

CHEMISTRY

Division of Natural Sciences and Mathematics

The mission of the Chemistry Department at Washington College is to provide outstanding undergraduate education in the chemical sciences by integrating classroom instruction with laboratory experimentation, faculty-student collaborative research, and service opportunities. Our goal is to inspire students to become liberally educated scientists. Our program is approved by the American Chemical Society. The Department offers two paths leading to the Bachelor of Science degree in Chemistry: an ACS-Certified Chemistry major and a non-ACS Certified Chemistry major.

The Chemistry program is designed to prepare students for graduate work in pure chemistry, for professional work in other scientific fields such as environmental science, engineering, medicine, dentistry, nursing, pharmacy, neuroscience, and veterinary science, for teaching at the secondary school level, and for work in industrial or governmental laboratories. Chemistry graduates have established diverse career paths that range from a dedication to pure or applied scientific research, to management of scientific and business concerns, to consultantships with industries and governments on scientific, environmental, legal, and business issues, and to service as medical personnel and elected public officials.

Students who have an interest in majoring in chemistry or double majoring in chemistry and another subject are advised to take CHE 120 Chem Principles Org Molecules with Lab and CHE 140 Reactions of Organic Molecules with Lab during their first year. Premedical students and students interested in the 3:4 pharmacy program are advised to take CHE 120 Chem Principles Org Molecules with Lab, CHE 140 Reactions of Organic Molecules with Lab and BIO 111 General Biology I with Lab, BIO 112 General Biology II with Lab during their first year.

Students intending to teach at the secondary school level should consult with the Chair of the Department of Education and the Chair of the Department of Chemistry about planning a full-course schedule as early as possible in their college career. Such students need to be aware that the National Association of State Directors of Teacher Education and Certification (NASDTEC) in Chemistry requires BIO 111 General Biology I with Lab, BIO 112 General Biology II with Lab and at least one course in computer science.

- Chemistry ACS-certified Major (<https://catalog.washcoll.edu/catalog/departments-programs/chemistry/chemistry-acs-certified-major/>)
- Chemistry Non-ACS certified Major (<https://catalog.washcoll.edu/catalog/departments-programs/chemistry/chemistry-non-acs-certified-major/>)
- Chemistry Minor (<https://catalog.washcoll.edu/catalog/departments-programs/chemistry/chemistry-minor/>)

Leslie Sherman, Chair
Jeremy Bard
Quin Hu
Anne Marteel-Parrish
Daniel May
Betsy Moyer-Taylor

CHE SCE Senior Capstone Experience 2 Credits

The Senior Capstone Experience (SCE) requires a literature-based research project or an experimental or computational project in collaboration with a chemistry faculty member and writing a thesis-quality report. Projects involve synthetic and preparative procedures and include the use of chemistry's research-grade UV-VIS, spectrofluorometer, FTIR, AA, NMR, GC, HPLC, GC-MS, ICP-MS, LC-MS, and the computational lab. The ACS-certified option requires a laboratory-based research project to meet the number of laboratory hours required by the ACS, which can be waived if ACS-certified option students have performed credit-based research in Fall or Spring semesters or during the summer. Seniors present project results in a poster session that is open to the College community. The SCE is graded (A-F).

Term(s) Offered: All Terms, All Years

CHE 110 Chemistry of the Environment with Lab 4 Credits

This introductory course focuses on the chemical dimensions of current environmental problems such as global warming, ozone depletion, water and soil contamination, and energy production. Fundamental principles of chemical bonding, reactions, and energy are studied as they arise in connection with each environmental issue. Interdisciplinary aspects are explored to further understand the multiple dimensions of the problems. Intended for students planning to major outside the sciences.

Cross-listed as: CHE 110/ENV 110

Term(s) Offered: Fall, All Years

Fees: \$50 Lab Fee

CHE 120 Chem Principles Org Molecules with Lab 4 Credits

This one-semester course provides a foundation in the fundamental principles of chemical structure and reactivity of organic molecules. Key topics include atomic and molecular structure, intramolecular and intermolecular forces, organic functional groups, thermochemistry, acid/base equilibria, kinetics, and basic organic reaction mechanisms. Laboratory work is designed to complement lecture material.

Term(s) Offered: All Terms, All Years

Fees: \$50 Lab Fee

CHE 122 Chemical Principles Orgnc Molecules Lab 0 Credits

This is the first lab course offered in the Chemistry sequence, coupled with the lecture CHE 120. This course focuses on fundamentals of the laboratory experience including coverage of safety, demonstration of techniques and use of instrumentation with lab experiments concentrating on synthesis and analysis. Analytical techniques learned in this course include melting point determination, Thin Layer Chromatography, rotary evaporation, separatory funneling, volumetric/weight measurement and quantitative analysis/stoichiometry. This foundational lab course is necessary before moving on to more complex laboratory experiences.

Term(s) Offered: All Terms, All Years

CHE 140 Reactions of Organic Molecules with Lab 4 Credits

Reactions of Organic Molecules (CHE 140) builds upon the fundamental principles discussed in CHE 120 Chemical Principles of Organic Molecules. This course focuses on the reactivity of organic molecules, including aliphatic and aromatic hydrocarbons, their halogenated derivatives, and molecules containing heteroatoms such as oxygen, nitrogen, and sulfur. Students are also exposed to chemical synthesis and the use of modern spectroscopic techniques for the determination of molecular structure.

Term(s) Offered: Spring, All Years

Fees: \$50 Lab Fee

CHE 142 Reactions of Organic Molecules Lab 0 Credits

Along with practicing and applying foundational practices learned in CHE 122, the Reactions of Organic Molecules Laboratory course (CHE 142) expands the laboratory-technique tool-kit to include column chromatography, distillation, refluxing (sometimes in a nitrogen environment), recrystallization and more. In this course, in-depth organic synthesis is done and instrumental analysis is conducted for the first time, using GC/MS, H-NMR and IR spectroscopy.

Term(s) Offered: Spring, All Years

CHE 190 Chemistry Internship 4 Credits

Internships are an opportunity for students to work with industries, governmental laboratories and institutes, and outside non-research-based institutions. Students work closely with an on-site supervisor to discover the numerous aspects of the working world. Participants produce a final report detailing the findings of their research. A maximum of four credits is allowed. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 194 Special Topics 4 Credits

An advanced Chemistry topic or topics is chosen based on student interest and faculty expertise.

CHE 195 On Campus Research 4 Credits

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted on campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

Term(s) Offered: All Terms, All Years

CHE 196 Off-Campus Research 4 Credits

An individual research project chosen by the student in consultation with a faculty mentor. The student, with the help of the mentor, design a project to be implemented during a one- or two-semester period or during the summer. Students conduct an appropriate literature search, carry out the research, and submit a written report by the end of each semester. Students may earn up to 4 credits for summer research for a maximum of eight credits. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 197 Independent Study 4 Credits

Students gain an opportunity for to work with a professor on a research project or on an in-depth literature review project during the academic year. Students may earn one or two credits per semester. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 210 Environmental Chemistry with Lab 4 Credits

The cycling of natural chemical species and pollutants in the water, soil and air of our earth system is a major component of our complex ecosystem. In this environmental chemistry course, students develop an understanding of the transport and reactions controlling natural chemical species in our environment, as well as the cycling of pollutants. Students study current issues of water, soil and air pollution, as well as energy production, and how society is working towards reducing the introduction and movement of pollutants through our environment. In the laboratory portion of the class, students investigate the water quality of local water bodies, including the Chester River, as well as conduct hands-on experiments related to the environmental topics studied in class.

Cross-listed as: CHE 210/ENV 210

Term(s) Offered: Spring, All Years

Fees: \$50 Lab Fee

CHE 220 Quantitative Chemical Analysis with Lab 4 Credits

This one-semester course is intended to provide an introduction to analytical methods utilized in chemistry. Both classical and instrumental methods of analysis are considered. A detailed treatment of simple and complex chemical equilibria with particular emphasis on acid-base, oxidation-reduction, and precipitation equilibria is presented as a basis for the classical gravimetric and titrimetric methods. The instrumental techniques include electroanalytical, UV-visible molecular spectroscopy, atomic spectroscopy, and chromatography. Other topics include a review of intermolecular forces and states of matter.

Term(s) Offered: All Terms, All Years

Fees: \$50 Lab Fee

CHE 222 Quantitative Chemical Analysis Lab 0 Credits

The Quantitative Chemical Analysis lab course focuses on analytical techniques and data analysis, coupled with CHE 220 (lecture). Instead of emphasizing the end result of chemical synthesis, quantitative data is collected and analyzed throughout the progression of the experiments. Experimental techniques used include colorimetry, titration, gravimetric analysis and pH determination. Students gain experience with precision measurement methods and employ statistical analyses to determine the precision and accuracy of each experiment.

Term(s) Offered: All Terms, All Years

CHE 235 Art in the Anthropocene 4 Credits

This course brings students into the chemist's lab and artist's studio at turns to offer interdisciplinary insight into the overlap between scientific versus artistic processes of inquiry. Students are taught the chemical processes of various art materials and how to make, harvest, or find their own environmentally friendly materials which are then incorporated into self-designed art projects. The laboratory curriculum asks students to identify environmental hazards of art materials, understand the link of these hazards to related ailments and devastations, and identify sustainable science solutions that avoid use of the hazards. The studio curriculum introduces students to aesthetic and conceptual frameworks that contemporary artists use, and encourage students to develop a distinctive creative voice that considers the meaning of the materials and processes they work with. This course fulfills the distribution requirement for either the Humanities and Fine Arts or the Natural Sciences and Quantitative. Chemistry majors on the non-ACS certified track, Chemistry minors, and Art and Art History majors/minors can count this course as an elective for their major or minor. Non ACS-certified majors can only count this course as an elective for the Fine Arts distribution.

Cross-listed as: ART 235/CHE 235

Term(s) Offered: Other, Even Years

CHE 240 Chemistry of the Elements with Lab 4 Credits

Chemistry of the Elements is a one-semester course that builds on knowledge acquired in Chemical Principles of Organic Molecules and Quantitative Chemical Analysis. This course covers the properties of all groups of elements in the periodic table with the exception of organic carbon chemistry. It also helps students discover the relationships between elements in different groups and understand the chemical reactions they undergo. The course focuses on the properties and reactions of selected important, essential, but also less commonly covered elements and compounds such as transition metals and organometallic complexes. The course goal is to demonstrate that the study of elements other than carbon is not an isolated branch of chemistry but is relevant in our everyday life as well as to many scientific fields such as pharmacy, medicine, biology, geology, environmental science, and materials science. An essential component of the course is a three-hour laboratory session which introduces students to how inorganic compounds are used in their environmental, biochemical, and industrial contexts. An introduction of green chemistry principles is a driving force in the lab portion of this course. This course is required for Chemistry majors (ACS and non-ACS track) as well as for students on the pre-health professions track. It serves as an elective for Chemistry minors and meets the requirement for the ACS certification as a foundation course in Inorganic Chemistry.

Term(s) Offered: Spring, All Years

Fees: \$50 Lab Fee

CHE 242 Chemistry of the Elements Lab 0 Credits

The Chemistry of the Elements laboratory course applies acquired laboratory skills to real-life applications with a main focus on sustainability and experiments investigating greener ways to utilize chemical elements. Experiments include cleaning up simulated oil spills, recycling lab waste from other laboratory experiments and determining ion concentrations in water samples from the science building. During this course, students use instrumentation such as H-, C-, and P-NMR, UV-Vis, and IR spectroscopy.

Term(s) Offered: Spring, All Years

CHE 290 Chemistry Internship 4 Credits

Internships are an opportunity for students to work with industries, governmental laboratories and institutes, and outside non-research-based institutions. Students work closely with an on-site supervisor to discover the numerous aspects of the working world. Participants produce a final report detailing the findings of their research. A maximum of four credits is allowed. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 294 Special Topics 4 Credits

An advanced Chemistry topic or topics is chosen based on student interest and faculty expertise.

Term(s) Offered: All Terms, All Years

CHE 295 On Campus Research 4 Credits

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted on campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

Term(s) Offered: Summer, All Years

CHE 296 Off-Campus Research 4 Credits

An individual research project chosen by the student in consultation with a faculty mentor. The student, with the help of the mentor, design a project to be implemented during a one- or two-semester period or during the summer. Students conduct an appropriate literature search, carry out the research, and submit a written report by the end of each semester. Students may earn up to 4 credits for summer research for a maximum of eight credits. Graded A-F.

Term(s) Offered: Summer, All Years

CHE 297 Independent Study 4 Credits

Students gain an opportunity for to work with a professor on a research project or on an in-depth literature review project during the academic year. Students may earn one or two credits per semester. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 303 Chem of Biological Compounds with Lab 4 Credits

This course is designed to provide a comprehensive introduction to the structure and function of biological molecules at the molecular level. We explore biomolecular structure (proteins, nucleic acids, carbohydrates, and lipids), fundamental concepts in enzyme reaction mechanisms, and apply these concepts to the breakdown and buildup of biomolecules. Students learn to interpret biochemical data, predict the impact of mutations associated with disease and visualize biomolecular structures with the aid of computer software commonly utilized in the field. Additional topics include protein modeling, metabolism, enzyme engineering and more.

Term(s) Offered: Spring, All Years

Fees: \$50 Lab Fee

CHE 305 Chemical Thermodynamics/Kinetics w/Lab 4 Credits

Thermodynamics is the study of the behavior of matter and the transformation between different forms of energy on a macroscopic scale. Reaction kinetics is the study of the rate at which the macroscopic properties and composition of matter change. These changes can involve either transport properties, such as thermal conductivity, viscosity, and diffusion or chemical kinetics. Some of the chemical kinetics topics covered are rate laws, temperature effects on reaction rates, reaction rate theories, reaction mechanisms, and enzyme catalysis. Applications of chemical thermodynamics and chemical dynamics are drawn from environmental chemistry and biochemistry. Laboratory exercises include determination of thermodynamic properties and kinetics experiments.

Term(s) Offered: Fall, All Years

CHE 306 Quantum Chem & Spectro with Lab 4 Credits

Quantum chemistry is the application of quantum mechanics to the field of chemistry. Topics included in the discussion of quantum chemistry are the early development of quantum mechanics, quantum mechanical models for molecular vibrations and rotations, and electronic structure of atoms and molecules. Spectroscopy is the study of the interactions of electromagnetic radiation with matter, and is the principal experimental tool used to investigate the predictions made using quantum mechanics. The laboratory exercises include spectroscopy experiments and the use of molecular modeling programs.

Term(s) Offered: Spring, All Years

Fees: \$50 Lab Fee

CHE 309 Biochemistry with Lab 4 Credits

The chemistry and metabolism of biological molecules. Students learn about the structure, function and metabolism of proteins, carbohydrates, and fats. Thermodynamics and enzyme-mediated catalysis are addressed, with an emphasis on how reaction rates and energetics affect biological processes and pathways. A laboratory is conducted weekly to introduce students to experimental techniques and molecular modeling.

Cross-listed as: BIO 409/CHE 309

Term(s) Offered: Fall, All Years

Fees: \$50 Lab Fee

CHE 310 Greener & Sustainable Chemistry 4 Credits

Environmentally friendly scientists and educators are increasingly conscious about the need to make chemistry more sustainable. Relying on chemistry as a science for society, three goals are proposed for this cross-disciplinary green chemistry course: 1. To introduce green chemistry from a historical point of view and present applications in our everyday life, in academia, and industry worldwide. 2. To place green chemistry in the wider world and discover how green chemistry can help in solving emerging global challenges. 3. To engage in forest thinking across disciplinary boundaries using green chemistry as the driving force. Real-world examples are used to illustrate the goals of green chemistry. Throughout the semester students have the opportunity to enhance their writing and oral presentation skills and improve their communication and discussion abilities.

Term(s) Offered: Other, Non Conforming

CHE 320 Introduction to Medicinal Chemistry 4 Credits

This course is designed to provide a comprehensive introduction to the interdisciplinary field of Medicinal Chemistry. This course will pull heavily from ideas in both chemistry and biology and will work at the intersection of both fields. We will focus on how drugs work to treat and prevent disease by working our way through the drug discovery and development pipeline. Students will learn the basics of pharmacology that can then be applied to any class of drug for any given disease. An emphasis on reading and critically evaluating primary literature will help students learn more about the topics in medicinal chemistry that most excite them.

Term(s) Offered: Fall, All Years

CHE 340 Synthesis of Organic Molecules with Lab 4 Credits

Organic Mechanisms and Synthesis delves deeper into the concepts from Reactions of Organic Molecules (CHE 140). In this course, students will learn about modern organic reactions, their mechanisms, and the application of these reactions in organic synthesis. Students will also be exposed to polymer and supramolecular chemistry, with a focus on the synthesis and properties of these compounds and their applications. The laboratory component of this course will provide students the opportunity to learn techniques that are required for the synthesis and characterization of organic, inorganic, and organometallic compounds, as well as, teach students how to think strategically about the chemical reactions needed to complete a chemical synthesis. This course will meet for three hours of lecture and three hours of lab per week.

Term(s) Offered: Fall, All Years

Fees: \$50 Lab Fee

CHE 390 Chemistry Internship 4 Credits

Internships are an opportunity for students to work with industries, governmental laboratories and institutes, and outside non-research-based institutions. Students work closely with an on-site supervisor to discover the numerous aspects of the working world. Participants produce a final report detailing the findings of their research. A maximum of four credits is allowed. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 392 Junior Seminar 2 Credits

This seminar course attempts to prepare our Chemistry majors for their future professional career, so they become successful professionals and experts in the chemistry field. This junior seminar course introduces students to professional preparation, scientific literacy proficiency, and research ethics. It is expected that at the end of this course, our majors will 1) understand the variety of career options available to chemists, 2) become proficient at literature searching, reading, and interpreting, and 3) realize the importance of the scientific code of conduct, and 4) improve their understanding of contemporary moral/societal issues in chemistry with an emphasis on sustainability science literacy. Therefore, at the end of this course, the following 4 Cs will have been practiced and mastered: Critical thinking and problem solving, Communication, Collaboration, and Creativity and innovation. Prerequisite: chemistry major and junior status.

Term(s) Offered: Spring, All Years

CHE 394 Special Topics 4 Credits

An advanced Chemistry topic or topics is chosen based on student interest and faculty expertise.

Term(s) Offered: All Terms, All Years

CHE 395 On-Campus Guided Research 4 Credits

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted on campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

Term(s) Offered: Summer, All Years

CHE 396 Off-Campus Research 4 Credits

An individual research project chosen by the student in consultation with a faculty mentor. The student, with the help of the mentor, design a project to be implemented during a one- or two-semester period or during the summer. Students conduct an appropriate literature search, carry out the research, and submit a written report by the end of each semester. Students may earn up to 4 credits for summer research for a maximum of eight credits.

Graded A-F.

Term(s) Offered: Summer, All Years

CHE 397 Independent Study 4 Credits

Students gain an opportunity for to work with a professor on a research project or on an in-depth literature review project during the academic year. Students may earn one or two credits per semester. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 403 Advanced Organic Chemistry with Lab 4 Credits

This course expands upon the topics discussed previously in the three semesters of organic chemistry. Topics that are covered are: Frontier Molecular Orbital (FMO) Theory and how this can be applied to chemical reactivity, Pericyclic Reactions, Linear Free-Energy Relationships, Molecular Rearrangements, Heterocyclic Chemistry, and Organometallic Chemistry. Heavy emphasis is placed on reaction mechanisms and synthesis.

Prerequisite: Chemistry 140 and Chemistry 220.

Term(s) Offered: Other, Non Conforming

CHE 410 Fundamentals of Materials Science 4 Credits

Our lives are influenced by all types of materials in transportation, housing, clothing, communication, recreation, and food production. The development on the ability to use existing materials, produce, manipulate, and select new materials suitable in many technologies that make our existence more comfortable. This course depicts relationships between the processing of a material, its structure, and finally its performance based on its properties in terms of the design, production, and utilization of the material. The overall goal of this course is to become familiar with the selection process that scientists and engineers use when designing a suitable material at a reasonable cost with minimal environmental impact.

Term(s) Offered: Spring, All Years

CHE 490 Chemistry Internship 4 Credits

Internships are an opportunity for students to work with industries, governmental laboratories and institutes, and outside non-research-based institutions. Students work closely with an on-site supervisor to discover the numerous aspects of the working world. Participants produce a final report detailing the findings of their research. A maximum of four credits is allowed. Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 494 Special Topics 4 Credits

An advanced Chemistry topic or topics is chosen based on student interest and faculty expertise.

Term(s) Offered: All Terms, All Years

CHE 495 On-Campus Guided Research 4 Credits

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor.

Research is conducted on campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

Term(s) Offered: Summer, All Years

CHE 496 Off-Campus Research 2 Credits

An individual research project chosen by the student in consultation with a faculty mentor. The student, with the help of the mentor, design a project to be implemented during a one- or two-semester period or during the summer. Students conduct an appropriate literature search, carry out the research, and submit a written report by the end of each semester. Students may earn up to 4 credits for summer research for a maximum of eight credits.

Graded A-F.

Term(s) Offered: All Terms, All Years

CHE 497 Independent Study 4 Credits

Students gain an opportunity for to work with a professor on a research project or on an in-depth literature review project during the academic year.

Students may earn one or two credits per semester. Graded A-F.

Term(s) Offered: All Terms, All Years