

# Chemistry

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wp.stolaf.edu/chemistry (<http://wp.stolaf.edu/chemistry>)

St. Olaf traditionally graduates more chemistry majors than any other four-year college in the United States. The college also ranks in the top five as a source of students who obtain the Ph.D. in chemistry and related fields. Chemistry faculty members have a fine record of achievement in teaching and research; several have won prestigious national awards. Students enjoy state-of-the-art instrumentation and computers in both the laboratory and the classroom.

The Chemistry Department offers an array of courses in the traditional areas of chemistry (organic, analytical, physical, inorganic). Courses in biochemistry, organometallic chemistry, medicinal chemistry, and other topics introduce students to interdisciplinary and bridging sciences that utilize a chemical perspective.

The department has an active summer research program in which faculty and students work together to investigate problems of current interest. Students graduating with chemistry majors have had excellent success in gaining admission to graduate and professional schools and in obtaining employment opportunities. A major in chemistry may lead to employment in chemical research and in related areas such as medical applications of chemistry, environmental chemistry, and materials science. A chemistry major also provides an excellent background for continued education in professional schools in medicine, dentistry, pharmacy, and related fields.

## Overview of the Major

An overview of general options for the chemistry major, including the graduation major and the American Chemical Society approved major may be found at <http://wp.stolaf.edu/chemistry/planning-a-st-olaf-college-chemistry-major>.

### Three First-Year Options

Select one of the following options:

Option A:

CHEM 121 & CHEM 123 & CHEM 126	General Chemistry and Atomic and Molecular Structure and Energies and Rates of Chemical Reactions	3.00
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Option B:

CHEM 125 & CHEM 126	Structural Chemistry and Equilibrium and Energies and Rates of Chemical Reactions	2.00
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Option C:

CH/BI 125 & CH/BI 126 & CH/BI 227	Integrated Chem/Bio I: Chemical Concepts with Biological Applications and Integrated Chem/Bio II: Thermodynamics and Kinetics with Bio Relevance and Integrated Chem/Bio III: Molecular and Cellular Biology	3.00
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### Upper-Level Core Courses

CHEM 247 & CHEM 253	Organic Chemistry I and Synthesis Laboratory I (0.25)	1.25
CHEM 248 & CHEM 254	Organic Chemistry II and Synthesis Laboratory II (0.25)	1.25
CHEM 255 & CHEM 256	Analytical Chemistry and Analytical Laboratory (0.25)	1.25
CHEM 371 & CHEM 357	Physical Chemistry and Physical Laboratory (0.25)	1.25

### Department Seminars

Attendance at 12 departmental seminars after the sophomore year

After the first year, the order of courses is not prescribed. Upper-level courses in addition to this core set are also required, as described under requirements for the major. Gaining experience in the laboratory is an important aspect of the major, and students are encouraged to participate in research either on-campus with St. Olaf faculty or at other institutions.

In addition, the Chemistry Department offers a degree approved by the American Chemical Society (ACS) through its Committee on Professional Training. Prospective majors in chemistry who desire the "ACS Major" should review the ACS Major course requirements and also consult with a faculty member in the Chemistry Department early in their studies.

## Intended Learning Outcomes for the Major (<http://wp.stolaf.edu/curriculum-committee/chemistry-major-ilos>)

## Distinction

See Academic Honors (<http://catalog.stolaf.edu/archive/2015-2016/academic-regulations-procedures/academic-honors/#distinction>)

The Chemistry Department seeks to encourage and recognize students who give evidence of creative and independent scholarship. A variety of opportunities are available for students to take a much greater responsibility for setting their goals and realizing the achievements of their education. Going beyond the regular course work, which introduces the theory and practice of chemistry, distinction challenges students to raise questions worthy of scientific investigation. Opportunities for distinction projects include, for example, summer research either on or off campus, CHEM 298 Independent Study, CHEM 398 Independent Research, CHEM 375 Advanced Laboratory (0.25), and faculty-approved literature research projects. All projects for distinction will be considered on a case-by-case basis.

A full description of the distinction process is available at <http://wp.stolaf.edu/chemistry/>.

## Recommendations for Graduate and Professional Study

Students planning graduate work in chemistry should expect to take additional optional courses above and beyond the single optional course required for the general major. In particular, students interested in graduate school should take CHEM 386 Advanced Inorganic Chemistry by the end of the junior year so that they have taken the background courses relevant to the Chemistry Graduate Record Examination prior to fall of the senior year, when that examination is typically taken. CHEM 255, CHEM 256, CHEM 371, and CHEM 357 should also be taken in advance of or during the semester when the Chemistry GRE is offered.

## American Chemical Society Approved Major

The St. Olaf College Chemistry Department offers a degree approved by the American Chemical Society (ACS) through its Committee on Professional Training. Students interested in the "ACS Major" should review the requirements for that major (<http://catalog.stolaf.edu/archive/2015-2016/academic-programs/chemistry/#requirementstext>) and consult with a member of the Chemistry Department early on in their studies.

## Special Programs

St. Olaf chemistry majors have a number of options for special study, both on-campus and elsewhere. On-campus programs that may include chemistry topics include concentrations in biomolecular science, environmental studies, neuroscience, and biomedical studies. Off-campus programs include the cooperative B.A.-B.S.E. engineering programs at Washington University in St. Louis and the University of Minnesota, where students may earn a degree in engineering; the Oak Ridge Science Semester; biochemistry at the Lancaster University (<http://www.lancaster.ac.uk/study/international-students/study-abroad/incoming>) (Lancaster, England); and the study of medicinal chemistry on an Interim abroad program in Jamaica. Internships in local industrial settings are also possible. Consult the International and Off-Campus Studies Office (<http://wp.stolaf.edu/international>) or the Piper Center for Vocation and Career (<http://wp.stolaf.edu/pipercenter>) for more information on these programs.

## Requirements

### Requirements for a Graduation Major

#### Introductory Sequence

Select one of the following options:

##### Option A:

CHEM 121 & CHEM 123 & CHEM 126	General Chemistry and Atomic and Molecular Structure and Energies and Rates of Chemical Reactions	3.00
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##### Option B:

CHEM 125 & CHEM 126	Structural Chemistry and Equilibrium and Energies and Rates of Chemical Reactions	2.00
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##### Option C:

CH/BI 125 & CH/BI 126 & CH/BI 227	Integrated Chem/Bio I: Chemical Concepts with Biological Applications and Integrated Chem/Bio II: Thermodynamics and Kinetics with Bio Relevance and Integrated Chem/Bio III: Molecular and Cellular Biology	3.00
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#### Upper-Level Core Courses

CHEM 247 & CHEM 253	Organic Chemistry I and Synthesis Laboratory I (0.25)	1.25
CHEM 248 & CHEM 254	Organic Chemistry II and Synthesis Laboratory II (0.25)	1.25
CHEM 255 & CHEM 256	Analytical Chemistry and Analytical Laboratory (0.25)	1.25
CHEM 371 & CHEM 357	Physical Chemistry and Physical Laboratory (0.25)	1.25

Select at least one additional course from the following:

CHEM 252	Organometallic Chemistry	1.00
CHEM 260	Medicinal Chemistry in Jamaica: An International Perspective (abroad)	1.00
CHEM 298	Independent Study <sup>1</sup>	1.00
CHEM 379	Biochemistry I	1.00
CHEM 380	Organic Analysis and Theory	1.00
CHEM 382	Instrumental Analysis	1.00
CHEM 384	Bioanalytical Chemistry	1.00
CHEM 386	Advanced Inorganic Chemistry	1.00
CHEM 388	Advanced Organic Chemistry	1.00
CHEM 391	Selected Topics in Chemistry	1.00
CHEM 398	Independent Research <sup>1</sup>	1.00

#### Physics

Through PHYS 125 or PHYS 232

#### Mathematics

Through MATH 126 or MATH 128

#### Chemistry Department seminars

Attend a total of 12 Chemistry Department seminars during junior and senior years

<sup>1</sup> Projects for CHEM 298 Independent Study or CHEM 398 Independent Research must have departmental approval.

Students must earn a grade of C or above in at least six Chemistry Department courses, at least four of which must be numbered 240 or above. Completion of at least one course credit in independent research (or completion of a summer research experience) is strongly recommended for students planning careers in chemistry. For more information, see <http://wp.stolaf.edu/chemistry/>.

## Requirements for a license to teach chemistry in grades 9-12 in Minnesota

A chemistry major who wishes to teach chemistry in grades 9-12 in Minnesota must hold a valid Minnesota teaching license (<http://catalog.stolaf.edu/archive/2015-2016/academic-programs/education/#requirementstext>) in chemistry. In addition to the chemistry major, additional science courses and the professional education sequence (<http://catalog.stolaf.edu/archive/2015-2016/academic-programs/education/#text>) are required. A license to teach grades 5-8 in science is also available with additional course requirements. Interested students should consult with a faculty advisor in the Education Department for details of requirements and available options.

## American Chemical Society Approved Major

The St. Olaf College Chemistry Department offers a degree approved by the American Chemical Society (ACS) through its Committee on Professional Training. Prospective majors in chemistry who desire the "ACS Major" will complete the following courses:

### Chemistry

One of the three first-year options (see above)

CHEM 247	Organic Chemistry I	1.00
CHEM 248	Organic Chemistry II	1.00
CHEM 253	Synthesis Laboratory I (0.25)	0.25
CHEM 254	Synthesis Laboratory II (0.25)	0.25
CHEM 255	Analytical Chemistry	1.00
CHEM 256	Analytical Laboratory (0.25)	0.25
CHEM 357	Physical Laboratory (0.25)	0.25
CHEM 371	Physical Chemistry	1.00
CHEM 379	Biochemistry I	1.00
CHEM 382 & CHEM 378	Instrumental Analysis and Instrumental Analysis Laboratory (0.25)	1.25
CHEM 386	Advanced Inorganic Chemistry	1.00

### Physics

Through PHYS 125 or PHYS 232

### Mathematics

Two mathematics courses beyond MATH 126 or MATH 128 <sup>2</sup>

### Chemistry Department seminars

Attendance during junior and senior years at 12 Chemistry Department seminars

<sup>1</sup> The chemistry/biology integrated course sequence (CH/BI 125, CH/BI 126, and CH/BI 227) may be substituted for CHEM 125 and CHEM 126.

<sup>2</sup> Typically selected from MATH 220, MATH 226, MATH 230, and STAT 212.

In addition, ACS majors must complete one or more advanced course from the following:

CHEM 252	Organometallic Chemistry	1.00
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CHEM 260	Medicinal Chemistry in Jamaica: An International Perspective (abroad)	1.00
CHEM 298	Independent Study <sup>1</sup>	1.00
CHEM 380	Organic Analysis and Theory	1.00
CHEM 384	Bioanalytical Chemistry	1.00
CHEM 385	Biochemistry II	1.00
CHEM 388	Advanced Organic Chemistry	1.00
CHEM 391	Selected Topics in Chemistry	1.00
CHEM 398	Independent Research <sup>1</sup>	1.00

<sup>1</sup> Projects for CHEM 298 Independent Study or CHEM 398 Independent Research must have departmental approval.

Additional laboratory hours must be obtained by completing at least 1.25 credits from the following (summer research can substitute for one of these experiences):

CHEM 373	Experimental Biochemistry (0.25)	0.25
CHEM 374	Advanced Synthesis Laboratory (0.25)	0.25
CHEM 375	Advanced Laboratory (0.25)	0.25
CHEM 380	Organic Analysis and Theory	1.00
CHEM 384	Bioanalytical Chemistry	1.00
CHEM 398	Independent Research	1.00

One laboratory experience must include either biochemistry topics or inorganic topics. CHEM 398 Independent Research and summer research must be accompanied by a comprehensive written report in order to satisfy ACS major requirements. For a full listing of requirements, see <http://wp.stolaf.edu/chemistry/planning-a-st-olaf-college-chemistry-major/>

## Courses

### CHEM 107: Forensic Science with Lab

In addition to the in-class experience shared with Chemistry 106 and described above, this course offers a laboratory component with experiments that feature the use of forensic techniques to collect and analyze evidence including fingerprinting, drug analysis, alcohol investigation, DNA fingerprinting, and fiber analysis. Students attend three classes and one three-hour laboratory per week. Offered alternate years in the spring semester.

### CHEM 110: Introductory Chemistry Supplemental Instruction (0.25)

This course provides supplemental instruction for students in CHEM 121 and CHEM 126. Emphasis is on the development of study skills and successful learning strategies through focused activities, problem solving sessions, and discussion. Taught each semester.

**Prerequisite:** permission of instructor.

### CHEM 111: Chemistry and the World

Students explore aspects of chemistry that are encountered in the world. Basic concepts in chemistry, such as matter and bonding, acid/base chemistry, and solution chemistry, are discussed within the context of society at large. Laboratory experiences complement the class material, and students have opportunities to explore chemistry principles. Students attend three hours of class and one three-hour laboratory per week. Does not count toward the major. Offered annually in the spring semester.

**CHEM 121: General Chemistry**

This course provides a study of chemical stoichiometry and equilibrium at a level and pace appropriate to students with little or no background in chemistry. The combination of this course and CHEM 123 (offered during Interim) provides coverage of topics equivalent to those in CHEM 125. Students planning to continue in chemistry should consider concurrent registration in MATH 119 or MATH 120. Students attend three classes and one three-hour laboratory per week. Offered annually in the fall semester.

**CHEM 123: Atomic and Molecular Structure**

This course, a continuation of CHEM 121, examines atomic and molecular structure, including classical and quantum theories, bonding models, molecular orbitals and coordination chemistry. CHEM 121 and CHEM 123 together are equivalent in content to CHEM 125 and are designed to prepare students for CHEM 126. Offered during Interim.

**Prerequisite:** CHEM 121.

**CHEM 124: A Matter of the Environment with Lab**

Students study contemporary questions concerning the environment from the fundamental properties of matter to human impact on natural processes, including damage to and protection of the environment. Students discover how chemistry intersects with everyday living, especially the abilities and limitations of science to address environmental issues. Laboratory work explores the characteristics and analysis of hazardous and beneficial materials. Counts toward environmental studies major (arts and humanities and social science emphases) and concentration; does not count toward chemistry major. Offered during Interim.

**CHEM 125: Structural Chemistry and Equilibrium**

This study of chemical stoichiometry, equilibrium, acid-base chemistry, coordination chemistry, and atomic and molecular structure supplies the fundamental background on which all later chemistry courses depend. It includes applications of equilibrium principles to acid-base chemistry. Students attend three classes and one three-hour laboratory each week. Offered annually in the fall semester. Counts toward biomolecular science concentration.

**Prerequisites:** high school chemistry and physics. Students planning to continue in chemistry should consider concurrent registration in MATH 119 or MATH 120. Placement via online placement exam is required. The course cannot be taken in conjunction with or after credit in CHEM 121.

**CH/BI 125: Integrated Chem/Bio I: Chemical Concepts with Biological Applications**

This course introduces chemical concepts that are important for students pursuing a study of chemistry or biology. Topics include atomic structure, the periodic table, bonding interactions within and between particles, water and its solutions, biological membranes, chemical reaction types, chemical stoichiometry, equilibrium systems, acids and bases, introduction to protein structure. Examples are often pulled from the realm of biological molecules and processes. Students attend three classes and one three-hour laboratory each week. Placement via online placement exam is required. Offered annually in the fall semester.

**Prerequisites:** high school biology, chemistry, and physics; concurrent registration in MATH 119 or MATH 120 is recommended.

**CHEM 126: Energies and Rates of Chemical Reactions**

This course provides a sequential introduction to physical chemistry. Beginning with an introduction to statistical aspects of chemical equilibria, it explores the relationships between energy, entropy and equilibria (thermodynamics); oxidation-reduction reactions and electrochemistry; transitions between phases; and rates of reactions. Students attend three classes and one three-hour laboratory per week. Offered annually in the spring semester. Counts toward biomolecular science concentration.

**Prerequisite:** CHEM 125, or CHEM 121 and CHEM 123 and MATH 119 or MATH 120 or permission of instructor.

**CH/BI 126: Integrated Chem/Bio II: Thermodynamics and Kinetics with Bio Relevance**

This course introduces physical chemistry with an emphasis on thermodynamics and kinetics of biologically relevant systems. Topics include probability as the driving force for chemical reactions; the relationship between chemical bonding energetics, entropy, and equilibria; oxidation-reduction reactions and electrochemistry; and rates of reactions, including enzyme-catalyzed reactions. Laboratory experiments and activities illustrate lecture topics and introduce new concepts. Offered during Interim.

**Prerequisites:** CH/BI 125 and MATH 119 or MATH 120.

**CH/BI 227: Integrated Chem/Bio III: Molecular and Cellular Biology**

This course builds on the principles learned in Chemistry/Biology 125/126 and explores how chemistry informs major principles of cellular and molecular biology. Topics include cell structure, metabolism, movement, signaling, and division. The course emphasizes problem-solving, quantitative reasoning, the scientific method, and scientific writing through lectures, discussions, readings, writing assignments, and lab work. Students attend three classes and one three-hour laboratory each week. Counts toward "cell biology" core category for the Biology major. Offered annually in the spring semester.

**Prerequisite:** CH/BI 126.

**CHEM 247: Organic Chemistry I**

Organic chemistry is the study of compounds containing carbon, emphasizing the structures and mechanisms of reaction of these molecules. This course focuses on structure, nomenclature, and reactions of aliphatic and alicyclic compounds, including aspects of stereochemistry and spectroscopic identification of organic compounds. A full treatment of introductory organic chemistry requires subsequent enrollment in CHEM 248. Offered annually in the fall semester. Counts toward biomolecular science concentration.

**Prerequisite:** CHEM 126, or CH/BI 227, or permission of instructor.

**CHEM 248: Organic Chemistry II**

This course is a continuation of CHEM 247 topics. Chemistry 248 delves into the chemistry of functional groups, especially those that play a role in the reactivity of biomolecules such as carbohydrates, lipids, proteins, and nucleic acids. Together, CHEM 247 and CHEM 248 provide a full treatment of introductory organic chemistry. Offered annually in the spring semester. Counts toward environmental studies major (natural science emphasis) and biomolecular science concentration.

**Prerequisite:** CHEM 247 or permission of instructor.



**CHEM 252: Organometallic Chemistry**

Students study the structure, bonding, and reactions of compounds containing metal-carbon bonds. Special topics include applications of organometallic chemistry to the synthesis of organic compounds, homogeneous catalysis, and biochemistry. Examples illustrate organometallic chemistry as a bridge between organic and inorganic chemistry. Students use bibliographic and electronic searching software to prepare research papers based on the current literature. Offered during Interim.

**Prerequisite:** CHEM 247.

**CHEM 253: Synthesis Laboratory I (0.25)**

This laboratory course introduces students to the synthesis and characterization of organic, organometallic and inorganic compounds and serves as a general introduction to green chemistry. Students purify the materials they produce by techniques such as chromatography and characterize them using optical rotation measurements, infrared spectroscopy, and nuclear magnetic resonance spectroscopy. Students attend one three-hour laboratory each week. P/N only. Offered annually in the fall semester. Counts toward biomolecular science concentration.

**Prerequisite:** previous or concurrent registration in CHEM 247.

**CHEM 254: Synthesis Laboratory II (0.25)**

This course is a continuation of CHEM 253. Students gain more experience with techniques used in CHEM 253 and in addition use gas chromatographic/mass spectrometric analyses. Students attend one three-hour laboratory each week. P/N only. Offered annually in the spring semester. Counts toward environmental studies major (natural science emphasis) and biomolecular science concentration.

**Prerequisites:** CHEM 253 and previous or concurrent registration in CHEM 248.

**CHEM 255: Analytical Chemistry**

Students not only investigate the theory of modern analytical chemistry, but also examine the statistical treatment of errors, equilibrium, activities, acid/base chemistry, spectroscopy, electrochemistry, and separations. The accompanying lab course, CHEM 256, illustrates the topics discussed in CHEM 255. Students taking this course use computers for solving problems. Offered each semester. Counts toward environmental studies major (all emphases) and concentration.

**Prerequisites:** CHEM 126 or CH/BI 227 or permission of the instructor, and concurrent registration in CHEM 256.

**CHEM 256: Analytical Laboratory (0.25)**

Students enrolled in this lab course practice techniques of modern analytical chemistry using state-of-the-art instrumentation, including pH meters, liquid chromatographs, and a variety of spectrophotometers. Data acquisition via computer-interfaced instrumentation and electronic record-keeping is emphasized. Students practice and develop group skills by working in "companies" throughout the semester. P/N only. Offered each semester. Counts toward environmental studies major (all emphases) and concentration.

**Prerequisite:** concurrent registration in CHEM 255.

**CHEM 260: Medicinal Chemistry in Jamaica: An International Perspective (abroad)**

In this course students gain an appreciation for the drug development process, including how natural products are isolated, how their structures relate to activities, and how research into the mechanism of disease leads to the targeted development of drugs. Issues relating to medicinal chemistry in a developing-world context, medicinal plants, and the chemical basis of folk medicine are discussed. Offered alternate years during Interim. Counts toward biomedical studies concentration (for students through class of 2016).

**Prerequisites:** CHEM 248 and CHEM 254.

**CHEM 294: Academic Internship****CHEM 298: Independent Study****CHEM 357: Physical Laboratory (0.25)**

Students perform experiments that illustrate the principles of physical chemistry and utilize modern instrumentation. Students characterize the thermodynamic properties of a biopolymer, perform spectroscopic measurements of molecular energy levels, calculate quantum mechanical quantities using computer workstations, and investigate the thermodynamics and kinetics of chemical reactions. Students also develop their scientific writing skills by preparing reports in the style of scientific publications. P/N only. Offered each semester.

**Prerequisite:** concurrent registration in CHEM 371.

**CHEM 371: Physical Chemistry**

Students delve further into the topics of kinetics, thermodynamics and atomic and molecular structure that were introduced in the first-year courses, with an emphasis on the mathematical aspects of chemistry. Specific topics include reaction mechanisms, the laws of thermodynamics, statistical thermodynamics, equilibrium, quantum mechanics, spectroscopy, and molecular orbital theory. Offered each semester.

**Prerequisites:** CHEM 126 or CH/BI 227 or permission of instructor and concurrent registration in CHEM 357; previous completion of PHYS 124 or PHYS 130 is recommended.

**CHEM 373: Experimental Biochemistry (0.25)**

This lab course is highly recommended to enhance the study of biochemistry and as preparation for further research in biochemistry and related fields. The course focuses on the isolation, purification, manipulation, and characterization of proteins, DNA, and RNA. The course aims to provide continuity in experimentation that is investigative in nature. Emphasis is placed on the collection, interpretation, and presentation of data. P/N only. Offered each semester. Counts toward neuroscience and biomolecular science concentrations.

**Prerequisite:** previous or concurrent registration in CHEM 379.

**CHEM 374: Advanced Synthesis Laboratory (0.25)**

Building upon skills learned in CHEM 253 and CHEM 254, students perform multi-step syntheses that require the use of advanced techniques for the synthesis, purification and characterization of organic compounds. The second half of the course may focus on a project chosen by each student in consultation with the instructor. P/N only. Offered annually in the spring semester.

**Prerequisites:** CHEM 253 and CHEM 254.

**CHEM 375: Advanced Laboratory (0.25)**

Students work on special projects during one afternoon of laboratory per week. Each student must have the sponsorship of a staff member. P/N only. Offered each semester. May be repeated if topic is different.

**CHEM 378: Instrumental Analysis Laboratory (0.25)**

Students explore how instrumentation is used to study analytical applications, problem solving, and how people and instruments operate together to investigate chemical questions. Specific lab experiences include interfacing chemical instruments with computers and subsequent signal processing, mass spectrometry, electrochemistry, and various spectroscopic (AA, ICP, UV) and separation techniques. A laboratory robot is used for sample preparation and analysis. P/N only. Offered annually in the fall semester.

**Prerequisite:** concurrent registration in CHEM 382.

**CHEM 379: Biochemistry I**

This course presents fundamental biological processes at the molecular level and serves as a general introduction to biochemistry. Topics include the structure and function of proteins, carbohydrates, lipids and nucleic acids, enzyme catalysis and regulation, bioenergetics and an introduction to carbohydrate metabolism. Subsequent enrollment in CHEM 385 is recommended for students desiring greater breadth and depth in the subject. Offered each semester. Counts toward biology major and neuroscience and biomolecular science concentrations.

**Prerequisite:** CHEM 248.

**CHEM 380: Organic Analysis and Theory**

In the laboratory, students investigate and identify organic compounds, singly and in mixtures. Lectures and discussion sessions investigate various spectroscopic methods and their applications to the elucidation of the structure of organic compounds. Offered during Interim.

**Prerequisites:** CHEM 248 and CHEM 254.

**CHEM 382: Instrumental Analysis**

Students study how an instrument functions mechanically, mathematically, optically, and electronically, and then how its parts are linked together. Topics covered include basic electronics and computer interfacing, spectrophotometric instruments, mass spectrometers, electrochemical instrumentation, and various separation methods. Offered annually in the fall semester. Counts toward management studies concentration.

**Prerequisites:** CHEM 255 and CHEM 256; previous or concurrent enrollment in PHYS 125 or PHYS 131 is recommended; concurrent registration in CHEM 378 is required.

**CHEM 384: Bioanalytical Chemistry**

This course introduces the fundamentals of bioanalytical chemistry and the application of modern analysis techniques to biological samples. Current clinical applications and examples of biological problems supplement lecture material. Daily lectures are closely integrated with laboratory experiences. Topics include different types of chromatography used to separate biological mixtures in various ways, 1D- and 2D-gel electrophoresis, capillary electrophoresis, radiochemical and immunological assays, centrifugation techniques, and biological mass spectrometry. Offered alternate years during Interim. Counts toward biomolecular science concentration.

**Prerequisites:** CHEM 255 or CHEM 379 or permission of instructor.

**CHEM 385: Biochemistry II**

This course builds depth of biochemical understanding upon the foundation laid in CHEM 379. Contents may include selected topics in catabolic and anabolic metabolism, integration and regulation of metabolism, photosynthesis and biochemical genetics. In addition, students will gain experience with the primary literature. Offered annually in the spring semester. Counts toward biomolecular science concentration.

**Prerequisite:** CHEM 379.

**CHEM 386: Advanced Inorganic Chemistry**

This course examines how modern theories of chemical bonding are applied to an understanding of the chemistry of the elements of the periodic table. Students explore chemical structures and spectra on the basis of molecular symmetry and group theory. Topics covered include inorganic reactions, chemical periodicity, acid-base systems, coordination compounds, organometallic compounds, nonmetal chemistry, and cluster compounds. Offered annually in the spring semester.

**Prerequisite:** CHEM 248.

**CHEM 388: Advanced Organic Chemistry**

This course explores the subject of organic chemistry at a greater depth and breadth than in CHEM 247 and CHEM 248. Topics may include analysis of reaction mechanisms, reaction kinetics, and reaction thermodynamics. Particular attention is paid to the interdependent relationship between experimental and theoretical results. Textbook subjects are augmented by readings from the primary research literature. Offered alternate years in the spring semester.

**Prerequisite:** CHEM 248.

**CHEM 390: The Literature of Chemistry (0.25)**

Students explore the literature of chemistry in a seminar setting. Experience is gained in reading, discussing, and presenting chemistry-related results from the current scientific literature. Each section has a distinct topical focus selected by the chemistry faculty from suggestions made by junior chemistry majors during the spring of the previous year. P/N only. Open to senior chemistry majors only. Offered annually in the spring semester.

**CHEM 391: Selected Topics in Chemistry**

The field of chemistry is constantly expanding into new frontiers. This course provides an in-depth study of advanced topics that are chosen with attention to student interest and available staff. Recent topics include biophysical chemistry and environmental chemical analysis. Topics are announced prior to registration for the term; see the current class and lab schedule. May be repeated if topic is different. Counts toward environmental studies major (all emphases) and concentration when taught with environmental science focus and approved by chair.

**Prerequisite:** permission of instructor.

**CHEM 394: Academic Internship****CHEM 396: Directed Undergraduate Research**

This course provides a comprehensive research opportunity, including an introduction to relevant background material, technical instruction, identification of a meaningful project, and data collection. The topic is determined by the faculty member in charge of the course and may relate to his/her research interests. Offered based on department decision. May be offered as a 1.00 credit course or .50 credit course.

**Prerequisite:** determined by individual instructor.

**CHEM 398: Independent Research****Related Courses**

BMOLS 201 Explorations in Biomolecular Science (0.25)

ID 230 Communicating Science and Mathematics (0.25)

**Faculty****Chair, 2015-2016****Robert M. Hanson**

Professor of Chemistry  
Organic chemistry, stereoselectivity in organic synthesis, chemical informatics

**Beth R.J. Abdella**

Associate Professor of Chemistry  
bio-organic chemistry

**George K.A. Anquandah**

Visiting Assistant Professor of Chemistry  
analytical and environmental chemistry

**Douglas J. Beussman**

Professor of Chemistry  
analytical area - mass spectrometry; chemical instrumentation; proteomics; forensic science; bioanalytical

**Adam J. Dittmer**

Instructor in Chemistry

**Daniel A. Everson**

Visiting Assistant Professor of Chemistry

**Paul T. Jackson**

Associate Professor of Chemistry and Environmental Studies  
green chemistry; environmental chemistry; water quality; sustainability

**Dipannita Kalyani**

Assistant Professor of Chemistry  
organic and organometallic chemistry

**Laura L. Listenberger** (on leave)

Associate Professor of Biology and Chemistry  
lipid biochemistry; cell and molecular biology

**Gary L. Miessler**

Professor of Chemistry  
inorganic chemistry; organometallic chemistry; chemical education

**Gregory W. Muth**

Associate Professor of Chemistry  
biochemistry

**Carolyn Ocampo**

Instructor in Chemistry

**Wesley Pearson**

Professor of Chemistry  
Organic chemistry, reaction mechanisms and stereochemistry

**William P. Roberts**

Visiting Assistant Professor of Chemistry

**Rodrigo Sanchez-Gonzalez**

Assistant Professor of Chemistry  
physical chemistry; laser diagnostics; thermal non-equilibrium systems

**Jeffrey J. Schwinefus** (on leave fall and Interim)

Associate Professor of Chemistry  
physical and biophysical chemistry

**William C. Solomon**

Instructor in Chemistry  
structural biology; nuclear magnetic resonance spectroscopy; protein/nucleic acid interactions

**Mary Walczak**

Professor of Chemistry, Associate Dean of Natural Sciences and Mathematics  
Chemistry education, analytical and physical chemistry, surface science