Chemistry

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Chemistry courses deal with the nature and composition of matter and the laws that govern chemical reactions. These courses 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, 345, 388, or BBMB 325. Premedical students should note that most medical schools require for entrance a full year of organic chemistry lecture and two credits of organic laboratory.

There are two ways to fulfill first-year general chemistry requirements. One is by taking the yearlong *General Chemistry* series of courses (Chemistry 125, 126, 135, 136). An accelerated option is to take a semester of *Advanced General Chemistry* (140 and 140 lab). Students with an AP score of 4 or 5 do not have to take 125 but should take 135 in the fall. Students with an AP score of 5 may take 140 and 140 lab and receive almost a full year of general chemistry credit (three credits for their AP score, three credits for the 140 lecture, and one credit for the 140 lab). *Note:* AP credit does not include credit for the Chemistry 135 lab.

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 and fluorescence spectroscopies, nuclear magnetic resonance spectrometry, ultraviolet spectrophotometry, mass spectrometry, capillary electrophoresis, 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 36 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.

Distribution: Courses completed in chemistry apply to the science and quantitative analysis (selected courses) distribution areas, with the exception of Chemistry 111.

Total credits required to complete a Chemistry major: 36 credits in Chemistry, 10 credits in Mathematics and Statistics, and 8 credits in Physics.

Learning Goals: Upon graduation, a student will be able to:

- **Major-Specific Areas of Knowledge**
  1. Meet nationally set standards in analytical, organic, inorganic, and physical chemistry.

- **Communication**
  2. Communicate scientific findings and information in graphical, written and oral format, both to technical and nontechnical audiences.

- **Critical Thinking**

3. Apply chemical knowledge, intuition, and logic to interpret data and devise and defend solutions to real-world problems.

• Quantitative Skills

4. Use appropriate mathematical, computational, and analytical techniques to solve chemical problems.

• Research Skills

5. Work collaboratively, design experiments, and perform standard laboratory techniques to collect data.

6. Employ modern scientific literature search tools to locate, retrieve, and organize scientific information**.**

7. Identify and mitigate risks in a chemistry laboratory**.**

• Beyond Whitman

8. Pursue career objectives in post-graduate education, industry, government, and other areas.

The Chemistry major: A minimum of 36 credits in chemistry, including:

Either Chemistry 125, 126, 135, 136, or Chemistry 140; and Chemistry 245, 246, 251, 252, 310, 320, 345, 346, 352, 360, 370; one credit of either Chemistry 401 or 402 taken no later than the penultimate semester at Whitman; and at least two credits of Chemistry 490 or 498.

The following nonchemistry courses are also required: Mathematics 125, 126, and 225; and one year of General Physics (Physics 145, 155, and Physics 146, 156), or one year of college-level physics for science majors with lab taken elsewhere. A minimum grade of 2.400 averaged over Chemistry 126 or 140, Chemistry 245 and 246, and Math 225 is required. For students with transfer credit from outside of Whitman in one or more of these courses, the grade earned at that institution shall be used. Students who wish to complete the American Chemical Society certified chemistry major also must complete BBMB 325 (note that Biology 111 is a prerequisite). Students who plan to pursue graduate work in chemistry are recommended to obtain additional coursework in mathematics and statistics, which may include Mathematics 240, 244, or 367, or possibly in biology, and should consult with their adviser.

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.

Honors in the Major: For the Chemistry and Chemistry-Environmental Studies majors, students do not apply to candidacy for honors. To qualify for honors, students must meet the following requirements: (a) a minimum cumulative GPA of 3.300 on all credits earned at Whitman and a minimum cumulative GPA of 3.500 in the major, (b) receive a Pass with Distinction in the Senior Assessment in the Major, (c) perform a substantive laboratory-based research project, and (d) receive a minimum grade of A– on the Honors Thesis (Chem 498). By no later than the twelfth week of the semester, the Chair of Chemistry will notify the student and the Registrar that the requirements have been met, at which point a second reader to the student's thesis will be assigned. An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library by no later than Reading Day.

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 15 credits in chemistry, involving either of the following sequences: (1) 126, 136, 245, 246, 251, 252 or (2) 140, 245, 246, 251, 252; and at least one of the following: 310, 345, 346, 388, BBMB 325. Any 300-400 chemistry course may be substituted for 300- level credit. Note: Chemistry 401 and 402 cannot be applied to the minor.

The Biochemistry, Biophysics, and Molecular 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 (or 140); 310**,** and at least two of 320, 346, 388; either Geology 110 and 111, 120 and 121, or 125 and 126**;** and 227, 270, 350, 405, 460, 470, and a minimum of one credit in 358; Mathematics 125, 126, Physics 145, 155. Seniors completing the chemistry-geology major will complete a written exam constructed by the geology faculty, a written exam constructed by the chemistry faculty, and an oral exam conducted jointly by faculty in both departments. Additionally, all students are

strongly encouraged to complete a senior research project under the guidance of a faculty member in either of the two disciplines, registering for a minimum of one credit of Chemistry 401 or 402, plus two credits in either Chemistry 490 or 498, or three credits of Geology 490 or 498.

The Chemistry-Environmental Studies combined major: The requirements are fully described in the *Environmental Studies* section of the catalog.

The Chemistry/Pre-Engineering major: The requirements are fully described in the *Engineering and Computer Science* section of the Catalog.

100 Introduction to Environmental Chemistry and Science

Not offered 2019-20 **3 credits**

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 the environmental sciences. Emphasis will be placed on historic environmental success and what major problems remain to be solved. Topics will include the availability of clean water, effective wastewater treatment, restoration of the stratospheric ozone layer, the removal of anthropogenic produced lead, past and current endocrine disruptors, the proper use of risk assessment, appropriate actions to combat human-caused global warming, and an effective environmental legal national and international framework. Emphasis will be placed on the chemistry of each topic. 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. Working knowledge of college-level algebra is required. Three lectures per week; no lab.

102 Chemistry in Art

Spring **D. Simon** **4 credits**

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 include 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. Three lectures and one three-hour laboratory per week. *Corequisite:* Chemistry 102L (laboratory). The course may not be taken without the laboratory. *Lab fee:* $40.

111 Problem-Solving in Chemistry

Fall **Boland** **1 credit**

This course focuses on developing skills and strategies relevant to solving the types of quantitative problems found in general chemistry. Students will learn to parse information given—and not given—in word problems, identify the information content of equations, and develop strategies to apply algebraic manipulation to solve problems of a range of complexity. Graded credit/no credit only. Does not fulfill science or quantitative analysis distribution. *Note:* May not be applied to the Chemistry major or minor. *Corequisite:* Chemistry 125.

125 General Chemistry I

Fall **Hartman, Hendricks, R. Russo** **3 credits**

The first semester of a yearlong course in general chemistry. Topics include: matter and measurement, atoms and elements, molecules and compounds, stoichiometry, aqueous reactions, gases, thermodynamics (including enthalpy, entropy, and free energy), the quantum-mechanical model of the atom, periodic properties of elements, and models of chemical bonding. Problem-solving involves the use of algebra, including logarithms and the quadratic equation. *Corequisite:* Chemistry 111 (unless placed out of it with a mandatory qualifying exam taken online prior to the Fall semester) and Chemistry 135.

126 General Chemistry II
Spring Dunnivant, Hartman, Machonkin, R. Russo 3 credits
The second semester of a yearlong course in general chemistry. Topics include: solids and liquids, properties of solutions, coordination chemistry, chemical equilibrium, acids and bases, aqueous ionic equilibria, kinetics, electrochemistry, nuclear chemistry, and other topics of the instructor's choosing. Problem-solving involves the use of more sophisticated algebraic manipulation than found in Chemistry 125. *Prerequisite:* Chemistry 125. *Corequisite:* Chemistry 136. *Note*: the corequisite of Chemistry 136 is not required for Geology or Geology-Environmental Studies majors.

135 General Chemistry Lab I
Fall Boland, Hartman, Hendricks, D. Simon 1 credit
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. *Lab fee:* $35.

136 General Chemistry Lab II
Spring Hartman, R. Russo, D. Simon 1 credit
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. *Lab fee: maximum $*20.

140 Advanced General Chemistry
Fall D. Biswas 4 credits
A one-semester accelerated course in introductory chemistry designed for students with AP or IB chemistry or other strong high school background in chemistry. The topics will include, but are not limited to, introductory chemistry concepts covered in CHEM 125-126, and will be covered in a greater detail at a faster pace. Laboratory experiments will complement the concepts developed in lecture, and will develop students' skills in gravimetric and volumetric analysis, quantitative reasoning, and data acquisition, analysis and visualization. Problem solving involves the use of algebra and some basic calculus. Three lectures and one three-hour laboratory per week. *Prerequisites:* Mathematics 125 or equivalent and either a 4 or 5 on the Chemistry AP, a 5 or higher on the Chemistry IB (HL), or a passing score on a qualifying exam (taken online) prior to Fall semester registration. *Lab fee:* $30.

245 Organic Chemistry I
Fall, Spring Fall: Collins; Spring: Götz 3 credits
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 or 140.

246 Organic Chemistry II
Fall, Spring Fall Götz; Spring: Collins 3 credits
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
Fall, Spring Fall: Götz, R. Russo; Spring: D. Biswas 1 credit
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 140. *Pre-* or *corequisite:* Chemistry 245. *Lab fee:* $20.

252 Organic Laboratory Techniques II
Fall, Spring Fall: Götz; Spring: D. Biswas, R. Russo 1 credit
Continuation of organic laboratory techniques involving intermediate exercises. The course covers more challenging syntheses as compared to Chemistry 251, as well as multistep synthesis and spectroscopic analysis of products. One three-hour laboratory per week. *Prerequisite:* Chemistry 251. *Pre-* or *corequisite:* Chemistry 246. *Lab fee:* $20.

275 Computational Chemistry: Structure and Reactivity of Organic Molecules
Fall D. Biswas 2 credits
Application of quantum mechanics in organic molecules will be covered in this course. Topics will include molecular orbital theory, conformational analysis, chemical bonding, aromaticity, molecular spectra (IR, NMR), selectivity, transition states, and thermodynamics and kinetics of reaction mechanism. Students will be introduced to sophisticated quantum chemistry software for these calculations. A combination of lecture and hands-on tutorials will be offered during the class, which will improve students' ability to generate chemical models essential for understanding the structure and reactivity of organic molecules. No prior knowledge of quantum mechanics is needed beyond the gen. chem. level. *Prerequisite:* Chemistry 245. *Corequisite:* Chemistry 246.

305 Water Chemistry
Not offered 2019-20 3 credits
Water is perhaps the most important molecule on earth: water sustains life, crumbles mountains, regulates climate, and transports other compounds from pole to pole. This course will apply basic chemical principals (thermodynamics, kinetics, redox, acid-base chemistry, solubility, etc.) to develop students' understanding of chemistry in lakes, streams, oceans, and soils. Students will integrate concepts from chemistry, biology, geology, physics, environmental science and humanities to evaluate case studies such as: CO_2 cycling in oceans, nutrient pollution in lakes and streams, biouptake of nutrients and pollutants, and drinking water disinfection. *Prerequisites*: Chemistry 125, 126, 135 and 136, or 140; sophomore status or above.

310 Quantitative Analysis and Chemical Equilibrium
Fall Boland 4 credits
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 80 minute lectures and one three-hour laboratory per week. *Prerequisites*: Chemistry 126 and 136 or 140. *Lab fee*: maximum $20.

320 Instrumental Methods of Analysis
Spring Dunnivant 4 credits
This course deals with sample preparation, data analysis, method development, and the theory of operation of modern laboratory instrumentation. Instrumental techniques discussed in lecture and used in the laboratory will include flame atomic absorption spectroscopy, capillary electrophoresis, inductively coupled plasma spectrometry, basic mass spectrometry, scanning electron microscopy with elemental detection, and ion, high pressure, and gas chromatography. Laboratory exercises will concentrate on real world applications of chemical analysis. One Friday afternoon field trip may be required. Three lectures and one three- to four-hour laboratory per week are required. *Prerequisites:* Chemistry 310, 251 and 252. *Pre-* or *corequisite:* Chemistry 345. *Lab fee:* maximum $20.

340 Materials Chemistry
Spring Hendricks 3 credits
This course will introduce synthetic methods, properties, and applications of materials synthesized through chemical means, ranging from organic polymers to inorganic crystals. An overview of the physics necessary to understand

polymer properties and electronic structure in solids will be included. Particular emphasis will be placed on the control of material structure through chemical mechanisms and how molecular and nanoscale structure translate to macroscale properties. A portion of the course will be dedicated to the study of nanomaterials and how unique properties emerge from constraining dimensions of materials to the nanoscale. Throughout the course students will be asked to consider the effect of the development and production of synthetic materials on society. *Prerequisites:* Chemistry 126 or 140; Chemistry 245 and 1-year of college physics recommended.

345 Physical Chemistry I: Quantum Chemistry and Spectroscopy

Fall **Hendricks** **4 credits**

This course is the first of a two-semester sequence exploring the fundamental behavior of chemical systems in terms of the physical principles which govern this behavior. The specific focus is on the quantum behavior of matter as it pertains to atomic energies, bonding, reactivity, spectroscopy, and spectrometry. In this course, we also will review and learn applied mathematical techniques, perform mathematical modeling exercises, and spectroscopic and spectrometric analyses of representative systems to provide concrete examples and applications of the material in the lecture portion of the class. Meets four hours per week. *Prerequisites:* Chemistry 126 or 140, Physics 156 or one year of introductory physics for science majors, and Mathematics 126 or equivalent. Mathematics 225 is recommended.

346 Physical Chemistry II: Statistical Thermodynamics, Classical Thermodynamics and Kinetics

Spring **Hendricks** **3 credits**

This course is the second of a two-semester sequence exploring the fundamental behavior of chemical systems in terms of the physical principles which govern this behavior. The specific focus is on the statistical description of matter and applications of this statistical analysis to classical thermodynamic principles. Furthermore, we will investigate the kinetic behavior of chemical reactions from a mechanistic and statistical perspective. In this course we will review and learn applied mathematical techniques, perform mathematical modeling exercises, and engage in literature review work which will provide concrete examples and applications of the material in the lecture portion of the class. Meets three hours per week. *Prerequisites:* Chemistry 126 or 140, Physics 156 or one year of introductory physics for science majors, and Mathematics 126 or equivalent. Mathematics 225 is recommended. Chemistry 345 strongly recommended.

352 Physical Chemistry Lab

Spring **Hendricks** **1 credit**

A physical chemistry laboratory, exploring spectroscopy, computational chemistry, thermodynamics, and/or reaction kinetics. One three-hour laboratory per week. Learning goals will emphasize both experimental design and proper data collection as well as data analysis and scientific communication. *Prerequisites*: Chemistry 345. *Pre- or corequisite*: Chemistry 346. *Lab fee:* maximum $20.

360 Inorganic Chemistry

Fall **Machonkin** **3 credits**

This course will explore the fundamentals of chemical bonding, both in main group compounds and transition metal complexes. The first half of the course will begin with atomic theory, then move to molecular orbital theory for diatomic molecules, group theory, and molecular orbital theory for polyatomic molecules. The second half, the course will cover the bonding, spectroscopy, and reactivity of transition metal complexes. Three lectures per week. *Prerequisite:* Chemistry 345.

370 Advanced Methods in Inorganic and Organic Synthesis and Characterization

Fall, Spring **Fall: Machonkin; Spring: Götz** **2 credits**

This is an advanced laboratory course that combines both organic and inorganic synthesis with physical methods of characterization. A large portion of this course is an independent project chosen and developed by students within a

specific theme. Two three- to four-hour laboratories per week. *Prerequisite:* Chemistry 246, 252, and 345. *Prerequisite (recommended) or corequisite:* Chemistry 360. *Lab fee:* maximum $20.

388 Environmental Chemistry and Engineering
Fall **Dunnivant** **4 credits**

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 the Johnston Wilderness Campus. *Prerequisites:* a good working knowledge of basic algebra (rearrangement of complicated equations and use of exponential functions); Chemistry 126 or 140. Offered in alternate years. There is a mandatory overnight field trip at the end of the semester. *Lab fee:* maximum $20.

390 Student Research
Fall, Spring **Staff** **1-3 credits**

This course will give students who have not yet reached senior status an opportunity to participate in research with faculty in the chemistry department. The research will involve laboratory work on original projects under the supervision of a member of the chemistry department. The student must select a supervising faculty member and project before registering for the course. May be repeated for a maximum of six credits. *Prerequisites:* Chemistry 125,126, 135, 136; or 140; and consent of instructor.

401, 402 Chemistry Seminar
Fall, Spring **Machonkin** **1 credit**

This course will consist primarily of research presentations by scientists from colleges, universities, government labs, and industry. Presentations will span a range of areas of chemistry (organic, inorganic, physical, analytical, biological) and related disciplines (such as structural biology, materials science, and environmental science). Students will learn to engage with scientific literature by reading primary literature articles authored by the presenters, writing response papers, participating in follow-up discussion with the presenters during the seminar. There will be periodic workshops on critical reading, critical writing and ethics in science. Evaluation is based on attendance, response papers, and participation in the question-and-answer portion of the seminars and in the workshops. Enrollment is limited to juniors and seniors. May be repeated for a maximum of four credits. *Note:* May not be applied to the Chemistry minor.

411 The Organic Chemistry of Drug Design
Not offered 2019-20 **3 credits**

This course focuses on the design of drugs, with an emphasis on how their chemical synthesis and mode of action establishes an interface between organic chemistry and pharmaceutical chemistry. The challenges associated with drug discovery faced by the pharmaceutical industry will be illustrated through several case studies, and metabolic modifications of medicinal agents that lead to excretion from the body will be examined. *Prerequisites:* Chemistry 246; Biology 111 or 112 is strongly recommended.

425 Computational Biochemistry
Not offered 2019-20 **2 credits**

An introductory survey of theories/simulations of proteins will be covered in this course. Topics will include molecular mechanics, molecular dynamics, de novo protein design, integrated quantum and molecular mechanics, and docking small molecules onto proteins for pharmaceutic drug design. This course will attempt to cultivate computational skills necessary to tackle current scientific problems at the interface of chemistry and biology with an

emphasis on graphical visualization and data analysis. A combination of lecture and hands-on tutorials will be offered during the class, which are expected to improve the students' ability to generate biochemical models essential for understanding the structure and functions of proteins. *Prerequisite:* Chemistry 246. *Corequisite:* BBMB 325.

447 Physical Organic Chemistry
Not offered 2019-20 **3 credits**

This course will address the quantitative and qualitative study of organic molecules and reactions. Topics to be addressed include thermodynamics, molecular orbital theory, stereochemistry, aromaticity, pericyclic reactions, and reaction mechanisms. The experimental and theoretical methods for elucidating organic reactions will be a major theme of this course. A survey of techniques for studying carbocations will explore methods developed for studying elusive reaction intermediates. Student-led discussion and presentations of readings from the primary chemical literature will be a significant component of this course. *Prerequisite:* Chemistry 246.

451, 452 Independent Study
Fall, Spring **Staff** **1-3 credits**

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.

456 Advanced Organic Synthesis
Not offered 2019-20 **3 credits**

This course will focus on topics in modern organic chemistry with an emphasis on asymmetric transformations. Topics from introductory organic chemistry will be expanded to include enhanced discussion of structure, reactivity, and selectivity in the context of complex molecular synthesis. Issues such as functional group compatibility, steric sensitivity, and stereoselectivity will be discussed using examples of key transformations drawn from the chemical literature. The application of these methods in total synthesis will be explored through review of classic examples. In these discussions, students will gain an appreciation for the strategic and tactical aspects of designing a multistep, asymmetric synthesis. Throughout the semester students will also work to develop their own proposal for the total synthesis of a natural product. Active participation in class discussion and the presentation of work will be a significant component of this class. *Prerequisite:* Chemistry 246.

460 Bioinorganic Chemistry
Spring **Machonkin** **3 credits**

This course will examine the role of trace metal ions in biological systems. Metal ions such as iron, copper, and zinc are essential for life and are required for the function of about one-third of all known enzymes. However, the inherent toxicity of these metals has led to the evolution of cellular machinery to control the uptake, transport, storage, and distribution of trace metals in organisms. This toxicity also has been exploited in the development of several metal-based drugs. The challenges of understanding the roles of trace metals in biological systems have led to the development of novel techniques for their study. The course will survey a selection of these methods, and will examine case studies of metal-containing enzymes, metal ion trafficking, and metal-based drugs. A major portion of this course will be student-led literature reviews, presentations, and discussion of these topics. *Prerequisite:* Chemistry 360 or BBMB 325 or consent of instructor.

481, 482 Advanced Topics in Chemistry
1-3 credits

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. *Prerequisite:* two years of college chemistry. Any current offerings follow.

490 Research
Fall, Spring Staff 1-3 credits

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
Fall, Spring Staff 1-3 credits

All students will register for 1-3 credits of Chemistry 490. For students who have met the requirements for Honors in Chemistry, the registration in their final semester will be changed to Chemistry 498 to designate this. Students must have completed at least 1 credit of Chemistry 490 in the previous semester. Students must complete an honors thesis and submit this to the Library by no later than reading day. Requirements for the honors thesis are provided on the Library website. Students should consult with their research advisor for additional requirements and advice on preparation of the thesis. A seminar presentation on the project is also required. *Prerequisite:* senior standing.