Chemistry and Biochemistry

Professors: Arias-Rotondo, Bartz (Chair), Furchak, Stevens-Truss, Tresca, Williams

Mission Statement

The Kalamazoo College Department of Chemistry and Biochemistry is a diverse community of students, faculty, and staff committed to the development of excellent chemistry and biochemistry majors in an environment of equity, inclusion, and respect. Our department strives to fulfill the College's mission "...to prepare its graduates to better understand, live successfully within, and provide enlightened leadership to a richly diverse and increasingly complex world."

Our curriculum is grounded in the liberal arts and aims to prepare graduates for direct entry to the workforce or for further study in graduate or professional school. Our courses are learner-focused and use evidence-based methods to engage everyone regardless of background. Our laboratory courses emphasize skill development and independence while promoting a safety culture.

Students who graduate from our program will have information literacy and scientific presentation skills, will be conscious of the environmental and social impacts of chemicals and chemical waste, and will have a molecular view of the world.

And we like to have fun while we build community.

Program Description

The chemistry program is an American Chemical Society (ACS) approved pre-professional undergraduate program that stresses the art of scientific thought and the role of chemistry and biochemistry in society. Chemistry and biochemistry 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 opportunities open to chemistry and biochemistry graduates include: medical, dental, or veterinary schools; business administration; 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 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 the SIP and courses designed for non-chemistry majors) plus 0.7 units of Chem Senior Seminar (Chem 490).

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

Required Courses

Foundational coursework

Recommended completion by the end of the first year:
CHEM 110: Chemical Composition and Structure with Lab (exempted if student begins in CHEM 120)
CHEM 120: Chemical Reactivity with Lab

Recommended completion by the end of the second year:
CHEM 210: Organic Chemistry I with Lab
CHEM 220: Organic Chemistry II with Lab
CHEM 240: Analytical Chemistry with Lab

*Recommended completion by the end of the third year:*
CHEM 310: Chemical Thermodynamics and Kinetics with Lab

*Completed junior spring and senior year*
CHEM 490: Senior Seminar - Professional Development for Chemists (minimum of 0.7 units required). Chemistry majors are encouraged to take 1.3 units of Chem 490, which would include four terms of CHEM 490 starting in the Junior Spring and continuing through each term of the Senior year.

*Exploratory coursework:* Two additional 300- or 400- level credited courses with lab

Chemistry majors who intend to pursue graduate studies in chemistry are encouraged to take additional courses in the department, beyond the two required exploratory courses.

*Required Cognates*
MATH 112: Calculus I (or its equivalent, MATH 110/111)
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 the eight units of chemistry and the required cognate courses with a grade of C- or better.

**Requirements for the Major in Biochemistry**

*Number of Units*
A minimum of eight units from credited courses (excluding the SIP and courses designed for non-chemistry majors) plus 0.7 units of Chem Senior Seminar (Chem 490).

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

*Required Courses*

**Foundational coursework**

*Recommended completion by the end of the first year:*
CHEM 110 Chemical Composition and Structure with Lab (exempted if student begins in CHEM 120)
CHEM 120 Chemical Reactivity with Lab

*Recommended completion by the end of the second year:*
CHEM 210 Organic Chemistry I with Lab
CHEM 220 Organic Chemistry II with Lab
CHEM 240 Analytical Chemistry with Lab

*Recommended completion by the end of the third year:*
CHEM 310 Chemical Thermodynamics and Kinetics with Lab

*Completed junior and/or senior year:*
CHEM 365 Biochemistry I,
CHEM 465 Biochemistry II,
CHEM 466 Biochemistry Lab (note: could be completed spring of sophomore year, provided prerequisites are completed)

*Completed junior spring and senior year*
CHEM 490 Senior Seminar - Professional Development for Chemists (minimum of 0.7 units required). Biochemistry majors are encouraged to take 1.3 units of Chem 490, which would include four terms of CHEM 490 starting in the Junior Spring and continuing through each term of the Senior year.

**Exploratory coursework:** Biochemistry majors who intend to pursue graduate studies in biochemistry are encouraged to take additional courses in the department.

**Required Cognates** There are five required cognates for the Biochemistry major

*All of the following cognates:*
- BIOL 112 Evolution and Genetics with Lab
- MATH 112 Calculus I (or its equivalent, MATH 110/111)
- MATH 113 Calculus II (additional work in mathematics is encouraged)
- PHYS 150 Introductory Physics I with Lab

*And one of the following cognate options:*
- BIOL 246 Cell and Molecular Biology with Lab
- PHYS 205 Applications of Physics in the Biosciences

In accordance with College policy, biochemistry majors must pass the eight units of chemistry and the required cognate courses with a grade of C- or better.

**ACS certified degree** In addition to obtaining a degree from an ACS-approved program, students can opt to pursue an ACS-certified degree. A certified degree is a valuable personal credential that serves as National-level recognition of successful completion of a rigorous academic chemistry curriculum. A certified major includes CHEM 210, 240, 310, 352 or 365, 430, a chemistry research-based SIP, and three additional chemistry courses above the 100-level (excluding CHEM 200 and CHEM 490). In addition, MATH 112 and 113, and PHYS 150 and 152 are required, and Math 214 and 240 are recommended. The certification curriculum, which provides thorough preparation in chemistry, mathematics, and physics, is recommended for students contemplating graduate study in chemistry.

**Placement exam** All students enrolling in the beginning Chemistry courses (CHEM 110, 120) 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 (AP) scores of 4 or 5, or IB scores of 5, 6, or 7, or who successfully pass the Chemistry placement 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. Refer to the full catalog program description page.

**Requirements for the Concentration in Biochemistry**

Directors: Stevens-Truss (contact person), Langeland, Moore

A major focus of modern scientific inquiry is uncovering the physical and chemical mechanisms underlying biological systems. Therefore, an interdisciplinary concentration in Biochemistry and Molecular Biology is offered for students interested in advanced study at the interface between biology and chemistry. Courses include a selection from the physical and biological sciences, all offered with labs that make use of sophisticated, cutting-edge instrumentation and techniques. Students interested in graduate studies of molecular-level biological phenomena are especially encouraged to consider this plan of study.

**Required Courses**
In Biology:
BIOL 246: Cell and Molecular Biology with Lab
BIOL 352: A Survey of Biochemistry (note: same as CHEM 352, need only do one)
BIOL 352L: Intro to Biochemical Analyses

In Chemistry:
CHEM 220: Organic Chemistry II with Lab
CHEM 310: Physical Chemistry I with Lab
CHEM 352: A Survey of Biochemistry (note: same as BIOL 352, need only do one)
CHEM 352L: Intro to Biochemical Analyses

One additional course in Biology or Chemistry – choose either:
BIOL 420: Advance Molecular Genetics with lab, or
CHEM 452: Advanced Biochemistry with Lab

In Mathematics:
MATH 112: Calculus I
MATH 113: Calculus II

In Physics:
PHYS 150: Introductory Physics I with Lab
PHYS 152: Introductory Physics II with Lab

Prerequisite Coursework
BIOL 112: Evolution and Genetics with Lab
CHEM 110: Chemical Composition and Structure with Lab
CHEM 120: Chemical Reactivity with Lab
CHEM 210: Organic Chemistry I with Lab

In accordance with College policy, concentrators in biochemistry and molecular biology must pass the required courses with a C- or better.

Note: Students cannot double major in Chemistry and Biochemistry; nor can they earn a major in Biochemistry and a concentration in Biochemistry and Molecular Biology.

Chemistry courses

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. Prerequisite: none

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 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 chemistry faculty. 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. A student may enroll in CHEM200 for no more than 3 quarters, with the same faculty member or with different faculty members. The three quarter need not be consecutive. Enrollment is by permission of the instructor only, availability of apprenticeships will vary over time, and are not guaranteed. This course does not count towards major.

CHEM 210 Organic Chemistry I w 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. Corequisite: CHEM-210L

CHEM 210L Organic Chemistry I Lab
Corequisite: CHEM-210

CHEM 220 Organic Chemistry II W/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. Corequisite: CHEM-220L

Prerequisite: CHEM-210 All course prerequisites must be met with a minimum grade of C-.

CHEM 220L Organic Chemistry II Lab
Corequisite: CHEM-220

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-210 All course prerequisites must be met with a minimum grade of C-.

CHEM 298 Independent Study
Chemistry Independent Study

CHEM 310 Chemical Thermodynamics & Kinetics W/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 310L Chemical Thermodynamics 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-310L may be taken concurrently

CHEM/BIOL 352 A Survey of 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; open to Chemistry majors only. All course prerequisites must be met with a minimum grade of C-.

CHEM/BIOL 352L Intro to Biochemical Analyses
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 365 Biochemistry I Fundamentals of Biochemistry
In-depth study of the chemical principles underlying the nature of biological molecules, as well as a study of protein folding, structure, and function, including how enzymes work. Prerequisite: Must have taken BIOL-112 and CHEM-220. All course prerequisites must be met with a minimum grade of C-

CHEM 410 Quantum Chemistry & Spectroscopy w Lab
Further study of chemical kinetics; elementary quantum mechanics applied to simple atoms and molecules; spectroscopy. Prerequisite: CHEM-210, 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 or Chemistry Seniors who have taken CHEM-240. All course prerequisites must be met with a minimum grade of C-. Chemistry seniors who have not taken CHEM-310 should contact the Registrar's Office
in order to register for this class. - Must be completed prior to taking this course.

**CHEM 430 Inorganic Chemistry with Lab**
Exploration of the electronic and atomic/molecular configuration of molecules and materials, using that knowledge to explain their properties and understand some of their applications (nuclear power, solar energy conversion, catalysis, etc.); 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 Intro to Drug & Natural Product Synthesis**
Study of local and reaction stereoechemistry, conformational analysis, and molecular orbital theory; preparative methods for asymmetric chemicals; applications of chiral transition metal complexes 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 W Lab Lab**
An advanced inorganic chemistry course where we study how the electronic structure of molecules and materials impacts their properties and reactivity. Coordination chemistry is one of the main axes of this class; topics covered include f-block chemistry, cross-coupling reactions, and photocatalysis. We also discuss nanomaterials, their synthesis and spectroscopic properties. Laboratory work emphasizes synthesis and reactivity studies on and physical characterization of inorganic and organometallic compounds as well as quantum materials.
*Prerequisite: Take CHEM-210. All course prerequisites must be met with a minimum grade of C-.*

**CHEM 452 Advanced Biochemistry w 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 465 Biochemistry II**
Biochemistry is the molecular-level study of the chemical processes that regulate biological functions. While living systems have tightly controlled and efficient pathways that help them maintain homeostasis, lots can go wrong leading to metabolic disorders. Organisms, therefore metabolize complex macromolecules (small and large) to provide the energy needed to drive life reactions and to create storage and support mechanisms. Drawing from information gained during Biochemistry I, students will analyze health problems caused by aberrant metabolism, and take a backwards view to assess where in metabolism the problem arose.
*Prerequisite: Must have taken CHEM-365 or BIOL/CHEM-352. 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: BIOL/CHEM-352 or CHEM-365 All course prerequisites must be met with a minimum grade of C-. Priority will be given to Senior Chemistry or Biochemistry majors first.*

**CHEM 490F Senior Seminar - Professional Development for Chemists**
This seminar course is a partial units course distributed among the three terms, intended for Chemistry and Biochemistry majors. Majors are required to complete 0.7 units of CHEM-490. Students who intend to complete their Graduation Shared Passages Seminar requirement will need to complete an additional 0.3 units of CHEM-490. This course 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. In this course majors attend a series of seminars by guest chemistry professionals, are exposed to on-campus resources, learn practical applications, and engage in peer workshops to develop oral and written presentation skills.
*Prerequisite: CHEM490S (0.3 units) - taken in spring of junior year as a preparative course for the SIP, can be taken again in spring of senior year. Prerequisite: Junior or Senior Chemistry or Biochemistry majors only. CHEM490F (0.4 units) and CHEM490W (0.3 units). Prerequisite: Chemistry or Biochemistry Senior standing. Prerequisite: Senior Chemistry majors only*

**CHEM 490S Senior Seminar - Professional Development for Chemists**
This seminar course is a partial units course distributed among the three terms, intended for Chemistry and Biochemistry majors. Majors are required to complete 0.7 units of CHEM-490. Students who intend to complete their Graduation Shared Passages Seminar requirement will need to complete an additional 0.3 units of CHEM-490. This course 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. In this course majors attend a series of seminars by guest chemistry professionals, are exposed to on-campus resources, learn practical applications, and engage in peer workshops to develop oral and written presentation skills. CHEM490S (0.3 units) - taken in spring of junior year as a preparative course for the SIP, can be taken again in spring of senior year. Prerequisite: Junior or Senior Chemistry or Biochemistry majors only. CHEM490F (0.4 units) and CHEM490W (0.3 units). Prerequisite: Chemistry or Biochemistry Senior standing.

Prerequisite: Junior or Senior Standing only.

CHEM 490W Senior Seminar - Professional Development for Chemists
This seminar course is a partial units course distributed among the three terms, intended for Chemistry and Biochemistry majors. Majors are required to complete 0.7 units of CHEM-490. Students who intend to complete their Graduation Shared Passages Seminar requirement will need to complete an additional 0.3 units of CHEM-490. This course 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. In this course majors attend a series of seminars by guest chemistry professionals, are exposed to on-campus resources, learn practical applications, and engage in peer workshops to develop oral and written presentation skills. CHEM490S (0.3 units) - taken in spring of junior year as a preparative course for the SIP, can be taken again in spring of senior year. Prerequisite: Junior or Senior Chemistry or Biochemistry majors only. CHEM490F (0.4 units) and CHEM490W (0.3 units). Prerequisite: Chemistry or Biochemistry Senior standing.

Prerequisite: Senior Chemistry majors only

CHEM 495 Physical Organic Chemistry
Study of organic structure and reactivity with a focus on thermodynamics in supramolecular, host-guest, and self-assembled systems. Learn how the basic techniques in physical organic chemistry can help dissect complex problems into measurable pieces. Highlights from current topics in the field illustrate applications of fundamental concepts in physical organic chemistry. Labs emphasize the use of organic synthesis, 1D and 2D NMR spectroscopy, and computational techniques in physical organic chemistry. Prerequisite: CHEM-220 and CHEM-310 All course prerequisites must be met with a minimum grade of C-.

Prerequisite: Must have taken CHEM-220 and CHEM-310. All course prerequisites must be met with a minimum grade of C-.

CHEM 593 Senior Integrated Project
Each program or department sets its own requirements for Senior Integrated 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 -&gt; Senior Integrated Project section of the Academic Catalog for more details.

Prerequisite: Permission of department and SIP supervisor required.

The Academic Catalog contains the most accurate information available at the time of publication. Statements contained therein are not contractual obligations, and verbal or other representations that are inconsistent with or not contained within the catalogues' offerings or policies are not binding. Kalamazoo College reserves the right to change, without specific notice, offerings, policies, procedures, qualifications, fees, and other conditions.

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