Chemistry

Department Website: http://chemistry.uchicago.edu/kb

PROGRAM OF STUDY

Chemistry is concerned with the preparation, composition, and structure of matter and with the equilibrium and kinetic laws that govern its transformations. The BA and BS degrees in Chemistry are designed to provide a broad foundation in the three principal branches of the science: inorganic, organic, and physical chemistry. Analytical chemistry, often regarded as an independent branch, is incorporated into the program. Both curricula discuss experimental and theoretical work and emphasize their interdependence. Both degree programs prepare the student for a career in chemistry. However, the BS degree offers a more intensive program of study. The BA degree also offers thorough study in the field of chemistry, but it provides a wide opportunity for elective freedom and for the pursuit of interdisciplinary interests in areas such as biochemistry, biophysics, chemical physics, geochemistry, premedicine, and education, as well as the ability to double major with many other departments in a straightforward way.

PROGRAM REQUIREMENTS

The principal distinction between the BA and BS programs is the number of Chemistry courses required.

Program Requirements: BA A minimum of eight courses in Chemistry beyond the general education requirement (which should be taken in the first year) is required for the BA degree.

Program Requirements: BS A minimum of twelve courses in Chemistry beyond the general education requirement (which should be taken in the first year) is typically required for the BS degree.

Please note that while the lower course requirement for the BA degree makes double majoring with many other programs of study feasible, double majoring with a BA and BS both in Chemistry is not allowed, as the BA in Chemistry is contained within the BS degree. Students who wish to double major with a BS in Biological Chemistry and a BA in Chemistry must fulfill the 30000-level Biochemistry course requirements in a Chemistry 30000-level course.

SUMMARY OF REQUIREMENTS: BA IN CHEMISTRY

GENERAL EDUCATION

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 11100-11200</td>
<td>200</td>
</tr>
<tr>
<td>One of the following sequences:</td>
<td></td>
</tr>
<tr>
<td>MATH 15100-15200</td>
<td>200</td>
</tr>
<tr>
<td>MATH 16100-16200</td>
<td>200</td>
</tr>
<tr>
<td>MATH 13100-13200</td>
<td>200</td>
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</table>

Total Units: 400

MAJOR

One of the following: 5*

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 11300</td>
<td>100</td>
</tr>
<tr>
<td>CHEM 12300</td>
<td>100</td>
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One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 18300</td>
<td>200</td>
</tr>
<tr>
<td>MATH 19620</td>
<td>200</td>
</tr>
<tr>
<td>MATH 20250</td>
<td>200</td>
</tr>
<tr>
<td>MATH 18400 &amp; MATH 18500</td>
<td>200</td>
</tr>
<tr>
<td>PHYS 13100-13200-13300</td>
<td>300</td>
</tr>
<tr>
<td>CHEM 20100</td>
<td>100</td>
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One of the following sequences:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 22000-22100-22200</td>
<td>300</td>
</tr>
<tr>
<td>CHEM 23000-23100-23200</td>
<td>300</td>
</tr>
<tr>
<td>CHEM 26100 &amp; CHEM 26200</td>
<td>200</td>
</tr>
</tbody>
</table>

5* Courses required beyond the general education requirement.
## SUMMARY OF REQUIREMENTS: BS IN CHEMISTRY

### GENERAL EDUCATION

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 11100-11200</td>
<td>Comprehensive General Chemistry I-II †‡</td>
<td>200</td>
</tr>
<tr>
<td>One of the following sequences:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH 15100-15200</td>
<td>Calculus I-II</td>
<td>200</td>
</tr>
<tr>
<td>MATH 16100-16200</td>
<td>Honors Calculus I-II</td>
<td></td>
</tr>
<tr>
<td>MATH 13100-13200</td>
<td>Elementary Functions and Calculus I-II (requires a grade of A- or higher)</td>
<td></td>
</tr>
</tbody>
</table>

Total Units: 400

### MAJOR

One of the following: †*

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 11300</td>
<td>Comprehensive General Chemistry III</td>
</tr>
<tr>
<td>CHEM 12300</td>
<td>Honors General Chemistry III</td>
</tr>
<tr>
<td>MATH 18300-18400-18500</td>
<td>Mathematical Methods in the Physical Sciences I-II-III</td>
</tr>
<tr>
<td>CHEM 20100-20200</td>
<td>Inorganic Chemistry I-II</td>
</tr>
<tr>
<td>PHYS 13100-13200-13300</td>
<td>Mechanics; Electricity and Magnetism; Waves, Optics, and Heat (or higher)</td>
</tr>
<tr>
<td>CHEM 22000-22100-22200</td>
<td>Organic Chemistry I-II-III</td>
</tr>
<tr>
<td>CHEM 23300</td>
<td>Intermediate Organic Chemistry</td>
</tr>
<tr>
<td>CHEM 26100-26200-26300</td>
<td>Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics</td>
</tr>
<tr>
<td>CHEM 26700</td>
<td>Experimental Physical Chemistry</td>
</tr>
</tbody>
</table>

One of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
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</thead>
<tbody>
<tr>
<td>CHEM 22700</td>
<td>Advanced Organic/Inorganic Laboratory</td>
</tr>
<tr>
<td>CHEM 26800</td>
<td>Quantum Molecular and Materials Modeling</td>
</tr>
</tbody>
</table>

Total Units: 1800

† Credit may be granted by examination.

* See following sections on Advanced Placement and Accreditation Examinations.

‡ CHEM 10100-10200 Introductory General Chemistry I-II and CHEM 12100-12200 Honors General Chemistry I-II also satisfy this requirement. Enrollment into a particular sequence is based on chemistry placement or AP score.

NOTE: The sequence MATH 18300-18400-18500 Mathematical Methods in the Physical Sciences I-II-III is the recommended course of study for Chemistry majors. Students who switch into the major later in their studies may also substitute MATH 15300/16300, MATH 19620, MATH 20250, or STAT 24300 for MATH 18300. Students who wish to double major or minor in Mathematics may consider alternative substitutions. The three-quarter sequence MATH 20300-20400-20500 Analysis in Rn I-II-III or the honors variation of this sequence (MATH 20700-20800-20900 Honors Analysis in Rn I-II-III) may be substituted for MATH 18400-MATH 18500 Mathematical Methods in the Physical Sciences II-III; please note that MATH 20250 Abstract Linear Algebra or STAT 24300 Numerical Linear Algebra is a prerequisite for MATH 20400. MATH 18600 Mathematics of Quantum Mechanics is recommended for Chemistry majors who plan to pursue advanced study in physical chemistry.

Optional Chemistry Advanced Placement Exams

First-year and transfer students with a strong Chemistry background (i.e. those that score an AP 5 or equivalent) may, after consultation and approval from the Director of Undergraduate Studies, take an advanced placement exam to qualify to be directly placed into more advanced courses such as CHEM 22000 Organic Chemistry I, CHEM 20100 Inorganic Chemistry I, or CHEM 26100 Quantum Mechanics. If a student is approved to pursue this option, they may substitute quality grades earned in any three of the following courses for their required General Chemistry course credit: CHEM 23300 Intermediate Organic Chemistry, CHEM 26100-26200-26300 Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics, CHEM 20100-20200 Inorganic Chemistry I-II, CHEM 26700 Experimental Physical Chemistry, CHEM 22700 Advanced Organic/Inorganic Laboratory, or CHEM 26800 Quantum Molecular and Materials Modeling. This advanced placement track may fast-track well-prepared students who wish to advance their studies into the various subfields of Chemistry, those who wish to double major or minor in Chemistry, or non-Chemistry majors who wish to enroll in advanced courses that require General Chemistry as a prerequisite.
Advanced Placement Credit

Students who earn a score of 5 on the AP exam in chemistry are given credit for CHEM 11100 Comprehensive General Chemistry I. Students with CHEM 11100 Comprehensive General Chemistry I credit may join CHEM 11200 Comprehensive General Chemistry II in the Winter Quarter. A score of 5 on the AP exam also permits students to take CHEM 12100-12200-12300 Honors General Chemistry I-II-III; students may opt to begin with CHEM 12100 Honors General Chemistry I in the Autumn Quarter or CHEM 12200 Honors General Chemistry II in the Winter Quarter. Students who complete the first quarter of Comprehensive General Chemistry or Honors General Chemistry forgo the AP credit. Note that no credit is given for IB chemistry, but students may pursue the Advanced Placement option described above.

Grading

Students majoring in Chemistry must earn (1) a major GPA of 2.0 or higher and (2) a C- or higher in all courses required by the Chemistry major, including those courses counting toward general education requirements in the mathematical and physical sciences. Nonmajors may take chemistry courses on a P/F basis; only grades of C- or higher constitute passing work.

Undergraduate Research and Honors

Students majoring in Chemistry are strongly encouraged to participate in research with a faculty member. For more information on research opportunities, visit chemistry.uchicago.edu/kb (http://chemistry.uchicago.edu/kb/).

Excellent students who pursue a substantive research project with a faculty member of the Department of Chemistry should plan to submit an honors thesis based on their work. Honors thesis work constitutes a sustained and in many cases multi-year project, with students typically beginning no later than their third year and continuing through the following summer and their fourth year. Students who wish to be considered for honors are expected to complete their arrangements with the departmental counselor before the end of the third year and to register for one quarter of CHEM 29900 Advanced Research in Chemistry or one year of CHEM 29600 Research in Chemistry during their third or fourth years.

To be eligible to receive honors, students in the BA or BS degree program in Chemistry must write a creditable honors paper describing their research. The paper must be submitted before the deadline established by the departmental counselor and must be approved by the Department of Chemistry. In addition, an oral presentation of the research is required. The research paper or project used to meet this requirement may not be used to meet the BA paper or project requirement in another major.

To earn a BA or BS degree with honors in Chemistry, students must also have an overall GPA of 3.0 or higher.

Sample Program

The following is a suggested schedule for completing a BA or BS degree in Chemistry:

First Year

CHEM 10100-CHEM 10200-CHEM 11300 Introductory General Chemistry I-II + Comprehensive General Chemistry III, or CHEM 11100-11200-11300 Comprehensive General Chemistry I-II-III, or CHEM 12100-12200-12300 Honors General Chemistry I-II-III

MATH 15100-15200-15300 Calculus I-II-III or equivalent

Second Year

CHEM 22000-22100-22200 Organic Chemistry I-II-III

MATH 18400 Mathematical Methods in the Physical Sciences II and MATH 18500 Mathematical Methods in the Physical Sciences III

Physics sequence (three quarters)

Third Year

CHEM 26100-26200-26300 Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics (if physics is taken in the second year)

CHEM 26700 Experimental Physical Chemistry

CHEM 20100 Inorganic Chemistry I

CHEM 20200 Inorganic Chemistry II, CHEM 23300 Intermediate Organic Chemistry, or CHEM 26300 Chemical Kinetics and Dynamics (for BS)

Fourth Year
CHEM 26100-26200-26300 Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics (if physics taken in the third year)
CHEM 26700 Experimental Physical Chemistry
CHEM 23300 Intermediate Organic Chemistry or CHEM 26300 Chemical Kinetics and Dynamics (for BS)
CHEM 22700 Advanced Organic/Inorganic Laboratory or CHEM 26800 Quantum Molecular and Materials Modeling (for BS)

JOINT DEGREE PROGRAMS

Students who achieve advanced standing through their performance on placement examinations or accreditation examinations may consider the formulation of a four-year degree program that leads to the concurrent award of the BS and MS degrees in Chemistry (http://collegecatalog.uchicago.edu/thecollege/jointdegreechem/). For more information, consult John Anderson at jsanderson@uchicago.edu and Vera Dragisich at vdragisi@uchicago.edu in the Department of Chemistry.

Laboratory Safety

In chemistry labs, safety goggles must be worn at all times. Students who require prescriptive lenses may wear prescription glasses under goggles; contact lenses may not be worn. Exceptions for medical reasons must be obtained from the lab director.

MINOR IN CHEMISTRY

Before a student can declare the minor in Chemistry, the student must complete the general education requirements in Chemistry. A student must receive the director of undergraduate studies’ approval for the minor program; this is done through the Consent to Complete a Minor Program (https://humanities-web.s3.us-east-2.amazonaws.com/college-prod/s3fs-public/documents/Consent_Minor_Program.pdf) form, which can be obtained from the student’s College adviser. Once signed by the director, this form must then be returned to the student’s College adviser by the end of Spring Quarter of the student’s third year.

To earn the minor in Chemistry, a student must complete five courses as outlined below. All lecture courses in the 20000 level (or above) in Chemistry can be used as electives for the minor; the student has to make sure that prerequisites for the chosen courses are fulfilled. Before meeting with the director, students should invest some thought into which courses they would like to complete for the minor and how those courses relate as a set.

Courses in the minor program may not be (1) double counted with the student’s major(s) or with other minors, or (2) counted toward general education requirements. Courses in the minor must be taken for quality grades, and more than half of the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers. Students minoring in Chemistry must earn (1) a minor GPA of 2.0 or higher and (2) a C– or higher in all courses required by the Chemistry minor.

SUMMARY OF REQUIREMENTS: MINOR IN CHEMISTRY

One of the following

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>CHEM 11300</td>
<td>Comprehensive General Chemistry III</td>
</tr>
<tr>
<td>CHEM 12300</td>
<td>Honors General Chemistry III</td>
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Four additional 20000-level (or higher) courses in Chemistry

Total units

* If this course is already counted toward the student’s major, a 20000-level (or higher) Chemistry course can be used as a substitution for this requirement.

Below are some examples of courses that would work as a set:

1. Organic Chemistry Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CHEM 22000</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>CHEM 22100</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>CHEM 22200</td>
<td>Organic Chemistry III</td>
</tr>
<tr>
<td>CHEM 23300</td>
<td>Intermediate Organic Chemistry</td>
</tr>
</tbody>
</table>

2. Organic/Inorganic Chemistry Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CHEM 22000</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>CHEM 22100</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>CHEM 20100</td>
<td>Inorganic Chemistry I</td>
</tr>
<tr>
<td>CHEM 20200</td>
<td>Inorganic Chemistry II</td>
</tr>
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</table>

OR

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 22000</td>
<td>Organic Chemistry I</td>
</tr>
</tbody>
</table>
CHEM 22100 Organic Chemistry II 100
CHEM 22200 Organic Chemistry III 100
CHEM 20100 Inorganic Chemistry I 100

3. Physical Chemistry Courses
CHEM 26100 Quantum Mechanics 100
CHEM 26200 Thermodynamics 100
CHEM 26300 Chemical Kinetics and Dynamics 100
CHEM 26700 Experimental Physical Chemistry 100
OR
CHEM 26100 Quantum Mechanics 100
CHEM 26200 Thermodynamics 100
CHEM 26300 Chemical Kinetics and Dynamics 100
CHEM 26800 Quantum Molecular and Materials Modeling 100

4. Organic/Physical Chemistry Courses
CHEM 22000 Organic Chemistry I 100
CHEM 22100 Organic Chemistry II 100
CHEM 26100 Quantum Mechanics 100
CHEM 26200 Thermodynamics 100
OR
CHEM 22000 Organic Chemistry I 100
CHEM 26100 Quantum Mechanics 100
CHEM 26200 Thermodynamics 100
CHEM 26300 Chemical Kinetics and Dynamics 100

5. Inorganic/Physical Chemistry Courses
CHEM 20100 Inorganic Chemistry I 100
CHEM 26100 Quantum Mechanics 100
CHEM 26200 Thermodynamics 100
CHEM 26300 Chemical Kinetics and Dynamics 100
OR
CHEM 20100 Inorganic Chemistry I 100
CHEM 20200 Inorganic Chemistry II 100
CHEM 26200 Thermodynamics 100
CHEM 26300 Chemical Kinetics and Dynamics 100

Chemistry Courses
CHEM 00111-00112-00113. Collaborative Learning in General Chemistry I-II-III.
This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 11100-11200-11300 Comprehensive General Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Comprehensive General Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Comprehensive General Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F based on the student’s level of participation and attendance.

CHEM 00111. Collaborative Learning in General Chemistry I. 000 Units.
This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 11100-11200-11300 Comprehensive General Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Comprehensive General Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Comprehensive General Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and
attendance, this zero-credit course is graded P/F based on the student’s level of participation and attendance. Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 11100
Note(s): Enrollment in CHEM 00111 is section specific: CHEM 11100-01 students should enroll in CHEM 00111-01 while CHEM 11100-02 students should enroll in CHEM 00111-02.
Instructor(s): B. Ratliff Terms Offered: Autumn
Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 11100
Note(s): Enrollment in CHEM 00111 is section specific: CHEM 11100-01 students should enroll in CHEM 00111-01 while CHEM 11100-02 students should enroll in CHEM 00111-02.

CHEM 00112. Collaborative Learning in General Chemistry II. 000 Units.
This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 1100-11200-11300 Comprehensive General Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Comprehensive General Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Comprehensive General Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F based on the student’s level of participation and attendance. Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 11100
Note(s): Enrollment in CHEM 00111 is section specific: CHEM 11100-01 students should enroll in CHEM 00111-01 while CHEM 11100-02 students should enroll in CHEM 00111-02.
Instructor(s): B. Ratliff Terms Offered: Winter
Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 11200
Note(s): Enrollment in CHEM 00112 is section specific: CHEM 11200-01 students should enroll in CHEM 00112-01 while CHEM 11200-02 students should enroll in CHEM 00112-02. CHEM 00111 is not a prerequisite for this course.

CHEM 00113. Collaborative Learning in General Chemistry III. 000 Units.
This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 11100-11200-11300 Comprehensive General Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Comprehensive General Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Comprehensive General Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F based on the student’s level of participation and attendance. Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 11300
Note(s): Enrollment in CHEM 00113 is section specific: CHEM 11300-01 students should enroll in CHEM 00113-01 while CHEM 11300-02 students should enroll in CHEM 00113-02. CHEM 00111 and CHEM 00112 are not prerequisites for this course.

CHEM 00220-00221-00222. Collaborative Learning in Organic Chemistry I-II-III.
This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 22000-22100-22200 Organic Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Organic Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Organic Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F based on the student’s level of participation and attendance.

CHEM 00220. Collaborative Learning in Organic Chemistry I. 000 Units.
This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 22000-22100-22200 Organic Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Organic Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Organic Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F.
OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300. Prerequisite(s): Enrollment limited to first-discussion, structured learning, and laboratory sessions is mandatory. FOR THE THIRD (SPRING) QUARTER through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at session per week and a laboratory component, special emphasis on scientific problem-solving skills is made. Experiments associated with the common ions and their separation and identification. Apart from one discussion quantitative measurements, investigation of the properties of the important elements and their compounds, and examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. The first two courses in this sequence meet the general education requirement in the physical sciences. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300. CHEM 10100-10200-11300. Introductory General Chemistry I-II; Comprehensive General Chemistry III. This three-quarter sequence is a systematic introduction to chemistry for beginning students in chemistry or for those whose exposure to the subject has been moderate. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. The first two courses in this sequence meet the general education requirement in the physical sciences. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300. Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 22000. Instructor(s): M. Goetz. L: M. Zhao. Terms Offered: Autumn Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 22200. Instructor(s): B. Ratliff Terms Offered: Winter Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 22100. Note(s): CHEM 00220 is not a prerequisite for this course. CHEM 00222. Collaborative Learning in Organic Chemistry II. 000 Units. This is an optional, limited enrollment workshop for students concurrently enrolled in CHEM 22000-22100-22200 Organic Chemistry I-II-III. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Organic Chemistry material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Organic Chemistry course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded F/F based on the student’s level of participation and attendance. Attendance at discussion, structured learning, and laboratory sessions is mandatory. The first two courses in this sequence meet the general education requirement in the physical sciences. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300. CHEM 10100. Introductory General Chemistry I. 100 Units. This three-quarter sequence is a systematic introduction to chemistry for beginning students in chemistry or for those whose exposure to the subject has been moderate. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300. Prerequisite(s): Corequisite: Concurrent enrollment in CHEM 22000. Instructor(s): B. Ratliff Terms Offered: Autumn Prerequisite(s): Enrollment limited to first-year students Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. CHEM 00220. Collaborative Learning in Organic Chemistry II. 100 Units. This three-quarter sequence is a systematic introduction to chemistry for beginning students in chemistry or for those whose exposure to the subject has been moderate. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300. Prerequisite(s): Enrollment limited to first-
year students Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

Instructor(s): B. Ratliff, L. M. Zhao. Terms Offered: Winter

Prerequisite(s): Enrollment limited to first-year students

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

CHEM 11300. Comprehensive General Chemistry III. 100 Units.

This three-quarter sequence is a systematic introduction to chemistry for beginning students in chemistry or for those whose exposure to the subject has been moderate. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300.

Instructor(s): L. Yu, L. M. Zhao. Terms Offered: Spring

Prerequisite(s): Good performance on the mathematics/calculus and chemistry placement tests

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

CHEM 11100-11200-11300. Comprehensive General Chemistry I-II-III.

Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. This three-quarter sequence is a comprehensive survey of modern descriptive, inorganic, and physical chemistry for students with a good secondary school exposure to general chemistry. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Attendance at one discussion session per week and laboratory sessions is required.

CHEM 11100. Comprehensive General Chemistry I. 100 Units.

Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. This three-quarter sequence is a comprehensive survey of modern descriptive, inorganic, and physical chemistry for students with a good secondary school exposure to general chemistry. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Attendance at one discussion session per week and laboratory sessions is required. Prerequisite(s): Good performance on the mathematics/calculus and chemistry placement tests

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

Instructor(s): B. Tian, G. Engel, L. M. Zhao. Terms Offered: Autumn

Prerequisite(s): Good performance on the mathematics/calculus and chemistry placement tests

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

CHEM 11200. Comprehensive General Chemistry II. 100 Units.

This three-quarter sequence is a systematic introduction to chemistry for beginning students in chemistry or for those whose exposure to the subject has been moderate. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300.

Instructor(s): N. Scherer, L. M. Zhao. Terms Offered: Winter

Prerequisite(s): Good performance on the mathematics/calculus and chemistry placement tests
Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

**CHEM 11300. Comprehensive General Chemistry III. 100 Units.**
This three-quarter sequence is a systematic introduction to chemistry for beginning students in chemistry or for those whose exposure to the subject has been moderate. We cover atomic and molecular theories, chemical periodicity, chemical reactivity and bonding, chemical equilibria, acid-base equilibria, solubility equilibria, phase equilibria, thermodynamics, electrochemistry, kinetics, quantum mechanics, and nuclear chemistry. Examples are drawn from chemical, biological, and materials systems. The laboratory portion includes an introduction to quantitative measurements, investigation of the properties of the important elements and their compounds, and experiments associated with the common ions and their separation and identification. Apart from one discussion session per week and a laboratory component, special emphasis on scientific problem-solving skills is made through two additional structured learning sessions per week devoted to quantitative reasoning. Attendance at discussion, structured learning, and laboratory sessions is mandatory. **FOR THE THIRD (SPRING) QUARTER OF THE SEQUENCE, STUDENTS WILL ENROLL IN CHEM 11300.**

Instructor(s): L. Yu. L: M. Zhao. Terms Offered: Spring
Prerequisite(s): Good performance on the chemistry placement test or a score of 5 on the AP chemistry test

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

**CHEM 12100-12200-12300. Honors General Chemistry I-II-III.**
Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. The subject matter and general program of this sequence is similar to that of the Comprehensive General Chemistry sequence. However, this accelerated course on the subject matter is designed for students deemed well prepared for a thorough and systematic study of chemistry. Introductory materials covered in the Comprehensive General Chemistry sequence are not part of the curriculum for this sequence; instead, special topics are included in each quarter to provide an in-depth examination of various subjects of current interest in chemistry. Attendance at one discussion session per week and laboratory sessions is required.

CHEM 12100. Honors General Chemistry I. 100 Units.
Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. The subject matter and general program of this sequence is similar to that of the Comprehensive General Chemistry sequence. However, this accelerated course on the subject matter is designed for students deemed well prepared for a thorough and systematic study of chemistry. Introductory materials covered in the Comprehensive General Chemistry sequence are not part of the curriculum for this sequence; instead, special topics are included in each quarter to provide an in-depth examination of various subjects of current interest in chemistry. Attendance at one discussion session per week and laboratory sessions is required.

Instructor(s): S. Sibener. L: M. Zhao. Terms Offered: Autumn
Prerequisite(s): Good performance on the mathematics/calculus and chemistry placement tests

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

CHEM 12200. Honors General Chemistry II. 100 Units.
Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. The subject matter and general program of this sequence is similar to that of the Comprehensive General Chemistry sequence. However, this accelerated course on the subject matter is designed for students deemed well prepared for a thorough and systematic study of chemistry. Introductory materials covered in the Comprehensive General Chemistry sequence are not part of the curriculum for this sequence; instead, special topics are included in each quarter to provide an in-depth examination of various subjects of current interest in chemistry. Attendance at one discussion session per week and laboratory sessions is required.

Instructor(s): S. King. L: M. Zhao. Terms Offered: Winter
Prerequisite(s): Good performance on the chemistry placement test or a score of 5 on the AP chemistry test

Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

CHEM 12300. Honors General Chemistry III. 100 Units.
Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences. The subject matter and general program of this sequence is similar to that of the Comprehensive General Chemistry sequence. However, this accelerated course on the subject matter is designed for students deemed well prepared for a thorough and systematic study of chemistry. Introductory materials covered in the Comprehensive General Chemistry sequence are not part of the curriculum for this sequence; instead, special topics are included in each quarter to provide an in-depth examination of various subjects of current interest in chemistry. Attendance at one discussion session per week and laboratory sessions is required.

Instructor(s): S. Vaikuntanathan. L: M. Zhao. Terms Offered: Spring
Prerequisite(s): Good performance on the chemistry placement test or a score of 5 on the AP chemistry test
Note(s): Enrollment by placement only. The first two courses in this sequence meet the general education requirement in the physical sciences.

CHEM 20100-20200. Inorganic Chemistry I-II.
The extraordinarily diverse chemistry of the elements is organized in terms of molecular structure, electronic properties, and chemical reactivity. CHEM 20100 concentrates on structure and bonding, solid state chemistry, and selected topics in the chemistry of the main group elements and coordination chemistry. CHEM 20200 focuses on organometallic chemistry, reactions, synthesis, and catalysis, as well as bioinorganic chemistry.

CHEM 20100. Inorganic Chemistry I. 100 Units.
CHEM 20100 concentrates on structure and bonding, solid state chemistry, and selected topics in the chemistry of the main group elements and coordination chemistry.
Instructor(s): D. Talapin. Terms Offered: Winter
Prerequisite(s): CHEM 11100-11200-11300 or equivalent, CHEM 22000 and CHEM 22100, or concurrent enrollment in CHEM 22100 or equivalent.

CHEM 20200. Inorganic Chemistry II. 100 Units.
CHEM 20200 focuses on organometallic chemistry, reactions, synthesis, and catalysis, as well as bioinorganic chemistry.
Instructor(s): J. Anderson. Terms Offered: Spring
Prerequisite(s): CHEM 20100 and CHEM 22100

CHEM 21400. Creative Machines and Innovative Instrumentation. 100 Units.
An understanding of the techniques, tricks, and traps of building creative machines and innovative instrumentation is essential for a range of fields from the physical sciences to the arts. In this hands-on, practical course, you will design and build functional devices as a means to learn the systematic processes of engineering and fundamentals of design and construction. The kinds of things you will learn may include mechanical design and machining, computer-aided design, rapid prototyping, circuitry, electrical measurement methods, and other techniques for resolving real-world design problems. In collaboration with others, you will complete a mini-project and a final project, which will involve the design and fabrication of a functional scientific instrument. The course will be taught at an introductory level; no previous experience is expected. The iterative nature of the design process will require an appreciable amount of time outside of class for completing projects. The course is open to undergraduates in all majors (subject to the pre-requisites), as well as Master's and Ph.D. students.
Instructor(s): Scott Wakely (Autumn), Erik Shirokoff (Winter), Stephan Meyer (Spring) Terms Offered: Autumn Spring Winter
Prerequisite(s): PHYS 12200 or PHYS 13200 or PHYS 14200; or CMSC 12100 or CMSC 12200 or CMSC 12300; or consent of instructor.
Equivalent Course(s): CMSC 21400, ASTR 21400, PSMS 31400, ASTR 31400, PHYS 21400

CHEM 22000-22100-22200. Organic Chemistry I-II-III.
The fundamental structures of organic molecules and the spectroscopic methods used to define them are studied. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature's important molecules.

CHEM 22000. Organic Chemistry I. 100 Units.
The fundamental structures of organic molecules and the spectroscopic methods used to define them are studied. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature's important molecules.
Instructor(s): J. Piccirilli. L: V. Keller. Terms Offered: Autumn
Prerequisite(s): An average grade of C or higher in CHEM 10100-10200-11300 or CHEM 11100-11200-11300 or CHEM 12100-12200-12300, or consent of the Dept.; lab and discussion linked.

CHEM 22100. Organic Chemistry II. 100 Units.
The fundamental structures of organic molecules and the spectroscopic methods used to define them are studied. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature's important molecules.
Instructor(s): S. Snyder. L: V. Keller. Terms Offered: Winter
Prerequisite(s): An average grade of C or higher in CHEM 10100-10200-10300 or CHEM 11100-11200-11300 or CHEM 12100-12200-12300, or consent of the department
Note(s): Students who receive a grade of B+ or higher in CHEM 22000 have the option of moving into honors organic chemistry for Winter/Spring. See following listing for CHEM 23100-23200. NOTE: Most medical schools require a full academic year of organic chemistry. A lab is one afternoon a week in addition to scheduled class time each quarter.

CHEM 22200. Organic Chemistry III. 100 Units.
The fundamental structures of organic molecules and the spectroscopic methods used to define them are studied. A comprehensive understanding of the reactions and properties of organic molecules (from
kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature’s important molecules.

Instructor(s): W. Tang. L: V. Keller. Terms Offered: Spring
Prerequisite(s): An average grade of C or higher in CHEM 10100-10200-10300 or CHEM 11100-11200-11300 or CHEM 12100-12200-12300, a 5 on the AP Chemistry exam, or consent of the department
Note(s): Students who receive a grade of B+ or higher in CHEM 22000 have the option of moving into honors organic chemistry for Winter/Spring. See following listing for CHEM 23100-23200.) NOTE: Most medical schools require a full academic year of organic chemistry. A lab is one afternoon a week in addition to scheduled class time each quarter.

CHEM 22700. Advanced Organic/Inorganic Laboratory. 100 Units.
This course combines a project approach with exposure to the more advanced techniques of organic and inorganic chemistry. Multistep synthesis, the synthesis of air-sensitive compounds, advanced chromatographic and spectroscopic characterization of products, and the handling of reactive intermediates are a part of the lab. Students who have previously taken Chem 299 in conjunction with conducting experimental research in organic or inorganic chemistry may, in certain circumstances, substitute this credit for the Chem 227 degree requirement. If this applies and is of interest to you, please contact Prof. John Anderson (Undergraduate Advisor for Chemistry; jsanderson@uchicago.edu) as soon as possible to discuss your situation.
Instructor(s): V. Rawal Terms Offered: Spring
Prerequisite(s): CHEM 20100 and 23300, or consent of instructor
Note(s): Consent required. Priority given to 4th and then 3rd year Chemistry/Biochemistry majors. Students in other majors will be considered only if the course has not met capacity by the start of the term.

CHEM 23000-23100-23200. Honors Organic Chemistry I-II-III.
This course studies the fundamental structures of organic molecules and the spectroscopic methods used to define. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature’s important molecules.

CHEM 23000. Honors Organic Chemistry I. 100 Units.
This course studies the fundamental structures of organic molecules and the spectroscopic methods used to define. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature’s important molecules.
Instructor(s): G. Dong. L: V. Keller Terms Offered: Autumn
Prerequisite(s): An average grade of B+ or higher in CHEM 11100-11200-11300 or equivalent, a 5 on the AP Chemistry exam, or consent of the department, and/or via placement exam.
Note(s): Students who have taken CHEM 22000 or 22100 with an average grade of B+ or higher may petition the department to move into the Honors sequence. Most medical schools require a full academic year of organic chemistry. A lab is one afternoon a week in addition to scheduled class time each quarter.

CHEM 23100. Honors Organic Chemistry II. 100 Units.
This course studies the fundamental structures of organic molecules and the spectroscopic methods used to define. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature’s important molecules.
Instructor(s): B. Dickinson. L: V. Keller Terms Offered: Winter
Prerequisite(s): An average grade of B+ or higher in CHEM 11100-11200-11300 or equivalent, a 5 on the AP Chemistry exam, or consent of the department, and/or via placement exam.
Note(s): Students who have taken CHEM 22000 or 22100 with an average grade of B+ or higher may petition the department to move into the Honors sequence. Most medical schools require a full academic year of organic chemistry. A lab is one afternoon a week in addition to scheduled class time each quarter.

CHEM 23200. Honors Organic Chemistry III. 100 Units.
This course studies the fundamental structures of organic molecules and the spectroscopic methods used to define. A comprehensive understanding of the reactions and properties of organic molecules (from kinetic, thermodynamic, and mechanistic viewpoints) is developed and applied to the synthesis of organic compounds and to an appreciation of nature’s important molecules.
Instructor(s): S. Rowan. L: V. Keller Terms Offered: Spring
Prerequisite(s): CHEM 22100 and received an A or higher, or CHEM 23100 and received an B or higher, or Organic Chemistry Accreditation exam.

CHEM 23300. Intermediate Organic Chemistry. 100 Units.
Proteins are the dominant natural products of the 21st century. This course will explore the organic chemistry of protein molecules: their chemical structure and biological functions, protein biosynthesis, intein-mediated protein splicing, and the use of chemistry to probe the molecular basis of the remarkable properties of proteins and enzymes.
Instructor(s): Y. Krishnan. Terms Offered: Autumn
Prerequisite(s): A grade of C or higher in CHEM 22200 or 23200, or consent of instructor
CHEM 26000. Light, Vision, and Matter. 100 Units.
This integrated lecture-and-lab course provides a novel introduction to matter-radiation interactions, image formation as a photon statistical process and inference problem, both single photon (statistical) and rate equation descriptions of light absorption and emission, (Fermi’s) Golden Rule for energy transfer processes, and “applications” in photo-chemistry and photo-physical processes such as photosynthesis and the first steps in vision. The labs involve single molecule/quantum dot detection and lifetime measurements, aspects of “super-resolution” microscopy, quantum interference and fluorescence resonance energy transfer (FRET); topics that are at the heart of current research in biophysics, cell biology, neuroscience and quantum physics. The course will favor physical and intuitive descriptions of topics complemented by essential mathematics vs. lengthy derivations. The course material is and labs are distinct from the Physical Chemistry sequence (Chem 261-263) and also Experimental Physical Chemistry (Chem 267), yet is complementary.
Instructor(s): Course Instructor: N. F. Scherer Lab Instructor: Dr. Z. Gasyna Terms Offered: Spring 2021 
Prerequisite(s): General Chemistry (Chem 110’s or higher), Physics (Phys 130’s or > higher), Calculus (Math 130’s or higher). Concurrent registration with > Math 200 sequence recommended.

CHEM 26100-26200-26300. Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics.
This three-quarter sequence studies the application of physical and mathematical methods to the investigation of chemical systems.

CHEM 26100. Quantum Mechanics. 100 Units.
This three-quarter sequence studies the application of physical and mathematical methods to the investigation of chemical systems. This course presents quantum mechanics, the Schrödinger wave equation with exact and approximate methods of solution, angular momentum, and atomic spectra and structure.
Prerequisite(s): CHEM 11300 or equivalent; MATH 20100 and PHYS 13300
Instructor(s): D. A. Mazziotti. Terms Offered: Autumn
Prerequisite(s): CHEM 11300 or equivalent; MATH 18500 or MATH 20100; PHYS 13300. MATH 18600 recommended.

CHEM 26200. Thermodynamics. 100 Units.
This course continues the sequence with the study of thermodynamic principles and applications, as well as statistical mechanics.
Instructor(s): P. M. Guyot-Sionnest Terms Offered: Winter
Prerequisite(s): CHEM 11300 or equivalent; MATH 18500 or MATH 20100, and PHYS 13300

CHEM 26300. Chemical Kinetics and Dynamics. 100 Units.
This course is a discussion of chemical kinetics and dynamics for processes in gases, in liquids, and at interfaces.
Instructor(s): B. Tian Terms Offered: Spring
Prerequisite(s): CHEM 11300 or equivalent; MATH 18500 or MATH 20100, and PHYS 13300

CHEM 26700. Experimental Physical Chemistry. 100 Units.
This course introduces the principles and practice of physical chemical measurements. Techniques used in the design and construction of apparatus are discussed in lectures, and practice is provided through lab exercises and experiments. Subjects covered include vacuum techniques, electronics, optics, use of computers in lab instrumentation, materials of construction, and data analysis.
Instructor(s): Staff. Terms Offered: Winter
Prerequisite(s): CHEM 26100

CHEM 26800. Quantum Molecular and Materials Modeling. 100 Units.
Quantum mechanical methods, including quantum chemistry, density functional theory (DFT), and many body perturbation theory, for simulating the properties of molecules and materials will be explored in this course. Numerical algorithms and techniques will be introduced that allow for solution of approximate forms of the Schröedinger and Boltzmann Equations that model structural and transport properties of molecules and materials. The coupling of DFT with molecular dynamics will be detailed for determining finite temperature properties. Coupling of DFT with spin Hamiltonians to study dynamical spin correlations in materials will also be described. Examples of the application of quantum mechanical methods to materials for energy conversion and quantum information technologies will be provided.
Instructor(s): Giulia Galli Terms Offered: Spring
Prerequisite(s): PHYS 23400 or CHEM 26100 or instructor consent
Equivalent Course(s): MENG 25510, MENG 35510, CHEM 36800

CHEM 29600. Research in Chemistry. 000 Units.
Students conduct advanced, individually-guided research. Because this is a 000 credit course, students must submit a written report covering their research activities to the undergraduate counselor, and this course may be taken as a fifth course. Research activities undertaken in this course may be used towards the writing of a thesis for consideration for departmental honors.
Instructor(s): Staff. Terms Offered: Autumn Spring Winter
Prerequisite(s): Consent of a faculty sponsor and/or the undergraduate counselor
Note(s): Graded P/F; Students are required to submit the College Reading/Research Course Form
CHEM 29900. Advanced Research in Chemistry. 100 Units.
Students conduct advanced, individually guided research. Students may submit a written report covering their research activities for consideration for departmental honors.
Instructor(s): Staff Terms Offered: Autumn Spring Summer Winter
Prerequisite(s): Consent of a faculty sponsor and the undergraduate counselor
Note(s): Open only to students majoring in chemistry who are eligible for honors. Available for either quality grades or for P/F grading. Students are required to submit the College Reading and Research Course Form.

CHEM 30100. Advanced Inorganic Chemistry. 100 Units.
Group theory and its applications in inorganic chemistry are developed. These concepts are used in surveying the chemistry of inorganic compounds from the standpoint of quantum chemistry, chemical bonding principles, and the relationship between structure and reactivity.
Instructor(s): W. Lin Terms Offered: Autumn
Prerequisite(s): CHEM 20100 and CHEM 26100

CHEM 30200. Synthesis and Physical Methods in Inorganic Chemistry. 100 Units.
This course covers theoretical and practical aspects of important physical methods for the characterization of inorganic molecules. Topics may include NMR, IR, RAMAN, EPR, and electronic and photoelectron spectroscopy; electrochemical methods; and single-crystal X-ray diffraction.
Instructor(s): W. Lin Terms Offered: Winter
Prerequisite(s): CHEM 30100

CHEM 30300. Organometallic Chemistry. 100 Units.
This course covers preparation and properties of organometallic compounds (notably those of the transition elements, their reactions, and the concepts of homogeneous catalysis).
Instructor(s): G. Dong Terms Offered: Spring
Prerequisite(s): CHEM 20100 and CHEM 26100

CHEM 30500. Nanoscale Materials. 100 Units.
This course provides an overview of nanoscale phenomena in metals, semiconductors, and magnetic materials (e.g., the fundamental aspects of quantum confinement in semiconductors and metals, superparamagnetism in nanoscale magnets, electronic properties of nanowires and carbon nanotubes, surface plasmon resonances in nanomaterials, photonic crystals). Special attention is paid to preparative aspects of nanomaterials, colloidal and gas-phase syntheses of nanoparticles, nanowires, and nanotubes. Engineered nanomaterials and their assemblies are considered promising candidates for a variety of applications, from solar cells, electronic circuits, light-emitting devices, and data storage to catalysts, biological tags, cancer treatments, and drug delivery. The course covers state-of-the art in these and other areas. Finally, the course provides an overview of the experimental techniques used for structural characterization of inorganic nanomaterials (e.g., electron microscopy, X-ray diffractometry, small-angle X-ray scattering, STM, AFM, Raman spectroscopy).
Instructor(s): Staff. Terms Offered: Not offered in 2020-2021
Prerequisite(s): CHEM 20200 and 26300, or consent of instructor

CHEM 30600. Chemistry Of The Elements and Materials. 100 Units.
This course surveys the descriptive chemistries of the main-group elements and the transition metals from a synthetic perspective, and reaction chemistry of inorganic molecules is systematically developed.
Instructor(s): J. Anderson Terms Offered: Winter
Prerequisite(s): CHEM 20100

CHEM 30700. Bioinorganic Chemistry. 100 Units.
This course covers various roles of metals in biology. Topics include coordination chemistry of bioinorganic units, substrate binding and activation, electron-transfer proteins, atom and group transfer chemistry, metal homeostasis, ion channels, metals in medicine, and model systems.
Instructor(s): C. He Terms Offered: Spring
Prerequisite(s): CHEM 20200 and 22200/23200

CHEM 32100. Physical Organic Chemistry I. 100 Units.
This course focuses on the quantitative aspects of structure and reactivity, molecular orbital theory, and the insight it provides into structures and properties of molecules, stereochemistry, thermochemistry, kinetics, substituent and isotope effects, and pericyclic reactions.
Instructor(s): M. Levin Terms Offered: Autumn
Prerequisite(s): CHEM 22200/23200 and 26200, or consent of instructor

CHEM 32200. Organic Synthesis and Structure. 100 Units.
This course considers the mechanisms, applicability, and limitations of the major reactions in organic chemistry, as well as of stereochemical control in synthesis.
Instructor(s): V. Rawal Terms Offered: Autumn
Prerequisite(s): CHEM 22200/23200 or consent of instructor
CHEM 32300. Strategies and Tactics of Organic Synthesis. 100 Units.
This course discusses the important classes for organic transformation. Topics include carbon-carbon bond formation; oxidation; and reduction using a metal, non-metal, or acid-base catalyst. We also cover design of the reagents and the scope and limitation of the processes.
Instructor(s): S. Snyder Terms Offered: Winter
Prerequisite(s): CHEM 22200/23200 or consent of instructor

CHEM 32400. Physical Organic Chemistry II. 100 Units.
Topics covered in this course include the mechanisms and fundamental theories of free radicals and the related free radical reactions, biradical and carbene chemistry, and pericyclic and photochemical reactions.
Instructor(s): Staff Terms Offered: Not offered in 2020-2021
Prerequisite(s): CHEM 32100

CHEM 32500. Bioorganic Chemistry. 100 Units.
A goal of this course is to relate chemical phenomena with biological activities. We cover two main areas: (1) chemical modifications of biological macromolecules and their potential effects; and (2) the application of spectroscopic methods to elucidate the structure and dynamics of biologically relevant molecules.
Instructor(s): Staff. Terms Offered: Not offered in 2020-2021

CHEM 33000. Complex Chemical Systems. 100 Units.
This course describes chemical systems in which nonlinear kinetics lead to unexpected (emergent) behavior of the system. Autocatalytic and spatiotemporal pattern forming systems are covered, and their roles in the development and function of living systems are discussed.
Instructor(s): Staff Terms Offered: Not offered in 2020-2021
Prerequisite(s): CHEM 22200/23200 and MATH 20100, or consent of instructor

CHEM 33100. New Synthetic Reactions and Catalysts. 100 Units.
This course presents recent highlights of new synthetic reactions and catalysts for efficient organic synthesis. Mechanistic details and future possibilities are discussed.
Instructor(s): Staff Terms Offered: Not offered in 2020-2021
Prerequisite(s): CHEM 23300

CHEM 33200-33300. Chemical Biology I-II.
This course emphasizes the concepts of physical organic chemistry (e.g., mechanism, molecular orbital theory, thermodynamics, kinetics) in a survey of modern research topics in chemical biology. Topics, which are taken from recent literature, include the roles of proteins in signal transduction pathways, the biosynthesis of natural products, strategies to engineer cells with novel functions, the role of spatial and temporal inhomogeneities in cell function, and organic synthesis and protein engineering for the development of molecular tools to characterize cellular activities.

CHEM 33200. Chemical Biology I. 100 Units.
The aim of this course is to teach chemical biology using primary literature examples, both classic and modern, focused on fundamental approaches and technologies. A general focus on the course are biomolecules - their biophysics, function, engineering, and repurposing and research tools. This course and the subsequent "Chemical Biology II course (Chem333) are geared toward those interested in pursuing chemical biology in their research endeavors or future career.
Instructor(s): W. Tang Terms Offered: Autumn
Prerequisite(s): CHEM 22200/23200, or consent of instructor

CHEM 33300. Chemical Biology II. 100 Units.
No description available.
Instructor(s): R. Moellering Terms Offered: Winter
Prerequisite(s): CHEM 33200, or consent of instructor

CHEM 33500. Chemistry of Enzyme Catalysis. 100 Units.
The course will cover fundamental aspects of the physical organic chemistry of enzyme catalysis, with special emphasis on the role of pre-oriented local electric fields in catalysis, and will use case studies based on the primary scientific literature--both classic and current papers. For each class, there will be primary scientific papers assigned that the student will be expected to have studied in depth prior to class, including "reading around" on the same and related topics; suggestions for supplementary reading will be given. Classes will be conducted as discussion sessions; guided by the Instructor--all students will be expected to be prepared to answer questions from the instructor, and to take active part in class discussions. Participation in class will count for a portion of the grade for each student.
Instructor(s): S. Kent Terms Offered: Winter

CHEM 33600. Biological Chemistry of Materials: Principles and Applications. 100 Units.
This course will focus on principles of bioconjugation techniques; preparation of immobilized-enzymes/proteins: adsorption, occlusion, cross-linking and covalent binding. Applications of cofactor-dependent enzymes: building of enzymatic electrodes and biofuel cells. Development of immunosensors based on ELISA, electrochemistry, optics, carbon nanotubes and piezoelectric methods. Principles and design of DNA/RNA based sensors (Ribozymes, SELEX, Aptamers, DNAzymes, Molecular Beacons). Amplification methods for nucleic acids
Chemistry

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detection in test tube and in cells. Preparation and characterization of nanoparticles in nucleic acids and proteins
sensing processes.
Terms Offered: Not offered in 2020-2021
Prerequisite(s): CHEM 23300 or consent of instructor

CHEM 33700. RNA Structure, Function, and Biology. 100 Units.
Students will learn principles of RNA structure and function, RNA catalysis, and RNA molecular cell biology
as they relate to the field of RNA metabolism. In recent years it has become apparent that much of an organisms
genome is transcribed, yielding a far more expansive collection of RNA molecules than previously thought:
many of these RNAs are classic messenger RNAs that code for proteins but many serve functions other than
protein coding (noncoding RNAs). These RNAs are processed, modified, and usually interact with RNA binding
proteins (RBPs) to form ribonucleoprotein (RNP) complexes. We will consider emerging themes in noncoding
RNA biology and investigate methods for interrogating their cellular structure and function.
Terms Offered: Not offered in 2020-2021

CHEM 33800. Current Topics and Methods in Chemical Biology. 100 Units.
The aim of this course is to teach modern chemical biology methods, technologies, and applications as applied
to problems and challenges in human health and biotechnology. Both classics in translational chemical biology
and emerging technologies will be used to teach general principles in the application of chemistry to therapeutic
development and biotechnology. As compared to the Chemical Biology course track (Chem332/Chem333),
this course is geared more toward non-experts in chemical biology or those with a less extensive chemistry
background.
Instructor(s): B. Dickinson. R. Moellering Terms Offered: Winter
Prerequisite(s): CHEM 22200/23200

CHEM 36100. Wave Mechanics and Spectroscopy. 100 Units.
This course presents the introductory concepts, general principles, and applications of wave mechanics to
spectroscopy.
Instructor(s): A. Dinner Terms Offered: Autumn
Prerequisite(s): CHEM 26300

CHEM 36200. Quantum Mechanics. 100 Units.
This course builds upon the concepts introduced in CHEM 36100 with greater detail provided for the role of
quantum mechanics in chemical physics.
Instructor(s): D. Mazziotti Terms Offered: Winter
Prerequisite(s): CHEM 36100

CHEM 36300. Statistical Thermodynamics. 100 Units.
This course covers the thermodynamics and introductory statistical mechanics of systems at equilibrium.
Instructor(s): S. Vaikuntanathan Terms Offered: Autumn
Prerequisite(s): CHEM 26100-26200

CHEM 36400. Advanced Statistical Mechanics. 100 Units.
Topics covered in this course may include statistics of quantum mechanical systems, weakly and strongly
interacting classical systems, phase transitions and critical phenomena, systems out of equilibrium, and
polymers.
Instructor(s): V. Goth Terms Offered: Winter
Prerequisite(s): CHEM 36300 or equivalent

CHEM 36500. Chemical Dynamics. 100 Units.
This course develops a molecular-level description of chemical kinetics, reaction dynamics, and energy transfer
in both gases and liquids. Topics include potential energy surfaces, collision dynamics and scattering theory,
reaction rate theory, collisional and radiationless energy transfer, molecule-surface interactions, Brownian
motion, time correlation functions, and computer simulations.
Instructor(s): G. Voth Terms Offered: Spring
Prerequisite(s): CHEM 36100 required; 36300 recommended

CHEM 37100. Advanced Spectroscopies. 100 Units.
This linear and nonlinear spectroscopy course includes notions on matter-radiation interaction, absorption,
scattering, and oscillator strength. They are applied mostly with the optical range, but we briefly touch upon
microwave (NMR, ESR) and X-rays at the extreme. We cover nonlinear optical processes such as coherent Raman,
harmonic, and sum-frequency; induced transparency; slow light; and X-ray generation. We also cover coherent
and incoherent dynamical probes, such as pump-probe, echos, and two-dimensional spectroscopy.
Terms Offered: Not offered in 2020-2021

CHEM 37300. Advanced Special Topics in Theory and Computation. 100 Units.
This course introduces topics in theoretical and computational chemistry beyond those in the traditional
graduate physical chemistry sequence. Specific topics will vary from year to year based on the interests
of the instructor and students. Representative topics are diagrammatic methods, field theories, renormalization,
onequilibrium statistical mechanics, and quantum dynamics.
Terms Offered: Not offered in 2020-2021
CHEM 38700. Biophysical Chemistry. 100 Units.
This course develops a physicochemical description of biological systems. Topics include macromolecules, fluid-phase lipid-bilayer structures in aqueous solution, biomembrane mechanics, control of biomolecular assembly, and computer simulations of biomolecular systems.
Instructor(s): R. Benoit Terms Offered: Spring
Prerequisite(s): CHEM 23300, CHEM 26200.

CHEM 39000. Solids, Materials, Surfaces. 100 Units.
This course is an introduction to modern materials chemistry. It covers basic chemistry and physics of condensed systems, such as solids, polymers, and nanomaterials. The electronic structure of metals, semiconductors and magnetically ordered phases will be discussed. We will review optical and electronic properties of different classes of materials using examples of hard and soft condensed matter systems and drawing structure-property relationships for conventional solids, polymers, and nanomaterials. Finally, the course will cover the fundamentals of surface science and material synthesis, applying modern understanding of nucleation and growth phenomena.
Instructor(s): D. Talapin Terms Offered: Autumn
Prerequisite(s): CHEM 26100, CHEM 26200, and CHEM 26300, or equivalent
Equivalent Course(s): MENG 35200

CHEM 39100. Polymer Synthesis. 100 Units.
This course introduces the most important polymerization reactions, focusing on their reaction mechanisms and kinetic aspects. Topics include free radical and ionic chain polymerization, step-growth polymerization, ring-opening, insertion, controlled living polymerization, crosslinking, copolymerization, and chemical modification of preformed polymers.
Instructor(s): Stuart Rowan Terms Offered: Winter
Prerequisite(s): CHEM 22000 and CHEM 22100
Equivalent Course(s): MENG 25110, MENG 35110