

# CHEMISTRY

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Chemistry is broadly defined as the study of the properties of matter and how matter is transformed. The faculty and staff of the Department of Chemistry work to maintain a student-centered curriculum, a supportive environment, and a vibrant intellectual community for Chemistry majors and non-majors alike. Students are guided to become ethical, productive members of society who apply their scientific knowledge and skills in a broad range of endeavors. Instruction in the discipline integrates learning through coursework, laboratory, and research. Consequently, students develop a variety of skills including laboratory methods, use of instrumentation, information literacy, problem solving, oral and written communication, and research design necessary to succeed in their future endeavors.

The curriculum is influenced by the guidelines from the American Chemical Society Committee on Professional Training (ACS CPT) and is comprised of courses covering the major sub-disciplines of chemistry. Feedback from alumni indicates that their Wooster education has prepared them well for a range of careers and life pursuits. Feedback from graduate and professional schools and employers indicate that students are well prepared in chemistry knowledge, techniques, instrumentation, and have the capabilities necessary to learn, adapt, and lead.

## **Major in Chemistry**

Consists of sixteen courses:

- CHEM 12000 (see note below)
- MATH 11100
- MATH 11200
- CHEM 21100
- CHEM 21200
- CHEM 21500
- PHYS 20300 (or 10100)
- PHYS 20400 (or 10200)
- CHEM 31800
- CHEM 31900
- CHEM 34000
- Two of the following courses: CHEM 21600, 31300, 31600, 32000, 34100, 39900, BCMB 30300, 33100, 33200, or 33300 (see note below)
- Junior Independent Study: CHEM 40100
- Senior Independent Study: CHEM 45100
- Senior Independent Study: CHEM 45200

## Minor in Chemistry

Consists of six courses:

- CHEM 12000 (see note below)
- CHEM 21100
- CHEM 21500
- Three Chemistry courses at the 200-level or above (see note below)

## Special Notes

- Students who intend to take Chemistry courses at Wooster should take the Chemistry placement exam. Enrollment into CHEM 12000 requires satisfactory performance on the Chemistry Department placement exam, completion of CHEM 11000 with a C- or better, or AP Chemistry credit. Students who test out of CHEM 11000 without AP Chemistry credit do not receive credit for CHEM 11000.
- For the major, students who begin in CHEM 11000 are only required to take one elective, and CHEM 31900 will count as their second elective for the major.
- For the minor, students who begin with CHEM 11000 are only required to take two Chemistry courses at or above the 200-level.
- The MATH 11100 requirement may be fulfilled by the successful completion of both MATH 10700 and 10800.
- 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 10100 concurrent with or after CHEM 12000.
- A student who presents a score of 4 or 5 on the Advanced Placement Examination in Chemistry automatically receives credit for CHEM 11000. Students who take the Chemistry Department placement exam will be placed into *Principles of Chemistry* (CHEM 12000) or *Organic Chemistry I* (CHEM 21100) 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 of Chemistry* (CHEM 12000) or *Organic Chemistry I* (CHEM 21100) depending upon the department placement exam results. If the student places into *Principles of Chemistry* (CHEM 12000), 1.0 credit will be awarded for CHEM 11000. If the student places into *Organic Chemistry I* (CHEM 21100), 2.25 credits will be awarded for CHEM 11000, CHEM 12000, and CHEM 12000L.
- 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: CHEM 12000, 21100, 21200, 21500, 31800, 31900, 34000, 40100, 45100, 45200, BIOL 20000, BCMB 33100, MATH 11100, 11200, PHYS 20300, 20400. This differs from the minimal Wooster major by two courses: *Principles of Biochemistry* (BCMB 33100) and its prerequisite *Foundations of Biology* (BIOL 20000).
  - (b) Chemistry/Chemical Physics: CHEM 12000, 21100, 21200, 21500, 31800, 31900, 34000, BIOL 20000, BCMB 33100, MATH 11100, 11200, PHYS 20300, 20400, two Physics courses beyond PHYS 20400, two advanced courses in theoretical chemistry, physics, or math; CHEM or PHYS 40100, 45100, 45200.

- Students considering a Chemistry major should consider one of the sequences below:

(i) beginning in CHEM 12000 with sufficient math preparation:

	Fall	Spring
First Year	CHEM 12000 MATH 11100	CHEM 21500 MATH 11200
Sophomore Year	CHEM 21100 PHYS 20300 (or 10100)	CHEM 21200 PHYS 20400 (or 10200)

(ii) beginning in CHEM 11000 with additional math preparation needed:

	Fall	Spring
First Year	CHEM 11000 MATH 10700	CHEM 12000 MATH 10800
Sophomore Year	CHEM 21100 PHYS 20300 (or 10100) MATH 11200	CHEM 21200 PHYS 20400 (or 10200) CHEM 21500

- 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.

## CHEMISTRY COURSES

### CHEMISTRY FOR THE NON-SCIENCE MAJOR

#### CHEM 10100-10103. 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 CHEM 12000. Students with CHEM 12000 credit may apply to serve as a Teaching Apprentice. Three class hours per week. *Annually. Fall and Spring. [Q, MNS]*

#### 10102. FORENSIC SCIENCE

Law enforcement techniques such as DNA typing, fingerprint identification, drug/explosives detection, and fiber analysis are covered in class and short laboratory experiments. The underlying principles of forensic techniques are discussed, drawing on examples from true crime investigations. The broader impact of such methods and investigations is covered in the course. *Not Offered 2011-2012.*

#### 10103. CHEMISTRY AND THE ENVIRONMENT - WATER

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. The chemistry involved in environmental topics such as climate change, ozone depletion, acid rain, and water pollution will be emphasized in this course offering. The central importance of water's physical and chemical properties to these topics will be highlighted as a theme throughout the semester. The popular media's role in covering environmental chemistry issues will also be addressed, with an emphasis on critical thinking. *Spring 2012.*

## CHEMISTRY FOR THE SCIENCE MAJOR

### **CHEM 11000. INTRODUCTORY CHEMISTRY (Biochemistry and Molecular Biology)**

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 development of critical thinking skills. The course is intended for students with limited chemistry and math preparation in high school. Three class hours per week. *Annually. Fall and Spring. [Q, MNS]*

### **CHEM 12000. PRINCIPLES OF CHEMISTRY (Biochemistry and Molecular Biology)**

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. (1.25 course credits) *Prerequisite: CHEM 11000 with a C- or better, or satisfactory performance on the Chemistry Department placement exam. Annually. Fall and Spring. [Q, MNS]*

### **CHEM 21100. ORGANIC CHEMISTRY I (Biochemistry and Molecular Biology)**

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. (1.25 course credits) *Prerequisite: CHEM 12000 with a C- or better. Annually. Fall. [MNS]*

### **CHEM 21200. ORGANIC CHEMISTRY II (Biochemistry and Molecular Biology)**

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 21100, 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. (1.25 course credits) *Prerequisite: CHEM 21100, C- or better. Annually. Spring. [W, MNS]*

### **CHEM 21500. ANALYTICAL CHEMISTRY (Biochemistry and Molecular Biology)**

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. Recommended previous course: CHEM 21200. (1.25 course credit) *Prerequisite: CHEM 12000, C- or better. Annually. Spring. [Q, MNS]*

### **CHEM 21600. ENVIRONMENTAL CHEMISTRY (Environmental Studies)**

Various aspects of the chemistry of the environment, both unpolluted and polluted, are discussed. Emphasis is placed on chemical reactions in the atmospheric and aquatic realms, the relationship between chemical structure and environmental transport, and the toxicity and effects of common environmental pollutants. Case studies are used from the literature to further explore the course material. Three class hours per week. Suggested previous course: CHEM 211. *Prerequisite: CHEM 120, C- or better. Alternate years. Prerequisite: CHEM 12000, C- or better. Alternate years. Not offered 2011-2012.*

### **CHEM 31300. 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: CHEM 21200, C- or better. Alternate years. Spring 2012.*

#### **CHEM 31600. INSTRUMENTAL ANALYSIS**

Modern methods of chemical analysis are covered with an emphasis on spectroscopy, mass spectrometry, separations, and surface analytical techniques. Particular focus is placed on the use of instruments in chemical industry, clinical analysis, and environmental monitoring. Laboratory work involves multi-week independent projects. Three class hours and one three-hour laboratory period per week. Suggested previous course: CHEM 31800. (1.25 course credits) *Prerequisite: CHEM 21500, C- or better. Fall 2011.*

#### **CHEM 31800. 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. (1.25 course credits) *Prerequisite: CHEM 12000 with a C- or better, and MATH 11100 with a C- or better. Annually. Fall. [MNS]*

#### **CHEM 31900. 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. (1.25 course credits) *Prerequisite: CHEM 12000 with a C- or better, and MATH 11200 with a C- or better. Annually. Spring. [MNS]*

#### **CHEM 32000. 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: CHEM 31800 or CHEM 31900 with a C- or better. Not offered 2011-2012. [MNS]*

#### **CHEM 34000. 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. (1.25 course credits) *Prerequisite: CHEM 21200, C- or better, or permission of the instructor. Annually. Fall. [MNS]*

#### **CHEM 34100. 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: CHEM 31800 and 34000, C- or better, or permission of the instructor. Alternate years. Not offered 2011-2012. [MNS]*

#### **CHEM 39900. 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: MATH 11100 or 10800 and either BCMB 33100 or CHEM 31800, with a C- or better. Not offered 2011-2012.*

#### **BCMB 30300. TECHNIQUES IN BIOCHEMISTRY AND MOLECULAR BIOLOGY**

#### **BCMB 33100. PRINCIPLES OF BIOCHEMISTRY**

#### **BCMB 33200. BIOCHEMISTRY OF METABOLISM**

#### **BCMB 33300. CHEMICAL BIOLOGY**

#### **CHEM 40000. TUTORIAL**

Advanced library and laboratory research problems in analytical, inorganic, organic, and physical chemistry and biochemistry. (.5 - 1.0 course credit) *Prerequisite: The approval of both the supervising faculty member and the chairperson is required prior to registration.*

#### **CHEM 40100. 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: CHEM 21200 with a C or better or Departmental approval.*

#### **CHEM 40700, 40800. 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 estab-

lished 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. (1 - 3 course credits) S/NC course. Prerequisite: junior standing; CHEM 21200, 21500, 31800, and 40100.

**CHEM 45100. SENIOR INDEPENDENT STUDY – SEMESTER ONE**

An original investigation is conducted, culminating in a thesis and an oral defense of the thesis in CHEM 45200. During the Fall each student gives a research seminar on the Independent Study research topic. Projects are offered in selected areas of analytical, inorganic, organic, physical chemistry, and biochemistry. Prerequisite: CHEM 21200 and 40100, C- or better, or approval of the Department.

**CHEM 45200. SENIOR INDEPENDENT STUDY – SEMESTER TWO**

The second semester of the Senior Independent Study project, which culminates in the thesis, the presentation of a poster, and an oral defense. Prerequisite: CHEM 45100.