CHEMISTRY (CHEM)

CHEM 100 Preparation for Chemistry (Units: 3)
Prerequisites: Category I or II placement for QR/Math. Category III or IV placement for QR/Math must co-enroll in MATH 122 and an associated B4 course; or in MATH 123 and MATH 124; or in MATH 107 or MATH 197; or have completed these courses with grades of C or better.

Elementary concepts of chemistry. Development of skills in applying mathematics to solving problems in chemistry. Preparation for CHEM 115 or CHEM 180. (Plus-minus ABC/NC grading only)

CHEM 101 Survey of Chemistry (Units: 3)
Prerequisites: Category I or II placement for QR/Math. Category III or IV placement for QR/Math must have completed MATH 197 with a grade of C or better or satisfied the B4 requirement. An ELM score of 50 or higher or exemption; or MATH 70 or ESM 70 with a grade of C or better. High school chemistry recommended.


Course Attributes:
- B1: Physical Science

CHEM 102 Survey of Chemistry Laboratory (Unit: 1)
Laboratory to accompany or follow CHEM 101. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

Course Attributes:
- B3: Lab Science

CHEM 115 General Chemistry I: Essential Concepts of Chemistry (Units: 5)
Prerequisites: Category I or II placement for QR/Math, or ELM score of 50 or higher or exemption, or MATH 70 or ESM 70 with a grade of C or better. Category III or IV for QR/Math must have completed MATH 197 with a grade of C or better or have satisfied the B4 requirement. Satisfactory score on the Chemistry readiness assessment. CHEM 100 is recommended for students needing additional preparation for the assessment and CHEM 115.

Essential concepts of atomic properties, atomic interactions, reaction chemistry, stoichiometry, thermodynamics, chemical kinetics, and equilibria. Lecture, 3 units; seminar, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

CHEM 130 General Organic Chemistry (Units: 3)
Prerequisite: CHEM 115* with a grade of C or better.

Common organic compounds and basic principles. For laboratory, see CHEM 234. Cannot be used for the Chemistry or Biochemistry degrees.

CHEM 180 Chemistry for the Energy and the Environment (Units: 3)
Prerequisites: Category I or II placement for QR/Math placement, or an ELM score of 50 or ELM exemption, or MATH 70 with a grade of C or better. Category III or IV for QR/Math placement must have completed MATH 197 with a grade of C or better or satisfied the GE Area B4 requirement. High school chemistry recommended.

Study of the fundamental chemical principles that underlie chemical processes in the environment and the chemical processes that are important to the generation of energy. Suitable for Engineering and Environmental Studies majors. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

Course Attributes:
- B1: Physical Science
- B3: Lab Science
- Environmental Sustainability

CHEM 215 General Chemistry II: Quantitative Applications of Chemistry Concepts (Units: 3)
Prerequisite: CHEM 115* with a grade of C or better.

Quantitative aspects of chemistry with an emphasis on kinetics, equilibria (acid-base, solubility, and buffer), thermodynamics, and electrochemistry.

CHEM 216 General Chemistry II Laboratory: Quantitative Applications of Chemistry Concepts (Units: 2)
Prerequisite: CHEM 215 with a grade of C or better (may be taken concurrently).

Determination of thermodynamic quantities including rate laws, acid dissociation constants, preparation and analysis of buffer solutions, and synthesis and analysis of a molecular complex. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

CHEM 233 Organic Chemistry I (Units: 3)
Prerequisites: Priority enrollment for Chemistry and Biochemistry majors; CHEM 115* and CHEM 215* with grades of C or better; other majors permitted on a space-available basis.


CHEM 234 Organic Chemistry I Laboratory (Units: 2)
Prerequisite: CHEM 233 or CHEM 130 with a grade of C or better (may be taken concurrently).

Techniques and selected experiments in organic chemistry. Lecture, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

CHEM 251 Mathematics and Physics for Chemistry (Units: 3)
Prerequisites: CHEM 215, MATH 226, MATH 227, PHYS 220, PHYS 222, PHYS 230, and PHYS 232 with grades of C or better; or consent of the instructor; concurrent enrollment in CHEM 351 is strongly recommended.

Integrated mathematics and physics for physical chemistry including fluids, wave motion, thermodynamics, partial derivatives, multiple integrals, introductory vector calculus, and introductory differential equations. (Plus-minus letter grade only)
CHEM 300 General Physical Chemistry I (Units: 3)
Prerequisites: CHEM 215*, CHEM 335*, MATH 227*, and PHYS 121* or PHYS 230* or PHYS 240* with grades of C or better; CHEM 340 or CHEM 349 recommended. For Chemistry, Biochemistry, and Biology majors.

Chemical thermodynamics, kinetic theory of gases, and properties of solutions. Designed for students in Biology, pre-professional curricula, Biochemistry, and Chemistry majors.

CHEM 301 General Physical Chemistry II (Units: 3)
Prerequisite: CHEM 300 with a grade of C or better or consent of the instructor.

Quantum mechanics, spectroscopy, biophysical spectroscopy, intermolecular forces, macromolecules, and statistical thermodynamics.

CHEM 321 Quantitative Chemical Analysis (Units: 3)
Prerequisites: CHEM 215* and CHEM 216* with grades of C or better.
Intended for Chemistry, Biochemistry, and Biology majors.

Foundation course in analytical chemistry with a focus on quantitative analysis. Topics include uncertainties, statistics, equilibria, titrimetric methods, potentiometry, molecular and atomic spectroscopy, mass spectroscopy, and chromatography. (Plus-minus letter grade only)

CHEM 322 Quantitative Chemical Analysis Laboratory (Units: 2)
Prerequisite: CHEM 321 with a grade of C or better (may be taken concurrently). Intended for Chemistry, Biochemistry, and Biology majors.

Practical experience in performing accurate and precise measurements of chemical species in a variety of real-world samples using gravimetric, titrimetric, potentiometric, spectroscopic, and chromatographic methods. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 325 Inorganic Chemistry (Units: 3)
Prerequisites: CHEM 215 and CHEM 335 with grades of C or better.
Intended for Chemistry, Biochemistry, and Biology majors.

Theories of chemical bonding and their application to inorganic systems with an emphasis on transition metal complexes. Molecular Symmetry. Acid/base, redox, and solid-state chemistry. An introduction to organometallic and bioinorganic chemistry.

CHEM 327 Practical GC and HPLC (Units: 4)
Prerequisites: CHEM 234, CHEM 321, and CHEM 322 with grades of C or better.

Theory, hardware, and experience in GC and HPLC separations. Emphasis on practical skills and common applications in natural products, environmental, and pharmaceutical analyses. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 335 Organic Chemistry II (Units: 3)
Prerequisite: CHEM 233* with a grade of C or better.

Continuation of CHEM 233.

CHEM 336 Organic Chemistry II Laboratory (Units: 2)
Prerequisites: CHEM 234 and CHEM 335 (may be taken concurrently) with grades of C or better. Intended for science majors.

Techniques and experiments in organic synthesis, isolation, purification, and characterization. Activity, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 338 Organic Chemistry II: Laboratory Honors (Units: 3)
Prerequisites: CHEM 233 and CHEM 234 with grades of B or better; concurrent enrollment in CHEM 335. Substitute for CHEM 336.

Experiments in organic synthesis and analysis plus a research project directed by faculty. Lecture, 1 unit; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 340 Biochemistry I (Units: 3)
Prerequisites: CHEM 215*, CHEM 233*, and CHEM 335* with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors.

Introduction to Biochemistry including protein structure and function, carbohydrate metabolism, enzyme kinetics and thermodynamics, and electron transport chain.

CHEM 341 Biochemistry II (Units: 3)
Prerequisite: CHEM 340 with a grade of C or better.

Biosynthesis and degradation of lipids, amino acids, and nucleotides. Protein synthesis, folding, and degradation. DNA and RNA structure. DNA replication and transcription.

CHEM 343 Biochemistry I Laboratory (Units: 3)
Prerequisites: Restricted to Chemistry and Biochemistry majors; CHEM 216*, CHEM 234*, and CHEM 340* (may be taken concurrently) or CHEM 349* (may be taken concurrently) with grades of C or better; CHEM 321 is recommended.

Chemical and enzymatic experiments involving proteins, carbohydrates, and nucleic acids with emphasis on enzyme kinetics. Utilization of standard and modern biochemical techniques. Lecture, 1 unit; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 349 General Biochemistry (Units: 3)
Prerequisites: CHEM 215* with a grade of C or better, and CHEM 130* with a grade of C or better or CHEM 335* with a grade of C- or better. Not intended for B.S. Biochemistry or Chemistry majors. Students who have completed CHEM 340 may not take CHEM 349 for credit.

Survey of major areas in Biochemistry including enzymology, bioenergetics, and carbohydrate, lipid, and nucleic acid metabolism.

CHEM 351 Physical Chemistry I: Thermodynamics and Kinetics (Units: 3)
Prerequisites: Restricted to upper-division standing; CHEM 233, CHEM 251 (may be taken concurrently), and CHEM 321 with grades of C or better; or consent of the instructor.

Thermodynamics and kinetic theory. Lecture, 2 units; laboratory, 1 unit.
CHEM 353 Physical Chemistry II: Quantum Chemistry and Spectroscopy (Units: 3)
Prerequisites: Restricted to upper-division standing; CHEM 233, CHEM 251, and CHEM 321 with grades of C or better; or consent of the instructor.

Quantum chemistry, spectroscopy of atoms and molecules, and statistical thermodynamics. Lecture, 2 units; activity, 1 unit.

CHEM 370 Computer Applications in Chemistry and Biochemistry (Units: 3)
Prerequisites: CHEM 321 and CHEM 233 with grades of C or better.

Data acquisition, manipulation, and presentation with an emphasis on software used in chemistry and biochemistry laboratories. Computational chemistry and molecular visualization software for small and large molecules. Development of interactive molecular visualization web pages. Lecture, 2 units; laboratory, 1 unit.

CHEM 380 Chemistry Behind Environmental Pollution (Units: 3)
Prerequisites: GE Areas A1, A2, A3, and B4; CHEM 115 or CHEM 180 with a grade of C- or better; or consent of the instructor.

Traditional and contemporary topics in environmental chemistry. Understanding and appreciation of various chemical processes and principles underlying environmental problems facing society.

Course Attributes:
- UD-B: Physical Life Science
- Environmental Sustainability

CHEM 390GW Contemporary Chemistry and Biochemistry Research - GWAR (Units: 3)
Prerequisites: Upper-division Chemistry and Biochemistry majors; GE Area A2; CHEM 216 or CHEM 234 with a grade of C or higher.

Improve skills in written and oral communication with an emphasis on the communication skills expected of professional chemists and biochemists. Lecture, 2 units; laboratory, 1 unit. (ABC/NC grading only)

Course Attributes:
- Graduation Writing Assessment

CHEM 399 Careers in Chemistry and Biochemistry (Unit: 1)
Prerequisite: Senior standing.

Discussion of the full spectrum of careers in Chemistry and Biochemistry including career counseling, resume and interview guidance and strategies, and outside speakers from education and industry. (CR/NC grading only)

CHEM 420 Environmental Analysis (Units: 3)
Prerequisites: CHEM 321 and CHEM 322 with grades of C or better.

Practical analysis of real-world samples and environmental pollutants. Statistics, QA/QC, heavy metal analysis via atomic spectroscopy, and organic pollutant analysis via GC/MS. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 422 Instrumental Analysis (Units: 4)
Prerequisites: CHEM 321 and CHEM 322 with grades of C or better.

Instrumental methods for chemical and biochemical analysis including basic electronics, molecular and atomic spectroscopy, IR and Raman spectroscopy, mass spectrometry, and chromatography. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 426 Advanced Inorganic Chemistry Laboratory (Units: 2)
Prerequisites: CHEM 321, CHEM 322, and CHEM 325 with grades of C or better; or consent of the instructor.

Modern techniques in inorganic chemistry with an emphasis on synthesis, characterization, and reactivity of metals in a variety of materials including biological and environmental samples. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 433 Advanced Organic Chemistry (Units: 3)
Prerequisites: CHEM 335 with a grade of C or better and CHEM 301 or CHEM 353 (may be taken concurrently).

Theoretical aspects of organic chemistry, molecular structure, and reaction mechanisms.

CHEM 443 Biophysical Chemistry Laboratory (Units: 4)
Prerequisites: CHEM 343 with a grade of C or better and CHEM 301 or CHEM 353 (may be taken concurrently).

Experiments using modern techniques in biochemistry, bioinformatics, molecular biology, and biophysics for the study of biological macromolecules. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 451 Experimental Physical Chemistry Laboratory (Units: 2)
Prerequisites: CHEM 321, CHEM 322, CHEM 351, CHEM 353 or CHEM 300 and CHEM 301, with grades of C or better, or consent of instructor.

Emphasis on molecular spectroscopy, thermodynamics, kinetics, electrochemistry, applications of computational chemistry, and error analysis. 2 laboratory periods per week. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 645 Research Trends in Chemistry and Biochemistry (Units: 3)
Prerequisites: CHEM 340 and one semester of physical chemistry; GPA of 3.0 or better.

Self-directed learning experience for undergraduates in modern research topics in chemistry and biochemistry.
**CHEM 677 Introduction to Optical Engineering for the Biological Sciences** (Units: 3)
Prerequisites: MATH 226; CHEM 215; BIOL 230 with C or better; consent of the instructor.

A hands-on introduction to applying advances in low-cost computers and digital cameras to microscope design. Learn the fundamentals of optical engineering and image processing used in digital microscopy. Includes building an inexpensive lensless microscope capable of capturing and processing images of plankton. The completed microscope will be used to conduct a research project. Learn essential skills in optical design, instrumentation, and fabrication. Lecture, 1 unit; laboratory, 2 units. (Plus-minus letter grade; RP grading only)

(This course is offered as BIOL 677 and CHEM 677. Students may not repeat the course under an alternate prefix.)

**CHEM 680 Chemical Oceanography** (Units: 3)
Prerequisite: CHEM 215 or equivalent.

Investigation of the composition and dynamics of the ocean through chemistry. (Plus-minus letter grade only)

**CHEM 685 Projects in the Teaching of Chemistry and Biochemistry** (Unit: 1)
Prerequisites: A grade of B or better in the course in which student will be instructing; consent of the instructor,

Instructional methods and techniques for effective student teaching, leading class discussions and activities, and carrying out class demonstrations. May be repeated for a total of 4 units.

**CHEM 693 Cooperative Education Program** (Units: 6-12)
Prerequisite: Consent of the instructor.

Supervised chemistry laboratory employment. Enrollment by prior arrangement with the employer and department. A final written report is required. A maximum of 2 units (1 unit for each semester) may be used to meet elective requirements in the Chemistry major programs. May be repeated for up to 24 units. (CR/NC grading only)

**CHEM 694 Cooperative Education in Chemistry** (Unit: 1)
Prerequisites: Upper-division standing or consent of the instructor.
Enrollment by prior arrangement with supervising faculty member and industry sponsor. See department adviser for details.

Supervised chemistry laboratory experience in the industry. A final written report is required. May be repeated for a total of 3 units. (Plus-minus letter grade only)

**CHEM 699 Independent Study** (Units: 1-6)
Prerequisite: Consent of the department and instructor.

Laboratory or library research work focused on chemistry and biochemistry problems directed by a department faculty. For advanced, superior students majoring or minoring in Chemistry or Biochemistry. Final written report required. May be repeated. (Plus-minus letter grade only)

**CHEM 741 Electron Microscopy** (Units: 4)
Prerequisite: Graduate or senior standing or consent of the instructor.

Preparation of biological and inorganic materials for scanning and transmission electron microscopy, x-ray microanalysis, EBSD, CL, the operation of the electron microscope(s), and data interpretation. Seminar, 1 unit; laboratory, 3 units. Extra fee required.

(This course is offered as BIOL 741, CHEM 741, and ERTH 741. Students may not repeat the course under an alternate prefix.)

**CHEM 800 Special Topics in Chemistry** (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Topic to be specified in Class Schedule. May be repeated as topics vary.

**CHEM 820 NMR Applications and Techniques** (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

FT NMR concepts and operating techniques; 1D and 2D experiments; relaxation and dynamics. Spectral interpretation. Lecture, 2 units; laboratory, 1 unit.

**CHEM 821 Mass Spectrometry - Principles and Practice** (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Fundamental principles and modern practice of mass spectrometry, instrumentation (mass analyzers, ionization modes, sample introduction systems) and applications (qualitative and quantitative analysis, environmental and biomedical applications). (Plus-minus letter grade only)

**CHEM 822 Organic Synthesis** (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Problems relating to current organic synthetic methods. Synthesis and reactions of the major classes of mono- and polyfunctional compounds.

**CHEM 834 Organic Spectroscopic Methods** (Units: 3)
Prerequisites: Graduate standing in Chemistry; CHEM 301 or CHEM 353; or consent of the instructor.

Relations between molecular structure and spectroscopic behavior. Mass spectrometry, infrared, electronic and magnetic resonance spectroscopy.

**CHEM 841 Enzymology** (Units: 3)
Prerequisites: Graduate standing in Chemistry; CHEM 341, CHEM 301 or CHEM 353; or consent of the instructor.

The relationships between enzyme structure and catalytic activity, including enzyme kinetics and mechanisms.

**CHEM 842 Bioorganic and Medicinal Chemistry** (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Molecular recognition, enzymatic reaction mechanisms, catalytic antibodies/polymers, enzymes in organic synthesis, pharmacodynamics, and drug action, drug design for pharmacokinetic problems.

**CHEM 846 Biology and Chemistry of Signaling Pathways** (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.

An interdisciplinary presentation of the mechanisms by which extracellular stimuli trigger intracellular biochemical reactions that lead to alterations in cellular function. (Plus-minus letter grade)

(This course is offered as BIOL 732 and CHEM 846. Students may not repeat the course under an alternate prefix.)

**CHEM 850 Valency and Spectroscopy** (Units: 3)
Prerequisite: Graduate Chemistry students; passing score on the ACS diagnostic examination in quantum chemistry; or consent of the instructor.

Relations between enzyme structure and spectroscopic behavior. Mass spectrometry, infrared, electronic and magnetic resonance spectroscopy.

**CHEM 851 Quantum Mechanics** (Units: 3)
Prerequisite: Graduate Chemistry students; passing score on the ACS diagnostic examination in quantum chemistry; or consent of the instructor.

Relations between enzyme structure and spectroscopic behavior. Mass spectrometry, infrared, electronic and magnetic resonance spectroscopy.
CHEM 851 Biochemical Spectroscopy (Units: 3)
Prerequisites: Graduate chemistry students; passing ACS diagnostic examination in quantum chemistry; a biochemistry course; or consent of the instructor.
Quantum chemistry elements. Principles, techniques, and biochemical applications of spectroscopy.

CHEM 852 Statistical Mechanics: Molecular Relaxation (Units: 3)
Prerequisites: CHEM 351 and CHEM 353 or equivalents.

CHEM 870 Computational Methods in Chemistry (Units: 3)
Prerequisites: Upper-division or graduate standing; one year of undergraduate physical chemistry.
Introduction to quantum chemical and classical mechanical methods for the computation of molecular structure, molecular spectroscopy, liquid state transport properties and molecular reactivity for small and large molecules, including solids and interactions at surfaces. Hands-on use of four software packages: Gaussian 09, AMBER molecular dynamics, LAMMPS dynamics for mesoscopic systems, and BEST for molecular hydrodynamics. (Plus-minus letter grade only)

CHEM 877 Introduction to Cellular Engineering (Units: 2)
Prerequisite: BIOL 230, MATH 226, and MATH 227; BIOL 240 recommended.
A quantitative approach to understanding, predicting, and engineering cellular behavior. Learn how to describe complex biological systems with protein, RNA, and DNA components using a mathematical framework. Consider the cell as a compartmentalized reactor with many simultaneously ongoing chemical processes and build models for natural and engineered biological systems. Design new biological circuits and predict their behavior. (Plus-minus letter grade only)
(This course is offered as BIOL 877 and CHEM 877. Students may not repeat the course under an alternate prefix.)

CHEM 879 Research Methods I (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.
Development of background, specific research aims, methods, and outcomes. Includes literature review, writing assignments, and oral presentations. (Plus-minus letter grade, RP grading only)

CHEM 880 Research Methods II (Units: 3)
Prerequisites: Restricted to graduate standing; CHEM 879; or consent of the instructor.
Exploration of current areas and methods of chemical research. Scientific writing and presentations emphasizing students’ independent research projects. (Plus-minus letter grade, RP grading only)

CHEM 885 Teaching College Chemistry (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.
Examination of the role of preparation, assessment, and feedback in teaching college-level chemistry laboratory and discussion sections. Emphasis on effective classroom techniques and organizational strategies. (Plus-minus letter grade only)

CHEM 895 Research Project (Units: 3)
Prerequisites: Consent of the instructor; approval of Advancement to Candidacy (ATC) and Culminating Experience (CE) forms by Graduate Studies.
Supervised independent and original laboratory investigation. Guidelines are available through the Department of Chemistry & Biochemistry. (CR/NC grading only)

CHEM 897 Research (Units: 1-9)
Prerequisites: Graduate Chemistry students; CHEM 880 (may be taken concurrently); or consent of the instructor.
Independent and original laboratory, computational, or theoretical research under faculty supervision. May be repeated for a total of 9 units. (Plus-minus letter grade, RP grading only)

CHEM 898 Master’s Thesis (Units: 3)
Prerequisites: Consent of the instructor; approval of Advancement to Candidacy (ATC) for the Master of Science in Chemistry and Culminating Experience (CE) forms by Graduate Studies.
(CR/NC grading only)