# CHEMISTRY

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The faculty and staff of the Department of Chemistry work to maintain an excellent student-centered curriculum, a supportive environment, and a vibrant intellectual community for Chemistry majors and non-majors alike. We strive to mentor students to become ethical, productive members of society who apply their scientific knowledge and skills in a broad range of endeavors. Our curriculum emphasizes the integration of teaching and research. Consequently, we work with the students as they construct their Chemistry knowledge and develop the skills (laboratory, instrumentation, information literacy, problem solving, oral and written communication, time management) necessary to succeed.

Chemistry is broadly defined as the study of the structure and function of all matter. The content of our curriculum is heavily influenced by the guidelines from the national American Chemical Society Committee on Professional Training (ACS CPT). Feedback from alumni indicates that their Wooster education has prepared them well for a range of career options and life pursuits. Feedback from graduate and professional schools and employers indicate that our students are well prepared in chemistry knowledge, techniques, instrumentation, and have the capabilities necessary to learn, adapt, and lead.

**Major in Chemistry:**

Required courses in the Chemistry Department Core:
- Principles 120[a]
- Organic 211, 212
- Analytical 215
- Physical 318, 319
- Inorganic 340

Electives[b] – two advanced courses from among:
- Environmental 216
- Organic 313
- Instrumental 316
- Physical 320
- Inorganic 341
- Biochemistry BCMB 303, 331, 332, 333
- Biophysical 399

Required courses in Physics and Mathematics:
- Introductory Physics 203 and 204 (or 101 and 102)
- Calculus MATH 111 (or 107 and 108) and 112

Introduction to Independent Study 401
Senior Independent Study Thesis 451, 452

[a]Students who intend to take Chemistry courses at Wooster should take the Chemistry placement exam. Enrollment into CHEM 120 requires satisfactory performance on the Chemistry Department placement exam, completion of CHEM 110 with a C- or better, or AP Chemistry credit. Students who test out of CHEM 110 without AP Chemistry credit do not receive credit for CHEM 110.

[b]Students who begin in CHEM 110 are only required to take one elective, and CHEM 319 will count as their second elective for the major.

*All courses counting towards the Chemistry major must be passed with a C– or better and may not be taken S/NC; this applies to classroom and laboratory components.

*Concurrent enrollment in both class and laboratory is required for students taking a course with a laboratory component. Students who do not complete the class or laboratory component of a course with a C– or better must repeat both the class and the laboratory.

*A student may not take CHEM 101 concurrent with or after CHEM 120, CHEM 111, or CHEM 112.

*A student who presents a score of 4 or 5 on the Advanced Placement Examination in Chemistry automatically receives credit for CHEM 110. Students who take the Chemistry Department placement exam will be placed into Principles (CHEM 120) or Organic Chemistry I (CHEM 211) depending upon the exam results.

*International students with a certificate from a foreign Baccalaureate program may receive either one or two Chemistry course credits. Students who take the Chemistry Department placement exam will be placed into Principles (CHEM 120) or Organic Chemistry I (CHEM 211) depending upon the department placement exam results. If the student places into Introductory (CHEM 120), 1.0 credit will be awarded for CHEM 110. If the student places into Organic Chemistry I (CHEM 211), 2.25 credits will be awarded for CHEM 110, CHEM 120, and CHEM 120L.

*Chemistry majors who plan to attend graduate school are strongly encouraged to pursue an ACS-certified degree. The requirements for an **American Chemical Society Certified Degree** are summarized below:

(a) Chemistry: 120, 211, 212, 215, 318, 319, 340, 401, 451, 452, BCMB 331, MATH 112, PHYS 204 (or 102). This differs from the minimal Wooster major by two courses: Biochemistry I (BCMB 331) and its prerequisite Foundations of Biology (BIOL 200).

(b) Chemistry/Chemical Physics: 120, 211, 212, 215, 318, 319, 340, 401, 451, 452, BCMB 331, MATH 112, PHYS 204 (or 102), two Physics courses beyond 203/204, two advanced courses in theoretical chemistry, physics, or math.

**Minor in Chemistry: (6 courses in the department of chemistry):**

Core:

Principles w/lab (120)*
Organic I w/lab (211)
Analytical w/lab (215)

Additional Requirements: Three chemistry courses at or above the 200-level.

*Students who begin with CHEM 110 are only required to take two chemistry courses at or above the 200-level.

Students considering a Chemistry major should follow one of the sequences below:
(i) beginning in CHEM 120 with sufficient math preparation:

| | Fall | Spring |
|---|---|---|
| First Year | CHEM 120 Principles of Chemistry w/Lab<br>MATH 111 Calculus I | CHEM 215 Analytical w/Lab<br>MATH 112 Calculus II |
| Second Year | CHEM 211 Organic I w/Lab<br>PHYS 203 Foundations (calc-based) w/Lab<br>(or PHYS 101 General I w/Lab) | CHEM 212 Organic II w/Lab<br>PHYS 204 Foundations (calc-based) w/Lab<br>(or PHYS 102 General II w/Lab) |

(ii) beginning in CHEM 110 additional math preparation needed:

| | Fall | Spring |
|---|---|---|
| First Year | CHEM 110 Introductory Chemistry<br>MATH 107 Calculus with Algebra A | CHEM 120 Principles of Chemistry w/Lab<br>MATH 108 Calculus with Algebra B |
| Second Year | CHEM 211 Organic I w/Lab<br>PHYS 203 Foundations (calc-based) w/Lab<br>(or PHYS 101 General I w/Lab)<br>MATH 112 Calculus II | CHEM 212 Organic II w/Lab<br>PHYS 204 Foundations (calc-based) w/Lab<br>(or PHYS 102 General II w/Lab)<br>CHEM 215 Analytical w/Lab |

## CHEMISTRY FOR THE NON-SCIENCE MAJOR

**101. CHEMISTRY AND THE WORLD IN WHICH WE LIVE** A study of chemistry is undertaken using the world around us as a starting point in developing an understanding of the facts, theories, and methodology of the chemical sciences. Topics may include environmental chemistry, food chemistry, forensics, and science in society. Topics will be announced in advance; past are listed below. Not open to students who have received credit for or are concurrently enrolled in Chemistry 120, 111, or 112. Students with Chemistry 120, 111, or 112 credit may apply to serve as a Teaching Apprentice. Three class hours per week. No prerequisite. Annually. Fall and Spring. [Q, +]

**TEN WONDERFUL THINGS** Ten important or fascinating items or topics are selected by the instructor and will be announced in advance. "The List" has included such items as air bags, birth control, bullet-proof vests, cholesterol, concrete, diamonds, DNA, fiber optics, fireflies, food, fool's gold, gasoline, ozone, proteins, rocket fuel, smoke detectors, solar cells, sports packs (hot and cold), stainless steel, Teflon, Viagra, vitamins.

**FORENSIC SCIENCE** Law enforcement techniques such as DNA typing, fingerprint identification, drug/explosives detection, and fiber analysis are covered in class and in short laboratory experiments. The underlying scientific principles of forensic techniques are discussed, drawing on examples from true crime investigations. The broader impact of science on the judicial system is covered in this course.

**CONTROVERSIES IN SCIENCE AND PUBLIC POLICY: RISK, DISEASE, WEAPONS & WAR** This course examines the relationship between science and public policy through case studies of controversial issues including weapons & war, and HIV/AIDS. We will develop an understanding of the fundamental chemical, biological and physical concepts and technologies. In-class laboratory exercises will explore key technical concepts to develop an understanding of scientific methods and processes. The social, political and ethical questions that surround each of these issues will be used to examine the relationship of science and society, the scope of science, its importance to society, its limitations, its values and how science is used and/or misused in the political sphere.

## CHEMISTRY FOR THE SCIENCE MAJOR

**110. INTRODUCTORY CHEMISTRY** Fundamental facts, concepts, and theories of chemistry and mathematical skills are emphasized. Topics include matter, measurements, calculations, elements, atomic theory, atomic mass, the mole, ionic and molecular compounds, types of bonding, mole calculations, types of reactions, limiting reagents, percent yield, solutions, gases, quantum mechanics, orbitals and electrons, electronic structure, atomic periodicity, and Lewis theory. Emphasis will be placed on problem-solving and the devel-

opment of critical thinking skills. The course is intended for students with limited chemistry and math preparation in high school. Three class hours per week. No prerequisite. One course credit. Annually. Fall. [Q,+]

**120. PRINCIPLES OF CHEMISTRY** Fundamental facts, concepts, and theories central to chemistry are examined. The topics include VSEPR, valence bond, and molecular orbital theories, intermolecular forces, solutions and colligative properties, chemical kinetics, reaction mechanisms, equilibria (chemical, acid-base, aqueous, ionic), thermodynamics (enthalpy, entropy, free energy), and electrochemistry. The laboratory focuses on fundamental techniques, data manipulation, notebook and reporting skills. Three class hours and one three-hour laboratory period per week. Prerequisite: CHEM 110 or 111 with a C- or better, or satisfactory performance on the Chemistry Department placement exam. One and one-fourth course credits. Annually. Fall and Spring. [Q, +]

**211. ORGANIC CHEMISTRY I** The fundamental principles of structure, bonding, and reactivity of organic compounds are introduced. Content focuses on functional groups, reaction mechanisms, spectroscopic techniques, data interpretation, and introductory synthetic methods. Critical thinking, application of general concepts to new examples, and problem-solving skills are emphasized. Laboratory experiments incorporate key synthetic organic laboratory skills, reactions, techniques, and instrumentation. The experiments promote independence, information literacy, safety, writing skills, and laboratory competency. Three class hours and one three-hour laboratory period per week. Prerequisite: Chemistry 112 or 120, with a C- or better. One and one-fourth credits. Annually. Fall. [+]

**212. ORGANIC CHEMISTRY II** The study of organic structure, bonding, and reactivity continues with more complex molecules including aromatics, carbonyl compounds, amino acids, and carbohydrates. Advanced spectroscopic data analysis and multi-step syntheses challenge students to be creative, critical thinkers. In the laboratory, students apply skills from CHEM 211, increase independence, and learn new techniques through research-based projects involving synthesis and spectroscopic identification. Information literacy, safety, and writing (notebooks, technical reports, summaries, and experimental plans) are emphasized. Three class hours and one three-hour laboratory period per week. Prerequisite: Chemistry 211, C- or better. One and one-fourth credits. Annually. Spring. [W, +]

**215. ANALYTICAL CHEMISTRY** The fundamental principles and methodology of chemical analysis are examined with examples from biochemistry and organic and inorganic chemistry. Topics include discussion of errors and statistical treatment of data, a review of equilibria, and introduction to spectroscopy, electrochemistry, and analytical separations. The laboratory emphasizes experimental design, using library resources, and methods for obtaining and evaluating quantitative data. Methods employed include spectroscopy, potentiometry, chromatography, mass spectrometry, and titrimetry. Three class hours and one three-hour laboratory period per week. Prerequisite: Chemistry 120 or 112, C- or better. Recommended previous course: Chemistry 212. One and one-fourth course credits. Annually. Spring. [Q, +]

**216. ENVIRONMENTAL CHEMISTRY** Various aspects of the chemistry of the environment, both unpolluted and polluted, are discussed. Consideration is given to chemical reactions in the aquatic, atmospheric, and geologic realms. Three class hours per week. Prerequisite: Chemistry 120 or 112, C- or better. Suggested previous course: Geology 110. One course credit. Alternate years. Fall. Not offered 2009-2010, intended 2010-2011.

**313. ADVANCED ORGANIC CHEMISTRY** The course focuses on the experimental, instrumental, and theoretical methods by which the structure, reactivity, and electronic properties of organic compounds are determined. Various aspects of modern organic chemistry, including synthesis, mechanism, advanced spectroscopic methods, and computational chemistry may be covered. Historic and current case studies are taken from the chemical literature. Three class hours per week. Prerequisite: Chemistry 212, C- or better. One course credit. Alternate years. Spring 2009-2010.

**316. INSTRUMENTAL ANALYSIS** The four major areas of instrumental chemical analysis—separations, spectroscopy, mass spectrometry, electrochemistry—are studied. In the first half of the semester fundamental and practical aspects of methods for analytical separations are emphasized. Gas and liquid chromatography are two major areas investigated. Other topics may include electrophoresis, affinity chromatography, and solvent extractions. In the second half of the semester, the fundamental and practical aspects of analytical spectroscopy and electrochemistry are covered. Laboratory work involves multi-week independent projects. Three class hours and one three-hour laboratory period per week. Prerequisite: Chemistry 215, C- or better. Suggested previous course: Chemistry 318. One and one-fourth course credits. Annually. Fall.

**318. PHYSICAL CHEMISTRY I** Chemical thermodynamics and kinetics. Topics include chemical kinetics, rate laws, laws of thermodynamics, free energy and chemical equilibrium. Additional topics may include chemical dynamic models, X-ray diffraction, solid-state structure, and structure determination. Three class

hours and one three-hour laboratory per week. Prerequisite: Chemistry 120 or 112 with a C- or better, and Mathematics 111 with a C- or better. One and one-fourth course credits. Annually. Fall. [+]

**319. PHYSICAL CHEMISTRY II** Quantum and statistical mechanics. Topics include quantum mechanical theory, quantum mechanical models for motion, the structure of atoms and molecules, molecular symmetry, molecular spectroscopy, and statistical mechanics and thermodynamics. Three class hours and one three-hour laboratory per week. Prerequisite: Chemistry 120 or 112 with a C- or better, and Mathematics 112 with a C- or better. One and one-fourth course credits. Annually. Spring. [+]

**320. TOPICS IN PHYSICAL CHEMISTRY** Advanced topics in physical chemistry are examined. Topics may include: computational chemistry, advanced spectroscopic methods, chemical modeling, atmospheric or condensed phase kinetics. Three class hours per week. Prerequisite: Chemistry 318 or Chemistry 319 with a C- or better. One course credit. Not offered 2009-2010. [+]

**BIOCHEMISTRY AND MOLECULAR BIOLOGY 331. BIOCHEMISTRY I** [+]

**BIOCHEMISTRY AND MOLECULAR BIOLOGY 332. BIOCHEMISTRY II** [+]

**399. BIOPHYSICAL CHEMISTRY** The underlying physical principles and laws that govern the behavior of biological systems and biochemical reactions are examined. The fundamental principles of molecular structure, chemical kinetics, and thermodynamics are explored in relationship to biological phenomena. Three class hours per week. Prerequisite: Mathematics 111 or 108 and either Biochemistry and Molecular Biology 331 or Chemistry 318, with a C- or better. One course credit. Spring 2009-2010.

**340. INORGANIC CHEMISTRY** The details of the chemistries of selected elements and their compounds are studied. For each class of substances studied, the topics of structure, bonding, and reactivity are linked, with some discussion of mechanism, in order to give an overall survey of the chemistry of elements from various portions of the periodic table. Three class hours and one three-hour laboratory period per week. Prerequisite: Chemistry 212, C- or better, or permission of the instructor. One and one-fourth course credits. Annually. Fall. [+]

**341. ADVANCED INORGANIC CHEMISTRY** Advanced aspects of inorganic chemistry are treated, including the organometallic chemistry of transition metal compounds and the chemistry of catalysis. The course is designed to emphasize structure, bonding, and spectroscopy, as well as syntheses and reaction mechanisms. Three class hours per week. Prerequisites: Chemistry 318 and 340, C- or better, or permission of the instructor. One course credit. Alternate years. Spring. Intended 2010-2011. [+]

**400. TUTORIAL** Advanced library and laboratory research problems in analytical, inorganic, organic, and physical chemistry and biochemistry. Approval of the chemistry chairperson is required. One-half to one course credit.

**401. INTRODUCTION TO INDEPENDENT STUDY** This course builds background knowledge and practical skills for independent scientific work. Activities in searching the literature, experimental design, drafting and revising scientific writing, and oral presentation culminate in a written research proposal for the Senior Independent Study project. Prerequisite: Chemistry 212 with a C or better or Departmental approval. One course credit. Annually. Spring.

**407, 408. CHEMICAL RESEARCH INTERNSHIP** Students are placed in research positions in non-academic laboratories. The normal schedule involves work during the summer months, in addition to either the fall or spring semester, on a research problem related to the function of the employing laboratory. The work is directed by scientists at the laboratory. Liaison is established by regularly-scheduled consultations with one or more faculty members of the Department of Chemistry. The student's schedule is arranged only after consultation with the chemistry chairperson. Prerequisites: junior standing; Chemistry 212, 215, 318, and 401. One to three course credits. *All internships are graded S/NC.*

**451, 452. INDEPENDENT STUDY THESIS** An original investigation is conducted, culminating in a thesis and an oral defense of the thesis. During the fall each student gives a research seminar on the Independent Study research topic and in the spring presents a poster. Projects are offered in selected areas of analytical, inorganic, organic, physical chemistry, and biochemistry. Prerequisites: Chemistry 212 and 401, C- or better, or approval of the Department. Two course credits.