

# Chemistry

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College of Arts and Science  
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The Department of Chemistry offers four undergraduate degree tracks, three leading to a Bachelor of Science and one leading to a Bachelor of Arts. A minor in chemistry and a Bachelor of Science degree with departmental honors also are offered.

At the graduate level, the department offers MS and PhD degrees in Chemistry.

## Faculty

**Rabjohn Professor** M. Harmata\*\*

**Schlundt Professor** K. S. Gates\*\*

**Professor** C. J. Anderson\*\*, L. J. Beamer\*\*, W. H. Bernskoetter\*\*, T. E. Glass\*\*, X. Guan\*\*, S. Handa\*\*, D. Kireev, T. D. Sewell\*\*, A. G. Suits\*\*, J. R. Walensky\*\*, X. Zeng\*\*

**Associate Professor** G. A. Baker\*\*, J. D. Brockman\*\*, W. B. Edwards\*\*, E. Goun\*\*, C. M. Greenlief\*\*, S. W. Keller\*

**Assistant Professor** D. Bauer\*\*, B. M. Broderick\*\*, K. R. Brorsen\*\*, H. M. Hennkens\*\*, B. MacDonald\*\*, V. K. Outlaw\*\*, M. J. Young\*

**Associate Teaching Professor** B. Ganley

**Assistant Teaching Professor** E. Moore, G. Reynders, N. Verma

\* Graduate Faculty Member - membership is required to teach graduate-level courses, chair master's thesis committees, and serve on doctoral examination and dissertation committees.

\*\* Doctoral Faculty Member - membership is required to chair doctoral examination or dissertation committees. Graduate faculty membership is a prerequisite for Doctoral faculty membership.

## Undergraduate

- Department Level Requirements (<https://catalog.missouri.edu/collegeofartsandscience/chemistry/chemistry-major-requirements/>)
- BA in Chemistry (<https://catalog.missouri.edu/collegeofartsandscience/chemistry/ba-chemistry/>)
- BS in Chemistry (<https://catalog.missouri.edu/collegeofartsandscience/chemistry/bs-chemistry/>)
- Minor in Chemistry (<https://catalog.missouri.edu/collegeofartsandscience/chemistry/minor-chemistry/>)

## Graduate

- MS in Chemistry (<https://catalog.missouri.edu/collegeofartsandscience/chemistry/ms-chemistry/>)
- PhD in Chemistry (<https://catalog.missouri.edu/collegeofartsandscience/chemistry/phd-chemistry/>)

College of Arts and Science  
125 Chemistry Building  
(573) 882-8374  
<https://chemistry.missouri.edu/>

**Director of Graduate Studies:** Kent Gates

The Department of Chemistry offers graduate degrees in all areas of modern chemistry, including analytical, biological, computational, inorganic, organic, physical and radiochemistry.

## Resources and Facilities

The department has well-equipped laboratories that contain state-of-the-art instrumentation and computing facilities for research. Major instrumentation includes NMR, X-ray diffraction and mass spectrometry centers, as well as a nuclear/radiochemistry lab. Other campus facilities widely used by the department include a central instrument shop, electronics shop, campus computing center and a 10-megawatt nuclear reactor. The latter provides a high neutron flux for radioisotope production, neutron activation analysis and neutron diffraction studies.

## Internal Funding

Fellowships and teaching and research assistantships are available for highly qualified applicants. Application forms are available on the department's website and should be submitted by February 1st.

## Graduate Degree Requirements

Students are strongly encouraged to visit the Department of Chemistry site (<http://chemistry.missouri.edu>) for the most up-to-date information.

## Entrance Criteria

An applicant for graduate work in chemistry should have either a Bachelor of Arts or Bachelor of Science degree in chemistry, essentially equivalent to those awarded at MU, with at least a B average or a score at the 70th percentile on the GRE general test.

## Examinations

All new graduate students in chemistry are required to take Departmental placement/qualifying examinations in all core areas (analytical, inorganic, organic and physical) prior to registration. Students must qualify in two areas. A student who performs well on an exam, as determined by the department's Graduate Program Committee, will be considered to have qualified in that area. Students who do not qualify in particular areas, via the placement examinations, must pass appropriate advanced-level courses in those areas to qualify. An A or B grade is required in these courses for qualification.

## Research, Advising, and the Committee

Affiliation with research advisor must be made by the end of the first semester through a formal process that is part of CHEM 7087. Student progress in the degree program is evaluated annually in May, using the Graduate Student Progress System through the Graduate School. In addition, the student's Graduate Program Committee meets with the student and their research advisor after their first summer of research to review degree progress. At this time the student will have submitted a formal Research Progress Report to their committee for consideration. All students are expected to attend Departmental Colloquium and Organic/DyNAMITE seminars.

### CHEM 1000: Introductory Chemistry

Introductory course for students with no high school background in chemistry. Covers fundamental principles of scientific measurement, stoichiometry, solutions, basic atomic structure, gases. No credit if taken after CHEM 1100 or CHEM 1320.

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**Credit Hours:** 2**Prerequisites or Corequisites:** MATH 1100

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**CHEM 1100: Atoms and Molecules with Lab**

One-semester introduction for non-science majors to the basic concepts and important applications of chemistry. Satisfies A&S requirement for a laboratory science. No credit if taken after CHEM 1000 or CHEM 1320.

**Credit Hours:** 4

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**CHEM 1100H: Atoms and Molecules with Laboratory - Honors**

One-semester introduction for non-science majors to the basic concepts and important applications of chemistry. Satisfies A&S requirement for a laboratory science. No credit if taken after CHEM 1000 or CHEM 1320.

**Credit Hours:** 4**Prerequisites:** Honors eligibility required

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**CHEM 1400: College Chemistry I**

First of two-course sequence emphasizing principles and applications of modern chemical sciences. Covers chemical nomenclature, stoichiometry, kinetic molecular theory, atomic structure, periodic properties, and molecular structure and bonding. Satisfies laboratory science requirement. No credit for CHEM 1320 and CHEM 1400/CHEM 1401.

**Credit Hours:** 3**Prerequisites:** MATH 1100. MATH 1050 is NOT an appropriate substitution for College Algebra

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**CHEM 1400H: College Chemistry I - Honors**

First of two-course sequence emphasizing principles and applications of modern chemical sciences. Covers chemical nomenclature, stoichiometry, kinetic molecular theory, atomic structure, periodic properties, and molecular structure and bonding. Satisfies laboratory science requirement. No credit for CHEM 1320 and CHEM 1400/CHEM 1401.

**Credit Hours:** 3**Prerequisites:** MATH 1100. MATH 1050 is NOT an appropriate substitution for College Algebra. Honors eligibility required

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**CHEM 1401: College Chemistry I Laboratory**

Laboratory section that goes along with the first of two-course sequence emphasizing principles and applications of modern chemical sciences. Covers chemical nomenclature, stoichiometry, kinetic molecular theory, atomic structure, periodic properties, and molecular structure and bonding. Satisfies laboratory science requirement. No credit for CHEM 1320 and CHEM 1400/CHEM 1401.

**Credit Hour:** 1**Prerequisites or Corequisites:** CHEM 1400**Prerequisites:** MATH 1100. MATH 1050 is NOT an appropriate substitution for College Algebra

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**CHEM 1401H: College Chemistry I Laboratory - Honors**

Laboratory section that goes along with the first of two-course sequence emphasizing principles and applications of modern chemical sciences. Covers chemical nomenclature, stoichiometry, kinetic molecular theory, atomic structure, periodic properties, and molecular structure and bonding. Satisfies laboratory science requirement. No credit for CHEM 1320 and CHEM 1400/CHEM 1401.

**Credit Hour:** 1**Prerequisites or Corequisites:** CHEM 1400. Honors eligibility required**Prerequisites:** MATH 1100. MATH 1050 is NOT an appropriate substitution for College Algebra

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**CHEM 1410: College Chemistry II**

Continuation of CHEM 1400. Covers intermolecular forces, solutions, kinetics, acid-base chemistry, electrochemistry, nuclear chemistry, thermodynamics. No credit for CHEM 1330 and CHEM 1410/CHEM 1411.

**Credit Hours:** 3**Prerequisites:** CHEM 1400, CHEM 1320, or CHEM 1320H and MATH 1100

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**CHEM 1410H: College Chemistry II - Honors**

Continuation of CHEM 1400. Covers intermolecular forces, solutions, kinetics, acid-base chemistry, electrochemistry, nuclear chemistry, thermodynamics. No credit for CHEM 1330 and CHEM 1410/CHEM 1411.

**Credit Hours:** 3**Prerequisites:** CHEM 1400, CHEM 1320, or CHEM 1320H and MATH 1100. Honors eligibility required

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**CHEM 1411: College Chemistry II Laboratory**

Laboratory course that goes alongside CHEM 1410. Covers intermolecular forces, solutions, kinetics, acid-base chemistry, electrochemistry, nuclear chemistry, thermodynamics. Satisfies requirement for a laboratory science. No credit for CHEM 1330 and CHEM 1410/CHEM 1411.

**Credit Hour:** 1**Prerequisites or Corequisites:** CHEM 1410**Prerequisites:** CHEM 1400 and CHEM 1401 or CHEM 1320; MATH 1100

**CHEM 1411H: College Chemistry II Laboratory - Honors**

Laboratory course that goes alongside CHEM 1410. Covers intermolecular forces, solutions, kinetics, acid-base chemistry, electrochemistry, nuclear chemistry, thermodynamics. Satisfies requirement for a laboratory science. No credit for CHEM 1330 and CHEM 1410/CHEM 1411.

**Credit Hour:** 1

**Prerequisites or Corequisites:** CHEM 1410

**Prerequisites:** CHEM 1400 and 1401; MATH 1100. Honors eligibility required

**CHEM 2030: Survey of Organic Chemistry**

One-semester introduction to structure and bonding, functional group chemistry, principles of reactivity, reaction mechanisms, the molecules of life.

**Credit Hours:** 3

**Prerequisites:** C- or better in CHEM 1400 and CHEM 1401.

Recommended CHEM 1410

**CHEM 2100: Organic Chemistry I**

First course of a two-semester sequence. Structure and bonding; chemistry of hydrocarbons, alkyl halides, alcohols and ethers; reaction mechanisms; principles of reactivity and synthesis; IR and NMR spectroscopy. Only 1 hour credit if taken after CHEM 2030 or equivalent.

**Credit Hours:** 3

**Prerequisites:** C- or higher in CHEM 1400 and CHEM 1401 or CHEM 1410

**Recommended:** CHEM 1410

**CHEM 2100H: Organic Chemistry I - Honors**

First course of a two-semester sequence. Structure and bonding; chemistry of hydrocarbons, alkyl halides, alcohols and ethers; reaction mechanisms; principles of reactivity and synthesis; IR and NMR spectroscopy. Only 1 hour credit if taken after CHEM 2030 or equivalent.

**Credit Hours:** 3

**Prerequisites:** C- or higher in CHEM 1400 and CHEM 1401 or CHEM 1410. Honors eligibility required

**Recommended:** CHEM 1410

**CHEM 2110: Organic Chemistry II**

Continuation of CHEM 2100. Aromatic hydrocarbons, carbonyls, amines; chemistry of carbanions; reactions of polar double bonds; nucleic acids, proteins, carbohydrates and fats.

**Credit Hours:** 3

**Prerequisites:** grade of C- or better in CHEM 2100 or equivalent, or departmental consent

**CHEM 2110H: Organic Chemistry II - Honors**

Continuation of CHEM 2100. Aromatic hydrocarbons, carbonyls, amines; chemistry of carbanions; reactions of polar double bonds; nucleic acids, proteins, carbohydrates and fats.

**Credit Hours:** 3

**Prerequisites:** grade of C- or better in CHEM 2100 or equivalent, or departmental consent; Honors eligibility required

**CHEM 2130: Organic Laboratory I**

Basic lab techniques, functional group manipulations, and short syntheses. Pre-lab and post-lab writing assignments. 1 hour recitation, 3 hours lab per week.

**Credit Hours:** 2

**Recommended:** Concurrent enrollment in CHEM 2110 or CHEM 2030.

No credit for students who have previous organic laboratory credit

**CHEM 2130H: Organic Laboratory I - Honors**

Basic lab techniques, functional group manipulations, and short syntheses. Pre-lab and post-lab writing assignments. 1 hour recitation, 3 hours lab per week.

**Credit Hours:** 2

**Prerequisites:** Honors eligibility required

**Recommended:** Concurrent enrollment in CHEM 2110 or CHEM 2030.

No credit for students who have previous organic laboratory credit

**CHEM 2140: Organic Laboratory II**

Continuation of CHEM 2130. Preparation and identification of organic compounds; application of instrumental techniques. 2 lab sessions, 1 recitation session per week.

**Credit Hours:** 2

**Prerequisites:** grade of C- or better in CHEM 2110 and CHEM 2130 or equivalent

**CHEM 2170H: Honors Organic Chemistry II with Lab - Honors**

Continuation of CHEM 2160H; includes laboratory. Content and structure similar to CHEM 2110, but with increased depth and breadth.

**Credit Hours:** 5

**Prerequisites:** honors eligibility, grade of B or better in CHEM 2160H or instructor's permission

**CHEM 2400: Fundamentals of Inorganic Chemistry with Lab**

A systematic introduction with laboratory to inorganic and organometallic compounds, reactions, and periodic properties.

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**Credit Hours:** 3**Prerequisites:** grade of C- or better in CHEM 2130

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**CHEM 2950: Undergraduate Research in Chemistry**

A laboratory research project and/or preparation of compounds with a written final report. Cannot be substituted for other chemistry courses required for a B.S. or B.A. degree. No more than 6 hrs. total credit.

**Credit Hour:** 1-3**Prerequisites:** sophomore standing, 2.75 GPA and/or instructor's consent

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**CHEM 3200: Quantitative Methods of Analysis with Lab**

Principles and practice of quantitative analysis, including the basic principles of modern instrumental methods.

**Credit Hours:** 4**Prerequisites:** CHEM 1410 and CHEM 1411 or CHEM 1500H

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**CHEM 3300: Fundamentals of Physical Chemistry**

Survey of physical chemistry. Satisfies physical chemistry prerequisite for BIOCHM 8430.

**Credit Hours:** 3**Prerequisites:** MATH 1700, a course in organic chemistry; PHYSCS 1210 and PHYSCS 1220 or PHYSCS 2750, or PHYSCS 2760

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**CHEM 3700: Undergraduate Seminar in Chemistry**

Methods for locating and presenting chemical information, data analysis techniques, professional issues.

**Credit Hours:** 3**Prerequisites:** CHEM 1330 and CHEM 2100

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**CHEM 3700W: Undergraduate Seminar in Chemistry - Writing Intensive**

Methods for locating and presenting chemical information, data analysis techniques, professional issues.

**Credit Hours:** 3**Prerequisites:** CHEM 1330 and CHEM 2100

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**CHEM 3800: Internship in Chemistry**

Cannot be substituted for other chemistry courses required for B.S. or B.A. degree.

**Credit Hour:** 1-6**Prerequisites:** departmental consent

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**CHEM 3820: Introduction to Archaeological Chemistry**

(same as ANTHRO 3820). This course will introduce students to the field of archaeological science and its contributions to our knowledge of the human past. It will review current topics, recent advances, and major debates in the field, with emphasis on the applied analytical chemistry methods that are commonly used. It will cover methodologies including neutron activation analysis, mass spectrometry, X-ray fluorescence, and biomolecular approaches used in the study of ceramics, pigments, glass, metals, biominerals (bone, teeth, shell), and sediments relevant to archaeological and cultural heritage contexts. Graded on A-F basis only.

**Credit Hours:** 3**Prerequisites:** One of CHEM 1320 and/or CHEM 1330**Recommended:** ANTHRO 2020 or ANTHRO 2021

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**CHEM 4001: Topics in Chemistry - General**

Organized study designed to broaden the knowledge base of students. Subjects on analytical, inorganic, organic and physical chemistry covered.

**Credit Hour:** 1-99**Prerequisites:** departmental consent

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**CHEM 4010: Advanced Chemistry Laboratory**

Advanced methods for the synthesis and characterization of organic, inorganic, and organometallic compounds.

**Credit Hours:** 3**Prerequisites:** CHEM 2400, CHEM 2140, or CHEM 2190H, CHEM 3200, CHEM 4330 (or CHEM 4330 corequisite)

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**CHEM 4050: Problems in Chemistry**

Individual study under the direction of a faculty member that supplements regular course work.

**Credit Hour:** 1-99**Prerequisites:** instructor's consent

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**CHEM 4160: Intermediate Organic Chemistry**

Stresses synthetic organic chemistry at an intermediate level.

**Credit Hours:** 3**Prerequisites:** at least one year organic chemistry

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**CHEM 4170: Medicinal Chemistry**

Chemical mechanisms of drug action. Topics include drug metabolism and action, chemical toxicology and medicines, enzyme activity, and specific drug case studies.

**Credit Hours:** 3

**Prerequisites:** CHEM 2110 or instructor's consent

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**CHEM 4200: Instrumental Methods of Analysis with Lab**

(cross-leveled with CHEM 7200). Chemical instrumentation methods including electrochemistry, spectroscopy, and advanced separations techniques.

**Credit Hours:** 3

**Prerequisites:** CHEM 3200, a semester of physical chemistry

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**CHEM 4280: Environmental Chemistry**

Surveys the chemistry of air and water environments; discusses the chemistry of waste treatment.

**Credit Hours:** 3

**Prerequisites:** 8 hours chemistry including organic and analytical

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**CHEM 4310: Physical Chemistry I**

Lecture only. Topics include the kinetic theory of gases, chemical kinetics, thermodynamics and chemical equilibrium.

**Credit Hours:** 3

**Prerequisites:** CHEM 2100, MATH 1700, and PHYSICS 1220 or PHYSICS 2760

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**CHEM 4330: Physical Chemistry II**

Lecture only. Covers wave mechanics, bonding, molecular spectroscopy and statistical mechanics.

**Credit Hours:** 3

**Prerequisites:** MATH 2300 or instructor approval. May be taken independently of CHEM 4310

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**CHEM 4330H: Physical Chemistry II - Honors**

Covers wave mechanics, bonding, molecular spectroscopy and statistical mechanics.

**Credit Hours:** 3

**Prerequisites:** MATH 2300 or instructor approval. May be taken independently of CHEM 4310. Honors eligibility required

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**CHEM 4340: Physical Chemistry Laboratory**

This course is intended to introduce the practice of experimental physical chemistry including applying the principles of thermodynamics, kinetics, and spectroscopy in experiments.

**Credit Hours:** 3

**Prerequisites:** Grade of C- or better in CHEM 3200; CHEM 4330 or CHEM 4330 concurrently

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**CHEM 4400: Inorganic Chemistry**

(cross-leveled with CHEM 7400). Atomic and molecular structure, bonding, kinetics and mechanism, ligand field theory, coordination compounds, acids and bases.

**Credit Hours:** 3

**Prerequisites:** CHEM 2400

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**CHEM 4490: Physics and Chemistry of Materials**

(same as NU\_ENG 4319, PHYSICS 4190, BIOL\_EN 4480; BME 4480; cross-leveled with CHEM 7490, NU\_ENG 7319, PHYSICS 7190, BIOL\_EN 7480). Physics and Chemistry of Materials is a 3 credit hours course offered every spring semester for students from Physics, Chemistry, Engineering and Medical Departments and consists of lectures, laboratory demonstrations, two mid-term and one final exam. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** PHYSICS 2750, CHEM 1320 or equivalent, or instructor's consent

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**CHEM 4600: Introduction to Radiochemistry with Lab**

Introduces application of radio-tracer techniques to chemical research.

**Credit Hours:** 3

**Prerequisites:** CHEM 1330

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**CHEM 4800: Chemistry Teaching Practicum**

Provides practical experience teaching introductory chemistry in discussion and laboratory settings. For students pursuing dual degrees in chemistry and secondary education. For students pursuing simultaneous dual degrees in chemistry and secondary education. Graded on S/U basis only.

**Credit Hours:** 3

**Prerequisites:** senior standing; departmental consent required

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**CHEM 4950: Senior Research**

A laboratory research project with approved written goals and a final written report. It may be taken twice.

**Credit Hours:** 3

**Prerequisites:** a 2.75 GPA, departmental consent

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**CHEM 4990H: Senior Honors Research I**

A laboratory research experience with a student-instructor prepared outline approved by the Honors Director, a final written report and a final oral presentation and examination. May replace CHEM 4950 in ACS Certification Track or 4000+ level elective requirement for

Medicinal Chemistry track. Must take CHEM 4990H and CHEM 4991H for departmental honors.

**Credit Hours:** 3

**Prerequisites:** a 3.33 GPA, departmental consent, and approval of project outline. Honors eligibility required

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**CHEM 4991H: Senior Honors Research II**

A laboratory research experience with a student-instructor prepared outline approved by the Honors Director, a final written report and a final oral presentation and examination.

**Credit Hours:** 3

**Prerequisites:** a 3.33 GPA, departmental consent, approval of project outline. Honors eligibility required

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**CHEM 7087: Seminar in Chemistry for Beginning Graduate Students**  
Seminar in Chemistry for Beginning Graduate Students

**Credit Hour:** 1

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**CHEM 7200: Instrumental Methods of Analysis with Lab**

(cross-leveled with CHEM 4200). Chemical instrumentation methods including electrochemistry, spectroscopy, and advanced separations techniques.

**Credit Hours:** 3

**Prerequisites:** CHEM 3200, a semester of physical chemistry

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**CHEM 7300: Intermediate Physical Chemistry**

Treatment of atomic and molecular, structure and spectroscopy based on quantum concepts. Designed to provide a broad base of knowledge in these fundamental areas to beginning graduate students in chemistry.

**Credit Hours:** 3

**Prerequisites:** departmental consent

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**CHEM 7400: Inorganic Chemistry**

(cross-leveled with CHEM 4400). Atomic and molecular structure, bonding, kinetics and mechanism, ligand field theory, coordination compounds, acids and bases.

**Credit Hours:** 3

**Prerequisites:** CHEM 2400

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**CHEM 7490: Physics and Chemistry of Materials**

(same as NU\_ENG 7319, PHYSICS 7190, BIOL\_EN 7480; cross-leveled with CHEM 4490, NU\_ENG 4319, PHYSICS 4190, BIOL\_EN 4480, BME 4480). Physics and Chemistry of Materials is a 3 credit

hours course offered every spring semester for students from Physics, Chemistry, Engineering and Medical Departments and consists of lectures, laboratory demonstrations, two mid-term and one final exam. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** PHYSICS 2750, CHEM 1320 or equivalent, or instructor's consent

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**CHEM 8003: Topics in Chemistry - Natural Science**

Organized study of selected topics. Subjects and earned credit may vary from semester to semester. Repeatable upon consent of department.

**Credit Hour:** 1-99

**Prerequisites:** instructor's consent

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**CHEM 8050: Non-Thesis Research in Chemistry**

Does not lead to dissertation.

**Credit Hour:** 1-99

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**CHEM 8085: Topics in Chemistry**

Organized study of selected topics. Subjects and earned credit may vary from semester to semester. Repeatable upon consent of department.

**Credit Hour:** 1-99

**Prerequisites:** instructor's consent

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**CHEM 8087: Seminar in Chemistry**

Seminar in Chemistry

**Credit Hour:** 1

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**CHEM 8090: Thesis/Dissertation (pre-candidacy) Research in Chemistry**

Research leading to thesis. Graded on a S/U basis only.

**Credit Hour:** 1-99

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**CHEM 8140: Polymer Chemistry**

This is an introduction to the chemistry of polymers. The morphology, molecular weight, mechanisms, testing and characterization, fabrication, and different types of polymers will be discussed. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** CHEM 2110 or CHEM 2110H



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**CHEM 8150: Organic Reaction Mechanisms**

Organic reaction mechanisms are discussed within a framework of structure-reactivity relationships. Particular attention directed to the chemistry of reactive intermediates and the application of stereochemical and molecular orbital concepts.

**Credit Hours:** 3

**Prerequisites:** 1 year of Organic Chemistry and Physical Chemistry

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**CHEM 8160: Organic Spectroscopy**

Structural analysis of organic compounds involving problem solving using modern NMR, IR, UV-VIS, MS CD/ORD and other spectroscopic techniques.

**Credit Hours:** 3

**Prerequisites:** CHEM 4330 or equivalent or instructor's consent

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**CHEM 8170: Applications of the Reactions of Organic Chemistry**

**Credit Hours:** 3

**Prerequisites:** CHEM 8150

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**CHEM 8210: Analytical Measurement**

Fundamental and applied aspects of scientific measurements. Topics include: Statistics, signal-to-noise, frequency analysis, sources of noise, digital and analog filtering, time vs. frequency domain measurements, Fourier transformation, sampling, convolution/deconvolution, autocorrelation and cross-correlation. Directed toward entering graduate students.

**Credit Hours:** 3

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**CHEM 8230: Separations and Chromatography**

Classical and instrumental methods of separation: gas, paper, thin film, and column chromatography; ion exchange.

**Credit Hours:** 3

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**CHEM 8240: Mass Spectrometry**

This course will cover various aspects of modern mass spectrometry. Topics will include instrumentation, theory, uses and interfaces to mass spectrometry. Graded on A-F basis only.

**Credit Hours:** 3

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**CHEM 8250: Analytical Spectroscopy**

Selected topics dealing with recent advances in analytical chemistry.

**Credit Hours:** 3

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**CHEM 8260: Surface Analysis and Characterization**

Covers various aspects of modern methods of surface analysis and characterization. Topics include instrumentation, theory, and data reduction methods. Major sections include electron spectroscopy, microscopy, and vibrational spectroscopy as applied to surfaces. Graded on A-F basis only.

**Credit Hours:** 3

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**CHEM 8265: Fluorescence Spectroscopy**

Advanced analytical chemistry course that explores the fundamental principles and uses of modern fluorescence spectroscopy in biology, materials science, chemistry, physics and engineering. Special emphasis is placed on the methodologies used to obtain specific information about a particular chemical system. Graded on A-F basis only.

**Credit Hours:** 3

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**CHEM 8270: Advanced Analytical Chemistry**

Continuation of CHEM 8250.

**Credit Hours:** 3

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**CHEM 8280: Bioanalytical Chemistry**

This course is aimed at introducing students to the instrumental and theoretical principles by which biological molecules are measured in vivo and in vitro. The course explores how protein, DNA and metabolite structures and quantities are determined in the laboratory with an emphasis on understanding historical methods up through cutting edge approaches in each field. The theory of measurement techniques, separation techniques and related instrumentation are explored in the context of understanding the chemical equilibria that govern each instance. Students will leave this course with a broad understanding for how many biological molecules are measured and what the limitations of various techniques may be. Graded on A-F basis only.

**Credit Hours:** 3

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**CHEM 8285: Nanochemistry**

Covers various aspects of nanochemistry. Topics include synthesis and characterization of nonmaterial, nanotoxicity, and catalysis. Graded on A-F basis only.

**Credit Hours:** 3

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**CHEM 8310: Quantum Chemistry**

Introduction to formal quantum mechanical theory, quantum measurement, simple model problems having exact solutions, angular

momenta, approximation methods (perturbation theory, variation principle, WKB), and the structure of many-electron atoms.

**Credit Hours:** 3

**Prerequisites:** CHEM 4330 or equivalent or instructor's consent

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**CHEM 8320: Chemical Kinetics**

Factors affecting rates, orders and mechanisms of chemical reactions, with emphasis on current theories and experimental techniques.

**Credit Hours:** 3

**Prerequisites:** CHEM 4330 or equivalent or instructor's consent

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**CHEM 8330: Computational Chemistry**

Theory and application of modern computational techniques (molecular mechanics, ab initio and semiempirical molecular orbital methods) for predicting the structures, energies, and properties of molecules and molecular systems.

**Credit Hours:** 3

**Prerequisites:** CHEM 3300 or equivalent or instructor's consent

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**CHEM 8340: Statistical Mechanics**

Principles of statistical mechanics and their application to chemical systems; ensemble theory; condensed phases.

**Credit Hours:** 3

**Prerequisites:** CHEM 4330 or equivalent or instructor's consent

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**CHEM 8360: Atomic-Scale Simulations**

This course will provide an in-depth introduction to the methods and applications of atomic-scale simulation methods (mainly classical molecular dynamics, hereafter "MD") for graduate students in chemistry, physics, materials science, and engineering. One of the beauties of MD methods is that, if applied judiciously and with skill, they provide exquisitely high-fidelity information about the fundamental properties and processes that occur on time scales ranging from femtoseconds to nanoseconds (or longer) and space scales ranging from Ångströms to approximately microns. In many cases, this information can be used to guide or assess theoretical developments, interpret experiments, or provide insights or predictions for thermodynamic or non-equilibrium states that are not easily achieved or are difficult to probe experimentally. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** Instructor consent

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**CHEM 8370: Introduction to Astrochemistry**

Introduction to Astrochemistry is a graduate-level course covering the chemistry and physics which gave rise to the Modern Universe, as well as that which currently governs the way in which new species are formed,

destroyed, and measured. We examine the events that immediately followed the Big Bang, the vast interstellar medium, Solar system and planet formation, and the number of routes by which complex organic molecules form. Throughout this course, it will be clear that the Universe, though largely inhospitable, is host to a rich chemistry that gave rise to life as we know it. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** CHEM 4330 or equivalent

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**CHEM 8410: Chemistry of the Main Group Elements**

Descriptive inorganic chemistry of the main group elements. Textbook material extensively supplemented with information from the current chemical literature.

**Credit Hours:** 3

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**CHEM 8420: Supramolecular Chemistry**

The basics of supramolecular chemistry will be covered, including host-guest complexes, reorganization, complementarity, thermodynamic interactions, self assembly and biochemical, molecular device and crystal engineering applications. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** BS in Chemistry, Biochemistry or Chemical Engineering

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**CHEM 8430: Coordination Chemistry and Reactivity**

The chemistry of the transition elements (d-block) and their reactivity will be discussed, including bonding, coordination numbers, oxidation states, and reactivity (kinetics). Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** CHEM 4400 or equivalent; graduate standing in chemistry or instructor's consent

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**CHEM 8440: Inorganic Structural Methods**

Chemical bonding, application of group theory, spectroscopy; diffraction as applied to structure determination; structural implications of dipole moment and magnetic susceptibility measurements.

**Credit Hours:** 3

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**CHEM 8450: Organometallics**

Condensations effected by organometallics; dissolving metal reductions; sandwich compounds and related organotransition metal derivatives.

**Credit Hours:** 3



**CHEM 8470: Actinide Chemistry**

The course covers the inorganic and organometallic chemistry of the actinides. Graded on A-F basis only.

**Credit Hours:** 3

**CHEM 8480: Chemistry of Nanomaterials**

This course will cover several aspects of nanomaterials including synthesis and processing of small particles, as well as their characterization by crystallography, scanning tunneling microscopy magnetism, and other optical properties. Also studied will be the application of quantum confinement to the electronic and optical properties of nanomaterials and the development of photonic materials. The nanostructure of organic polymers, micelles, and the process of biomineralization to make organic-inorganic hybrid materials will also be discussed.

**Credit Hours:** 3

**CHEM 8600: Radiochemistry and Detection with Lab**

An introductory course in the applications of radionuclides in chemistry. Topics include radioactive decay, interactions of radiation with matter, radioactive tracers, and nuclear methods of analysis. Directed towards entering graduate students.

**Credit Hours:** 3

**CHEM 8610: Advanced Radiochemistry**

Reviews current advances in radiochemistry, hot atom chemistry, radiation chemistry, nuclear spectrometry.

**Credit Hours:** 3

**Prerequisites:** CHEM 8600 or equivalent

**CHEM 8615: Atomistic Materials Analytics**

(same as CMP\_SC 8615, CH\_ENG 8615, BIOL\_EN 8615 DATA\_SCI 8615, ECE 8615, MAE 8615). Introduction to the principles of materials characterization and analysis leading to information extraction from experimental and computational data sets. Examines theoretical and practical issues associated with understanding the relationships between atomic/molecular structure and material properties. Describes encoding and visualizing atomic structure information. Measurement techniques covered include Ultraviolet-Visible (UV-Vis) spectroscopy, (Fourier Transform) Infrared Spectroscopy (FTIR), X-ray diffraction (XRD), and electronic conductivity. Covers standard data processing techniques, including sparse vs. abundant data, preprocessing and normalization, fixed length vs. variable length data, heterogeneous data streams, feature extraction, and the role of simulated data. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** DATA\_SCI 7010, DATA\_SCI 8010, and Instructor consent

**CHEM 8630: Radiopharmaceutical Chemistry**

The radiotracer concept, history of nuclear medicine, radionuclide production, organic and inorganic chemistry of radiopharmaceutical chemistry, and applications will be discussed. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** undergraduate organic and inorganic chemistry; graduate standing in chemistry or instructor's consent

**CHEM 8640: Biological Radiochemistry**

(same as V\_M\_S 8640). Covers the interaction of radiation on biological material. The effects of radiation overdose is discussed along with the use of radiation in therapy. Graded on A-F basis only.

**Credit Hours:** 3

**CHEM 9090: Post-candidacy Dissertation Research in Chemistry**

Research leading to Ph.D. dissertation. Graded on a S/U basis only.

**Credit Hour:** 1-99