

Chemistry

Allison Calhoun, *Chair*

Frank M. Dunnivant

Marion Götz

Timothy Machonkin

James E. Russo

Deborah M. Simon

Tommaso Vannelli

Leroy G. Wade

Chemistry courses deal with the nature and composition of matter and the laws that govern chemical reactions. They are offered to meet the needs of three groups of students: those who choose to make chemistry or chemical engineering their profession; those who require a certain amount of chemistry as an adjunct to some related vocation; and those who desire a knowledge of chemistry as part of a general education.

Students expecting to major in any of the basic sciences should take either (1) Chemistry 125, 126 and the associated laboratories, Chemistry 135, 136 or (2) the more accelerated Chemistry 140. These courses offer an introductory survey of all fields of chemistry (inorganic, analytical, organic, physical, and biochemistry). An extended study of chemistry for the nonmajor may be obtained by taking Chemistry 245, 246 *Organic Chemistry*, Chemistry 345 *Physical Chemistry*, Chemistry 388 *Environmental Chemistry and Science*, or BBMB 325 *Biochemistry*. Pre-medical students should note that most medical schools require for entrance a full year of organic chemistry lecture and two credits of organic laboratory.

The department also offers two one-semester courses in chemistry (Chemistry 100 and 102) for the student wishing a general knowledge of the field to fulfill breadth of study requirements.

The department is well-equipped with instrumentation for chemical analysis. A “hands on” policy allows extensive use of the instruments, beginning in the first year with experiments involving pH meters, analytical balances, and visible spectrophotometers. In advanced courses, students are introduced to atomic absorption, infrared, fluorescence, nuclear magnetic resonance, ultraviolet spectrophotometry, mass spectrometry, gas chromatography, high performance liquid chromatography and electrochemistry. The aim is to give practical

experience with modern chemical instrumentation so that students can learn not only what an instrument does, but also how it works. In advanced courses, students will use various computer software packages for data analysis and presentation, and for laboratory report writing.

A student who enters Whitman without any previous college-level chemistry courses will need to complete 35 chemistry credits to fulfill the requirements for the major. Additional credits are required in other departments. These are listed below with the requirements for the chemistry major. Courses completed in the chemistry department apply to the science and quantitative analysis (selected courses) distribution areas.

The Chemistry major: A minimum of 35 credits in chemistry including:

Either Chemistry 125, 126, 135, 136, or Chemistry 140; and Chemistry 240, 245, 246, 251, 252, 320, 345, 346, 360, 361, 362, and at least three credits of Chemistry 490 or 498. A minimum grade of C (2.0) is required in either Chemistry 240 or Chemistry 345, whichever is taken first. Students contemplating a major in chemistry are encouraged to take Chemistry 240 in their sophomore year.

The following nonchemistry courses are also required: Mathematics 225 and Physics 155 or 165, 156 or 166. Mathematics 244, 300 and 128, plus a reading knowledge of a foreign language are strongly recommended for chemistry majors.

Subsequent to the declaration of a chemistry major or minor, no chemistry courses within the major or minor may be taken on a P-D-F basis.

Senior Assessment in Major: The successful completion of a chemistry degree requires the student to pass both a comprehensive written examination and a one-hour oral examination.

The Chemistry minor: A minimum of 19 credits in chemistry, involving either of the following sequences: (1) 125, 126, 135, 136, 245, 246, 251, 252; at least one of the following: 240, 345, 388, BBMB 325; or (2) 140, 245, 246, 251, 252; at least two of the following: 240, 345, 346, 388, BBMB 325.

The Biochemistry, Biophysics, and Mo-

lecular Biology (BBMB) major: See BBMB under the *Courses and Programs* section in the catalog for a description of the courses and major offered at the interface of biology, chemistry, and physics.

The Chemistry-Geology combined major:

Either Chemistry 125, 126, 135, 136, 240 or Chemistry 140, 240; Chemistry 346; either Geology 110, 120, or 210, and 220, 345, 346, 350, 460, 470, and a minimum of one credit in 258; Mathematics 125, 126; Physics 155 or 165, 156 or 166. Courses completed in this major apply to the science and quantitative analysis (selected courses) distribution areas.

The Chemistry-Environmental Studies combined major: The requirements are fully described in the *Environmental Studies* section of the catalog. Courses completed in this major apply to the science and quantitative analysis (selected courses) distribution areas.

100 Introduction to Environmental Chemistry

x, 3

Dunnivant

The goal of this course is to prepare students to be environmentally responsible citizens and empower them with scientific knowledge to make the right decisions concerning the environment. Chemistry 100 is a one-semester introduction to important topics in chemistry, environmental chemistry, and environmental engineering. Connections will be made between environmental chemistry and most disciplines taught at Whitman College. Topics will include major U.S. environmental laws, basic chemistry, sources of pollution, water quality, water scarcity, water and wastewater treatment, pollutant fate and transport modeling, global environmental issues (acid rain, global warming, and stratospheric ozone depletion), and risk assessment. No chemistry background is presumed. Highly recommended for environmental studies students not majoring in a natural science. Students may not receive credit for Chemistry 100 if they have taken Chemistry 125 or a more advanced college chemistry course. Three lectures per week; no lab. Distribution area: science and quantitative analysis.

102 Chemistry of Art

x, 3

Simon

This course, for nonscience majors, will cover the principles of chemistry within the context of the production, analysis, and conservation of art. The influence of science and technology on art will be explored through such topics as color theory, the chemistry of pigments, dyes, binders, papers, inks and glazes, forensic analysis of forgeries, conservation of works of art, and photography. Possible laboratory topics in-

clude pigments, etching, papermaking, textile dyeing, ceramics, electroplating, jewelry making, alternative photographic methods, and fused glass. No artistic skill or chemistry background is presumed. Students may not receive credit for Chemistry 102 if they have completed any other college level-chemistry course. Two lectures and one three-hour laboratory per week. *Fee:* \$20. Distribution area: science with lab and quantitative analysis.

125 General Chemistry

3, x

Staff

The first semester of a yearlong course in introductory chemistry. Topics include atomic and molecular structure; periodic properties of the elements; chemical bonding; properties of gases, liquids, and solids; stoichiometry; aqueous solution reactions; and perhaps an introduction to organic chemistry and biochemistry. Problem-solving involves the use of algebra. Three lectures per week. *Prerequisite:* two years of high school mathematics or consent of instructor.

126 General Chemistry

x, 3

Staff

The second semester of a yearlong course in introductory chemistry. Topics include properties of solutions, elementary thermodynamics, introduction to chemical equilibrium, kinetics, oxidation-reduction and electrochemistry, acids and bases, environmental issues, and nuclear chemistry. Problem-solving in this course involves the use of logarithms and algebra including the quadratic formula. Three lectures per week. *Prerequisite:* Chemistry 125.

135 General Chemistry Lab I

1, x

Staff

Laboratory exercises in physical and chemical properties of matter, with an introduction to both qualitative and quantitative methods of analysis. Topics include gravimetric and volumetric analysis, molecular structure, chemical synthesis, acid-base chemistry, properties and reactions of various groups of elements, and thermochemistry. One three-hour laboratory per week. *Corequisite:* Chemistry 125.

136 General Chemistry Lab II

x, 1

Staff

A continuation of Chemistry 135 with emphasis on descriptive chemistry and discovery-based experiments. Topics include analysis, kinetics, synthesis, and an introduction to spectrophotometric methods of analysis. One three-hour laboratory per week. *Prerequisite:* Chemistry 135; *Corequisite:* Chemistry 126.

140 Advanced General Chemistry I

4, x

Calhoun

A one-semester accelerated course in introductory chemistry designed for students with a strong high school background in chemistry. Topics similar to those in Chemistry 125 and 126 will be covered at a faster rate and a deeper level. Laboratory exercises emphasize the concepts and methods developed in lecture and will involve experiments similar to, but not necessarily identical with, those covered in Chemistry 135 and 136. Problem solving involves the use of algebra. Three lectures and one three- to four-hour laboratory per week. Enrollment is limited to 46 students. *Chemistry 140 is equivalent to the sequence of Chemistry 125, 126, 135, and 136. Prerequisites:* two years of high school mathematics, one year of high school chemistry (two recommended), and a passing score on a qualifying exam given on campus immediately prior to first semester registration. *Fee:* \$30.

240 Quantitative Analysis and Chemical Equilibrium

4, x

Machonkin

The principles of chemical equilibrium and methods of quantitative analysis. Topics include statistical analysis of data, activities, and the systematic treatment of acid-base, precipitation, complexation, and oxidation-reduction equilibria. Laboratory exercises involve the exploration and elucidation of the concepts and methods developed in lecture, and include gravimetric, titrimetric, and colorimetric analyses, with an introduction to selected instrumental methods of analysis and instruction in and use of electronic spreadsheets for data analysis and graphing. Two lectures and two three- to four-hour laboratories per week. *Prerequisites:* Either Chemistry 126 and 136 or Chemistry 140.

245 Organic Chemistry I

3, x

Staff

The first semester of a yearlong course in organic chemistry. Topics include reaction mechanism, nomenclature, stereochemistry, spectroscopy, and the synthesis and reactions of alkyl halides, alkenes, alcohols, ethers, and alkynes. Three lectures per week. *Prerequisite:* Chemistry 126.

246 Organic Chemistry II

x, 3

Staff

A continuation of Chemistry 245. Topics include spectroscopy, aromatic chemistry, carbonyl compounds, and biomolecules such as carbohydrates and amino acids. Three lectures per week. *Prerequisite:* Chemistry 245.

251 Organic Laboratory Techniques I

1, 1

Götz, Staff

Introduction to fundamental organic laboratory techniques. Topics include recrystallization, distillation, melting point determination, chromatography, extraction, and one-step syntheses. One three-hour laboratory per week. *Prerequisite:* Chemistry 126 or Chemistry 140; *Pre- or Corequisite:* Chemistry 245.

252 Organic Laboratory Techniques II

x, 1

Götz, Staff

Continuation of organic laboratory techniques involving intermediate exercises. The course covers more challenging syntheses as compared to Chemistry 251, as well as multi-step synthesis and spectroscopic analysis of products. One three-hour laboratory per week. *Prerequisite:* Chemistry 251; *Pre- or Corequisite:* Chemistry 246.

320 Instrumental Methods of Analysis

3, x

Dunnivant

This course deals with the theories and methods in instrumental procedures and significant developments in modern chemical analysis and separation techniques. Instrumental techniques will include flame atomic absorption, capillary electrophoresis, inductively coupled plasma spectroscopic methods, basic mass spectrometry, and ion, high pressure, and gas chromatography. One afternoon or weekend field trip may be required. Three lectures per week. *Prerequisites:* Chemistry 240, 251 and 252. *Pre- or corequisite:* Chemistry 345. Distribution area: science.

345 Physical Chemistry I

3, x

Calhoun

This course is the first semester of a two-semester course exploring the fundamental behavior of chemical systems in terms of the physical principles which govern their behavior. The specific focus is on microstructure of atoms, the role of this microstructure in the formation of molecules and the statistical descriptions of system behavior in terms of the microstructure. Topics covered include quantum chemistry, bonding, molecular structure, spectroscopy, NMR, properties of gases and statistical thermodynamics. *Prerequisites:* Chemistry 126 or 140, Physics 156 or 166, and Mathematics 126 or equivalent. Mathematics 255 is recommended.

346 Physical Chemistry II

x, 3

Calhoun

This course is the second semester of a two-semester course exploring the fundamental behavior of chemical systems in terms of the physical principles which govern their behavior. The specific focus is on system behavior to explain spontaneity, energy transformations, chemical and physical equilibrium and the rates of chemical reactions. Topics covered include classical thermodynamics, phase equilibria, chemical equilibria, kinetics of chemical processes and surface chemistry. *Prerequisites:* Chemistry 126 or 140, Physics 156 or 166, and Mathematics 126 or equivalent. Mathematics 255 is recommended. Chemistry 345 strongly recommended.

360 Advanced Inorganic Chemistry

x, 3

Machonkin

The concepts of modern inorganic chemistry at an advanced level. Selected topics are explored in depth rather than in a review of the entire field. Possible topics include transition-metal complexes and

theories of metal-ligand bonding, acid-base theories and nonaqueous solvents, kinetics and mechanisms of transition-metal-complex reactions, bonding in solids, atomic structure and term symbols, symmetry and group theory. Three lectures per week. *Pre- or corequisites:* Chemistry 346.

361 Integrated Advanced Laboratory I
2, x **Dunnivant, Götz**

An advanced integrated laboratory course jointly taught by the analytical and organic chemists in the department, with emphasis on the use of analytical instrumentation and advanced synthesis projects. Two three- to four-hour laboratories per week. *Prerequisites:* Chemistry 246, 251, and 252. *Pre- or corequisite:* Chemistry 320.

362 Integrated Advanced Laboratory II
x, 2 **Calhoun, Machonkin**

An advanced integrated laboratory course jointly taught by the inorganic and physical chemists in the department, with emphasis on inorganic synthesis, analytical techniques used in inorganic chemistry, and physical chemistry concepts in the laboratory. Two three- to four-hour laboratories per week. *Prerequisite:* Chemistry 345 and 361. *Corequisite:* Chemistry 346 and 360.

388 Environmental Chemistry and Science
x, 4 **Dunnivant**

This course will examine (1) the basic chemistry associated with pollutant fate and transport modeling in environmental media, especially acid-base, oxidation/reduction, solubility, speciation, and sorption reactions, (2) basic physical concepts for modeling the fate and transport of pollutants in environmental media, and (3) pollutant risk assessment based on humans as receptors. Additional topics might include major U.S. environmental laws, global environmental issues (e.g., global warming and stratospheric ozone depletion), and selected scientific articles. The laboratory portion will concentrate on pollutant monitoring and chemical aspects of pollutants, measuring dispersion and pollutant transport in small-scale systems, and data analysis. Three lectures, one three- to four-hour laboratory per week, and one weekend field monitoring trip to Johnston Wilderness Campus. *Prerequisites:* A good working knowledge of basic algebra (rearrangement of complicated equations and use of exponential functions); Chemistry 126 or 140; Chemistry 251 and 252 or consent of instructor. Offered in alternate years. There is a mandatory overnight field trip at the end of the semester.

420 Advanced Analytical Instrumentation
x, 1 **Dunnivant**

This project-based course will focus on expanding students' knowledge of modern instrumentation based on their field of study. Students will choose from a variety of instrumentation including UV-Vis spectroscopy, atomic absorption and emission spectroscopy, ion chromatography, liquid chromatography, gas chromatography, and mass spectrometry. *Prerequisites:*

Chemistry 140, or 126 and 136, and consent of instructor. *Additional Prerequisites for Chemistry majors:* Chemistry 320 and 361. Distribution area: science.

451, 452 Independent Study
1-3, 1-3 **Staff**

An advanced laboratory project or a directed reading project selected by the student in consultation with the staff and supervised by the staff member best qualified for the area of study. For a laboratory project, a written report reflecting the library and laboratory work carried out is required. The student must select a supervising staff member and obtain approval for a project prior to registration. If any part of the project involves off-campus work, the student must consult with the department chair for approval before beginning the project. Each credit of independent study laboratory work corresponds to one afternoon of work per week. A maximum of three credits may be counted toward degree requirements. *Prerequisites:* two years of college chemistry and consent of instructor.

457 Organic Synthesis and Spectroscopy
3; not offered 2008-09

Reactions and synthesis in organic chemistry. Topics include retrosynthetic analysis, carbon-carbon bond-forming reactions, functional-group interchanges, control of stereochemistry, ring-forming reactions, synthesis of heterocycles, and determination of product structure using mass spectrometry and NMR, IR, and UV spectroscopy. *Prerequisite:* Chemistry 246. Offered upon request.

459 Physical Organic Chemistry
3; not offered 2008-09

Mechanisms, kinetics, structure, and theory in organic chemistry. Topics include general acid/base catalysis, linear free energy relationships, isotope effects, transition state theory, photochemistry, spectroscopy, and pericyclic reactions. Three lectures per week. *Prerequisite:* Chemistry 246. *Recommended corequisite:* Chemistry 345. Offered in alternate years.

481, 482 Advanced Topics in Chemistry
1-3

A detailed study of specialized subjects such as organic qualitative analysis, conformational analysis, natural products, quantum chemistry, chemical kinetics, protein structure and function, physical biochemistry, and spectroscopy. Topics to be offered will be announced each year in the class schedule. *Prerequisite:* two years of college chemistry.

490 Research
1-3, 1-3 **Staff**

Two consecutive semesters, or a summer and a subsequent semester, of work on projects of current interest to the staff. The research may involve laboratory work on original projects, reports based on library searches, development of instructional laboratory exercises, etc. The student must select a supervising faculty member and obtain approval for a project prior

to registration for the first semester of the two-semester sequence, or prior to registration for the fall semester if the project will commence during the summer. A final written report, and a seminar on the project will be required. May be repeated for a maximum of six credits. *Prerequisites*: two years of college chemistry and consent of instructor.

498 Honors Thesis**3, 3****Staff**

Independent research or projects leading to the preparation of an undergraduate thesis. Credit cannot be earned simultaneously for Chemistry 498 and 490. Required of and limited to senior honors candidates in chemistry. An adviser for the thesis must be chosen by the end of the junior year. *Prerequisite*: admission to honors candidacy.