Chemistry

Professors: Bartz (Chair), Frantz, Furchak, Furge, Slough, T. Smith, Stevens-Truss, Williams

The chemistry program stresses the art of scientific thought and the role of chemistry in society. Chemistry students benefit from a close working relationship with faculty members in an atmosphere that encourages research. Majors can gain preparation suitable for graduate study in chemistry, biochemistry, chemical and materials engineering, environmental sciences, pharmacology, medicinal chemistry, clinical chemistry, or molecular biology. Other professional schools open to chemistry graduates include the following: human, dental, or veterinary medicine; business administration; or patent or environmental law. Majors will also have a background appropriate for becoming a professional research or process chemist in industrial, pharmaceutical, or government laboratories; teaching high school or community college chemistry; doing environmental monitoring or remediation; working in sales, product development, or in laboratory safety; becoming a writer on science topics, working in science libraries or other information services, doing conservation work in art museums; or performing forensic analyses for law enforcement agencies.

Requirements for the Major in Chemistry

Number of Units
A minimum of eight units from credited courses, excluding courses designed for non-chemistry majors. Also does not include the SIP.

Advanced Placement
With a chemistry advanced placement score of 4 or 5or IB score of 5, 6, or 7, one unit of AP credit will be awarded towards the minimum of eight units required for the major in chemistry provided a student begins the chemistry sequence at CHEM 120 or higher.

Required Courses
CHEM 110 Chemical Composition and Structure with Lab (exempted if student begins in CHEM 120 or CHEM 125)
CHEM 120 Chemical Reactivity with Lab or CHEM 125 Chemical Composition, Structure, and Reactivity with Lab
CHEM 210 Organic Chemistry I with Lab
CHEM 220 Organic Chemistry II with Lab
CHEM 240 Analytical Chemistry with Lab
CHEM 310 Physical Chemistry I with Lab
CHEM490 Senior Seminar (minimum of 0.7 units required)
Two additional 300- or 400- level credited courses with lab

Required Cognates
MATH 112 Calculus I
MATH 113 Calculus II (Additional work in mathematics is encouraged.)
PHYS 150 Introductory Physics I with Lab
PHYS 152 Introductory Physics II with Lab

In accordance with College policy, chemistry majors must pass eight units of chemistry and the mathematics and physics cognates with a C- or better.

Kalamazoo College appears on the American Chemical Society's list of schools that offer approved pre-professional undergraduate programs in chemistry. This program includes: CHEM 210, 240, 310, 352, 430, a chemistry research-based SIP, and three additional chemistry courses above the 100-level. In addition MATH 112 and 113 and PHYS 150 and 152 are required and Math 214 and 240 are recommended. This curriculum, which provides thorough preparation in chemistry, mathematics, and physics, is recommended for students contemplating graduate study in chemistry.

A research-based SIP work in chemistry is typically done in the summer following the junior year, worked on during fall of senior year, and defended during either the winter or spring departmental symposia.

All students enrolling in the beginning Chemistry courses (CHEM 110, 120, or 125) **must** complete the placement examination prior to enrolling in either of these courses. Results from the placement examination may permit exemption for one or both beginning courses (with exemption from CHEM 120 also requiring proof of extensive laboratory preparation). Students entering Kalamazoo College with Advanced Placement or IB scores of 4 or 5 on the Chemistry examination are automatically exempt from CHEM 110.

3/2 Pre-Engineering in Chemical Engineering
Students intending to follow the 3/2 Pre-Engineering Program in chemical engineering should follow the course sequence for the chemistry major through the third year and meet the requirements for admission to chemical engineering schools after the third year. Each student pursuing this program must successfully complete the following courses while in residence at Kalamazoo College: CHEM 110, 120, 210, 220, 240, 310; MATH 112, 113, 214, 240, 280; PHYS 150, 152, 220.

Biochemistry and Molecular Biology Concentration
Students interested in Biochemistry and Molecular Biology should refer to the full program description for the concentration.

All courses offered by the chemistry department may be used as a Natural Sciences (NS) Area of Study (AOS) courses.

Chemistry courses

CHEM 105 The Physical Earth
Introduction to an integrated structural, geochemical, and geophysical description of the Earth: emphasis on the interaction of the planet's solar and internal heat engines considered from the perspective of plate tectonics; historical origins of current views of Earth's structure and dynamics; experimental component includes both laboratory exercises and a field project. Intended for students of the natural sciences, for students who are not majoring in the natural sciences, for Environmental Studies concentrators, and for students intending to teach Earth Sciences in high schools.

CHEM 108 Toxicology and Carcinogenesis
Examination of the basics of chemical carcinogenesis, the environmental contributions to cancer, current methods for studying cancer in both clinical and basic research settings, and the development and uses of chemotherapeutic and chemopreventative medicines. The course aims to prepare students to evaluate discussions of cancer risk, diagnosis, and treatments in the lay press and to examine ambiguity and varying viewpoints on the causes and prevention of cancer. The course will also examine the impact of cancer on individuals and society. Laboratory work includes an experiment using the Ames Test for chemical mutagens and a written scientific report based on laboratory findings. Intended for students who are not majoring in the natural sciences.

CHEM 110 Chemical Composition and Structure with Lab
Fundamental principles of chemistry: chemical calculations and symbolism; atomic and molecular structure and bonding; periodic properties; intermolecular interactions, classification of chemical reactions, and the solid state. Laboratory work includes introduction to chemical instrumentation.

CHEM 120 Chemical Reactivity with Lab
Classification of chemical reactions; chemical kinetics; chemical equilibrium; energetics of chemical reactions (thermodynamics); acid-base, solubility-precipitation, oxidation-reduction, complexation reactions; electrochemistry; descriptive chemistry of selected elements. Laboratory work includes use of chemical instrumentation.
Prerequisite: CHEM-110 All course prerequisites must be met with a minimum grade of C-.

CHEM 125 Chemical Structure, Composition, and Reactivity
Fundamental principles of chemistry: chemical calculations and symbolism; atomic and molecular structure and bonding; periodic properties; intermolecular interactions; the solid state; classification of chemical reactions; chemical kinetics; chemical equilibrium; energetic of chemical reactions (thermodynamics); acid-base, solubility-precipitation, oxidation-reduction, complexation reactions; electrochemistry; descriptive chemistry of selected elements. Laboratory work includes use of chemical instrumentation. Intended for students with strong high school preparation in chemistry as demonstrated on the Chemistry Placement Examination.
Prerequisite: Chemistry Placement Exam Required or Instructor Permission

CHEM 200 Research Apprenticeship in Chemistry
Students who anticipate majoring in chemistry may participate in apprenticeships, which are intended to provide opportunities for the students to become involved in ongoing research projects with faculty on a regular basis. To be

considered for a research apprenticeship position, a student must approach a faculty member regarding joining the faculty member's research laboratory. A minimum of 50 hours of work is expected for each quarter. A student may work with the same faculty member for a number of different quarters or may opt to work with different faculty in different quarters. Enrollment is by permission of instructor only and availability of apprenticeships vary over time and are not guaranteed.

CHEM 210 Organic Chemistry I with Lab
Basic principles of structure, nomenclature, and reactivity applied to aliphatic hydrocarbons; valence bond and molecular orbital structure models; inductive, resonance, and steric effects on reactivity; stereoisomerism; laboratory emphasis on techniques used in the synthesis and purification of organic compounds.
Prerequisite: CHEM-120 or CHEM-125 All course prerequisites must be met with a minimum grade of C-.

CHEM 220 Organic Chemistry II with Lab
Continuation of CHEM 210 that includes classroom and laboratory study of the structure, nomenclature, chemical properties, and spectrometric identification of common organic compounds; emphasis on reaction mechanisms and organic synthesis. Intended for research-oriented natural science students with career interests in chemistry, chemical engineering, or biochemistry and related fields.
Prerequisite: CHEM-210 All course prerequisites must be met with a minimum grade of C-.

CHEM 240 Analytical Chemistry with Lab
Treatment of experimental data; systematic solution stoichiometry; the study of acid-base, precipitation-solubility, oxidation-reduction, and complex formation-dissociation equilibria; introduction to quantitative applications of gravimetry, titrimetry, and chromatography, electrochemistry, and spectrophotometry.
Prerequisite: CHEM-120 or CHEM-125 All course prerequisites must be met with a minimum grade of C-.

CHEM 310 Physical Chemistry I with Lab
Study of chemical thermodynamics, statistical mechanics, and kinetics. Intended for chemistry majors and biologists with a strong cellular or molecular orientation.
Prerequisite: CHEM-120 or CHEM-125, MATH 113, and PHYS-152 All course prerequisites must be met with a minimum grade of C-.

CHEM 310 Physical Chemistry I
Study of chemical thermodynamics, statistical mechanics, and kinetics. Intended for chemistry majors and biologists with a strong cellular or molecular orientation.
Prerequisite: CHEM-120 or CHEM-125, MATH 113, and PHYS-152 All course prerequisites must be met with a minimum grade of C-.

CHEM 310L Physical Chemistry I Lab
Study of chemical thermodynamics, statistical mechanics, and kinetics. Intended for chemistry majors and biologists with a strong cellular or molecular orientation.
Prerequisite: CHEM-120 or CHEM-125, MATH 113, and PHYS-152 All course prerequisites must be met with a minimum grade of C-. CHEM-310 may be taken concurrently

CHEM/BIOL 352 Biochemistry with Lab
Overview of the chemical mechanisms underlying biological processes including structure and function of proteins, polysaccharides, and lipids; enzymatic catalysis and kinetics; an introduction to bioenergetics; detailed treatment of carbohydrate metabolism; survey of lipid and amino acid metabolism; and integration of metabolism. Laboratory will emphasize protein isolation and characterization, enzyme kinetics, and bioinformatics.
Prerequisite: CHEM-220 All course prerequisites must be met with a minimum grade of C-.

CHEM/BIOL 352 Biochemistry
Overview of the chemical mechanisms underlying biological processes including structure and function of proteins, polysaccharides, and lipids; enzymatic catalysis and kinetics; an introduction to bioenergetics; detailed treatment of carbohydrate metabolism; survey of lipid and amino acid metabolism; and integration of metabolism. Prerequisite: CHEM-220. All course prerequisites must be met with a minimum grade of C-.
Prerequisite: CHEM-220 All course prerequisites must be met with a minimum grade of C-.

CHEM/BIOL 352L Biochemistry Lab
Overview of basic biochemical laboratory techniques with emphasis on protein isolation and characterization, enzyme kinetics, and bioinformatics. Students will devise and execute independent research projects as part of the course final project. Laboratory and scientific writing, oral communication, and preparation of quality figures and tables will also be emphasized. Prerequisites: CHEM-220 and CHEM/BIOL352 (can be taking concurrently). All course prerequisites must be met with a minimum grade of C-.
Prerequisite: CHEM-220, Minimum grade C- CHEM/BIOL-352 must be taken previously or concurrently

CHEM 395 Organic Spectroscopy and Structure Determination

Organic molecules are everywhere including a growing inventory throughout the universe. With and unimaginable array of possibilities, how is organic chemical structure eluciated? This course examines modern spectroscopic techniques through in-class activities. With data collected, strategies will be developed to assign chemical structure and identify dynamic processes within a molecule. Mass spectroscopy and 1D- and 2D-NMR methods will be emphasized. Intended for students interested in the molecular and chemical sciences.
Prerequisite: CHEM-220. All course prerequisites must be met with a minimum grade of C-.

CHEM 410 Physical Chemistry II with Lab
Further study of chemical kinetics; elementary quantum mechanics applied to simple atoms and molecules; spectroscopy.
Prerequisite: CHEM-120 or CHEM-125, MATH-113, and PHYS-152 All course prerequisites must be met with a minimum grade of C-.

CHEM 420 Instrumental Analysis with Lab
Study of instrumental methods of analysis including trace techniques; emphasis on spectroscopy, electrochemistry, and chromatography, introduction to electronic signal processing, and computer data acquisition.
Prerequisite: CHEM-240 and CHEM-310 All course prerequisites must be met with a minimum grade of C-.

CHEM 430 Inorganic Chemistry with Lab
Exploration of the properties of the elements and their compounds except for hydrocarbons and their organic derivatives; emphasis on structures, bonding, and reactivities of main-group, transition-metal, and organometallic compounds; laboratory work emphasizing synthesis, analysis and reactivity characterization of inorganic compounds.
Prerequisite: CHEM-310 All course prerequisites must be met with a minimum grade of C-.

CHEM 440 Advanced Organic Chemistry with Lab
Study of local and reaction stereochemistry, conformational analysis, and molecular orbital theory; preparative methods for asymmetric chemicals; applications of chiral transition metal complexes in catalyzed organic reactions; laboratory work emphasizing chromatographic techniques and 1D and 2D NMR analysis.
Prerequisite: CHEM-220 and CHEM-310 All course prerequisites must be met with a minimum grade of C-.

CHEM 450 Molecular Structure and Reactivity with Lab
An advanced course dealing with molecular symmetry and group theory applied to the description of molecular structure and bonding in inorganic, organic, organometallic, and solid-state systems; molecular and electronic structure determination by spectroscopy, magnetism, and X-ray crystallography; examination of selected chemical reactions with focus on transition metal and metalloprotein redox and energy generation; laboratory work emphasizing synthesis and reactivity studies on and physical characterization of inorganic, organic, and organometallic compounds.
Prerequisite: CHEM-430 recommended

CHEM 460 Advanced Biochemistry with Lab
Study of selected topics in biochemistry through review articles and primary research literature, emphasizing experimental methods, critical analysis and interpretation of data, and integration of biochemical concepts. Laboratory will utilize an investigative approach to strategies of enzyme studies and bioinformatics.
Prerequisite: BIOL/CHEM 352 and BIOL/CHEM-352L All course prerequisites must be met with a minimum grade of C-.

CHEM 470 Principles of Medicinal Chemistry with Lab
This course will survey the world of medicinal drug design, from target choice to structural drug determinants, to drug toxicology and disposition. The course will illustrate to students the significance of chemical structure and their physiochemical properties, and address molecular modification of molecules in the rational design of drug entities. The ultimate goal is to help students relate drug chemistry to therapeutic applications. We will review some general principles learned in Introductory and Organic Chemistry, Biochemistry, and Cell Biology, and will introduce several Pharmacological and Physiological principles, as they relate to the molecular mechanism of action of select drug classes. Emphasis will be placed on drug-target interactions at the molecular level by employing 3-D visualization tools.
Prerequisite: CHEM-220 and BIOL/CHEM-352 All course prerequisites must be met with a minimum grade of C-. Senior Chemistry majors only

CHEM 490F Senior Seminar - Professional Development for Chemists
Senior Seminar combines activities currently in the Chemistry senior program and two practicum experiences with the goal of preparing senior majors to present a public seminar covering their Senior Individualized Project and to present themselves professionally as they move into chosen professions. The Chemistry discipline relies heavily on both written and verbal communication skills to disseminate scientific information, and as such, practitioners must be able to articulate concise and scientifically accurate descriptions of their work. This scours utilizes a series of seminars by guest chemistry professionals, on-campus resources, practical applications, and peer workshops to develop oral and written presentation skills. This course is for SENIORS only.
Prerequisite: Senior Chemistry majors only

CHEM 490S Senior Seminar - Professional Development for Chemists

Senior Seminar combines activities currently in the Chemistry senior program and two practicum experiences with the goal of preparing senior majors to present a public seminar covering their Senior Individualized Project and to present themselves professionally as they move into chosen professions. The Chemistry discipline relies heavily on both written and verbal communication skills to disseminate scientific information, and as such, practitioners must be able to articulate concise and scientifically accurate descriptions of their work. This course utilizes a series of seminars by guest chemistry professionals, on-campus resources, practical applications, and peer workshops to develop written and oral presentation skills. This course is open to juniors and sniors.
Prerequisite: Junior or Senior Standing only.

CHEM 490W Senior Semn - Professional Development for Chemists
Senior Seminar combines activities currently in the Chemistry senior program and two practicum experiences with the goal of preparing senior majors to present a public seminar covering their Senior Individualized Project and to present themselves professionally as they move into chosen professions. The Chemistry discipline relies heavily on both written and verbal communication skills to disseminate scientific information, and as such, practitioners must be able to articulate concise and scientifically accurate descriptions of their work. This course utilizes a series of seminars by guest chemistry professionals, on-campus resources, practical applications, and peer workshops to develop oral and written presentation skills. This course is for SENIORS only.
Prerequisite: Senior Chemistry majors only

CHEM 593 Senior Individualized Project
Each program or department sets its own requirements for Senior Individualized Projects done in that department, including the range of acceptable projects, the required background of students doing projects, the format of the SIP, and the expected scope and depth of projects. See the Kalamazoo Curriculum -> Senior Individualized Project section of the Academic Catalog for more details.
Prerequisite: Permission of department and SIP supervisor required.