Chemistry

Degrees Offered

- Master of Science
- Doctor of Philosophy

Nature of the Program

The Department of Chemistry offers graduate studies leading to the degrees of master of science and doctor of philosophy with research concentration in the areas of analytical, biological, inorganic, organic, and physical chemistry. The master of science and doctor of philosophy degrees require completion of a research project which represents the principal component of the graduate program. The M.S. program is limited in scope and involves advanced coursework and a study of a problem in chemical research culminating in the preparation and oral defense of a M.S. thesis.

The Ph.D. program has a much wider scope than the M.S. program. Ph.D. students are expected to take a broad range of advanced coursework, both within and outside of the major area of interest. The major emphasis of the Ph.D. program is on research. A typical research problem may take several years to complete and involves many advanced techniques and concepts at the frontiers of chemical knowledge. The Ph.D. program culminates in the preparation and defense of the Ph.D. dissertation.

Prerequisites

Applicants for graduate studies in chemistry must have a bachelor’s degree as a minimum requirement. Applicants must have a major or concentration in chemistry and an appropriate background in physics and mathematics. All entering graduate students in chemistry are required to take departmental guidance examinations in the major areas of chemistry. These examinations, at the undergraduate level, are administered before registration and serve to guide the faculty in recommending a course program for the beginning graduate student. Deficiencies revealed by the departmental guidance examinations need to be corrected in a manner prescribed by the faculty.

FACULTY

CHAIR
- Kung K. Wang - Ph.D. (Purdue University)
  Eberly Distinguished Professor of Chemistry, Organic Chemistry, Stereoselective Synthesis, Natural Products

ASSOCIATE CHAIR
- Jeffrey L. Petersen - Ph.D. (University of Wisconsin-Madison)
  Physical Inorganic Chemistry, Electrophillic Transition Metal Complexes, X-ray Crystallography

PROFESSORS
- Harry O. Finklea - Ph.D. (California Institute of Technology)
  Analytical/Physical Chemistry, Electron Transfer Kinetics, Solid Oxide Fuel Cells, Gas Phase Sensors
- Terry Gullion - Ph.D. (William and Mary)
  Physical Chemistry, Solid State NMR, Biological Materials, Polymers
- Charles Jaffe - Ph.D. (University of Colorado)
  Theoretical Chemistry, Molecular Dynamics, Chaotic Systems
- Fred L. King - Ph.D. (University of Virginia)
  Analytical Chemistry, Mass Spectrometry, Trace Elements, Gas-phase Chemistry
- John H. Penn - Ph.D. (University of Wisconsin-Madison)
  Chemical Education, Online Instruction Methods in Organic Chemistry
- Kenneth Showalter - Ph.D. (University of Colorado)
  Bennett Distinguished Professor, Physical Chemistry, Chemical Kinetics, Multistability and Oscillating Systems
- Bjorn C. Soderberg - Ph.D. (Royal Institute of Technology, Sweden)
  Organic Synthesis Using Transition Metals

ASSOCIATE PROFESSOR
- Suzanne Bell - Ph.D. (New Mexico State University)
  Analytical Chemistry, Forensic Science
- Lisa Holland - Ph.D. (University of North Carolina-Chapel Hill)
  Micro-separations, High Throughput Drug Screening
- Michelle Richards-Babb - Ph.D. (Lehigh University)
Chemical Education

• X. Michael Shi - Ph.D. (University of Maryland)
  Organic Synthesis, Bioorganic Chemistry
• Ronald B. Smart - Ph.D. (University of Michigan)
  Environmental Analytical Chemistry, Electrochemistry, Trace Metals, Coal Chemistry
• Alan M. Stolzenberg - Ph.D. (Stanford University)
  Inorganic Chemistry, Bioinorganic Chemistry, Organometallic Chemistry

ASSISTANT PROFESSOR

• Jonathan Boyd - Ph.D. (Texas Tech University)
  Analytical Biochemistry and Toxicology
• Fabien Goulay - Ph.D. (University of Rennes, France)
  Physical Chemistry, Laser Spectroscopy
• Jessica Hoover - Ph.D. (University of Washington)
  Organometallic Chemistry, Catalysis
• Justin Legleiter - Ph.D. (Carnegie Mellon University)
  Biophysical Chemistry, Atomic Force Microscopy
• Blake Mertz - Ph.D. (Iowa State University)
  Computational Biophysics and Chemistry
• Brian Popp - Ph.D. (University of Wisconsin-Madison)
  Organic and Organometallic Chemistry, Catalysis
• Stephen Valentine - Ph.D. (Indiana University)
  Mass Spectrometric Analysis of Biomolecules

Master of Science

The principal requirements of the Chemistry M.S. program are divided into three general categories, including coursework, research, and thesis defense. Coursework is in the major areas of chemistry and includes emphasis in the chosen research area. A research project is chosen in the area of the student's interest and in consultation with the faculty. The thesis defense shows the ability of the student to defend scientific conclusions based on their research project.

Thesis/Credits

The WVU general requirements for the master of science degree are outlined elsewhere in this catalog. Graduate students in the M.S. program in chemistry are required to submit a research thesis. They may apply up to six hours of research credit toward the thirty-hour requirement. The remaining twenty-four hours of credit must be earned in the basic graduate courses which reflect a diversified exposure to chemistry; no more than ten hours may be elected outside the department, and coursework taken at the 500 to 700-level must include at least three three-credit-hour courses distributed in at least two areas outside the student’s major area of research. Students are required to enroll in the departmental seminar program and are required to attend special lectures and seminars offered by visiting scientists. A final oral examination is administered after completion and submission of the thesis.

Doctor of Philosophy

The program for the degree of doctor of philosophy reflects a flexible, research-oriented approach geared to develop the interests, capability, and potential of students. A program of courses is recommended to suit individual needs based on background and ability. These courses are classified as basic graduate courses, which present the essentials of a given discipline on an advanced level, and specialized graduate courses, which take one to the frontiers in a specific area of research. The course offerings are designed to provide guidelines from which students can launch their independent studies in preparation for candidacy examinations. Students are required to enroll in the departmental seminar program and attend special lectures and seminars offered by visiting scientists. Graduate students in the Ph.D. program are required to satisfactorily complete a minimum of three courses (three credits each) at the 500 to 700-level offered by the Department of Chemistry and distributed in at least two areas outside their major area of research. In addition, each major area in chemistry requires students in that area to enroll in basic graduate courses presenting the essentials of that discipline on an advanced level.

Research

Research, which is the major theme of graduate studies, may be initiated as early as the student and faculty feel appropriate for the individual. Normally, a student will begin laboratory work no later than the second semester. Upon successful completion of an original piece of research, the candidate will present results in a Ph.D. dissertation and, at the appropriate time, defend the work in a final oral examination.
Candidacy

Candidacy examinations contain written and oral portions. The written examinations are of the cumulative type and are offered eight times a year. After notification of successful completion of the written cumulative exams, the student will present and defend an original research proposal. The proposal must demonstrate originality and independence on the part of the student. This proposal is presented in writing to the student’s research committee and defended before that group and any other interested faculty members.

COURSES

**CHEM 512. Environmental Chemistry. 3 Hours.**

**CHEM 514. Mass Spec Principles & Practic. 3 Hours.**
PR: CHEM 310. Fundamental principles underlying modern mass spectrometry. Gas phase chemistry related to the formation and fragmentation of ions. The design of instrumental systems for mass spectrometry. Application of mass spectrometric techniques to multidisciplinary problems of current interest. (3 hr. lec.).

**CHEM 516. Bioanalytical Chemistry. 3 Hours.**
PR: (CHEM 310 and AGBI 410) or equivalent. Analytical principles and instrumental methods as they are applied to biochemical questions. Students are taught to evaluate and formulate methods and approaches for biochemical analyses.

**CHEM 521. Organometallic Chemistry. 3 Hours.**
PR: Graduate standing in chemistry or consent. Syntheses, structure, and reactivity of organometallic compounds. Applications of organometallic compounds to catalysis and organic synthesis. (3 hr. lec.).

**CHEM 522. Advanced Organic Chemistry 1. 3 Hours.**
PR: CHEM 234. Structural concepts, bonding, tautomerism, static and dynamic stereochemistry, mechanistic classifications of reagents, and reactions including some applications. (3 hr. lec.).

**CHEM 523. Advanced Organic Chemistry 2. 3 Hours.**
PR: CHEM 521. Continuation of CHEM 531 with emphasis upon synthetic methods and reaction mechanisms. (3 hr. lec.).

**CHEM 540. Bonding & Molecular Structure. 3 Hours.**
PR: CHEM 348. Introduction to the quantum theory of chemical bonding. Atomic structure, theoretical spectroscopy, predictions of molecular structures and bond properties. (3 hr. lec.).

**CHEM 541. Chemical Thermodynamics. 3 Hours.**
PR: CHEM 348. Principles of classical and statistical thermodynamics and their application to chemical problems. (3 hr. lec.).

**CHEM 547. Chemical Crystallography. 3 Hours.**
PR or Conc: (CHEM 346 and CHEM 348) or CHEM 341 or consent. Applications of X-ray diffraction of crystals to the study or crystal and molecular structure. Includes diffraction theory, space group symmetry, and crystallographic methods of analysis. (3 hr. lec.).

**CHEM 548. Biophysical Chemistry. 3 Hours.**
Biophysical chemistry lies at the interface between physics, chemistry, and biology, applying theories and methods of the physical sciences toward understanding biological systems. This course focuses on the physical chemistry of biological macromolecules. Topics to be covered include protein structure formation and stability, forces/interactions in biological molecular systems, bio-macromolecule folding dynamics, phase transitions in proteins, and membrane physics.

**CHEM 549. Proximal Probe Techniques. 3 Hours.**
Proximal probe techniques rely on the use of nanoscale probes, positioned and scanned in the immediate vicinity of surfaces. Their development is often viewed as a first step towards nanotechnology, since they demonstrate the feasibility of building purposeful structures one atom or one (macro) molecule at a time. This course provides thorough physical background of scanning probe microscopy techniques.

**CHEM 552. Biochemical Toxicology. 3 Hours.**
Introduction to the principles of toxicology, with a focus on the processes that occur at the cellular and molecular levels when chemicals interact with living organisms.

**CHEM 591A-Z. Advanced Topics. 1-6 Hours.**
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

**CHEM 593A-Z. Special Topics. 1-6 Hours.**
A study of contemporary topics selected from recent developments in the field.

**CHEM 697. Research. 1-15 Hours.**
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U.).

**CHEM 713. Electrochemistry/Instrumentatn. 3 Hours.**
PR: CHEM 310. Electronic instrumentation applied to study of mass transfer kinetics of electrode reactions, voltammetry, and high-frequency methods. (3 hr. lec.).
CHEM 714. Analytical Atomic Spectrometry. 3 Hours.
PR: CHEM 450. Theory of atomic spectroscopy relevant to elemental analysis. Considerations in the design and use of modern optical spectrometry systems. (3 hr. lec.).

CHEM 715. Chemical Separations. 3 Hours.
PR: CHEM 215 and CHEM 233, and physical chemistry. Fundamentals of transport and flow processes underlying all separation techniques. Empirical coverage of chromatographic and electrophoretic methods for analytical separations. (3 hr. lec.).

CHEM 723. Phys Methods In Inorganic Chem. 3 Hours.
PR: CHEM 422. Symmetry, vibrational spectroscopy, theory and applications of NMR and EPR methods, magnetism, optical activity, dynamic processes and fluxional behavior. (3 hr. lec.).

CHEM 724. Coordination Chemistry. 3 Hours.
PR: CHEM 422. Symmetry, hybridization, ligand field theory, molecular orbital theory, metal-ligand bonding in coordination complexes and organometallics. (3 hr. lec.).

CHEM 725. Inorganic Reactions/Mechanisms. 3 Hours.
PR: CHEM 422. Inorganic reactions (ligand substitution aquation, organometallic reactions, electron transfer;) kinetics and mechanistic studies. (3 hr. lec.).

CHEM 727. Bioinorganic Chemistry. 3 Hours.
PR:CHEM 422 or consent. Metal ions in biological systems; proteins, nucleic acids, and cofactors as ligands; metal uptake, storage, and regulation; structural and catalytic roles; substance activation, electron transfer, and group transfer reactions; metals in medicine.

CHEM 733. Physical Organic Chemistry. 3 Hours.
PR: CHEM 531. Theoretical considerations of organic molecules, kinetics, and other methods used in the study of organic structure and reaction mechanisms; linear free energy relationship and other related topics. (3 hr. lec.).

CHEM 743. Chemical Kinetics. 3 Hours.
PR: CHEM 348. Theories and applications of kinetics in gaseous state and in solution. (3 hr. lec.).

CHEM 744. Statistical Mechanics. 3 Hours.
PR: CHEM 746. Theory and application of statistical mechanics to chemical systems. (3 hr. lec.).

CHEM 745. Theoretical Chemistry 1. 3 Hours.
PR: Differential equations. Theoretical background for quantum mechanics. (3 hr. lec.).

CHEM 746. Theoretical Chemistry 2. 3 Hours.
PR: CHEM 745. Theories and applications of quantum mechanics in chemistry. (3 hr. lec.).

CHEM 747. Molecular Spectroscopy/Structr. 3 Hours.
PR: CHEM 450 or graduate standing in chemistry, or consent. Advanced applications of spectral methods to the study of molecular structure. (3 hr. lec.).

CHEM 750. Introduction ot Proteomics. 3 Hours.
Introduction to protein separations and sequencing by modern mass spectrometry, and the application of these methods to the study of biological systems in health and environmental sciences.

CHEM 789. Research Seminar. 1 Hour.
PR: Graduate student in chemistry. Research seminars by visiting lecturers.

CHEM 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of chemistry. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading will be P/F.).

CHEM 791A-Z. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CHEM 792A-Z. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

CHEM 793A-Z. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CHEM 794A-Z. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

CHEM 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CHEM 796. Graduate Seminar. 1 Hour.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.
CHEM 796A. Grad Sem: Inorganic Chemistry. 1 Hour.
PR: Consent. It is anticipated that each graduate student will present at least one seminar to the assembled faculty and graduate student body of his/her program.

CHEM 796B. Grad Sem: Organic Chemistry. 1 Hour.
PR: Consent. It is anticipated that each graduate student will present at least one seminar to the assembled faculty and graduate student body of his/her program.

CHEM 796C. Grad Sem: Physical Chemistry. 1 Hour.
PR: Consent. It is anticipated that each graduate student will present at least one seminar to the assembled faculty and graduate student body of his/her program.

CHEM 797. Research. 1-15 Hours.
PR: Consent. Research activities leading to thesis, program report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U).

CHEM 798. Dissertation. 1-6 Hours.
PR: Consent. This is an optional course for programs that wish to provide formal supervision during the writing of student reports (698), or dissertations (798). Grading is normal.

CHEM 799. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use of the University’s facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department’s 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is P/F; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.