CHEMISTRY

Chair: Mariusz M. Kozik, PhD

INTRODUCTION

Chemistry or Biochemistry graduates enter a variety of professions, including careers in research and industry, the health professions, teaching, technical writing, business, sales, patent law and civil service. A major in chemistry or biochemistry is an excellent preparation for entrance into medical, dental and pharmacy schools. It also prepares students to enter a range of graduate programs including chemistry, biochemistry, biotechnology, bioinformatics, medicinal chemistry, chemical engineering, environmental science, bioengineering, business and law.

The Department of Chemistry and Biochemistry offers three tracks that lead to a BS degree in Chemistry. They include the Chemistry track that is certified by the American Chemical Society (CHM ACS certified track), Chemistry Health Professions track, and Chemistry track designed for students who intend to pursue employment in industry.

Advisors in the Department will help you choose the track that best fits your interests and career plans. Students in all program tracks will gain hands-on experience with a wide variety of modern, sophisticated laboratory instrumentation; this helps provide the experience necessary to be competitive in today’s job market and/or to gain entrance into highly ranked graduate programs.

All Chemistry tracks can be completed with a business minor. This option provides a very useful preparation for employment in sales, marketing, or other industrial professions, as well as preparing students for graduate studies in business or administration.

Please go to the Chemistry and Biochemistry website (https://www.canisius.edu/academics/programs/chemistry-and-biochemistry) for a more detailed description of the program, faculty, facilities, and academic and co-curricular opportunities.

QUALIFICATIONS

Students must attain the grade of C or greater in General Chemistry II (CHM 112) and C- or greater in Organic Chemistry II (CHM 228) in order to progress into the major. Several two-semester courses (CHM 111 and CHM 112, CHM 227 and CHM 228, BCH 301 and BCH 302) have a requirement for a minimum grade of C- in the first course to continue with the second course.

ADVISEMENT

All students have an advisor in the major and should contact the department directly to have an advisor assigned if they do not already have one. Major advisors are assigned in the freshman year to provide specific major-related advisement in addition to the advisement provided by the student’s GRIF 101 facilitator. Meetings with academic advisors are required prior to students receiving their PIN for course registration each semester. All majors should work closely with their advisor in discussing career expectations, choosing their major electives, developing their entire academic program and planning their co-curricular or supplemental academic experiences.

SPECIAL PROGRAMS OFFERED BY THE DEPARTMENT

Early Assurance Program with University at Buffalo Medical School or Syracuse Medical School

Qualified students may apply to the University at Buffalo Medical School or Syracuse University Medical School during their sophomore year. Those accepted will be admitted into the Medical School freshman class after their graduation from Canisius.

Early Assurance Program with University at Buffalo Dental School

Qualified students may apply to the University at Buffalo Dental School during their sophomore year. Those accepted will be admitted into the Dental School freshman class after their graduation from Canisius.

Pre-Medical and Pre-Dental

The Chemistry and Biochemistry BS degrees are excellent preparations for entering into medical and dental schools, and a third of the graduates from this Department typically enter into these programs. Students applying to medical or dental schools must take the Medical College Admission Test (MCAT) or Dental Admission Test (DAT).

Pre-Pharmacy

For pre-pharmacy students we recommend the CHM Health Professions track, since students in this track can meet all pharmacy school entrance requirements. Students applying to most pharmacy schools must take the Pharmacy College Admission Test (PCAT).

MAJOR EXPERIENCES

Following their freshman year, and sometimes earlier, chemistry and biochemistry majors are encouraged to become involved in research or other professional projects. Stipends for qualified students are often available so that work can be done on these projects during the summer and school year in the Department. Summer work in industrial laboratories and research institutions is also available. Our close relationship with local industries and institutions aids students in job placement before and after graduation. Students may also choose to undertake industrial internships for advanced elective course credit.

DUAL MAJORS

Students who wish to expand their educational opportunities may decide to declare a dual major. The decision may be based on career goals or planned graduate studies. Before a student declares a dual major, it is important to meet with the appropriate academic departments for advisement. Some dual major combinations can be completed within the minimum 120 credit hour degree requirement, but in some cases additional course work may be required. In order to declare a dual major, the student must complete the appropriate dual major request form and get the signature of each department chairperson and the appropriate associate dean.

MINORS

Minors provide students the opportunity to pursue additional interests but generally do not require as many courses as a major. Minors generally range from five to eight required courses. The minors page (http://catalog.canisius.edu/archive/2016-2017/undergraduate/minors) provides a complete list of minors and provides links to each minor. Some majors and minors can be completed within the minimum 120 credit hour degree
requirement, but in some cases additional coursework may be required. Students must complete the appropriate minor request form.

**GENERAL EDUCATION REQUIREMENTS**

All undergraduate students must complete either the Canisius Core Curriculum (http://catalog.canisius.edu/archive/2016-2017/undergraduate/academics/curricular-information/core-curriculum) or the All-College Honors Curriculum (http://catalog.canisius.edu/archive/2016-2017/undergraduate/academics/curricular-information/all-college-honors-program).

**FREE ELECTIVES**

Free electives are courses in addition to the Core Curriculum or Honors Curriculum and major requirements sufficient to reach the minimum of 120 credit hours required for graduation. Students may graduate with more but not less than 120 credit hours.

**MAJOR REQUIREMENTS**

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CHM 111 &amp; 111L</td>
<td>General Chemistry I and General Chemistry I Laboratory</td>
<td>4</td>
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<tr>
<td>CHM 112 &amp; 112L</td>
<td>General Chemistry II and General Chemistry II Laboratory</td>
<td>4</td>
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<tr>
<td>CHM 227 &amp; 227L</td>
<td>Organic Chemistry I and Organic Chemistry I Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>CHM 228 &amp; 228L</td>
<td>Organic Chemistry II and Organic Chemistry II Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>CHM 230 &amp; 230L</td>
<td>Analytical Chemistry and Analytical Chemistry Laboratory</td>
<td>4</td>
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<td>CHM 244</td>
<td>Inorganic Chemistry</td>
<td>3</td>
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<td>CHM 301 &amp; 301L</td>
<td>Classical Physical Chemistry and Classical Physical Chemistry Laboratory</td>
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<td>Modern Physical Chemistry and Modern Physical Chemistry Laboratory</td>
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<td>BCH 301</td>
<td>Introduction to Biochemistry</td>
<td>3</td>
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<td>BCH 302</td>
<td>Cellular Biochemistry</td>
<td>3</td>
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<tr>
<td>CHM 381</td>
<td>Scientific Literature and Communication</td>
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<td>CHM 480</td>
<td>Communicating Concepts in Chemistry</td>
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<td>CHM 481</td>
<td>Communicating Research Literature</td>
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<td>Spectrometric Analysis and Spectrometric Analysis Lab</td>
<td>4</td>
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<td>CHM 420 &amp; 420L</td>
<td>Materials Chemistry and Materials Chemistry Laboratory</td>
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<td>CHM 430 &amp; 430L</td>
<td>Instrumental Analytical Chemistry and Instrumental Analytical Chemistry Laboratory</td>
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<tr>
<td>One year of physics:</td>
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**ACS certified track:**

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<th>Title</th>
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<tr>
<td>PHY 201 &amp; 201L</td>
<td>College Physics I and College Physics I Laboratory</td>
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<tr>
<td>PHY 202 &amp; 202L</td>
<td>College Physics II and College Physics II Laboratory</td>
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**Other CHM tracks:**

**Option 1:**

<table>
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<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>PHY 223 &amp; 223L</td>
<td>General Physics for Physical Science Majors I and General Physics for Physical Science Majors I Laboratory</td>
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</tr>
<tr>
<td>PHY 224 &amp; 224L</td>
<td>General Physics for Physical Science Majors II and General Physics for Physical Science Majors II Laboratory</td>
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**Option 2:**

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<td>General Physics for Physical Science Majors I and General Physics for Physical Science Majors I Laboratory</td>
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<td>PHY 224 &amp; 224L</td>
<td>General Physics for Physical Science Majors II and General Physics for Physical Science Majors II Laboratory</td>
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**One year of mathematics:**

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<td>MAT 112</td>
<td>Calculus II</td>
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**Health professions track:**

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<th>Credits</th>
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<tbody>
<tr>
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<td>Introductory Biology I and Introductory Biology Laboratory I</td>
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</tr>
<tr>
<td>BIO 112 &amp; 112L</td>
<td>Introductory Biology II and Introductory Biology Laboratory II</td>
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**Total Credits:**

72-76

1. Lab not required for the Health Professions track
2. Required only for the ACS certified track
3. Required only by the Health Professions track
4. Not required by the Health Professions track
5. Note: Most pharmacy schools require MAT 111 and MAT 141. Some pharmacy schools require MAT 111, MAT 112, and MAT 141.
6. Note: Most pharmacy schools require BIO 111/BIO 111L and BIO 112/BIO 112L, Microbiology (3), and one year of Anatomy and/or Physiology (6).

**MAJOR ELECTIVES**

Two or three major electives are required by each track.

**CHM ACS certified track requires:**

- two chemistry electives (6 credits)

**CHM track requires:**

- three chemistry electives (6 credits)

**CHM Health Professions track requires:**

- one chemistry elective with lab (4 credits)
- one science elective with lab (4 credits)
- one science elective (3 credits)

Science electives may come from CHM and BCH or from other science departments (BIO, PHY, CSC, MAT). BCH 450 or CHM 450 Research in Biochemistry or Chemistry (3 credits) and BCH 451 or CHM 451 Research in Biochemistry or Chemistry (4 credits) can be taken instead of one advanced elective in biochemistry or chemistry.

### ADDITIONAL COURSE CONSIDERATIONS

MAT 211 is highly recommended for students interested in pursuing a PhD degree. In addition, MAT 219 and MAT 222 are highly recommended for students interested in pursuing a PhD degree in physical, inorganic, or analytical chemistry.

### RECOMMENDED SEMESTER SCHEDULE FOR MAJOR COURSE REQUIREMENTS

#### CHM ACS Certified Track

<table>
<thead>
<tr>
<th>Class</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
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<tr>
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<td>CHM 227 &amp; 227L</td>
<td>CHM 301 &amp; 301L</td>
<td>CHM 334 &amp; 334L</td>
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<td></td>
<td>BIO 111 &amp; 111L</td>
<td>PHY 224 &amp; 224L</td>
<td>CHM 381 &amp; CHM Elective</td>
<td>BCH 301 &amp; CHM 481</td>
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<td>MAT 111</td>
<td>CHM 244</td>
<td>CHM 420 &amp; 420L</td>
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<td>&amp; 223L</td>
<td>&amp; 230L</td>
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#### CHM Track

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<td>MAT 111</td>
<td>CHM 244</td>
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<td>CHM 112</td>
<td>CHM 228 &amp; 228L</td>
<td>CHM Elective</td>
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<td>&amp; 112L</td>
<td>&amp; 228L</td>
<td>CHM 480</td>
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<td>CHM 301 &amp; 301L</td>
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<td>&amp; 223L</td>
<td>&amp; 230L</td>
<td>ACC 201</td>
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#### CHM ACS Certified Track with Business Minor

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<th>Junior</th>
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<tr>
<td>Fall</td>
<td>CHM 111 &amp; 111L</td>
<td>CHM 227 &amp; 227L</td>
<td>CHM 301 &amp; 301L</td>
<td>CHM 334 &amp; 334L</td>
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<td>PHY 224 &amp; 224L</td>
<td>CHM 381 &amp; CHM Elective</td>
<td>BCH 301 &amp; CHM 481</td>
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<td>MAT 111</td>
<td>CHM 244</td>
<td>CHM 420 &amp; 420L</td>
<td>CHM 481</td>
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<td>CHM 112</td>
<td>CHM 228 &amp; 228L</td>
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<td>&amp; 112L</td>
<td>&amp; 228L</td>
<td>CHM 480</td>
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<td>CHM 301 &amp; 301L</td>
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<td>&amp; 223L</td>
<td>&amp; 230L</td>
<td>ACC 201</td>
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</table>
CHM 481

CHM Track with Business Minor

Freshman

Fall
CHM 111 & 111L
BIO 111 & 111L
MAT 111

Sophomore

Fall
CHM 227 & 227L
PHY 201 & 201L

Junior

Fall
BCH 301
CHM 244
ECO 101

Senior

Fall
CHM 301 & 301L
CHM 334 & 334L
CHM 481
ACC 201
MKT 201

CHM Health Professions Track

Freshman

Fall
CHM 111 & 111L
BIO 111 & 111L
MAT 111

Sophomore

Fall
CHM 227 & 227L
PHY 201 & 201L

Junior

Fall
BCH 301
CHM 244

Senior

Fall
CHM 301 & 301L

CHM Health Professions Track with Business Minor

Freshman

Fall
CHM 111 & 111L
BIO 111 & 111L
MAT 111

Sophomore

Fall
CHM 227 & 227L
PHY 201 & 201L

Junior

Fall
BCH 301

Senior

Fall
CHM 301 & 301L

LEARNING GOALS AND OBJECTIVES

Student Learning Goal 1:
Knowledge: Department majors will demonstrate an understanding of fundamental chemical concepts. Students will:

- Objective A (Concepts): Demonstrate broad knowledge of chemical concepts;
- Objective B (Reactions): Predict and analyze the effects of chemical changes;
- Objective C (Derivations): Manipulate expressions of chemical quantities to derive higher-order relationships;
- Objective D (Safety): Demonstrate knowledge of chemical, instrumental and workplace safety.
Student Learning Goal 2:
Professional Skills; Department majors will be able to work effectively in a professional or laboratory setting. Students will:

- Objective A (Scientific Literacy): Identify, access and use chemical literature sources;
- Objective B (Scientific Method): Define chemical problems, then formulate hypotheses and design experiments to address them;
- Objective C (Laboratory Skills): Carry out experiments (follow directions, manipulate materials and lab apparatus, record data);
- Objective D (Laboratory Instrumentation): Use modern instrumentation (prepare samples, operate systems, troubleshoot common problems, organize and label data).

Student Learning Goal 3:
Communication; Department majors will be proficient in the communication of chemical information. Students will:

- Objective A (Oral Communication): Construct and deliver an effective oral presentation;
- Objective B (Written Communication): Write an effective, properly formatted scientific report.

Students majoring in various disciplines such as biology, mathematics, physics, bioinformatics, computer science, psychology and business can benefit from pursuing a minor in chemistry. The chemistry minor requires a student to complete the following sequence of courses:

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<thead>
<tr>
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<th>Course Title</th>
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<tbody>
<tr>
<td>CHM 111 &amp; 111L</td>
<td>General Chemistry I and General Chemistry I Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>CHM 112 &amp; 112L</td>
<td>General Chemistry II and General Chemistry II Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>CHM 227 &amp; 227L</td>
<td>Organic Chemistry I and Organic Chemistry I Laboratory</td>
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</tr>
<tr>
<td>CHM 228 &amp; 228L</td>
<td>Organic Chemistry II and Organic Chemistry II Laboratory</td>
<td>4</td>
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</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CHM 230 &amp; 230L</td>
<td>Analytical Chemistry and Analytical Chemistry Laboratory</td>
<td>4</td>
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<td>CHM 334 &amp; 334L</td>
<td>Spectrometric Analysis and Spectrometric Analysis Lab</td>
<td>4</td>
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<tr>
<td>CHM 430 &amp; 430L</td>
<td>Instrumental Analytical Chemistry and Instrumental Analytical Chemistry Laboratory</td>
<td>4</td>
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Select one of the following:

- CHM 244 Inorganic Chemistry
- CHM 301 Classical Physical Chemistry

Select one of the following:

- CHM 300 or 400 level course

Total Credits: 20

CHM 104 Energy, Environment, and Society 3 Credits
Designed to provide a better understanding of energy and our environment, including man's interaction with his environment and the consequences facing society today. This course satisfies the goals and objectives of Field 6, Natural Sciences.

Fulfills College Core: Field 6 (Natural Sciences)
Offered: every fall.

CHM 109 General Chemistry I with Review - Part I 3 Credits
General Chemistry I for science majors, Part I, three lectures and one recitation per week. This course reviews some mathematical concepts, emphasizes dimensional analysis, nomenclature, stoichiometry, solutions, basic chemical reactions, and thermochemistry. This course satisfies the goals and objectives of Field 6, Natural Sciences.

Fulfills College Core: Field 6 (Natural Sciences)
Offered: every fall.

CHM 110 General Chemistry I with Review - Part II 3 Credits
General Chemistry I for science majors, Part II, three lectures, one laboratory, and one recitation per week. This course emphasizes atomic and molecular structure, periodic properties, gas laws, and states of matter. The CHM 109 and CHM 110 sequence is equivalent to CHM 111 and a free elective. Students completing the CHM 109 and CHM 110 sequence are eligible to take CHM 112 in the fall of their sophomore year or during the summer. A minimum grade of C- in CHM 110 is required for both CHM 112 (General Chemistry II) and CHM 227 (Organic Chemistry I).

Prerequisite: minimum grade of C- in CHM 109. Corequisite: CHM 111L.
Offered: every spring.

CHM 111 General Chemistry I 3 Credits
General Chemistry I for science majors, three lectures, one laboratory, and one recitation per week. This course is recommended for students with a very good background in mathematics and significant exposure to high school chemistry. The course emphasizes dimensional analysis, nomenclature, stoichiometry, solutions, basic chemical reactions, thermochemistry, atomic and molecular structure, periodic properties, gas laws, and states of matter. A minimum grade of C- in CHM 111 is a prerequisite for both CHM 112 (General Chemistry II) and CHM 227 (Organic Chemistry I). This course satisfies the goals and objectives of Field 6, Natural Sciences.

Prerequisite: minimum score of 580 in MSAT or permission of instructor.
Corequisite: CHM 111L.
Fulfills College Core: Field 6 (Natural Sciences)
Offered: every fall.

CHM 111L General Chemistry I Laboratory 1 Credit
One three-hour lab per week.
Corequisite: CHM 110 or CHM 111.
Offered: every fall.

CHM 112 General Chemistry II 3-4 Credits
General Chemistry II for science majors, three lectures, one laboratory, and one recitation per week. The course emphasizes properties of solutions, kinetics, chemical equilibrium concepts, calculations involving acid/base and precipitation equilibria, thermodynamics, electrochemistry, nuclear chemistry, and chemistry of the environment. A minimum grade of C in CHM 112 is required for all chemistry and biochemistry majors. This course satisfies the goals and objectives of Field 6, Natural Sciences.

Prerequisite: minimum grade of C- in either CHM 110 or CHM 111.
Corequisite: CHM 112L.
Fulfills College Core: Field 6 (Natural Sciences)
Offered: every fall & spring.

CHM 112L General Chemistry II Laboratory 1 Credit
One three-hour lab per week.
Corequisite: CHM 112.
Offered: every fall & spring.
CHM 227 Organic Chemistry I  
Natural treatment of organic chemistry. Includes bonding, structure, nomenclature and stereochemistry of organic functional groups. Introduces mechanisms and reactivity in substitution and elimination reactions. Laboratory covers techniques of separation, purification and analysis of organic compounds. Three lectures, one laboratory, and one recitation per week.  
Prerequisite: minimum grade of C- in either CHM 110 or CHM 112.  
Corequisite: CHM 227L.  
Offered: every fall.

CHM 227L Organic Chemistry I Laboratory  
One three-hour lab per week.  
Prerequisite: minimum grade of C- in CHM 111L. Corequisite: CHM 227.  
Offered: every fall.

CHM 228 Organic Chemistry II  
Fundamental treatment of organic chemistry. Includes chemistry and reaction mechanisms of unsaturated compounds, and oxygen and nitrogen-containing functional groups. Introduces the organic chemistry of carbohydrates, lipids and peptides. Laboratory expands on techniques for the synthesis, purification and investigation of the chemical properties of organic compounds. Three lectures, one laboratory, and one recitation per week.  
Prerequisite: minimum grade of C- in CHM 227. Corequisite: CHM 228L.  
Offered: every spring.

CHM 228L Organic Chemistry II Laboratory  
One three and a half-hour lab per week.  
Prerequisite: minimum grade of C- in CHM 227L. Corequisite: CHM 228.  
Offered: every spring.

CHM 230 Analytical Chemistry  
Principles and methodology of modern analytical chemistry presented with particular emphasis on statistical error analysis, solution equilibrium, and potentiometry. Three lectures, one laboratory, and one recitation per week.  
Prerequisite: minimum grade of C in CHM 112. Corequisite: CHM 230L.  
Offered: every spring.

CHM 230L Analytical Chemistry Laboratory  
One four-hour lab per week.  
Corequisite: CHM 230.  
Offered: every spring.

CHM 232 Environmental Analytical Chemistry  
Environmental applications of analytical chemistry. Sampling techniques and statistical analysis of data. Soil chemistry, aquatic chemistry and atmospheric chemistry. Trace analysis with electroanalytical, liquid and gas chromatography, atomic absorption spectroscopy and ion selective electrodes. Three lectures, one laboratory and one recitation per week.  
Prerequisite: CHM 112. Corequisite: CHM 232L.  
Offered: spring 2017.

CHM 232L Environmental Analytical Chemistry Laboratory  
One four-hour lab per week.  
Prerequisite: CHM 112L. Corequisite: CHM 232.  
Offered: spring 2017.

CHM 244 Inorganic Chemistry  
Electronic configuration of atoms, periodic classification of the elements, nature of chemical bonding, symmetry and application of group theory to molecular orbitals, structures and thermodynamics of solids, bonding in metals and semiconductors, acid/base concepts, electrochemistry, isomerism, bonding, reactions and spectroscopy of coordination compounds, and other aspects of modern inorganic chemistry. Three lectures and one recitation per week.  
Prerequisite: minimum grade of C in CHM 112.  
Offered: every fall.

CHM 301 Classical Physical Chemistry  
Principles of thermodynamics with applications to phase and chemical equilibria. Kinetic theory of gases and chemical kinetics. Three lectures and one recitation per week.  
Prerequisite: minimum grade of C in CHM 112, successful completion of MAT 111 or MAT 110, and a year of physics (PHY 201 & PHY 202 or PHY 223 & PHY 224).  
Offered: every fall.

CHM 302 Modern Physical Chemistry  
Introduction to quantum chemistry with applications to the structure of atoms and molecules. Molecular spectroscopy. Three lectures and one recitation per week.  
Prerequisite: minimum grade of C in CHM 112, successful completion of MAT 111 or MAT 110; MAT 112; and a year of physics (PHY 201 & PHY 202 or PHY 223 & PHY 224).  
Offered: every fall.

CHM 302L Modern Physical Chemistry Laboratory  
Selected experiments demonstrating principles of thermodynamics and chemical kinetics. One four-hour lab per week.  
Prerequisite: minimum grade of C in CHM 230L & C in CHM 301 (or concurrent registration in CHM 301).  
Fulfills College Core: Advanced Writing-Intensive  
Offered: every fall.

CHM 303 Intermediate Organic Chemistry  
Important basic concepts in organic chemistry are reviewed at a higher level than is possible in the introductory courses. New concepts are presented in the areas of reaction mechanisms, frontier molecular orbitals, physical organic chemistry, and in stereoelectronic effects.  
Prerequisite: CHM 228.  
Offered: fall 2017.
CHM 344 Metal Ions in Biological Systems 3 Credits
Chemical processes in biological systems, which include participation of metal ions, are covered. The course begins with the principles of coordination chemistry and structural biochemistry. The rest of the course is organized according to the functions performed by the metal centers: gene expression and signal transduction, digestion, bioenergetics and electron transfer, oxygen transport, liver functions and anticancer drugs.
Prerequisite: CHM 228.
Offered: occasionally in spring.

CHM 381 Scientific Literature and Communication 1 Credit
First of three student-faculty seminars for majors. Introduces scientific literature, technical writing and oral communication in chemistry and allied fields.
Prerequisite: CHM 228 & junior standing.
Offered: every fall.

CHM 401 Modern Synthetic Methods 3 Credits
Structure-reactivity relationships in organometallic chemistry and the application of organometallic compounds in organic synthesis, including industrial catalysis.
Prerequisite: CHM 228 & CHM 244.
Offered: occasionally in spring.

CHM 401L Modern Synthetic Methods Laboratory 1 Credit
Designed to illustrate some of the most important synthetic and physical techniques used by modern synthetic chemists.
Prerequisite: CHM 401 (or concurrent registration).
Offered: occasionally in spring.

CHM 402 Advanced Physical Chemistry 3 Credits
Introduction to statistical thermodynamics. Applications of group theory to chemical bonding and molecular spectroscopy. Angular momentum coupling in atomic and molecular spectroscopy. Three lectures per week.
Prerequisites: MAT 111 & MAT 112; CHM 244; CHM 302 (may be taken concurrently); and either PHY 201 & PHY 202 or PHY 223 & PHY 224.
Offered: Spring 2017.

CHM 420 Materials Chemistry 3 Credits
A survey of topics and applications in modern materials chemistry including solid state materials, semiconductors, polymers, nanomaterials, and introductions to mechanical properties, device fabrication, and structure-activity relationships.
Prerequisite: CHM 228 & CHM 244 (or concurrent registration in CHM 244). Corequisite: CHM 420L.
Offered: fall 2016.

CHM 420L Materials Chemistry Laboratory 1 Credit
One four-hour lab per week.
Prerequisite: CHM 228L. Corequisite: CHM 420.
Offered: fall 2016.

CHM 430 Instrumental Analytical Chemistry 3 Credits
Advanced instrumental methods of analysis including spectroscopy, chromatography and various electrochemical techniques. Three lectures and one laboratory per week.
Prerequisite: CHM 112 & CHM 228 (or concurrent registration in CHM 228).
Offered: every spring.

CHM 430L Instrumental Analytical Chemistry Laboratory 1 Credit
One four-hour lab per week.
Prerequisite: CHM 112L & CHM 228L (or concurrent registration in CHM 228L). Corequisite: CHM 430.
Offered: every spring.

CHM 450 Research in Chemistry 3 Credits
Independent research under the direction of the chemistry faculty. Students are required to spend 9 hours per week conducting research. CHM 450 may be taken in place of a chemistry elective without lab. Research and consultation times to be arranged after approval of department chair.
Prerequisite: permission of department chair.
Offered: fall & spring.

CHM 451 Research in Chemistry 4 Credits
Independent research under the direction of the chemistry faculty. Students are required to spend 12 hours per week conducting research. CHM 451 may be taken in place of a chemistry elective with lab. Research and consultation times to be arranged after approval of department chair.
Prerequisite: permission of department chair.
Offered: fall & spring.

CHM 455 Medicinal Chemistry 3 Credits
Chemical principles are used to explain the interaction of drugs with biological targets. Strategies used in the design and development of medicines are discussed.
Prerequisite: minimum grade of C- in both CHM 228 & BCH 301.
Offered: spring 2017.

CHM 480 Communicating Concepts in Chemistry 1 Credit
Second of three student-faculty seminars for majors. Students give a 25-minute presentation on an advanced coursework topic. Emphasis is placed on the process and the mechanics of constructing a scientific talk.
Prerequisite: CHM 228 & junior standing.
Offered: every spring.

CHM 481 Communicating Research Literature 1 Credit
Third of three student-faculty seminars for majors. Students give a 45-minute presentation on a scientific work from the chemical literature. Emphasis is placed on constructing a narrative and gaining a working understanding of the scientific issues in the presented paper.
Prerequisite: CHM 228 & junior standing.
Fulfills College Core: Oral Communication
Offered: every fall.

CHM 490 Chemistry Internship 3 Credits
Internships in chemical or biochemical industry under the direction of company and faculty supervisors.
Prerequisite: permission of department chair & associate dean.
Offered: fall & spring.

CHM 499 Independent Study 3-4 Credits
Independent study under the direction of the chemistry faculty. Independent studies require an application and approval by the associate dean.
Prerequisite: permission of the instructor, department chair, & associate dean.
Offered: fall & spring.