introducing the concept for device fabrication. Prerequisite: Chem 4310.

CHEM 6380 Inorganic Materials Chemistry (LEC 3.0)
Chemical processing of solid materials. Introduction to point groups, space groups, and x-ray diffraction. Bonding in solids - from molecular orbital theory to band theory. Nonstoichiometric materials and Kroger-Vink notation. Optical and electrical properties of semiconductors. Epitaxial growth. Quantum effects in nanophase materials. Prerequisite: Chem 4310 or permission of instructor.

CHEM 6450 Spectroscopy (LEC 3.0)
Introduction to the interaction of electromagnetic radiation with matter. Emphasis on the ultraviolet, visible, and radio portions of the spectrum. Prerequisite: Chem 3420 or equivalent.

CHEM 6460 Advanced Molecular Engineering of Materials (LEC 3.0)
This advanced course focuses on the fundamentals of molecular science and engineering and their applications including renewable/clean energy solutions, energy storage, and optoelectronics. Topics include principles of carbon chemistry, macromolecules, metal(covalent)-organic frameworks, sol-gel processing, crystal growth and other advanced topics. Prerequisites: Graduate Standing or consent of instructor. (Co-listed with MS&E 6460).

CHEM 6510 Separations (LEC 3.0)
An in-depth study of all types of analytical and preparativescale separations. A special emphasis will be placed on chromatography and chromatographic theory. Prerequisite: Chem 4510 or equivalent.

CHEM 6550 Chemical Spectroscopy (LEC 3.0)
A study of the electronic, vibrational, rotational and nuclear magnetic resonance spectra of atoms and molecules. A basic understanding of the underlying theoretical principles and the interpretations of results is stressed. Prerequisite: Chem 4510, Chem 3420 or equivalent courses.

CHEM 6555 Principles And Applications Of Mass Spectrometry (LEC 3.0)
The course covers fundamental physical principles of mass spectrometry, instrumentation, interpretation of spectra, and applications in environmental, polymer, biomedical, and forensic fields. Prerequisite: Chem 4510 or equivalent.

CHEM 6570 Electrochemistry (LEC 3.0)
Introduction to the fundamentals, methods and applications of electrochemistry. Fundamentals cover the thermodynamics/kinetics of electrode reactions, and the modes of mass transport in the electrolyte. Methods cover potentiometric, amperometric, and a.c. techniques. Applications focus on analysis and study of materials. Prerequisite: Chem 3430.

CHEM 6650 Free Radicals In Biochemistry (LEC 3.0)
The study of the basic principles of free radical chemistry and biochemistry. Prerequisites: Chem 2210, Chem 2220 and Bio Sci 2113.

CHEM 6840 Polymer Physical Chemistry and Analysis (LEC 3.0)
A study of the physical properties of macromolecular systems including polymer solutions, gels, bulk polymers and rubbers. The chemical characterization of polymers based on their thermal, spectroscopic, microstructure and molecular weight is also discussed. Prerequisite: Chem 4810 or MS&E 4810 or Chem 5810 or MS&E 5810; thermodynamics. (Co-listed with MS&E 6840).