CHEMISTRY AND BIOCHEMISTRY

The undergraduate degrees in chemistry and biochemistry emphasize knowledge and awareness of:

• the basic principles of chemistry—atomic and molecular theory, reactivities and properties of chemical substances and the states of matter;
• the basic subfields of chemistry—organic, physical, analytical and inorganic chemistry (and biochemistry for biochemistry majors);
• mathematics sufficient to facilitate the understanding and derivation of fundamental relationships and to analyze and manipulate experimental data;
• the basic principles of physics (and for biochemistry majors, knowledge of biology); and
• safe chemical practices, including waste handling and safety equipment.

In addition, students completing a degree in chemistry or biochemistry are expected to acquire the ability and skills to:

• read, evaluate and interpret information on a numerical, chemical and general scientific level;
• assemble experimental chemical apparatus, design experiments and use appropriate apparatus to measure chemical composition and properties (for biochemistry students, this includes properties of proteins, nucleic acids and other biochemical intermediates); and
• communicate results of scientific inquiries verbally and in writing.

Course code for this program is CHEM.

Bachelor's Degrees

• Biochemistry - Bachelor of Arts (BA) (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/biochemistry-bachelor-arts-ba)
• Chemistry - Bachelor of Arts (BA) (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/chemistry-bachelor-arts-ba)

Minors

• Biochemistry - Minor (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/biochemistry-minor)
• Chemistry - Minor (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/chemistry-minor)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Ahn, Natalie (https://experts.colorado.edu/display/fisid_106044) Professor; PhD, University of California-Berkeley

Asirvatham, Margaret (https://experts.colorado.edu/display/fisid_103670) Senior Instructor; PhD, University of California-Berkeley

Batey, Robert T. (https://experts.colorado.edu/display/fisid_122668) Professor; PhD, Massachusetts Institute of Technology

Bierbaum, Veronica (https://experts.colorado.edu/display/fisid_101124) Professor; PhD, University of Pittsburgh

Browne, Eleanor Carol (https://experts.colorado.edu/display/fisid_156464) Assistant Professor; PhD, University of California-Berkeley

Cameron, Jeffrey Carlyle (https://experts.colorado.edu/display/fisid_156473) Assistant Professor; PhD, Washington University

Caruthers, Marvin H (https://experts.colorado.edu/display/fisid_103328) Distinguished Professor; PhD, Northwestern University

Cech, Thomas R (https://experts.colorado.edu/display/fisid_103252) Distinguished Professor; PhD, University of California-Berkeley

Copley, Shelley (https://experts.colorado.edu/display/fisid_104067) Professor; PhD, Harvard University

Cuk, Tanja Associate Professor; PhD, Stanford University

Damrauer, Niels Harley (https://experts.colorado.edu/display/fisid_129797) Associate Professor; PhD, University of California-Berkeley

Dukovic, Gordana (https://experts.colorado.edu/display/fisid_147414) Associate Professor; PhD, Columbia University In the City of New York

Eaves, Joel David (https://experts.colorado.edu/display/fisid_147419) Assistant Professor; PhD, Massachusetts Institute of Technology

Ellison, G. Barney Professor Emeritus; PhD, Yale University; PhD, Yale University

Falke, Joseph (https://experts.colorado.edu/display/fisid_101970) Professor; PhD, California Institute of Technology

George, Steven (https://experts.colorado.edu/display/fisid_103289) Professor; PhD, University of California-Berkeley

Gin, Douglas L. (https://experts.colorado.edu/display/fisid_122861) Professor; PhD, California Institute of Technology

Goodrich, James Andrew (https://experts.colorado.edu/display/fisid_109239) Professor; PhD, Carnegie Mellon University

Gough, Raina V (https://experts.colorado.edu/display/fisid_149207) Instructor

Hendrickson, Susan Marie (https://experts.colorado.edu/display/fisid_145101) Senior Instructor; PhD, Colorado State University

Hynes, James T (https://experts.colorado.edu/display/fisid_106076) Distinguished Professor; PhD, Princeton University
Jimenez-Palacios, Jose Luis (https://experts.colorado.edu/display/fisid_125580)
Professor; PhD, Massachusetts Institute of Technology

Jonas, David (https://experts.colorado.edu/display/fisid_107145)
Professor; PhD, Massachusetts Institute of Technology

Koch, Tad H.
Professor Emeritus; PhD, Iowa State University; PhD, Iowa State University

Koval, Carl A (https://experts.colorado.edu/display/fisid_101151)
Professor; PhD, California Institute of Technology

Kugel, Jennifer Franzen (https://experts.colorado.edu/display/fisid_109472)
Assoc Research Professor; PhD, University of Colorado Boulder

Lineberger, William Carl (https://experts.colorado.edu/display/fisid_101695)
Distinguished Professor; PhD, Georgia Institute of Technology

Liu, Xuedong (https://experts.colorado.edu/display/fisid_118458)
Professor; PhD, University of Wisconsin-Madison

Luca, Oana (https://experts.colorado.edu/display/fisid_157952)
Assistant Professor; PhD, Yale University

Marshak, Michael Pesek (https://experts.colorado.edu/display/fisid_156422)
Assistant Professor; PhD, Massachusetts Institute of Technology

McHenry, Charles
Professor Emeritus; PhD, University of California, Santa Barbara

Nozik, Arthur (https://experts.colorado.edu/display/fisid_113395)
Research Professor; PhD, Yale University

Palmer, Amy E (https://experts.colorado.edu/display/fisid_141901)
Associate Professor; PhD, Stanford University

Pardi, Arthur (https://experts.colorado.edu/display/fisid_105996)
Professor; PhD, University of California-Berkeley

Parker, Roy Robert (https://experts.colorado.edu/display/fisid_151440)
Professor; PhD, University of California-San Francisco

Parson, Robert (https://experts.colorado.edu/display/fisid_101032)
Professor; PhD, University of Michigan Ann Arbor

Peters, Kevin
Professor Emeritus

Pierpont, Cortlandt G.
Professor Emeritus; PhD, Brown University

Sammakia, Tarek (https://experts.colorado.edu/display/fisid_101597)
Professor; PhD, Yale University

Schnizer-Luger, Karoline (https://experts.colorado.edu/display/fisid_156579)
Professor; PhD, Univ of Basel (Switzerland)

Schwartz, Daniel K. (https://experts.colorado.edu/display/fisid_118479)
Professor; PhD, Harvard University

Sharma, Sandeep (https://experts.colorado.edu/display/fisid_158286)
Assistant Professor; PhD, Massachusetts Institute of Technology

Sievers, Robert E (https://experts.colorado.edu/display/fisid_102866)
Professor; PhD, University of Illinois at Urbana-Champaign

Skodje, Rex T (https://experts.colorado.edu/display/fisid_103448)
Professor; PhD, University of Minnesota Twin Cities

Sousa, Marcelo Carlos (https://experts.colorado.edu/display/fisid_122806)
Professor; PhD, Univ of Buenos Aires (Argentina)

Spencer, Sabrina Leigh (https://experts.colorado.edu/display/fisid_154911)
Assistant Professor; PhD, Massachusetts Institute of Technology

Stephen, Ricardo Hugh (https://experts.colorado.edu/display/fisid_145994)
Instructor; PhD, University of Colorado Boulder

Taatjes, Dylan J (https://experts.colorado.edu/display/fisid_102436)
Associate Professor; PhD, University of Colorado Boulder

Tan, Zhongping (https://experts.colorado.edu/display/fisid_149809)
Assistant Professor; PhD, Columbia University In the City of New York

Tolbert, Bert Mills
Professor Emeritus

Tolbert, Margaret A (https://experts.colorado.edu/display/fisid_104976)
Distinguished Professor; PhD, California Institute of Technology

Vaida, Veronica (https://experts.colorado.edu/display/fisid_100313)
Professor; PhD, Yale University

Volkamer, Rainer (https://experts.colorado.edu/display/fisid_144988)
Associate Professor; PhD, Univ of Heidelberg (Germany)

Walba, David M (https://experts.colorado.edu/display/fisid_105830)
Professor; PhD, California Institute of Technology

Walczak, Maciej Andrzej (https://experts.colorado.edu/display/fisid_153323)
Assistant Professor; PhD, University of Pittsburgh

Wang, Xiang (https://experts.colorado.edu/display/fisid_145812)
Associate Professor; PhD, Boston University

Weber, Jorg Mathias (https://experts.colorado.edu/display/fisid_142930)
Associate Professor; PhD, Univ of Kaiserslautern (Germany)

Wuttke, Deborah S (https://experts.colorado.edu/display/fisid_108412)
Professor; PhD, California Institute of Technology

Yin, Hang Hubert (https://experts.colorado.edu/display/fisid_144763)
Associate Professor; PhD, Yale University

Zhang, Wei (https://experts.colorado.edu/display/fisid_146429)
Associate Professor; PhD, University of Illinois at Urbana-Champaign
 Courses

CHEM 1011 (3) Environmental Chemistry 1
Lect. Introduces basic principles of chemistry with applications to current environmental issues including toxic chemicals, air and water pollution, energy sources and their environmental impact, and climate change resulting from the greenhouse effect. No credit given to chemistry or biochemistry majors for this course if students already have credit in any college-level chemistry course numbered 1113/1114 (formerly 1111) or higher.
Additional Information: GT Pathways: GT-SC2 -Natural Physical Sci:Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Chemistry
MAPS Course: Physics

CHEM 1021 (4) Introductory Chemistry
Lect. and Lab. For students with no high school chemistry or a very weak chemistry background. Remedies a deficiency in natural science MAPS requirements and prepares students for CHEM 1113 and CHEM 1114. No credit given to chemistry or biochemistry majors for this course if students already have credit in any college-level chemistry course numbered 1113/1114 (formerly 1111) or higher. Department enforced prerequisite: one year high school algebra or concurrent enrollment in MATH 1011.
Additional Information: GT Pathways: GT-SC1 - Natural Physical Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab
MAPS Course: Natural Science Lab or Lab/Lec

CHEM 1031 (4) Environmental Chemistry 2
Lect. and Lab. Applications of chemical principles to current environmental issues including acid rain, stratospheric ozone depletion, the Antarctic ozone hole, solar energy conversion and fuel cells, and the environmental consequences of nuclear war. Laboratory experience is included. No credit given to chemistry or biochemistry majors for this course if students already have credit in any college-level chemistry course numbered 1113/1114 (formerly 1111) or higher.
Requisites: Requires prerequisite course of CHEM 1011 (minimum grade C-).
Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 1041 (3) Biotechnology and Society
Covers recent advances in biotechnology and how those impact society. Content and discussion will focus on both the science behind technological advances, their impact on society, and the ethical issues raised by new technologies. Topics change each semester but can include: GMO crops, genome editing, drug discovery and development, stem cell therapies, and use of new cancer treatments, human genome sequencing and its impact on diagnosis and treatments, human microbiome, neurodegenerative diseases.
Requisites: Restricted to students with 0-56 credits (Freshmen or Sophomore) only.
Grading Basis: Letter Grade

CHEM 1113 (4) General Chemistry 1
Lect., rec. Intended for first-semester students whose academic plans require advanced work in chemistry. Subjects: components of matter, stoichiometry, classes of reactions, gases, thermochemistry, atomic structure, electron configuration, chemical bonding, molecular shapes, covalent bonding, organic compounds, intramolecular forces, equilibrium. Department enforced prerequisites: one year high school chemistry or CHEM 1021 (min grade C-); high school math through pre-calculus. Not recommended for students with grades below B- in CHEM 1021. Department enforced corequisite: CHEM 1114. Not open to engineering students with exception of EPEN majors.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 1400 or CHEM 1221 or CHEN 1211
Requisites: AMEN, AREN, ASEN, CHEN, CSEN, CVEN, ECEN, EEEN, EVEN, MCEN, OPEN or CBEN majors are not allowed to take this class.
Additional Information: GT Pathways: GT-SC2 -Natural Physical Sci:Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 1114 (1) Laboratory in General Chemistry 1
Lab. Intended for first-semester students whose academic plans require advanced work in chemistry. Instruction in experimental techniques which coordinate with lecture topics in CHEM 1113. Department enforced prerequisites: one year high school chemistry or CHEM 1021 (min grade C-); high school math through pre-calculus. Not recommended for students with grades below B- in CHEM 1021. Department enforced corequisites: CHEM 1113. Not open to engineering students with exception of EPEN majors.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 1400 or CHEM 1221 or CHEN 1211
Requisites: AMEN, AREN, ASEN, CHEN, CSEN, CVEN, ECEN, EEEN, EVEN, MCEN, OPEN or CBEN majors are not allowed to take this class.
Additional Information: GT Pathways: GT-SC1 - Natural Physical Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

Ziemann, Paul Jeffrey (https://experts.colorado.edu/display/fisid_153281)
Professor; PhD, Pennsylvania State University Central Office
Arts Sci Gen Ed: Distribution—Natural Sciences

Grading Basis: majors only.

Requisites: CHEM 1251.

calculus. Not recommended for students with grades below B- in CHEM 1021 (minimum grad C-) and high school math through pre-calculus. Not recommended for students with grades below B- in CHEM 1021. Department enforced corequisite: CHEM 1400.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 1114 or CHEM 1400

Requisites: Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Grading Basis: Letter Grade

Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

Chemistry and Biochemistry

CHEM 1133 (4) General Chemistry 2

Lect., rec. Intended for second-semester students whose academic plans require advanced work in chemistry. Subjects: acid-base equilibria, buffers and titrations, thermodynamics, redox reactions, electrochemistry, transition elements and their coordination compounds, solubility/solubility equilibria, crystal field theory, kinetics, nuclear chemistry. Department enforced corequisite: CHEM 1134.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 2100

Requisites: Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (formerly CHEM 1251) or CHEM 1211 and CHEM 1221 (all minimum grade C-).

Additional Information: GT Pathways: GT-SC2 - Natural Physical Sci: Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 1134 (1) Laboratory in General Chemistry 2

Lab. Intended for second-semester students whose academic plans require advanced work in chemistry. Instruction in experimental techniques which coordinate with lecture topics in CHEM 1133. Department enforced corequisite: CHEM 1133.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 2100

Requisites: Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (formerly CHEM 1251) or CHEM 1211 and CHEM 1221 (all minimum grade C-).

Additional Information: GT Pathways: GT-SC2 - Natural Physical Sci: Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 1221 (1) Engineering General Chemistry Lab

Meets general chemistry laboratory requirement for engineering students. Designed to illustrate chemical concepts and introduce basic techniques in chemical measurement and synthesis. Department enforced prerequisites: one year of high school chemistry or CHEM 1021 (min. grade C) and high school algebra; B- in CHEM 1021 recommended.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 1113 or CHEM 1114 or CHEM 1400

Requisites: Requires prerequisite course of CHEN 1211 or CHEM 1133 (minimum grade C), or corequisite course of CHEM 1211 or CHEM 1133.

Restricted to undergraduate engineering students only.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 1400 (4) Foundations of Chemistry

Covers core concepts in chemistry: nature of matter (atomic and molecular structure, bonding and macroscopic properties), transformations of matter (chemical reactivity), and quantifying chemical transformations (thermochemistry, thermodynamics and kinetics). Emphasizes critical thinking and cultivate core problem solving skills utilized by scientists. Intended for first semester CHEM/BCHM majors. Department enforced prerequisites: one year high school chemistry or CHEM 1021 (minimum grad C) and high school math through pre-calculus. Not recommended for students with grades below B- in CHEM 1021. Department enforced corequisite: CHEM 1401. Formerly CHEM 1251.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 1113

Requisites: Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Grading Basis: Letter Grade

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 1401 (1) Foundations of Chemistry Lab

Coordinates with lecture topics in CHEM 1400. Intended for first-semester CHEM and BCHM majors. Emphasizes the development of hands-on practical laboratory skills, experimental design, data interpretation, problem solving and open inquiry. Department enforced prerequisites: one year high school chemistry or CHEM 1021 (minimum grad C) and high school math through pre-calculus. Not recommended for students with grades below B- in CHEM 1021. Department enforced corequisite: CHEM 1400.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 1114 or CHEM 1400

Requisites: Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Grading Basis: Letter Grade

Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 2100 (4) Chemical Energetics and Dynamics

Covers the energetic principles that determine when chemical reactions occur and the dynamic principles that determine how rapidly they will occur. Applications include ionic equilibria in solution (acids and bases, buffers and titrations), oxidation-reduction reactions, electrochemistry and chemical kinetics. These applications will be situated in a context of current research problems in areas such as renewable energy and atmospheric chemistry. Department enforced corequisite: CHEM 2101. Formerly CHEM 1271.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 1113

Requisites: Requires prerequisite courses of CHEM 3331 or CHEM 3471 (formerly CHEM 3371) or CHEM 3491 and MATH 2300 or APPM 1360 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 2101 (1) Laboratory for Chemical Energetics and Dynamics

Coordinates with the lectures in CHEM 2100. Required for fourth semester CHEM majors and an elective for BCHM majors. Emphasizes the acquisition of more advanced laboratory skills, experimental design, data interpretation and analysis. Department enforced corequisite: CHEM 2100.

Requisites: Requires a prerequisite course of CHEM 3341 or CHEM 3381 (minimum grade C).

Grading Basis: Letter Grade

Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 3151 (3) Air Chemistry and Pollution

Examines the composition of the atmosphere, and sources of gaseous and particulate pollutants: their chemistry, transport and removal from the atmosphere. Applies general principles to acid rain, smog and stratospheric ozone depletion. Department enforced prerequisite: two semesters of chemistry.

Equivalent - Duplicate Degree Credit Not Granted: ATOC 3500

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
CHEM 3251 (3) Sustainable Energy from a Chemistry Perspective
Explores qualitative and quantitative chemical aspects of energy systems (production, transmission, storage, utilization) including fossil, wind, solar, nuclear and biomass energy. Applies chemical principles including composition, structure, bonding, physical properties, thermodynamics, equilibrium and kinetics to energy systems and sustainability, especially environmental implications. Describes the importance of energy to the chemical industries and society as a whole.

Requisites: Requires prerequisite course of CHEM 1133 and 1134 or CHEM 2100 or CHEM 1211 and CHEM 1221 (all minimum grade C).

CHEM 3311 (4) Organic Chemistry 1
Lect. and rec. Intended primarily for nonmajors. Topics include structure and reactions of alkanes, alkenes, alkynes, alkyl halides, and aromatic molecules; nomenclature of organic compounds; stereochemistry; reaction mechanisms and dynamics. Department enforced corequisite: CHEM 3321 or CHEM 3361.

Requisites: Requires prerequisite course of CHEM 1133 and CHEM 1134 or CHEM 1400 and CHEM 1401 or CHEM 2100 (formerly CHEM 1271) or CHEM 1211 and CHEM 1221 (all minimum grade C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 3321 (1) Laboratory in Organic Chemistry 1
Lab. Instruction in experimental techniques of modern organic chemistry emphasizing chemical separations and reactions of alkanes, alkenes, and aromatic compounds. Stereochemical modeling and the identification of organic unknowns by spectroscopic and chemical methods are also introduced. Department enforced corequisite: CHEM 3311 or CHEM 3451.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 3361

Requisites: Requires prerequisite course of CHEM 1133 and CHEM 1134 or CHEM 2100 or CHEM 1400 and CHEM 1401 or CHEM 1211 and CHEM 1221 (all minimum grade C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 3331 (4) Organic Chemistry 2
Lect. and rec. Intended primarily for nonmajors. Topics include structure and reactions of alkyl halides, alcohols, ethers, carboxylic acids, aldehydes, ketones, and amines; introduction to the chemistry of heterocycles, carbohydrates, and amino acids; nomenclature of organic compounds; synthesis; and reaction mechanisms. Department enforced corequisite: CHEM 3341 or CHEM 3381.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 3471 (formerly CHEM 3371) or CHEM 3491

Requisites: Requires prerequisite courses of CHEM 3311 or CHEM 3351 and CHEM 3321 or CHEM 3361 (all minimum grade C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 3341 (1) Laboratory in Organic Chemistry 2
Lab. For biochemistry and nonchemistry majors. Instruction in experimental techniques of modern organic chemistry emphasizing reactions involving alcohols, ketones, carboxylic acids, and their derivatives. Multistep syntheses are also introduced. Department enforced corequisite: CHEM 3331 or CHEM 3471 or CHEM 3491.

Requisites: Requires prerequisite courses of CHEM 3311 or CHEM 3451 and CHEM 3321 or CHEM 3361 (all minimum grade C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 3361 (2) Laboratory in Organic Chemistry 1 for Chemistry Majors
Lab. Required course for chemistry majors. Instruction in experimental techniques of modern organic chemistry emphasizing chemical separations and reactions of alkanes, alkenes, alcohols, ketones, and alkyl halides. Explores stereochemical modeling and the chemical identification of organic unknowns. Department enforced corequisite: CHEM 3351 or CHEM 3311 or CHEM 3451.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 3321

Requisites: Requires prerequisite course of CHEM 1133 and CHEM 1134 or CHEM 2100 or CHEM 1400 and CHEM 1401 or CHEM 1211 and CHEM 1221 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 3381 (2) Laboratory in Organic Chemistry 2 for Chemistry Majors
Lab. Required course for chemistry majors. Instruction in experimental techniques of modern chemistry, emphasizing reactions involving alcohols, ketones, carboxylic acids, aromatic compounds, and their derivatives. Multistep syntheses are also introduced. Department enforced corequisite: CHEM 3331 or CHEM 3471 or CHEM 3491.

Requisites: Requires prerequisite courses of CHEM 3311 or CHEM 3451 and CHEM 3321 or CHEM 3361 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 3451 (4) Organic Chemistry for Chemistry and Biochemistry Majors
Covers bonding, acidity, reaction mechanisms, nomenclature of organic compounds; stereochemistry, structure and reactions of aldehydes, ketones, and carboxylic acids and derivatives. Department enforced corequisite: CHEM 3361 or CHEM 3321.

Requisites: Requires prerequisite courses of CHEM 1400 and CHEM 1401 (minimum grade C-) or CHEM 1133 and CHEM 1134 (minimum grade B+). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 3471 (4) Organic Chemistry 2 for Chemistry Majors
Covers Amines, alkylation reactions, additions to unsaturated C-C bonds, aromaticity, and aromatic reactivity, organic materials, biomolecules, nomenclature of organic compounds, reaction mechanisms. Department enforced corequisite: CHEM 3381 or CHEM 3431. Formerly CHEM 3371.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 3331 and CHEM 3491

Requisites: Requires prerequisite courses of CHEM 3451 and CHEM 3361 or CHEM 3321 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 3491 (4) Organic Chemistry 2 for Biochemistry Majors
Covers amines, alkylation reactions, additions to unsaturated C-C bonds, aromaticity and aromatic reactivity, organic materials, biomolecules, nomenclature of organic compounds, reaction mechanism. Department enforced corequisite: CHEM 3341 or CHEM 3381.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 3471 (formerly CHEM 3371) and CHEM 3331

Requisites: Requires prerequisite courses of CHEM 3451 and CHEM 3321 or CHEM 3361 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
CHEM 4011 (3) Modern Inorganic Chemistry
Lect. Required course for chemistry majors. Introduces modern inorganic chemistry for undergraduates. Includes atomic structure, chemical periodicity, structure and bonding in molecules and crystals, reaction mechanisms, chemistry of selected main group and transition elements, and emphasis on catalyst, materials, bioinorganic, and organometallic systems.
**Requisites:** Requires a prerequisite course of CHEM 3331 or CHEM 3471 (formerly CHEM 3371) or CHEM 3491 (minimum grade C-). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4021 (3) Inorganic Laboratory
One lect. and two 3-hour labs per week. Instruction in experimental techniques of modern inorganic chemistry. Includes syntheses and spectroscopic characterizations of transition metal and main group compounds, experience in manipulation of air sensitive compounds, and techniques involving unusual conditions of pressure or temperature.
**Requisites:** Requires prerequisite course of CHEM 4011 (minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 4131 (3) Chemistry of Global Health
Understanding the chemistry associated with health care in resource-poor countries is the objective of this course. Focuses on preventing, diagnosing and treating the world’s deadliest infectious diseases with a particular emphasis on Africa and Central America.
**Requisites:** Requires prerequisite courses of CHEM 3311 or CHEM 3451 and EBio 1210 or MCDB 1150 (all minimum grade C-).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4141 (3) Environmental Water and Soil Chemistry
Application of basic chemical principles to understanding the processes that determine the chemical composition of oceans, lakes, rivers, soils and sediments. Topics include air-water exchange; acid-base, redox, coordination, precipitation and dissolution, ion exchange and sorption reactions; nutrient chemistry; and the use of simple equilibrium and kinetic models for describing the chemistry of inorganic and organic species in air-water-soil systems.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 5141
**Requisites:** Requires prerequisite course of CHEM 2100 or CHEM 1133 and CHEM 1134 (minimum grade C). Restricted to students with 57-180 credits (Juniors or Seniors).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4171 (3) Instrumental Analysis - Lecture and Laboratory 1
Two Lect. and 3 hours of lab per week. Instruction and experience in using instrumental methods of chemical analysis to address problems in chemistry, biochemistry, industrial chemistry and environmental chemistry.
**Requisites:** Requires prerequisite course of CHEM 3331 or CHEM 3471 (formerly CHEM 3371) or CHEM 3491 and CHEM 3341 or CHEM 3381 and PHYS 1140 or CHEM 4400 (minimum grade C-). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
**Grading Basis:** Letter Grade
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 4181 (3) Instrumental Analysis - Lecture and Laboratory 2
Two lect. and 3 hours of lab per week. Instruction and experience in using instrumental methods of chemical analysis. Builds on material learned in CHEM 4171.
**Requisites:** Requires prerequisite course of CHEM 4171 (minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
**Grading Basis:** Letter Grade
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

CHEM 4251 (3) Materials Chemistry and Properties
Lec. Understanding of materials from chemistry perspective including metals, oxides, semiconductors and polymers. Basic description of chemical preparation of materials. Overview of fundamental properties of materials including structural, chemical, mechanical, thermal, electrical, and optical properties. Description of behavior of materials and various applications in modern technology. Discussion of materials characterization methods.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 5251
**Requisites:** Requires prerequisite course of CHEM 3331 or CHEM 3471 or CHEM 3491 and CHEM 4521 or CHEM 4531 (all minimum grade C-).

CHEM 4261 (3) Organic Materials: Structures and Functions
Overview of the preparation and functioning mechanism of novel organic materials that have recently been developed, including conductive polymers, 2-D macrocyclic structures, 3-D molecular cages, molecular machines/muscles-switches, fulleren derivatives and carbon nanotube composites. Emphasizes the use of organic and physical chemistry as tools to develop novel materials and probe their structure-property relationship.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 5261
**Requisites:** Requires prerequisite courses of CHEM 3331 or CHEM 3471 or CHEM 3491 and CHEM 4521 or CHEM 4531 (all minimum grade C-).

CHEM 4271 (3) Chemistry of Solar Energy
Chemical principles of conversion of solar energy into electricity and fuels in molecular and semiconductor-based systems. Overview of solid-state electronic structure of materials and interfaces, light-matter interactions, principles of harvesting photoexcited currents and useful chemical species. Description of processes utilized in established and emerging solar energy technologies.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 5271
**Requisites:** Requires prerequisite courses of CHEM 3331 or CHEM 3471 or CHEM 3491 and CHEM 4531 (all minimum grade C-).

CHEM 4400 (4) Core Concepts in Physical Chemistry for Biochemists
Introduces thermodynamics, kinetics and spectroscopy, emphasizing macromolecule and biochemical applications. Includes thermodynamics, chemical and physical equilibriums, solution chemistry, rates of chemical and biochemical reactions, chemical bonds and principles and selected examples of spectroscopies applied to biological systems. Department enforced prerequisite or corequisite: PHYS 1120 or PHYS 2020. Formerly CHEM 4411.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 5400 and CHEM 4511
**Requisites:** Requires prerequisite courses CHEM 3331 or CHEM 3471 or CHEM 3491 and PHYS 1110 or PHYS 2010 and MATH 2300 or APPM 1360 (all minimum grade C).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences
CHEM 4491 (3) Modern Biophysical Methods
Covers the basic theory of biophysical methods widely employed in biochemistry and biology, including: electrophoresis, mass spec, calorimetry, evanescent waves, plasmon resonance, X-ray diffraction, absorbance and fluorescence spectroscopy, magnetic resonance, electron and optical microscopy and single molecule methods. Discusses ways to maximize rigor and reproducibility in biophysical studies. Department enforced prerequisites: undergraduate chemistry (general, organic physical); physics; calculus.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5491
Requisites: Requires prerequisite courses of CHEM 3311 or CHEM 3451 and PHYS 1110 or PHYS 2010 and MATH 2300 or APPM 1360 and CHEM 4400 (formerly CHEM 4411) or CHEM 4511 or corequisite of CHEM 4400 or CHEM 4511 (all minimum grade C).
Grading Basis: Letter Grade
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4511 (3) Physical Chemistry 1
Lect. Chemical thermodynamics and kinetics. Includes study of laws of thermodynamics, thermochemistry, entropy, free energy, chemical potential, chemical equilibriums, and the rates and mechanisms of chemical reactions. Department enforced prereq or coreq., PHYS 1120 (minimum grade C).
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4400 and CHEM 5400
Requisites: Requires prerequisite of courses CHEM 3311 or CHEM 3451 and MATH 2400 or APPM 2350 and PHYS 1110 or PHYS 2020 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4531 (3) Physical Chemistry 2
Lect. Introduces the quantum theory of atoms, molecules and chemical bonding, and statistical thermodynamics. Includes principles of quantum mechanics and their application to atomic structure, molecular spectroscopy, symmetry properties, and the determination of molecular structure. Also includes principles of statistical mechanics and their applications to properties of gases, liquids, and solids.
Requisites: Requires prerequisite courses of CHEM 4511 and PHYS 1120 or PHYS 2020, and MATH 2400 or APPM 2350 (all minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4555 (4) Theoretical and Computational Chemistry
Explores computational methods to understand chemical systems. Topics include: atomic and molecular electronic structure calculations, Monte Carlo and molecular dynamics simulations and thermodynamic calculations. Not recommended for students with a grade below B- in the prerequisite course.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5555
Requisites: Requires prerequisite course of CHEM 4531 (minimum grade C).
Grading Basis: Letter Grade

CHEM 4581 (1) Physical Chemistry Lab 1
One 3-hour lab per week. Instruction in experimental techniques of modern physical chemistry. Experiments illustrate the fundamental principles of thermodynamics and chemical kinetics. Illustrates the material discussed in CHEM 4511.
Requisites: Requires prerequisite or corequisite course of CHEM 4511 (minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4591 (2) Physical Chemistry Lab 2
One lect. and one 3-hour laboratory every two weeks. A continuation of CHEM 4581, but may be taken concurrently with CHEM 4531. Experiments illustrate the principles of quantum chemistry and spectroscopy discussed in CHEM 4531.
Requisites: Requires prerequisite courses of CHEM 4511 and CHEM 4581 (all minimum grade C). Requires prerequisite or corequisite course of CHEM 4531 (minimum grade C). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4611 (3) Survey of Biochemistry
Lec. One-semester survey of the main themes of modern biochemistry: biomolecular structure/function, metabolism, biosynthesis, DNA from genome to proteome and cellular signaling. For biology and engineering majors and others wanting a survey of biochemistry.
Requisites: Requires prerequisite course of CHEM 3311 or CHEM 3451 (minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4621 (3) Genome Databases: Mining and Management
Lec. Develops essential skills for performing genomic analyses, with focus on developing practical research tools. Introduces human genome and microbiome projects, Python/Sql scripting, accessing and understanding genomic data, sequence alignment and search, evolutionary models, expression data, biological networks, and macromolecular structure. Department enforced corequisite: CSCI 2270.
Equivalent - Duplicate Degree Credit Not Granted: MCDB 4621 or MCDB 5621 (CHEM 5621)
Requisites: Requires prerequisite course of CHEM 4700 or CSCI 3104 or MCDB 3500 (minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4700 (4) Foundations of Biochemistry
Covers chemistry of aqueous solutions; energetics in biology; structure of proteins, nucleic acids, carbohydrates, and membranes; protein evolution; macromolecular interactions; enzyme kinetics, mechanism and regulation. Will be taught from a strong chemical perspective and mastery of basic concepts of organic and physical chemistry will be required. Formerly CHEM 4711.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5700
Requisites: Requires prerequisite course of CHEM 3331 or CHEM 3471 or CHEM 3491 (minimum grade C).
Grading Basis: Letter Grade
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4720 (4) Metabolic Pathways and Human Disease
Covers energy metabolism and anabolic/catabolic pathways; metabolism of carbohydrates, lipids, amino acids, and nucleic acids; photosynthesis; special topics on human diseases with pathologies and metabolic pathways.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5720
Requisites: Requires a prerequisite course of CHEM 4700 (formerly CHEM 4711; minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
CHEM 4740 (4) Biochemistry of Gene Transmission, Expression and Regulation
Covers biosynthesis and function of macromolecules including DNA, RNA and proteins; molecular basis of replication, transcription and translation; biochemistry of subcellular systems; signaling and regulation of gene expression in eukaryotes; and special topics.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5740
Requisites: Requires a prerequisite course of CHEM 4700 (formerly CHEM 4711; minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4751 (3) Current Topics in Biochemical Research
Lec. Covers current topics in modern biochemical research through lectures, reading recent research articles, critical thinking and class discussion. Topics include protein and nucleic acid structure and function, biomolecular interactions, enzyme function and cellular signaling and regulation.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5751
Requisites: Requires prerequisite courses of CHEM 4700 and CHEM 4740 or MCDB 3135 (all minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4761 (4) Biochemistry Laboratory
Two 5-hour periods per week. The first hour of each period is lecture, the remainder is laboratory. Introduction to modern biochemical techniques. Topics include enzymology, spectrophotometry, electrophoresis affinity chromatography, radioisotopes, recombinant DNA, and molecular cloning.
Requisites: Requires a prerequisite course of CHEM 4700 (formerly CHEM 4711; minimum grade C-). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.

CHEM 4791 (3) Bioorganic Chemistry in Biotechnology
Lec. Explores examples of antibodies, peptides, proteins, RNA, DNA, carbohydrates and lipids. Uses the primary literature and requires student participation.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5791
Requisites: Requires prerequisite courses of CHEM 3331 or CHEM 3471 (formerly CHEM 3371) or CHEM 3491 and CHEM 4700 (minimum grade C-).
Recommended: Prerequisite undergraduate molecular biology.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

CHEM 4901 (1-6) Independent Study in Chemistry and Biochemistry
For undergraduate study. Department consent required.
Repeatable: Repeatable for up to 8.00 total credit hours.