Chemistry

Courses offered by the Department of Chemistry are listed under the subject code CHEM on the ExploreCourses web site (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=CHEM&filter-catalognumber-CHEM=on). Chemistry is central to many scientific disciplines and plays an important role in the emerging areas of biotechnology, catalysis, human health, materials, and earth and environmental sciences. Developing new probes of molecular molecules, modeling of protein folding and reactivity, manipulation of carbon nanotubes, development of new oxidation and polymerization catalysts, and synthesis of organic molecules for probing ion-channels are all research areas that are pursued actively in the Chemistry Department. The overarching theme of these pursuits is a focus at the atomic and molecular levels, whether this concerns probing the electronic structure and reactivity of molecules as small as dihydrogen or synthesizing large polymer assemblies. The ability to synthesize new molecules and materials and to modify existing biological structures allows the properties of complex systems to be analyzed and harnessed for scientific and societal benefit.

Mission of the Undergraduate Program in Chemistry

The mission of the undergraduate program in Chemistry is to provide students with the fundamental concepts of the molecular sciences through a program of coursework and laboratory experiences. Students acquire in-depth knowledge of the principles of chemistry, the methodologies necessary to solve complex problems, and the ability to articulate their ideas effectively to the scientific community. The Chemistry program also has a long-standing tradition of encouraging undergraduate majors to become involved in research during the academic year and through a ten-week summer research program. The major is designed to provide students with excellent preparation for further study in graduate or professional schools as well as careers in chemistry.

Learning Outcomes (Undergraduate)

The department expects undergraduate majors in the program to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the department’s undergraduate program. Students are expected to:

1. understand the knowledge and master the skills to solve problems in the synthesis, measurement and modeling of chemical systems.
2. critically assess and integrate the reasoning process used in chemical science and communicate it effectively in written and spoken form.
3. apply the knowledge and skills gained by study of specific chemical systems to understand and predict the chemistry of a broad range of complex systems of scientific and societal interest.
4. apply the understanding of synthesis, measurement and modeling to extract new chemical information from experimental data and to propose new chemical investigations.

Chemistry Premedical Recommendations

The department recommends that students interested in a health profession take the following courses for a letter grade:

Select one of the following: Units

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 31A &amp; CHEM 31B</td>
<td>Chemical Principles I and Chemical Principles II</td>
<td>4-10</td>
</tr>
<tr>
<td>CHEM 31X</td>
<td>Chemical Principles</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 33</td>
<td>Structure and Reactivity</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 35</td>
<td>Organic Monofunctional Compounds</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 36</td>
<td>Organic Chemistry Laboratory I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 130</td>
<td>Organic Chemistry Laboratory II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 131</td>
<td>Organic Polyfunctional Compounds</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 135</td>
<td>Physical Chemical Principles</td>
<td>3</td>
</tr>
</tbody>
</table>
or CHEM 171 | Physical Chemistry | 3   |
| CHEM 181 | Biochemistry I | 3   |

Historically, these courses have fulfilled the chemistry requirements at most medical schools. For information on medical school advising and resources, please download the Undergraduate Advising and Research publication (http://www.stanford.edu/dept/undergrad/cgi-bin/drupal_ual/AP_planning_school_GraduateSchool.html#85).

Graduate Programs in Chemistry

The University’s basic requirements for the M.S. and Ph.D. degrees are discussed in the “Graduate Degrees” section of this bulletin.

Learning Outcomes (Graduate)

The purpose of the master’s program is to further develop knowledge and skills in Chemistry and to prepare students for a professional career or doctoral studies. This is achieved through completion of courses, in the primary field as well as related areas, and experience with independent work and specialization.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research and analysis in the field of chemistry. Through completion of advanced course work and rigorous skills training, the doctoral program prepares students to make original contributions to the knowledge of chemistry and to interpret and present the results of such research.

General Requirements

Placement Examinations

Each new graduate student must take placement examinations upon entrance. These consist of three written examinations of two hours each in the fields of inorganic, organic, and physical chemistry, and cover such material as ordinarily is given in a rigorous one-year undergraduate course in each of these subjects. Students majoring in biophysical chemistry or chemical physics must take examinations in biophysical or chemical physics, physical chemistry, and organic or inorganic chemistry. All placement examinations are given the week before instruction begins in Autumn Quarter, and must be taken at that time. Each new graduate student
meets with a member of the graduate study committee to define a program of courses based on results of the placement examinations.

Candidates for advanced degrees must have a minimum grade point average (GPA) of 3.0 for all Chemistry lecture courses as well as for all courses taken during graduate study. Required courses must be taken for a letter grade. Most course work ends in the second year of studies, and students will then focus on full-time dissertation research. During the period in which a dissertation is being read by members of the faculty, candidates must be available for personal consultation until the dissertation has received final department approval.

Course Requirements

Students may major in biophysical, inorganic, organic, or physical chemistry. All graduate students are required to take six graduate-level lecture courses (course numbers greater than 199) of at least 3 units each in chemistry or related disciplines (for example, biochemistry, electrical engineering, mathematics, chemical and systems biology, physics, and so on), to be selected in consultation with their research adviser and the Graduate Study Committee. A minimum of four courses should be completed by the end of the first year for a letter grade.

In addition:

Students majoring in inorganic chemistry must complete:

- CHEM 258A
- CHEM 258B
- CHEM 258C

Students majoring in organic chemistry must complete:

- CHEM 273
- CHEM 275
- CHEM 278A
- CHEM 278B

Students in physical or biophysical chemistry or chemical physics must complete:

- CHEM 271
- CHEM 273
- CHEM 275
- CHEM 278A
- CHEM 278B

Students majoring in inorganic chemistry must complete:

- CHEM 258A
- CHEM 258B
- CHEM 258C

Fellowships and Scholarships

In addition to school fellowships and scholarships open to properly qualified students, there are several department fellowships in chemistry. Undergraduate scholarships are administered through the Financial Aid Office. Teaching assistantships and research assistantships are open to graduate students. Graduate fellowships, scholarships, and teaching assistantships are administered through the Department of Chemistry.

Teaching Credentials

The requirements for certification to teach chemistry in the secondary schools of California may be ascertained by consulting the section on credentials under the "School of Education (http://exploredegrees.stanford.edu/archive/2012-13/schoolofeducation)" section of this bulletin and the Credential Administrator of the School of Education.

Chemical Physics

Students with an exceptionally strong background in physics and mathematics may, upon special arrangement, pursue a program of studies in chemical physics.

Bachelor of Science in Chemistry

Entrance Preparation

Entrance credit in the preparatory subjects of chemistry, physics, and especially mathematics provides flexibility in creating a four-year schedule for students intending to major in Chemistry.

Degree Requirements

Additional information on the undergraduate program, including suggested course schedules, can be found on the Department of Chemistry web site beginning with the Requirements for the B.S. Degree in Chemistry (http://chemistry.stanford.edu/undergradprograms/requirements-bs-degree). All degree courses must be taken for a letter grade. In addition, students should have exposure to computer programming at the level of CME 192 Introduction to MATLAB, MATH 51M Introduction to MATLAB for Multivariable Mathematics, CME 100 Vector Calculus for Engineers, or CS 106A Programming Methodology.

Chemistry Option

Requirements for students choosing the Chemistry Option:

- Select one of the following: 4-10
  - CHEM 31A
  - CHEM 31B
  - CHEM 31X

  - and Chemical Principles II
  - Chemical Principles

Required Chemistry Courses (48)

- CHEM 33 Structure and Reactivity 4
- CHEM 35 Organic Monofunctional Compounds 4
- CHEM 36 Organic Chemistry Laboratory I 3
- CHEM 130 Organic Chemistry Laboratory II 4
- CHEM 131 Organic Polynuclear Compounds 3
- CHEM 132 Synthesis Laboratory 3
- CHEM 134 Analytical Chemistry Laboratory 5
- CHEM 151 Inorganic Chemistry I 3
- CHEM 153 Inorganic Chemistry II 3
- CHEM 171 Physical Chemistry 3
- CHEM 172 Physical Chemistry 3
- CHEM 174 Physical Chemistry Laboratory I 4
- CHEM 175 Physical Chemistry 3
- CHEM 176 Physical Chemistry Laboratory II 3

Mathematics or CME (15-20)

Select one of the following series: 15-20

Series A

- MATH 41 Calculus
- MATH 42 Calculus
- MATH 51 Linear Algebra and Differential Calculus of Several Variables
- MATH 53 Ordinary Differential Equations with Linear Algebra

Series B

- CME 100 Vector Calculus for Engineers
- CME 102 Ordinary Differential Equations for Engineers
- CME 104 Linear Algebra and Partial Differential Equations for Engineers

Physics Required Courses (14)
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<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
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<td>PHYSICS 41</td>
<td>Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 44</td>
<td>Electricity and Magnetism Lab</td>
<td>1</td>
</tr>
<tr>
<td>PHYSICS 45</td>
<td>Light and Heat</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 46</td>
<td>Light and Heat Laboratory</td>
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</tr>
<tr>
<td><strong>Total Units</strong></td>
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<td><strong>81-92</strong></td>
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**Biological Chemistry Option**

Requirements for students choosing the Biological Chemistry Option:

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 31A</td>
<td>Chemical Principles I and Chemical Principles II</td>
<td>4-10</td>
</tr>
<tr>
<td>CHEM 31B</td>
<td>Chemical Principles I and Chemical Principles II</td>
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</tr>
<tr>
<td>CHEM 31X</td>
<td>Chemical Principles I and Chemical Principles II</td>
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**Required Chemistry and Biology courses (56)**

<table>
<thead>
<tr>
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<tr>
<td>CHEM 35</td>
<td>Organic Monofunctional Compounds</td>
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<td>CHEM 36</td>
<td>Organic Chemistry Laboratory I</td>
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<td>CHEM 130</td>
<td>Organic Chemistry Laboratory II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 131</td>
<td>Organic Polyfunctional Compounds</td>
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</tr>
<tr>
<td>CHEM 132</td>
<td>Synthesis Laboratory</td>
<td>3</td>
</tr>
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<td>CHEM 134</td>
<td>Analytical Chemistry Laboratory</td>
<td>5</td>
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<tr>
<td>CHEM 151</td>
<td>Inorganic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 171</td>
<td>Physical Chemistry</td>
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<tr>
<td>CHEM 173</td>
<td>Physical Chemistry</td>
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<tr>
<td>CHEM 176</td>
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<td>Course Code</td>
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<tr>
<td>CHEM 181</td>
<td>Biochemistry I</td>
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<tr>
<td>CHEM 183</td>
<td>Biochemistry II</td>
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<tr>
<td>CHEM 184</td>
<td>Biological Chemistry Laboratory</td>
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<tr>
<td>CHEM 185</td>
<td>Biochemistry III</td>
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<tr>
<td>BIO 42</td>
<td>Cell Biology and Animal Physiology</td>
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</table>

**Mathematics or CME (15-20)**

Select one of the following Series:

**Series A**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 41</td>
<td>Calculus</td>
<td></td>
</tr>
<tr>
<td>MATH 42</td>
<td>Calculus</td>
<td></td>
</tr>
</tbody>
</table>

**Series B**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MATH 51</td>
<td>Linear Algebra and Differential Calculus of Several Variables</td>
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</tr>
<tr>
<td>MATH 53</td>
<td>Ordinary Differential Equations with Linear Algebra</td>
<td></td>
</tr>
</tbody>
</table>

**Required Physics Courses (8)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>PHYSICS 41</td>
<td>Mechanics</td>
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</tr>
<tr>
<td>PHYSICS 43</td>
<td>Electricity and Magnetism</td>
<td>4</td>
</tr>
</tbody>
</table>

**Elective (3-4)**

| Units | 3-4 |
Select one graduate-level elective course related to your biochemical interests.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 221</td>
<td>Advanced Organic Chemistry</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
</tr>
<tr>
<td>CHEM 227</td>
<td>Synthesis and Analysis at the Chemistry-Biology Interface</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
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<tr>
<td>CHEM 235</td>
<td>Applications of NMR Spectroscopy</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
</tr>
<tr>
<td>CHEM 255</td>
<td>Advanced Inorganic Chemistry</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
</tr>
<tr>
<td>CHEM 271</td>
<td>Advanced Physical Chemistry</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
</tr>
<tr>
<td>CHEM 277</td>
<td>Materials Chemistry and Physics (strongly recommended)</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
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<tr>
<td>BIOC 241</td>
<td>Biological Macromolecules</td>
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</tr>
<tr>
<td>BIOPHYS 232</td>
<td>Advanced Imaging Lab in Biophysics</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
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<tr>
<td>BIOE 222B</td>
<td>Multimodality Molecular Imaging in Living Subjects II</td>
<td><a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;Toolbar=PageWizard">Link</a></td>
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<tr>
<td>BIOE 300A</td>
<td>Molecular and Cellular Bioengineering</td>
<td>[Link](<a href="https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;">https://exploredegrees-nextyear.stanford.edu/courseleaf/js/fckeditor/editor/fckeditor.html?InstanceName=attr_bachelorstext&amp;</a> Toolbar=PageWizard)</td>
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</tbody>
</table>
Total Units 86-98

For further information on the undergraduate program, see the Department of Chemistry (http://chemistry.stanford.edu/undergraduate-programs) website.

Elective courses must be used to complete the University Writing, General Education, and Language Requirements. They may also be used to broaden one’s background in science and non-science areas and to provide an opportunity for advanced study in Chemistry.

## Course Schedules for the Chemistry Major

Below are possible schedules for the traditional concentration and the biological chemistry concentration. The schedules are each followed by an example accelerated schedule.

### Traditional Schedule

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Principles I (CHEM 31A)</td>
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<tr>
<td>Calculus (MATH 41)</td>
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<td>Chemical Principles II (CHEM 31B)</td>
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<td>Structure and Reactivity (CHEM 33)</td>
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<tr>
<td>Linear Algebra and Differential Calculus of Several Variables (MATH 51)</td>
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<th>Second Year</th>
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<th>Winter</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Organic Monofunctional Compounds (CHEM 35)</td>
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<tr>
<td>Organic Chemistry Laboratory I (CHEM 36)</td>
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<tr>
<td>Light and Heat (PHYSICS 45) (for Traditional Concentration)</td>
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<tr>
<td>Light and Heat Laboratory (PHYSICS 46) (for Traditional Concentration)</td>
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<tr>
<td>Organic Chemistry Laboratory II (CHEM 130)</td>
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<td>Organic Polymonomer Compounds (CHEM 131)</td>
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<tr>
<td>Mechanics (PHYSICS 41)</td>
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<tr>
<td>Analytical Chemistry Laboratory (CHEM 134)</td>
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<tr>
<td>Electricity and Magnetism (PHYSICS 43)</td>
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<tr>
<td>Electricity and Magnetism Lab (PHYSICS 44) (for Traditional Concentration)</td>
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<thead>
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<th>Units</th>
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<th>Spring</th>
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<tr>
<td>Synthesis Laboratory (CHEM 132)</td>
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<td>Inorganic Chemistry I (CHEM 151)</td>
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<td>Physical Chemistry (CHEM 171)</td>
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<tr>
<td>Ordinary Differential Equations with Linear Algebra (MATH 53)</td>
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<thead>
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<th>Fourth Year</th>
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<th>Winter</th>
<th>Spring</th>
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<td>Physical Chemistry (CHEM 173)</td>
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<tr>
<td>Physical Chemistry Laboratory I (CHEM 174)</td>
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<tr>
<td>Physical Chemistry Laboratory II (CHEM 176)</td>
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<tr>
<td>Inorganic Chemistry II (CHEM 153)</td>
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<td>Year Total:</td>
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<td>6</td>
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**Total Units in Sequence:** 92
# Accelerated Schedule for the Traditional Concentration

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<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Chemical Principles (CHEM 31X)</td>
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<td></td>
</tr>
<tr>
<td>Linear Algebra and Differential Calculus of Several Variables (MATH 51)</td>
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<tr>
<td>Structure and Reactivity (CHEM 33)</td>
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<td>Mechanics (PHYSICS 41)</td>
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<td></td>
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<tr>
<td>Organic Monofunctional Compounds (CHEM 35)</td>
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<tr>
<td>Organic Chemistry Laboratory I (CHEM 36)</td>
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<td></td>
<td></td>
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<tr>
<td>Electricity and Magnetism (PHYSICS 43)</td>
<td>4</td>
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<tr>
<td>Electricity and Magnetism Lab (PHYSICS 44) (for Traditional Concentration)</td>
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<td>Year Total:</td>
<td>9</td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Organic Chemistry Laboratory II (CHEM 130)</td>
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<tr>
<td>Organic Polyfunctional Compounds (CHEM 131)</td>
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<td>Light and Heat (PHYSICS 45) (for Traditional Concentration)</td>
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<td>Light and Heat Laboratory (PHYSICS 46) (for Traditional Concentration)</td>
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<tr>
<td>Synthesis Laboratory (CHEM 132)</td>
<td>3</td>
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<tr>
<td>Inorganic Chemistry I (CHEM 151)</td>
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<tr>
<td>Ordinary Differential Equations with Linear Algebra (MATH 53)</td>
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<tr>
<td>Analytical Chemistry Laboratory (CHEM 134)</td>
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<tr>
<td>Physical Chemistry (CHEM 171)</td>
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<tbody>
<tr>
<td>Physical Chemistry (CHEM 173)</td>
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<td>Physical Chemistry Laboratory I (CHEM 174)</td>
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<td>Physical Chemistry (CHEM 175)</td>
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<td>Physical Chemistry Laboratory II (CHEM 176)</td>
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<td>Inorganic Chemistry II (CHEM 153)</td>
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| Total Units in Sequence: | 76 |

# Biological Chemistry Concentration

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<thead>
<tr>
<th>First Year</th>
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<th>Autumn</th>
<th>Winter</th>
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<tbody>
<tr>
<td>Chemical Principles I (CHEM 31A)</td>
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<td>Calculus (MATH 41)</td>
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<td>Chemical Principles II (CHEM 31B)</td>
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<tr>
<td>Calculus (MATH 42)</td>
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<tr>
<td>Structure and Reactivity (CHEM 33)</td>
<td>4</td>
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<tr>
<td>Linear Algebra and Differential Calculus of Several Variables (MATH 51)</td>
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<td>Organic Monofunctional Compounds (CHEM 35)</td>
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<td>Organic Polyfunctional Compounds (CHEM 131)</td>
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<tr>
<td>Mechanics (PHYSICS 41)</td>
<td>4</td>
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<tr>
<td>Analytical Chemistry Laboratory (CHEM 134)</td>
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<td>Electricity and Magnetism (PHYSICS 43)</td>
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<thead>
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<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Synthesis Laboratory (CHEM 132)</td>
<td>3</td>
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<td>Inorganic Chemistry I (CHEM 151)</td>
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<tr>
<td>Cell Biology and Animal Physiology (BIO 42)</td>
<td>5</td>
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<tr>
<td>Physical Chemistry (CHEM 171)</td>
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<tr>
<td>Ordinary Differential Equations with Linear Algebra (MATH 53)</td>
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<td>Year Total:</td>
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<tr>
<td>Physical Chemistry (CHEM 173)</td>
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<tr>
<td>Biochemistry I (CHEM 181)</td>
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<tr>
<td>Physical Chemistry Laboratory II (CHEM 176)</td>
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<td>Biochemistry II (CHEM 183)</td>
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<td>Biological Chemistry Laboratory (CHEM 184)</td>
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<tr>
<td>Biochemistry III (CHEM 185)</td>
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<td>Year Total:</td>
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| Total Units in Sequence: | 94 |

# Accelerated Schedule for the Biological Chemistry Concentration

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Chemical Principles (CHEM 31X)</td>
<td>4</td>
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<td></td>
<td></td>
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<tr>
<td>Linear Algebra and Differential Calculus of Several Variables (MATH 51)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure and Reactivity (CHEM 33)</td>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>Mechanics (PHYSICS 41)</td>
<td>4</td>
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</table>
Chemistry

Courses offered by other departments that may be of interest to Chemistry

**Related Courses**

Courses offered by other departments that may be of interest to Chemistry majors include:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>BIO 41</td>
<td>Genetics, Biochemistry, and Molecular Biology</td>
<td>5</td>
</tr>
<tr>
<td>BIO 42</td>
<td>Cell Biology and Animal Physiology</td>
<td>5</td>
</tr>
<tr>
<td>BIO 43</td>
<td>Plant Biology, Evolution, and Ecology</td>
<td>5</td>
</tr>
<tr>
<td>CHEMENG 20</td>
<td>Introduction to Chemical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CHEMENG 120A</td>
<td>Fluid Mechanics</td>
<td>4</td>
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<tr>
<td>CHEMENG 120B</td>
<td>Energy and Mass Transport</td>
<td>4</td>
</tr>
<tr>
<td>CHEMENG 130</td>
<td>Separation Processes</td>
<td>3</td>
</tr>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
<td>5</td>
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<tr>
<td>CME 192</td>
<td>Introduction to MATLAB</td>
<td>1</td>
</tr>
<tr>
<td>CS 106A</td>
<td>Programming Methodology (recommended for students planning graduate study)</td>
<td>3-5</td>
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</tbody>
</table>

**American Chemical Society Certification:**

Students who wish to be certified as having met the minimum requirements of the American Chemical Society for professional training must complete, in addition to the above requirements:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 181</td>
<td>Biochemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 183</td>
<td>Biochemistry II</td>
<td>3</td>
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<tr>
<td>PHYSICS 45</td>
<td>Light and Heat</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 190</td>
<td>Introduction to Methods of Investigation (6 units)</td>
<td>1-5</td>
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</tbody>
</table>

**Honors Program**

A B.S. degree in Chemistry with honors is available to those students interested in chemical research. Admission to the honors program requires a scientific grade point average (GPA) of 3.3 and an overall GPA of 3.0 in all University courses. Beyond the standard B.S. course requirements for each track, 9 units of research credit, and 9 units of course work need to be completed during the junior and senior academic years. A thesis, approved by a Chemistry research adviser, must be completed during the senior year. Theses must be completed by May 15 to be considered for the Firestone or Golden award. The use of a single course for multiple requirements for honors, major, minor, or coterminal requirements is not allowed. Students who wish to be admitted to the honors program should register in the student services office in the Mudd Chemistry Building in Spring Quarter of their junior year.

CHEM 190 Introduction to Methods of Investigation towards honors may be completed, once accepted into the program, in any laboratory within Chemistry or with courtesy faculty in Chemistry. Other chemical research can be approved through a formal petitioning of the undergraduate studies committee. At least 3 units of must be completed during the senior year. Participation in a summer research program in an academic setting between junior and senior years may be used in lieu of 3 units of CHEM 190 Introduction to Methods of Investigation. For each quarter, a progress report reflecting the units undertaken is required. This report must be signed by the Chemistry faculty adviser and filed in the department student services office in Mudd Chemistry before the last day of finals in the quarter during which the research is performed. The 9 units of course work for honors must be completed from courses approved by the undergraduate studies committee and taken for a letter grade. At least six of these units need to be taken from the following CHEM courses:
Courses offered in previous years that may count toward the M.S. include approximately two-thirds must be in the department and must include a minimum of 45 graduate-level units and a M.S. thesis. Of the 45 required to complete, in addition to the requirements for the bachelor's of a coterminal program. Applicants for the M.S. degree in Chemistry are The Master of Science is available only to current Ph.D. students or as part

<table>
<thead>
<tr>
<th>Minor in Chemistry</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 33 Structure and Reactivity</td>
<td>4</td>
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<tr>
<td>CHEM 35 Organic Monofunctional Compounds</td>
<td>4</td>
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<tr>
<td>CHEM 36 Organic Chemistry Laboratory I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 130 Organic Chemistry Laboratory II</td>
<td>4</td>
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<tr>
<td>CHEM 131 Organic Polyfunctional Compounds</td>
<td>3</td>
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<tr>
<td>CHEM 134 Analytical Chemistry Laboratory</td>
<td>5</td>
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<td>CHEM 151 Inorganic Chemistry I</td>
<td>3</td>
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<td>CHEM 171 Physical Chemistry (Prerequisite MATH 51)</td>
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<td><strong>Total Units</strong></td>
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Master of Science in Chemistry

The Master of Science is available only to current Ph.D. students or as part of a coterminal program. Applicants for the M.S. degree in Chemistry are required to complete, in addition to the requirements for the bachelor’s degree, a minimum of 45 graduate-level units and a M.S. thesis. Of the 45 units, approximately two-thirds must be in the department and must include at least 12 units of graduate level lecture courses exclusive of the thesis. Courses offered in previous years that may count toward the M.S. include CHEM 285.

<table>
<thead>
<tr>
<th>Ph.D. Minor in Chemistry</th>
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<tbody>
<tr>
<td>CHEM 271 Advanced Physical Chemistry 3</td>
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<tr>
<td>CHEM 273 Advanced Physical Chemistry 3</td>
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<tr>
<td>CHEM 275 Advanced Physical Chemistry 3</td>
</tr>
<tr>
<td>CHEM 277 Materials Chemistry and Physics 3</td>
</tr>
<tr>
<td>CHEM 280 Single-Molecule Spectroscopy and Imaging 3</td>
</tr>
<tr>
<td>CHEM 297 Bio-Inorganic Chemistry 3</td>
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</tbody>
</table>

Doctor of Philosophy in Chemistry

Graduate students are eligible to become formal candidates for the Ph.D. degree after taking the department placement examinations, satisfactory completion of most of the formal lecture course requirements, and satisfactory progress on a dissertation research project. Admission to candidacy for the Ph.D. degree must be done before June of the second year of graduate registration.

After taking the departmental placement examinations, students select a research adviser by interviewing members of the Chemistry faculty. An Application to Start Research form is submitted to the Department as research begins under the supervision of the adviser. All students in good standing are required to start research by the end of Winter Quarter of the first year of graduate registration.

There is no foreign language requirement for the Ph.D. degree. Candidates for the Ph.D. degree are required to participate continually in the department colloquium (CHEM 300 Department Colloquium) and in the division seminar of the major subject. In addition, continuous enrollment in CHEM 301 Research in Chemistry is expected after the student has chosen a research supervisor.

Before candidates may request scheduling of the University oral examination, clearance must be obtained from the major professor and the chair of the Graduate Study Committee. Conditions that must be fulfilled before clearance is granted vary with the different divisions of the department and may be ascertained by consulting the chair of the committee.

It is the policy of the department to encourage and support in every possible way the pursuit of research and other advanced work by qualified students. Information about faculty members with lists of their recent research publications is found in Chemistry at Stanford, the Directory of Graduate Research published by the American Chemical Society, and at the Department of Chemistry (http://chemistry.stanford.edu) web site.

Ph.D. Minor in Chemistry

Candidates for the Ph.D. degree in other departments who wish to obtain a minor in chemistry must complete, with a GPA of 3.0 or higher, 20 graduate-level units in Chemistry including four lecture courses of at least three units each.

_Emeriti: (Professors) Hans C. Andersen, John I. Brauman, James P. Collman, Carl Djerassi, Harden M. McConnell, Robert Pecora, John Ross Chair: W. E. Moerner Vice Chair: T. Daniel P. Stack_  
_Associate Professors: Christopher E. D. Chidsey, Justin Du Bois, T. Daniel P. Stack_  
_Assistant Professors: Noah Z. Burns, Lynette Cegelski, Bianxiao Cui, Matthew Kanan, Hemamala Karunadasa, Thomas E. Markland_
Courtesy Professors: Stacey F. Bent, Curtis W. Frank, Daniel Herschlag

Courtesy Associate Professors: James K. Chen, Karlene A. Cimprich, Yi Cui, Jianghong Rao, Thomas J. Wandless

Lecturers: Charles Cox, Hillary Hua, Megan McClory, Jennifer Schwartz (Poehlmann)

Director of Undergraduate Laboratories: Hillary Hua