

# CHEMISTRY

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## Overview

Chemistry is the study of matter and its transformations, from the smallest scale - atoms and subatomic particles - to the macromolecules that provide structure and function to living organisms. Chemistry is often called the "central science" because it touches on other STEM disciplines including physics, biology, medicine, environmental science, geology, mathematics, materials science, technology, and many others. A degree in Chemistry can prepare you for a wide range of meaningful careers discovering and applying scientific knowledge. Modern chemistry combines computer modeling and experimental observation using procedures that are much safer and more environment-friendly than in past generations. Learning chemistry also teaches you important critical thinking skills that can be valuable in any career. Students with MS degrees have job opportunities in research and technical laboratory services. In addition, flexible programs can be designed to combine chemical knowledge and skills with other interests of the MS-level student (i.e. biology or environmental science).

## Graduate Program

The MS degree offered at CU Denver is a broad-based chemistry degree that allows students to take courses and do research in the following basic fields: analytical, biochemistry, inorganic, organic, physical or environmental chemistry.

The MS program is available to both full- and part-time students. The chemistry faculty strives to ensure that students receive excellent advising and supervision of work. Students enrolled in the program have an opportunity to be appointed as laboratory teaching assistants. Research activities on the part of the chemistry faculty provide opportunities for graduate students to obtain research assistantships.

## Admission Requirements

Applicants must meet the Downtown Campus Graduate School admission requirements according to Graduate School Policies and Procedures in addition to the following requirements of the Department of Chemistry:

An undergraduate major in Chemistry or a closely related discipline is required, including two semesters of organic chemistry as well as training in analytical chemistry, physical chemistry, and inorganic chemistry. Students missing more than one of these courses may be limited in the tracks that they are eligible to select. Students missing more than one of these courses may be provided a provisional admission. An undergraduate GPA of 3.0 (on a 4 point scale) is desired although each application is considered on its own merits.

- The GRE examination is recommended but not required.
- International students have additional admission requirements concerning immigration status, proof of financial responsibility and acceptable TOEFL or IELTS scores or completion of the CU Denver English as a Second Language Academy.

- Students currently in a BS program at CU Denver or elsewhere may want to consider the Chemistry BS/MS. This option includes the opportunity to enroll in graduate classes before enrolling in the MS program at CU Denver. At least 20 credits must be earned on campus. However, for the remaining courses, enrollment through CU ONLINE or on one of the other CU campuses is possible. Furthermore, the Chemistry Master's Program accepts transfer credits from accredited Universities with approval from the Graduate Program Director.

## Programs

- Chemistry, MS (<http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-ms/>)

## Faculty

### Professors:

**Robert Damrauer**, PhD, Massachusetts Institute of Technology

**David Engelke**, PhD, Washington University (St. Louis)

**Doris Kimbrough**, PhD, Cornell University

**Hai Lin**, PhD, University of Science and Technology of China

**Scott Reed**, PhD, University of Oregon

**Haobin Wang**, PhD, Wayne State University

**Xiaotai Wang**, PhD, University of Virginia

### Associate Professors:

**Jefferson Knight**, PhD, Yale University

**Yong Liu**, PhD, University of Michigan

**Xiaojun Ren**, PhD, Jilin University

**Marino Resendiz**, PhD, University of California, Los Angeles

**Liliya Vugmeyster**, PhD, State University of New York at Stony Brook

### Assistant Professors:

**John (Nick) Fisk**, PhD, University of Wisconsin, Madison

**Emilie Guidez**, PhD, Iowa State University

**Jung-Jae Lee**, PhD, University of Notre Dame

### Clinical Associate Professors:

**Marta Maron**, PhD, University of Colorado

### Clinical Assistant Professor:

**Priscilla Burrow Crocker**, PhD, University of Colorado

### Instructors:

**Vanessa Fishback**, PhD, University of Northern Colorado

**Kyung Kim**, PhD, University of Notre Dame

## Chemistry (CHEM) Courses

**CHEM 5010 - Advanced Inorganic Chemistry (3 Credits)**

Covers the fundamental principles of inorganic chemistry. Topics include atomic structure and periodicity, molecular symmetry, bonding, structural chemistry, main-group chemistry, coordination chemistry, and organometallic chemistry. Prerequisite knowledge in Undergraduate Inorganic and Physical Chemistry assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4010. Term offered: fall. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5073 - RM-MSMSP Research Experience for Teachers - Chemistry Cohort (1-6 Credits)**

The Research Experience for Teachers (RET) program will be a five-week research exploration in which twelve RM-MSMSP teachers will raise their level of relevant scientific understanding by engaging in a "hands on" workshop, transforming what they have learned into new curricular materials that will improve the scientific abilities of their students and hopefully stimulate them to consider a STEM career. Note: Credit may not apply toward any CLAS degree. Max Hours: 6 Credits.

Grading Basis: Letter Grade

**CHEM 5110 - Advanced Analytical Chemistry (3 Credits)**

Explores the fundamental principles of analytical chemistry. Topics will focus on meteorology (the science of making measurements), measurements based on energy transfer (e.g. spectroscopic analysis), and measurements based on mass transfer (e.g. chemical separations and electrochemistry). Requisite knowledge in Undergraduate Instrumental Analysis is assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4110. Term offered: spring. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5221 - Practical Applications of Spectroscopy (3 Credits)**

This course surveys spectroscopic methods in order to deduce the structure of organic compounds from an examination of spectra, with an emphasis on infrared spectroscopy, mass spectrometry, nuclear magnetic resonance spectroscopy, and ultraviolet spectroscopy. Students will be introduced to a wide array of powerful and elegant tools for obtaining qualitative information about the structure of matter. This course will require a good amount of thought, yet all of the concepts and associated mathematical manipulations are within the reach of a student who has met the prerequisites. Restriction: Restricted to degree-granting graduate programs. Cross-listed with CHEM 4221. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5310 - Advanced Organic Chemistry (3 Credits)**

An exploration of structure, bonding and reactivity in organic modules that includes extensive analysis of the chemical literature, culminating in written and seminar presentations of individual projects. Requisite knowledge in Undergraduate Organic Chemistry and Physical Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4310. Term offered: fall. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5421 - Cannabis Chemistry (3 Credits)**

An exploration of the terpene to cannabinoid compounds including biosynthesis pathways; human receptor structures and mechanism; current analytical methods for Quality Assurance and Quality Control and current research in medical applications. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4421. Term offered: spring. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5510 - Computational Chemistry (3 Credits)**

Classical and ab initio molecular dynamics are covered from theory to application. Students have access to high-performance computational resources and cover current topics in the field. Requisite knowledge in Undergraduate Physical Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4510. Term offered: fall. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

Typically Offered: Fall.

**CHEM 5530 - Advanced Physical Chemistry (3 Credits)**

Explores fundamental properties of molecules (bond length and strength, the potential energy surface, reaction rates, etc.) and examines how these properties are measured, using original literature as the primary source, and culminating in written and seminar presentations of individual projects. Requisite knowledge in Undergraduate Physical Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4530. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5550 - Applications of Group Theory in Chemistry (3 Credits)**

Introduces the basic principles of the group theoretical method as well as its applications in organic, inorganic, and physical chemistry. Covers Mo's for main-group and transition metal compounds, ligand field theory, molecular vibrations, and electron absorption spectroscopy. Requisite knowledge in Undergraduate Physical Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5600 - Graduate Topics in Chemistry (1-3 Credits)**

Graduate students in chemistry or a related discipline explore a special topic in chemistry or biochemistry. A description of topics to be covered in the current semester is maintained on the Chemistry department website. Restriction: Restricted to degree-granting Graduate programs. Term offered: spring. Repeatable. Max hours: 6 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

Restriction: Restricted to degree-granting graduate programs

**CHEM 5610 - Understanding & Presenting Chemical Research (1-2 Credits)**

This course will improve your ability to systematically search for chemical information, help you interpret the information you find, & improve your ability to summarize and present that information. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4610.

Term offered: fall, spring. Repeatable. Max Hours: 2 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 2.

Restriction: Restricted to degree-granting graduate programs

**CHEM 5630 - Programming for Data Analysis in the Physical Sciences (1 Credit)**

This course will be taught using live coding format (the instructor will code live in the classroom with the students). In this course, you will learn to process data using python scripts that you will write. Data include for example absorption spectra, protein pdb files, coordinate files. You will also learn how to use Python libraries and write functions (for example to create high resolution graphs). Finally, you will learn best coding practices, how to keep track of different versions of your code and share your code using Github. Restriction: Restricted to students enrolled degree-granting graduate programs. Cross-listed with CHEM 4630. Max hours: 1 Credit.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5655 - Teaching Assistant Bootcamp (1 Credit)**

This course is 4-5 8-hour days of intensive training in suitable pedagogy for general chemistry and organic chemistry laboratory classes, procedures for teaching laboratory sections, and laboratory techniques. Students must have a teaching assistant contract with the Chemistry Department in order to take this course. Restriction: Restricted to degree-granting graduate programs. Cross-listed with CHEM 4655. Term offered: fall. Repeatable. Repeatable. Max Hours: 1 Credit.

Grading Basis: Letter Grade

Repeatable. Max Credits: 2.

Restriction: Restricted to degree-granting graduate programs

**CHEM 5700 - Environmental Chemistry (3 Credits)**

A discussion of the sources, reactions, transport, effects, and fates of chemical species in the water, soil and air environments. Requisite knowledge in Undergraduate Organic and Analytical Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 4700. Term offered: spring. Max hours: 3 Credits. Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5810 - Graduate Biochemistry I (4 Credits)**

Topics include proteins, mechanisms and kinetics of enzymes, carbohydrates, lipids and membranes, nucleic acids, genetic engineering, signaling pathways, and energetics, which are integrated with critical analysis of recent journal papers, culminating in written and seminar presentations of individual projects. Requisite knowledge in Undergraduate Organic Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Term offered: fall. Max hours: 4 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5815 - Structural Biology of Neurodegenerative Diseases (3 Credits)**

Advanced course in Biochemistry/Biophysics. Principles of Protein Folding, Structure-Function Relationship, and spectroscopic techniques related to characterization of these processes as applied to neurodegenerative diseases such as Parkinson's and Alzheimer's. Restriction: Restricted to degree-granting graduate programs. Cross-listed with CHEM 4815, BIOL 4815, and BIOL 5815. Term offered: spring. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5825 - Biochemistry of Metabolic Disease (3 Credits)**

Advanced course in biochemistry. An expanded study of selected topics in metabolism and how they relate to diseases, including inflammation, diabetes, obesity, and rare genetic disorders. Restriction: Restricted to degree-granting graduate programs. Cross-listed with CHEM 4825, BIOL 4825, and BIOL 5825. Term offered: fall. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5830 - Graduate Biochemistry II (4 Credits)**

Topics include biosynthesis & metabolism of carbohydrates, lipids & amino acids, & genetic information flow of DNA replication, transcription, translation & regulation of transcription, which are integrated with critical analysis of recent literature, culminating in written & seminar presentations of individual projects. Continuation of 5810. Prereq: CHEM 5810 with a B- or higher. Restriction: Restricted to degree-granting Graduate programs or permission of instructor. Term offered: spring. Max hours: 4 Credits.

Grading Basis: Letter Grade

Prereq: CHEM 5810 with a B- or higher Restriction: Restricted to degree-granting Graduate programs

Typically Offered: Spring.

**CHEM 5835 - Biochemistry of Gene Regulation and Cancer (3 Credits)**

Explores the biochemical and molecular aspects of cancer biology. Topics include DNA mutations and repair, gene regulation, oncogenes and tumor suppressors, stem cells and differentiation, and cancer drug development. Restriction: Restricted to degree-granting graduate programs. Cross-listed with CHEM 4835, BIOL 4835, and BIOL 5835. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5840 - Independent Study (1-3 Credits)**

Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the Graduate School for approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 9 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 9.

**CHEM 5845 - Molecular Modeling and Drug Design (3 Credits)**

Advanced course in biochemistry. An introductory course on modern molecular modeling techniques and their applications to computer-aided rational drug design. Restriction: Graduate standing. Cross-listed with CHEM 4845. Term offered: fall. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

**CHEM 5860 - Bioinorganic Chemistry: Bioinorganic compounds in medicine (3 Credits)**

Explore the roles of metals in biochemistry and medicine by studying chemical/physical properties of metal coordinated compounds. The course focus on metal coordination resulting biopolymer folding and the function of macromolecules that is involved into iron cytochromes, zinc and copper enzymes, iron sulfur proteins, oxygen transport, iron storage, electron transfer, inorganic model compounds, metals in medicine, and toxicity of inorganic species. Topic is extended to biomedical application such as chemotherapy. Prereq: CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Cross-listed with CHEM 4860. Max hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: CHEM 3810 or 4810 or 5810 with a C- or higher

## CHEM 5880 - Directed Research (1-6 Credits)

Students will engage in original research projects supervised and mentored by faculty. Students must work with faculty prior to registration to develop a proposal for their project and receive permission to take this course. Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the Graduate School for approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 6 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

## CHEM 5939 - Internship (1-6 Credits)

Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the Graduate School for approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 9 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 9.

## CHEM 5950 - Master's Thesis (1-8 Credits)

Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the Graduate School for approval. Term offered: fall, spring, summer. Max hours: 8 Credits.

Grading Basis: Letter Grade with IP

Additional Information: Report as Full Time.

## CHEM 6000 - Chemistry Seminar (1-3 Credits)

Faculty and student presentations of CU-Denver research projects and other current chemistry topics. Note: All chemistry students are encouraged to attend, but credit is given only to those who present seminars. Prerequisite knowledge in Undergraduate Physical or Environmental Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Term offered: fall, spring, summer. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

## CHEM 6001 - Master's Research Seminar (1 Credit)

Students present a formal seminar to the department describing their master's research work. Note: Required for all students completing a thesis-based master's degree; optional for those completing master's projects. Prereq: CHEM 6000 with a B- or higher. Term offered: fall, spring, summer. Max hours: 1 Credit.

Grading Basis: Letter Grade

Prereq: CHEM 6000 with a B- or higher

## CHEM 6002 - Chemistry Seminar I (1 Credit)

The art of listening to and giving a chemistry seminar. Introduces the chemical literature, the pedagogical techniques of seminar giving, and the critical thinking skills required to understand a technical presentation. Note: Seminar presentations by faculty, outside speakers, and advanced graduate students are analyzed by the students participating in the course. Restriction: Restricted to degree-granting Graduate programs. Max Hours: 1 Credit.

Max Hours: 1 Credit.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

## CHEM 6003 - Chemistry Seminar II (1 Credit)

Students prepare and give a chemical seminar based on a literature paper. Note: Seminar presentations by students and outside speakers are analyzed by students in the course. Restriction: Restricted to degree-granting Graduate programs. Max Hours: 1 Credit.

Grading Basis: Letter Grade

Restriction: Restricted to degree-granting graduate programs

## CHEM 6840 - Independent Study: CHEM (1-6 Credits)

Repeatable. Max Hours: 9 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 9.

## CHEM 6950 - Master's Thesis (1-6 Credits)

Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the Graduate School for approval. Term offered: fall, spring, summer. Max hours: 6 Credits.

Grading Basis: Letter Grade with IP

Additional Information: Report as Full Time.

## CHEM 6960 - Master's Report (1-6 Credits)

Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the Graduate School for approval. Term offered: fall, spring, summer. Repeatable. Max hours: 6 Credits.

Grading Basis: Letter Grade with IP

Repeatable. Max Credits: 6.

Additional Information: Report as Full Time.