CHEMISTRY AND BIOCHEMISTRY

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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, 600 MHz NMR, multiple custom-built and commercial EPR spectrometers, ICP-mass spectrometer and OES, Raman microscope, photon counting lifetime fluorescence, nanosecond laser flash photolysis, atmospheric aerosol particle monitoring and collection equipment, circular dichroism, fluorescence microscopy, and multiple gloveboxes, HPLCs and FPLCs.

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. Collaboration between research groups is very common. 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

- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

English Conditional Admission: No, this program does not offer English Conditional Admission.

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.

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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.
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English Conditional Admission: No, this program does not offer English Conditional Admission.

Doctoral Program

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

Code	Title	Credits
Required Courses		
Chemical systems (three-quarter sequence)		
CHEM 3110	Chemical Systems I	3
CHEM 3120	Chemical Systems II	3
CHEM 3130	Chemical Systems III	3
Molecular structure and energetics (two-quarter sequence)		
CHEM 3310	Structure and Energetics I	3
CHEM 3320	Structure and Energetics II	3
Biochemistry (two-quarter sequence)		
CHEM 3831	Advanced Protein Biochemistry	3
CHEM 3705	Topics in Biochemistry	3
Analytical		
CHEM 3220	Advanced Analytical Chemistry	3
Independent research (repeats allowed)		**62-66**
CHEM 4995	Independent Research	1-8
Additional Coursework		**0-4**
Advanced topics		
CHEM 3XXX or 4XXX or others if pre-approved by the graduate committee		
Total Credits		**90**

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

- 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's Programs

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 advance 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

Code	Title	Credits
Required Courses		
Chemical systems (three-quarter sequence)		
CHEM 3110	Chemical Systems I	3
CHEM 3120	Chemical Systems II	3
CHEM 3130	Chemical Systems III	3
Molecular structure and energetics (two-quarter sequence)		
CHEM 3310	Structure and Energetics I	3
CHEM 3320	Structure and Energetics II	3
Biochemistry (two-quarter sequence)		
CHEM 3811	Biochemistry-Proteins	3
or CHEM 3831	Advanced Protein Biochemistry	
CHEM 3812	Biochemistry-Membranes/Metabolism	3
or CHEM 3705	Topics in Biochemistry	
Analytical		
CHEM 3220	Advanced Analytical Chemistry	3
Seminar		
Independent study or independent research (repeats allowed)		**6**
CHEM 4991	Independent Study	
CHEM 4995	Independent Research	
Additional Coursework		**15**
One advanced topic course or additional research credits		
CHEM 4XXX or others if pre-approved by the graduate committee		
Total Credits		**45**

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.

Degree Requirements

Coursework Requirements

Code	Title	Credits
Required Courses		
Chemical systems (three-quarter sequence)		
CHEM 3110	Chemical Systems I	3
CHEM 3120	Chemical Systems II	3
CHEM 3130	Chemical Systems III	3
Molecular structure and energetics (two-quarter sequence)		
CHEM 3310	Structure and Energetics I	3
CHEM 3320	Structure and Energetics II	3
Biochemistry (two-quarter sequence)		
CHEM 3831	Advanced Protein Biochemistry	3
CHEM 3705	Topics in Biochemistry	3
Analytical		
CHEM 3220	Advanced Analytical Chemistry	3
Independent research (repeats allowed)		
CHEM 4995	Independent Research	1-10
Additional Coursework		**11-20**
Advanced topics or additional research		
CHEM 4XXX or others if pre-approved by the graduate committee		
Total Credits		**45**

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.

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.

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 and CHEM 2453.

CHEM 3413 Aerosol Science (3 Credits)
CHEM 3413 is an introductory course that presents fundamental concepts associated with atmospheric aerosols in both natural and human environments. The course will focus on the sources, behavior, and effects of atmospheric aerosols, or particulate matter (PM) within the contexts of the natural environment and climate, human health, and industrial applications. The course will provide an overview of the chemical and physical characteristics of particulate matter and measurement methods, including chemical reactions that lead to aerosol formation and transformation. Examples and demonstrations will discuss applications to medical science, public health, clouds and climate, air pollution, colors in the sky, the built environment, mechanical engineering, chemical industry, and many other topics that stimulate curiosity. Aerosols affect almost every aspect of the environment and human health and are an important part of countless industrial processes or commercial products. The course is designed to provide a background to students interested in further study or careers broadly in (a) the environmental sciences, (b) medical or health sciences, or (c) many chemical or other scientific or engineering fields where aerosol processes are involved. CHEM 3413 will be taught at an upper-division (3000) level, but with enough flexibility to expect all environmental science, chemistry, biochemistry, biology, ecology, or engineering majors with the prerequisite year of chemistry to have fun and be able to learn effectively and succeed. The course is lecture-only; no lab is required, although demonstrations and hands on activities will be involved. The course fulfills requirements for the Environmental Chemistry B.S. major or minor, elective credit toward the Environmental Science B.S. or B.A. majors, and elective credit toward graduate programs in Chemistry. Prerequisite: CHEM 2240 or CHEM 2131.

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 4980 Internship-Graduate (0 Credits)
The work will have a well-defined chemistry or biochemistry component that will enhance the student's understanding of the field and provide hands-on real-world experience.

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