CHEMISTRY AND BIOCHEMISTRY

Office: F.W. Olin Hall, Room 202
Mail Code: 2190 E. Iliff Ave., Denver, CO 80208
Phone: 303-871-2435
Email: cheminfo@du.edu
Web Site: https://science.du.edu/chemistry

Why study chemistry at the University of Denver?
Consider the advantages:

- Excellent, research-active faculty
- Small classes, personal attention
- First-rate teaching facilities
- Modern, state-of-the-art equipment

At the University of Denver, we offer the training and activities to energize your graduate experience and help you develop into a professional scientist.

The Department of Chemistry and Biochemistry at the University of Denver offers programs leading to MA, MS or PhD degree in chemistry.

Our faculty members actively involve students in research programs supported with more than $1.5 million in annual funding from federal agencies, state governments and private industries. In our programs, you will enjoy the benefits of a friendly, personalized learning environment that offers nationally competitive and extremely productive research opportunities.

The Department of Chemistry and Biochemistry has much to offer a graduate student: close and frequent student-faculty interaction; an integrated program of courses; and excellent equipment and facilities including 500 MHz NMR, single-crystal X-ray diffraction, multiple EPR spectrometers, ICP-mass spectrometer, Raman microscope, photon counting lifetime fluorescence, nanosecond laser flash photolysis, aerosol particle monitoring spectrometer, and fluorescence microscopy.

Faculty research interests encompass biophysical, organic, analytical and environmental chemistry, and biochemistry. The department’s relatively small size allows a broader, more interdisciplinary approach than in large departments. Our instructional format merges traditional disciplines into interdisciplinary courses that more closely reflect current trends in chemistry.

The department of Chemistry and Biochemistry also participates in an interdepartmental PhD program in Molecular and Cellular Biophysics at the University of Denver. See the molecular and cellular biophysics bulletin (http://bulletin.du.edu/graduate/schoolscollegesanddivisions/divisionofnaturalscienceandmathematics/naturalsciencesgeneral/#programofstudytext) for more specific details.

Doctor of Philosophy in Chemistry

Degree and GPA Requirements

- Bachelor’s degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.
- Grade point average: The minimum undergraduate GPA for admission consideration for graduate study at the University of Denver is a cumulative 2.5 on a 4.0 scale or a 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree. An earned master’s degree or higher from a regionally accredited institution supersedes the minimum standards for the baccalaureate. For applicants with graduate coursework but who have not earned a master’s degree or higher, the GPA from the graduate work may be used to meet the requirement. The minimum GPA is a cumulative 3.0 on a 4.0 scale for all graduate coursework undertaken.
- Program GPA requirement: The minimum undergraduate GPA for admission consideration for this program is a cumulative 2.5 on a 4.0 scale.

Prerequisites

- Applicants must earn and submit proof of earning the equivalent of a baccalaureate degree in chemistry, biochemistry or a related field from a regionally accredited institution prior to beginning graduate coursework at DU.

Additional Requirements

- Applicants may be contacted to schedule an admissions interview.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
Master of Arts in Chemistry

Degree and GPA Requirements
- Bachelor’s degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.
- Grade point average: The minimum undergraduate GPA for admission consideration for graduate study at the University of Denver is a cumulative 2.5 on a 4.0 scale or a 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree. An earned master’s degree or higher from a regionally accredited institution supersedes the minimum standards for the baccalaureate. For applicants with graduate coursework but who have not earned a master’s degree or higher, the GPA from the graduate work may be used to meet the requirement. The minimum GPA is a cumulative 3.0 on a 4.0 scale for all graduate coursework undertaken.
- Program GPA requirement: The minimum undergraduate GPA for admission consideration for this program is a cumulative 2.5 on a 4.0 scale.

Additional Requirements
- Applicants may be contacted to schedule an admissions interview.

English Language Proficiency Test Score Requirements
The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:
- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Master of Science in Chemistry

Degree and GPA Requirements
- Bachelor’s degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.
- Grade point average: The minimum undergraduate GPA for admission consideration for graduate study at the University of Denver is a cumulative 2.5 on a 4.0 scale or a 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree. An earned master’s degree or higher from a regionally accredited institution supersedes the minimum standards for the baccalaureate. For applicants with graduate coursework but who have not earned a master’s degree or higher, the GPA from the graduate work may be used to meet the requirement. The minimum GPA is a cumulative 3.0 on a 4.0 scale for all graduate coursework undertaken.
- Program GPA requirement: The minimum undergraduate GPA for admission consideration for this program is a cumulative 2.5 on a 4.0 scale.

Prerequisites
- Applicants must earn and submit proof of earning the equivalent of a baccalaureate degree in chemistry, biochemistry or a related field from a regionally accredited institution prior to beginning graduate coursework at DU.

Additional Requirements
- Applicants may be contacted to schedule an admissions interview.

English Language Proficiency Test Score Requirements
The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:
- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115
Doctor of Philosophy in Chemistry

The PhD is the highest degree awarded and is intended for students seeking a career in scientific research. The ultimate aim of this degree is to train a scientist who can independently design and supervise a research project. To facilitate the educational process, each student has an advisory committee that functions to both advise the student and monitor the student’s progress.

Degree Requirements

Coursework Requirements

<table>
<thead>
<tr>
<th>Code</th>
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<th>Credits</th>
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<tbody>
<tr>
<td>Required Courses</td>
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<tr>
<td>Chemical systems (three-quarter sequence)</td>
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<tr>
<td>CHEM 3110</td>
<td>Chemical Systems I</td>
<td>3</td>
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<tr>
<td>CHEM 3120</td>
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<td>CHEM 3130</td>
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<td>Molecular structure and energetics (two-quarter sequence)</td>
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<td>Biochemistry (two-quarter sequence)</td>
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<tr>
<td>CHEM 3831</td>
<td>Advanced Protein Biochemistry</td>
<td>3</td>
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<tr>
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<td>Topics in Biochemistry</td>
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<tr>
<td>CHEM 4995</td>
<td>Independent Research</td>
<td>1-10</td>
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<tr>
<td>Additional Coursework</td>
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<td>Advanced topics</td>
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<tr>
<td>CHEM 4XXX or others if pre-approved by the graduate committee</td>
<td>56-65</td>
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<tr>
<td>Total Credits</td>
<td>90</td>
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</table>

Minimum credits required for degree: 90 (of which a minimum of 75 hours must be earned at the University of Denver)

Because a PhD in chemistry is primarily a degree in which competence in research is learned and demonstrated, a large percentage of these hours are earned as credit for research (CHEM 4995 Independent Research). A minimum of 70 graduate level quarter hours must be in CHEM courses; a maximum of 20 quarter hours may be outside of CHEM courses, but must remain within natural sciences (e.g., courses with BIOL, MATH, GEOG and/or PHYS prefixes). The formal or classroom course requirements are the same as those for the MS degree.

The graduate core curriculum must be completed with a GPA of 3.0 or better.

Non-coursework Requirements

• Qualifying Examinations

All students in the PhD program are required to take a qualifying examination at the end of the spring quarter in their first academic year. This examination covers the material presented in the core curriculum, with each course contributing 100 points. To qualify for continuance in the program, the student must score at least 500 (out of 800 points). The faculty will meet to discuss exam results and decide whether the candidate will continue in the PhD program.

• Cumulative Examinations

The PhD candidate must complete the cumulative examination requirement by the seventh quarter in residence. These examinations are prepared from topics appearing in the current literature and fundamental materials found in review articles.

• Research Proposal Examination

By the end of the eighth quarter in residence, the student should give an oral presentation of a scholarly proposal developed by the student concerning a topic that is within the scope of the adviser’s research program. It is possible to propose a topic that is unrelated to the research program, but only with the prior approval of the adviser. After the public presentation, the student will defend the proposal before a committee of four faculty members (the advisory committee and one additional member). A written version of the proposal will also be required one week prior to the public presentation.

• Dissertation
A dissertation of publishable quality based on the student's original research must be completed. A summary of the dissertation is presented in a public seminar and later defended in a private oral examination. The dissertation examination committee will consist of the three members of the student's advisory committee, one additional member of the chemistry faculty to be selected by the advisory committee, and an outside chair.

- **Seminars**

  All students in the PhD program are expected to present a departmental "non-thesis" seminar. This seminar should be presented fairly early in the degree program. In addition, the student must present public seminars as part of the proposition oral exam and final thesis defense. The student is also expected to attend Departmental seminars.

## Master of Arts in Chemistry

The MA degree is intended primarily to meet the needs of students, such as those working full time in local industry or secondary education, who are seeking an advanced degree with only a small research component. The primary difference between the MA degree and the MS degree is that a research thesis is required for the MS degree. The research required for the MS degree is often not feasible for students who work full time or is not of interest to those preparing for a career, for example, in secondary education. To facilitate the educational process, each student has an advisory committee that functions to both advise the student and monitor the student's progress.

### Degree Requirements

#### Coursework Requirements

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<td><strong>Seminar</strong></td>
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<td>CHEM 4991</td>
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<td>One advanced topic course or additional research credits</td>
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**Minimum credits required for degree: 45 (of which a minimum of 35 credit hours must be earned at the University of Denver)**

The graduate core curriculum must be completed with a GPA of 3.0 or better. If it is appropriate, and approved by the graduate committee, other graduate courses may be substituted for part of the graduate core curriculum.

**Independent Study and/or Research**

A minimum of six credit hours of independent study and/or independent research approved by the student’s advisory committee must be completed.

**Courses in Other Departments**

A minimum of 35 credit hours must be taken in courses offered by the Department of Chemistry and Biochemistry. As many as 10 credit hours may be taken in science-related 3000- to 4000- graduate level courses approved by the student’s advisory committee.

**Seminars**

All students in the MA degree program must present a technical seminar and attend Departmental seminars.
**Master of Science in Chemistry**

The MS degree is intended for students who wish an advanced degree in chemistry primarily for the purpose of better preparation to conduct research work in chemistry or biochemistry. To facilitate the educational process, each student has an advisory committee that functions to both advise the student and monitor the student's progress.

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The graduate core curriculum must be completed with a GPA of 3.0 or better.

#### Seminars

All students in the MS program must present one departmental “non-thesis” seminar, in addition to the thesis seminar and attend Departmental seminars.

#### Non-coursework Requirements

**Thesis**- A thesis of publishable quality must be completed. A summary of the thesis is presented in an oral defense. The thesis defense committee will consist of a minimum of two faculty members from the Department of Chemistry and Biochemistry and an outside chair.

**Faculty**

Allegra T. Aron, Assistant Professor, PhD, University of California, Berkeley

Emily Faye Barter, Teaching Associate Professor, PhD, Indiana University Bloomington

Erich Galen Chapman, Assistant Professor, PhD, University of Oregon

Bryan L. Cowen, Teaching Associate Professor, PhD, Yale University

Gareth Eaton, Professor, PhD, Massachusetts Institute of Technology

Sandra Eaton, Professor, PhD, Massachusetts Institute of Technology

Scott Horowitz, Associate Professor, PhD, University of Michigan

Alex Huffman, Associate Professor, PhD, University of Colorado - Boulder

Ogar Ofuka Ichire, Teaching Associate Professor, PhD, University of Montana

Michelle Knowles, Associate Professor, PhD, University of Oregon
Courses

CHEM 3110 Chemical Systems I (3 Credits)
Advanced discussion of modern concepts of organic chemistry; bonding, stereochemistry, reaction mechanisms. Prerequisites: CHEM 2453 and equivalent of one year of physical chemistry.

CHEM 3120 Chemical Systems II (3 Credits)
Interpretation of trends in the chemistry of the elements in terms of orbital interactions. Most examples will be taken from the third row transition metals and the boron and carbon groups. Prerequisites: CHEM 2131, CHEM 3310 and CHEM 3110.

CHEM 3130 Chemical Systems III (3 Credits)
Advanced-level physical biochemistry course intended for advanced-level undergraduates and graduate students. Focuses on kinetic, thermodynamic and dynamic aspects of biopolymers; delineates the relationship of these properties to the mechanism and function of biological macromolecules. Prerequisites: CHEM 3811, CHEM 3812, CHEM 3813, CHEM 3610 or the equivalent.

CHEM 3220 Advanced Analytical Chemistry (3 Credits)
Principles of chemical instrumentation applied to analytical measurements; principles, instrumentation and applications of spectrometric and chromatographic measurements. Prerequisites: CHEM 3210 and CHEM 3621, or the equivalent.

CHEM 3310 Structure and Energetics I (3 Credits)
Fundamentals of quantum chemistry, and introduction to symmetry and molecular structure of small and large systems. Prerequisite: one year of physical chemistry.

CHEM 3320 Structure and Energetics II (3 Credits)
Computational methods in chemistry. Prerequisites: CHEM 3310, one year of physical chemistry.

CHEM 3410 Atmospheric Chemistry (3 Credits)
The concepts of equilibrium thermodynamics, kinetics, and photochemistry will be applied to understanding atmospheric processes. Covers urban air pollution in detail with focus on primary pollutants. Also covers stratospheric chemistry with focus on ozone chemistry and the chemistry of climate change. Prerequisites: (CHEM 2270 and CHEM 2453) OR CHEM 2240.

CHEM 3411 Aquatic Chemistry (3 Credits)
The circulation of the oceans and their chemical make-up. 'Classical water pollution problems' like biological oxygen demand and turbidity are discussed. Also presented: aquifer structure and flow, ground water chemistry, pollutant partitioning between stationary and mobile phases, heterogeneous surface chemistry, and the detection of trace contaminants. Prerequisites: (CHEM 2270 and CHEM 2453) or CHEM 2240.

CHEM 3412 Environmental Chemistry & Toxicology (3 Credits)
A survey of environmental toxicology concepts: animal testing, dose-response data, epidemiology, risk assessment. The course includes ecotoxicology, focusing on the alteration of biological and chemical systems beyond the simple response of an individual to an environmental chemical. Prerequisites: (CHEM 2270 or CHEM 2411) and CHEM 2453.

CHEM 3610 Physical Chemistry I (3 Credits)
Fundamentals of thermodynamics, including phase and reaction equilibria, properties of solutions, and electrochemistry needed for advanced study in life sciences and for Physical Chemistry II and III. May be taken for graduate credit by nonchemistry majors. Prerequisites: CHEM 2453, calculus and physics.
CHEM 3620 Physical Chemistry II (3 Credits)
Fundamentals of quantum chemistry, including theories of atomic and molecular structure and spectroscopy. May be taken for graduate credit by nonchemistry majors. Prerequisite: CHEM 3610.

CHEM 3621 Physical Chemistry III (3 Credits)
Fundamentals of kinetic theory and statistical mechanics. May be taken for graduate credit by nonchemistry majors. Prerequisite: CHEM 3620.

CHEM 3703 Topics in Organic Chemistry (3 Credits)
May include organic photochemistry, organic synthesis, organic electrochemistry or natural products. May be repeated for credit. Prerequisites: CHEM 3110 or equivalent and others depending on topic.

CHEM 3705 Topics in Biochemistry (3,4 Credits)
May include physical techniques for exploring biological structure, biological catalysis, and selected fields within biochemistry taught from original literature. May be repeated for credit. Prerequisites: CHEM 3831 and 3813.

CHEM 3811 Biochemistry-Proteins (3 Credits)
Protein structure and function, starting with the building blocks and forces that drive the formation of protein structure and the basic concepts of protein structure, and continuing with enzyme catalysis, kinetics, and regulation. Prerequisites: CHEM 2453 or instructor permission.

CHEM 3812 Biochemistry-Membranes/Metabolism (3 Credits)
Membranes and membrane mediated cellular processes, energy and signal transduction, and metabolic/biosynthetic pathways. Prerequisite: CHEM 3811 or CHEM 3831.

CHEM 3813 Biochemistry-Nucleic Acids (3 Credits)
Molecular processes underlying heredity, gene expression and gene regulation in prokaryotes and eukaryotes. Prerequisites: CHEM 2453 and CHEM 3811.

CHEM 3831 Advanced Protein Biochemistry (3 Credits)
This course provides fundamental insights into the chemistry and physics of proteins. It investigates how amino acids form proteins with highly complex three-dimensional structures and how these structures mediate function. We examine key research articles and their contribution to our current understanding of proteins. Topics range from protein folding to enzyme kinetics and emphasize basic principles. Prerequisites: CHEM 2453 and instructor permission.

CHEM 3991 Independent Study (1-10 Credits)
May be repeated for credit.

CHEM 3995 Independent Research (1-10 Credits)
Research project conducted under guidance of a faculty member. Credit hours and projects arranged on an individual basis. May be repeated for credit.

CHEM 4900 Chemistry Seminar (0 Credits)
A weekly presentations of research in progress and of current literature by outside speakers, faculty and graduate students.

CHEM 4991 Independent Study (1-10 Credits)
CHEM 4995 Independent Research (1-10 Credits)
CHEM 5991 Independent Study (1-10 Credits)
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