CHEMISTRY

Chair: Dr. Hai Lin
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Website: clas.ucdenver.edu/chemistry (http://clas.ucdenver.edu/chemistry/)

Overview

Undergraduate Information

Chemistry is the study of matter and its transformations, from the smallest scale - atoms and subatomic particles - to the macromolecules that provide structure and function to living organisms. Chemistry is often called the "central science" because it touches on other STEM disciplines including physics, biology, medicine, environmental science, geology, mathematics, materials science, technology, and many others. A degree in Chemistry or Biochemistry can prepare you for a wide range of meaningful careers discovering and applying scientific knowledge. Modern chemistry combines computer modeling and experimental observation using procedures that are much safer and more environment-friendly than in past generations. Learning chemistry also teaches you important critical thinking skills that can be valuable in any career.

For more information regarding major options, contact a Major Advisor: Dr. Marta K. Maroń (marta.maron@ucdenver.edu) or Dr. Kyoung N. Kim (https://clas.ucdenver.edu/chemistry/kyoung-nan-kim/).

Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-bs/) to learn about the requirements for the Major in Chemistry.

Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/biochemistry-bs/) to learn about the requirements for the Major in Biochemistry.
Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-bs-acs-certified/) to learn about the requirements for the American Chemical Society Certified Major in Chemistry.

Biochemistry Minor

For more information contact the Biochemistry Minor Advisor: Dr. Kyoung N. Kim (https://clas.ucdenver.edu/chemistry/kyoung-nan-kim/). All biochemistry minors should contact the minor advisor no later than the semester prior to the semester of planned graduation.

Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/biochemistry-minor/) to learn about the Certificate in Biochemistry.

Chemistry Minor

For more information contact the Chemistry Minor Advisor: Dr. Priscilla Burrow (priscilla.burrow@ucdenver.edu). All Chemistry minors should contact the minor advisor the semester prior to the semester of planned graduation.

Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-minor/) to learn about the requirements for a Minor in Chemistry.

Certificate in Biochemistry

For more information contact the Biochemistry Certificate Advisor: Dr. Kyoung N. Kim (https://clas.ucdenver.edu/chemistry/kyoung-nan-kim/). Students applying for the certificate should contact the certificate advisor once they start completing the certificate requirements, but no later than the semester before the certificate is planned to be awarded.

Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/biochemistry-certificate/) to learn about the Certificate in Biochemistry.

Chemistry BS/MS Program

Click here (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-bs-ms/) to learn about our BS/MS Program.
For more information contact the Graduate Advisor: Dr. Haobin Wang (haobin.wang@ucdenver.edu).

Departmental Honors

Qualified students are encouraged to participate in the Chemistry Honors Program. Three levels of honors are awarded by the CU Denver Chemistry Department.

To earn *cum laude* honors in Chemistry or in Biochemistry, a student must satisfy one of the following criteria:

1. an overall GPA of 3.2 or better and a chemistry GPA of 3.5 or better; or
2. an overall GPA of 3.2, a chemistry GPA of 3.2 or better, and six hours of CHEM 4880 Directed Research, spread over a minimum of two semesters.

To earn *magna cum laude* or *summa cum laude* honors in Chemistry or Biochemistry, a student must satisfy each of the following criteria:

1. an overall GPA of 3.2 or better,
2. a chemistry GPA of 3.5 or better;
3. six hours of CHEM 4880 Directed Research, spread over a minimum of two semesters with a GPA of 3.2 or better;
4. Presentation and approval of a thesis based on the independent study research to a faculty advisory committee. If the thesis is approved, the faculty committee can recommend graduation at either the magna cum laude (high) or summa cum laude (highest) level.

Guidelines for Thesis

The advisory committee is to include three faculty from the University, including at least one faculty member from Chemistry and at least one faculty member from outside the department. If the PI is chemistry department faculty, then the PI is the chair of the committee. If the PI is faculty in another department, the student needs to recruit a Chemistry faculty member who has familiarity with the research topic to serve as committee chair. The student should have the committee members in place during the first month of the semester in which the student plans to graduate.

The committee chairperson by agreeing to serve validates that the presented research has been performed by the student.

The thesis is written using the primary journal style of the research sub-specialty. The student gives committee members the finished thesis two weeks prior to the thesis presentation unless the student has been otherwise informed by the committee members. The student organizes the time and place of examination. The last date to schedule the oral examination of the thesis is the Friday before the last week of the regular

semester. This gives the student two weeks to make corrections and changes specified by the committee. The last day to turn in a completed and signed off thesis is the Friday of finals week at 4 pm. The committee signs the Thesis Examination Form, gives a copy to departmental advisor along with a copy of the thesis.

Graduate Information

At the graduate level, an MS degree program is offered. Students with MS degrees have job opportunities in research and technical laboratory services. In addition, flexible programs can be designed to combine chemical knowledge and skills with other interests of the MS-level student (e.g., biology or environmental science). Please go to the **Graduate** catalog to read about our graduate programs.

Programs

- Biochemistry, BS (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/biochemistry-bs/)
- Chemistry, BS (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-bs/)
- Chemistry, BS - ACS Certified (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-bs-acs-certified/)
- Chemistry, BS/MS (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-bs-ms/)
- Biochemistry Minor (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/biochemistry-minor/)
- Chemistry Minor (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/chemistry-minor/)
- Biochemistry Undergraduate Certificate (http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-liberal-arts-sciences/chemistry/biochemistry-certificate/)

Faculty

Professors:

Doris Kimbrough, PhD, Cornell University
Jefferson Knight, PhD, Yale University
Hai Lin, PhD, University of Science and Technology of China
Scott Reed, PhD, University of Oregon
Haobin Wang, PhD, Wayne State University
Xiaotai Wang, PhD, University of Virginia

Associate Professors:

John D. (Nick) Fisk, PhD, University of Wisconsin
Jung-Jae Lee, PhD, University of Notre Dame
Yong Liu, PhD, University of Michigan
Marino Resendiz, PhD, University of California, Los Angeles
Liliya Vugmeyster, PhD, State University of New York at Stony Brook

Assistant Professors:

Emilie Guidez, PhD, Kansas State University
Woonghee Lee, PhD University of Wisconsin–Madison

Teaching Professors:

Marta Maroń, PhD, University of Colorado Boulder

Teaching Associate Professors:

Priscilla Burrow Crocker, PhD, University of Colorado Boulder

Teaching Assistant Professor:

Kyoung Kim, PhD, University of Notre Dame

Instructors:

Damian Dunford, PhD, Cardiff University

Chemistry (CHEM)

CHEM 1000 - Foundations for General Chemistry (3 Credits)
This is a lecture- only course intended for students pursuing a degree in science or a health-related field. The course is designed for students who have never had a chemistry course or who have not taken general chemistry in 5+ years. Topics include the classification of matter, the Metric system, dimensional analysis, atomic theory and the structure of atoms, periodic relationships, energy and temperature, gas laws and the kinetic molecular theory, compounds and nomenclature of inorganic compounds, the mole, stoichiometry, types of chemical reactions, balancing equations, electron configurations, and chemical bonding. Enrollment in this course is strongly encouraged prior to enrollment in Chem 2031 if the student does not have a strong and recent background in general chemistry. Note: College Algebra or the equivalent is strongly recommended for optimal student success. Students may not receive credit for this course if they have already received credit for CHEM 2031 and CHEM 2061. Term offered: fall, spring, summer. Max hours: 3 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall, Spring, Summer.

CHEM 1115 - Chemistry Content (1-3 Credits)
Covers content areas of undergraduate chemistry. Topics include periodicity; the mole and chemical bonding; the kinetic theory and states of matter; chemical reactions; solutions and chemical equilibria. Note: Students may not receive credit for this course if they have already received credit for CHEM 2031 and CHEM 2061. Max hours: 3 Credits.
Grading Basis: Letter Grade

CHEM 1474 - Core Chemistry: Chemistry for Everyday (4 Credits)
Focuses on the common household chemicals that affect us on a daily basis. Students explore current topics in chemistry and the underlying chemistry of nuclear power, plastics, sunscreens, food, acid rain, etc. Home-based laboratory experiments with safe, common substances. No co-credit: Students may not receive credit for this course if they have already received credit for CHEM 2031 and CHEM 2061. Term offered: fall, spring, summer. Max hours: 4 Credits. GT: Course is approved by the Colorado Dept of Higher Education for statewide guaranteed transfer, GT-SC1.
Grading Basis: Letter Grade
Additional Information: Denver Core Requirement, Biol Phys Sci - Lec/Lab; GT courses GT Pathways, GT-SC1, Nat Phy Sci:Course w/Req Lab.
Typically Offered: Fall, Spring, Summer.

CHEM 1494 - Forensic Chemistry (4 Credits)
This one semester chemistry lecture and laboratory course is designed to engage a non-science major through the high-interest topic: criminal investigations. In this course, using the theme of forensic science students will be introduced to a basic understanding of chemistry, the physical and chemical properties of matter, simple types of chemical reactions and equations, and molecular structure of drugs and biomolecules. Note: Two years of high school science and one year of high school algebra are strongly recommended for optimal success. Students will not receive credit for this course if they have already received credit for CHEM 2031 and CHEM 2061. Term offered: spring, summer. Max Hours: 4 Credits.
Grading Basis: Letter Grade
Additional Information: Denver Core Requirement, Biol Phys Sci - Lec/Lab; GT courses GT Pathways, GT-SC1, Nat Phy Sci:Course w/Req Lab.
Typically Offered: Spring, Summer.

CHEM 1575 - Chemistry: History and Policies (4 Credits)
A study of the building blocks of all matter: chemicals. A focus on how the study of chemistry began and how it has changed over the course of history. The course explores how chemistry has impacted man from the earliest times: from the Bronze Age to the present and beyond. Students learn about the first use of manufactured chemical substances in history and the progression of chemical knowledge throughout history. Students also study how certain substances introduced into the environment throughout history have affected the environment and what policies have been put in place to control or remediate the release of these substances. Eight home#based laboratory experiments will be performed during the semester. High school algebra is strongly recommended preparation for this course. Math concepts critical for this course include basic operations#addition, subtraction, multiplication and division#, order of operations, exponents, square roots and the ability to rearrange and solve algebraic equations. Term offered: fall. Max Hours: 4 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall.

CHEM 1600 - Introductory Topics in Chemistry (1-3 Credits)
This course is designed primarily for non-chemistry majors. Students will explore a special topic related to chemistry or biochemistry. A description of topics to be covered in the current semester is maintained on the Chemistry department website. Term offered: Fall, Spring, Summer. Repeatable. Max hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.
Typically Offered: Fall, Spring, Summer.

CHEM 2031 - General Chemistry I (3 Credits)
This is the first of a two semester sequence designed for students pursuing a degree in science or a health related field. Chem 2031 is designed for students who have recently completed high school chemistry or Chem 1000 with a C- or better. Note: Non- science majors should review the course description for Chem 1474 as an alternative, non-majors science CU Denver Undergraduate Core course, with lab credit. Topics covered include the classification of matter, the Metric system, dimensional analysis, atomic theory and the structure of atoms, periodic relationships, empirical formulas, thermochemistry, gas laws and the kinetic molecular theory, compounds and nomenclature of inorganic compounds, the mole, balancing equations, stoichiometry, types of chemical reactions, solution stoichiometry and dilutions, electron configurations, chemical bonding, Lewis Dot Theory, Valence Shell Electron Pair repulsion Theory, and other topics as time allows. This course is a prerequisite or co-requisite for General Chemistry 1 Lab, Chem 2038. No co-credit with CHEM 2081. Note: a beginning course for science majors, medical technologists, pre-medical and pre-dental students. It is strongly recommended that students have taken CHEM 1000 and MATH 1110 or their high school equivalents to be adequately prepared to succeed in this course. Term offered: fall, spring, summer. Max hours: 3 Credits. GT: Course is approved by the Colorado Dept of Higher Education for statewide guaranteed transfer, GT-SC2.
Grading Basis: Letter Grade
Additional Information: Denver Core Requirement, Biol Phys Sci - Lec; GT courses GT Pathways, GT-SC2, Nat Phy Sci:Lec w/o Req Lab.
Typically Offered: Fall, Spring, Summer.

CHEM 2032 - Majors General Chemistry I (3 Credits)
This is the first of a two semester sequence designed for chemistry/biochemistry majors and other STEM majors/minors pursuing a degree in science or a health related field. CHEM 2032 is designed for students who have recently completed high school chemistry or CHEM 1000 with a C- or better. Topics covered include the classification of matter, the Metric system, dimensional analysis, atomic theory and the structure of atoms, periodic relationships, empirical formulas, thermochemistry, gas laws and the kinetic molecular theory, compounds and nomenclature of inorganic compounds, the mole, balancing equations, stoichiometry, types of chemical reactions, solution stoichiometry and dilutions, electron configurations, chemical bonding, Lewis dot structures, Valence Shell Electron Pair Repulsion Theory, and other topics as time allows. Note: It is strongly recommended that students have taken CHEM 1000 and MATH 1110 or their high school equivalents to be adequately prepared to succeed in this course. Max hours: 3 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall.

CHEM 2038 - General Chemistry Laboratory I (1 Credit)
Laboratory course designed to accompany Chem 2031. Topics include gravimetric analysis, statistical analysis, stoichiometry, Avogadro's number, thermochemistry, atomic spectroscopy, paper chromatography, and gas laws. No co-credit with CHEM 2088 and CHEM 2039. Coreq: CHEM 2031 or CHEM 2081. Term offered: fall, spring, summer. Max hours: 1 Credit. GT: Course is approved by the Colorado Dept of Higher Education for statewide guaranteed transfer, GT-SC1.
Grading Basis: Letter Grade
Coreq: CHEM 2031 or CHEM 2081
Additional Information: Denver Core Requirement, Biol Phys Sci - Lab; GT courses GT Pathways, GT-SC1, Nat Phy Sci:Course w/Req Lab.
Typically Offered: Fall, Spring, Summer.

CHEM 2039 - Majors General Chemistry I Laboratory (2 Credits)
Students perform laboratory experiments on topics covered in General Chemistry I (CHEM 2031) or the companion Majors General Chemistry I course. Students gain experience in observing, recording, and interpreting physical and chemical phenomena. Majors General Chemistry I Laboratory is distinguished from the regular General Chemistry Laboratory by smaller sections, and greater access to specialized techniques, open ended experiments, instrumentation, and introduction to computational chemistry. Note: This course is intended for Chemistry and Biochemistry majors and minors. Note: No co-credit with CHEM 2038. Coreq: Requires corequisite course of CHEM 2032 (minimum grade D-). Restriction: Restricted to Chemistry and Biochemistry majors and minors. Term offered: fall, spring, summer. Max hours: 2 Credits.
Grading Basis: Letter Grade
Restricted to Chemistry and Biochemistry majors and minors only. Requires corequisite course of CHEM 2032 (minimum grade D-).
Typically Offered: Fall, Spring, Summer.

CHEM 2061 - General Chemistry II (3 Credits)
This is a continuation of Chem 2031 and is the second course of a two semester sequence designed for students pursuing a degree in science or a health related field. CHEM 2061 builds upon the understanding of chemistry rooted in the molecular nature of matter and change from General Chemistry I and expands to include topics such as intermolecular forces, solution chemistry, kinetics, chemical equilibrium, acid-base chemistry, buffer chemistry, solubility, thermodynamics and time permitting, electrochemistry. Specific topics include: the use of bonding theories to explain the relationships between atomic structure, molecular shape, and macroscopic properties of matter including boiling point, vapor pressure, surface tension, viscosity, and capillarity; the understanding of molecular structure to explain the energetics of solution formation as well as vapor pressures of pure liquids and solutions; the application of rates of reactions to define the state of equilibrium; the application of problem solving techniques for systems at equilibrium to acid/base and solubility chemistry; and the thermodynamic underpinnings of chemical reaction rates and the spontaneous conversion of chemical species to attain a state of dynamic equilibrium. This course is a prerequisite or co-requisite for General Chemistry II Lab, Chem 2068. Prereq: CHEM 2031 or 2081 with a C- or higher. No co-credit with CHEM 2091. Term offered: fall, spring, summer. Max hours: 3 Credits. GT: Course is approved by the Colorado Dept of Higher Education for statewide guaranteed transfer, GT-SC2.
Grading Basis: Letter Grade
Prereq: CHEM 2031 or 2081 with a C- or higher
Additional Information: Denver Core Requirement, Biol Phys Sci - Lec; GT courses GT Pathways, GT-SC2, Nat Phy Sci:Lec w/o Req Lab.
Typically Offered: Fall, Spring, Summer.

CHEM 2062 - Majors General Chemistry II (3 Credits)
This is the second of a two-semester sequence designed for chemistry/biochemistry majors and other STEM majors/minors pursuing a degree in science or a health related field. It is a co-requisite to Majors general chemistry II laboratory (CHEM 2069). CHEM 2062 builds upon the understanding of chemistry rooted in the molecular nature of matter and change from General Chemistry I and expands to include topics such as intermolecular forces, solution chemistry, kinetics, chemical equilibrium, acid-base chemistry, buffer chemistry, solubility, thermodynamics and time permitting, electrochemistry. Specific topics include: the use of bonding theories to explain the relationships between atomic structure, molecular shape, and macroscopic properties of matter including boiling point, vapor pressure, surface tension, viscosity, and capillarity; the understanding of molecular structure to explain the energetics of solution formation as well as vapor pressures of pure liquids and solutions; the application of rates of reactions to define the state of equilibrium; the application of problem solving techniques for systems at equilibrium to acid/base and solubility chemistry; and the thermodynamic underpinnings of chemical reaction rates and the spontaneous conversion of chemical species to attain a state of dynamic equilibrium. Pre-req: CHEM 2031 or CHEM 2032 or equivalent and CHEM 2039 or CHEM 2038 equivalent with a C- or higher. Max hours: 3 Credits.
Grading Basis: Letter Grade
Pre-req: CHEM 2031 or CHEM 2032 and CHEM 2039 or CHEM 2038 with a C- or higher.
Typically Offered: Spring.

CHEM 2068 - General Chemistry Laboratory II (2 Credits)
Laboratory course designed to accompany Chem 2061. Topics include colligative properties, spectroscopic analysis, kinetics, equilibrium, acid-base chemistry, titrations, and qualitative analysis of metal cations. No co-credit with CHEM 2098 and CHEM 2069. Prereq: CHEM 2038 or CHEM 2039 or 2088 with a C- or higher. Term offered: fall, spring, summer. Max hours: 2 Credits. GT: Course is approved by the Colorado Dept of Higher Education for statewide guaranteed transfer, GT-SC1.
Grading Basis: Letter Grade
Prereq: CHEM 2038 or CHEM 2039 or CHEM 2088 with a C- or higher.
Additional Information: Denver Core Requirement, Biol Phys Sci - Lab; GT courses GT Pathways, GT-SC1, Nat Phy Sci:Course w/Req Lab.
Typically Offered: Fall, Spring, Summer.

CHEM 2069 - Majors General Chemistry II Laboratory (2 Credits)
Students perform laboratory experiments on topics covered in the Majors General Chemistry II (CHEM 2061) course. Students gain experience in observing, recording, and interpreting physical and chemical phenomena. Majors General Chemistry II Laboratory is distinguished from the regular General Chemistry Laboratory by greater access to specialized techniques and instrumentation, open ended experiments, and a strong emphasis on scientific writing. Students are introduced to college-level laboratory exercises at a faster pace than traditional General Chemistry laboratory coursework, such that at the end of this course, they are ready to take on more sophisticated work. Notes: No co-credit with CHEM 2068. Prereq: CHEM 2031, CHEM 2038, or CHEM 2039 with a C- or higher. Coreq: CHEM 2062. Restriction: Restricted to Chemistry and Biochemistry majors and minors. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 2031, CHEM 2038, or CHEM 2039 with a C- or higher. Coreq: CHEM 2062. Restriction: Restricted to Chemistry and Biochemistry majors and minors (BCHM-CERU, BICM-ADL, BICM-BS, BICM-MIN, CHEM-ADL, CHEM-BS, CHEM BS2, CHEM-MIN).
Typically Offered: Fall, Spring.

CHEM 2081 - Honors General Chemistry I (3 Credits)
Topics include gas laws, thermochemistry, the quantum mechanical model of the atom, periodic properties, bonding and molecular geometry and intermolecular forces. Prepares students to take upper division chemistry courses. Honors section: Course assumes knowledge of stoichiometry and basic atomic structure. Note: Students may not receive credit for this course if they have already received credit for CHEM 2031. Prereq: Admission into specific CU Denver program or consent of instructor is required to enroll. Working knowledge of high school algebra and advanced high school chemistry are required. Restriction: Restricted to Chemistry Honors students (CH01). Term offered: fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to Chemistry Honors students.
Typically Offered: Fall.

CHEM 2088 - Honors General Chemistry I Laboratory (2 Credits)
Laboratory experiments on topics covered in CHEM 2031 or CHEM 2081, gaining experience in observing, recording, and interpreting physical and chemical phenomena. Offers smaller sections and greater access to specialized techniques, open ended experiments, and instrumentation, requiring a faster pace and more sophisticated work. Note: Students may not receive credit for this course if they have already received credit for CHEM 2038. Prereq: Admission into specific CU Denver program or consent of instructor is required to enroll. Coreq: CHEM 2031 or CHEM 2081. No co-credit with CHEM 2038 and CHEM 2039. Term offered: fall. Max hours: 2 Credits.
Grading Basis: Letter Grade
Coreq: CHEM 2031 or CHEM 2081. Restriction: Restricted to Chemistry Honors students.
Typically Offered: Fall.

CHEM 2091 - Honors General Chemistry II Lecture (3 Credits)
Continuation of CHEM 2081. Additional topics may include kinetics, equilibria and thermodynamics. Note: Students may not receive credit for this course if they have already received credit for CHEM 2061. Note: Admission into specific CU Denver program or consent of the instructor is required. Prereq: CHEM 2081 or 2031 with a C- or higher. Restriction: Restricted to Chemistry Honors students (CH01). No co-credit with CHEM 2061. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 2081 or 2031 with a C- or higher Restriction: Restricted to Chemistry Honors students (CH01)
Typically Offered: Spring.

CHEM 2098 - Honors General Chemistry II Laboratory (2 Credits)
Students perform laboratory experiments on topics covered in General Chemistry II (CHEM 2061) or the companion Honors General Chemistry II course. Students gain experience in observing, recording, and interpreting physical and chemical phenomena. Honors General Chemistry II Laboratory is distinguished from the regular General Chemistry Laboratory by smaller sections, and greater access to specialized techniques, open ended experiments, and instrumentation. Students use the laboratory skills they developed in Honors General Chemistry I Laboratory to work independently with a special emphasis on recording, interpreting, and expressing data, chemical safety, the scientific literature, innovation in the laboratory, and presentation of scientific information in oral and poster formats. Prereq: Admission into specific CU Denver program or consent of instructor is required to enroll. Prereq: CHEM 2038 or CHEM 2088. Coreq: CHEM 2091 or CHEM 2061. Restriction: Restricted to Chemistry Honors Students. No co-credit with CHEM 2068 and CHEM 2069. Term offered: spring. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 2038 or CHEM 2088 Coreq: CHEM 2091 or CHEM 2061
Restriction: Restricted to Chemistry Honors Students
Typically Offered: Spring.

CHEM 2300 - Nutritional Chemistry (3 Credits)
Introduces nutrition intended primarily for majors in nursing, physical therapy, physical education. Topics include structure and metabolism of carbohydrates, lipids and proteins, functions of vitamins and minerals and food constituents. Prereq: Requires prerequisite course of CHEM 1000 or CHEM 1474 or CHEM 2031 or CHEM 2032 or CHEM 2081 (all minimum grade C-). Term offered: Summer. Max hours: 3 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 1000 or CHEM 1474 or CHEM 2031 or CHEM 2032 or CHEM 2081 (all minimum grade C-).
Typically Offered: Summer.

CHEM 2600 - Introductory Topics in Chemistry (1-3 Credits)
This course is designed primarily for non-chemistry majors. Students will explore a special topic related to chemistry or biochemistry. A description of topics to be covered in the current semester is maintained on the Chemistry department website. Max hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.

CHEM 2840 - Independent Study: CHEM (1-3 Credits)
Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the CLAS undergraduate advising office for approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 3.
Typically Offered: Fall, Spring, Summer.

CHEM 2939 - Internship (1-3 Credits)
Experiences involving application of specific, relevant concepts and skills in supervised employment situations. Prereq: 15 hours of 2.75 GPA. Department consent required. Repeatable. Max hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.

CHEM 3011 - Inorganic Chemistry (3 Credits)
The fundamentals of inorganic chemistry, including: atomic, molecular and crystal structures; the energetics of reactions, acid-base interactions; and the chemistry of main group and transition metal elements, including coordination and organometallic chemistry. Prereq or Coreq: CHEM 3421 or 3491 with a C- or higher. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq or Coreq: CHEM 3421 or CHEM 3491 with a C- or higher
Typically Offered: Spring.

CHEM 3018 - Inorganic Chemistry Laboratory (2 Credits)
Combines theoretical concepts with hands-on laboratory experience and introduces students to modern inorganic chemistry. Experiments cover both main group and transition metal chemistry with an emphasis on synthesis, characterization, and application of inorganic compounds. Prereq or Coreq: CHEM 3011 with a C- or higher. Term offered: spring. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq or Coreq: CHEM 3011 with a C- or higher
Typically Offered: Spring.

CHEM 3111 - Analytical Chemistry (3 Credits)
Topics include sampling, volumetric analyses, instrumental analyses and statistical treatment of data. Note: Lecture course for chemistry, biology, medical technology and environmental students. Prereq: Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-). Term offered: fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-).
Typically Offered: Fall.

CHEM 3118 - Analytical Chemistry Laboratory (2 Credits)
CHEM 3118 provides a strong background in those chemical principles that are particularly important to analytical chemistry, such as the ability to obtain high-quality analytical data. Students gain experience with techniques of sampling and analysis, including an introduction to instrumental methods. Additionally, students develop the skills needed to solve analytical problems in a quantitative manner, with the aid of spreadsheet tools. The post laboratory assignments demonstrate a writing process that follows the guidelines of the American Chemical Society. Note: Laboratory course to be taken concurrently with CHEM 3111. Prereq: Requires prerequisite course of CHEM 2068 or CHEM 2069 or CHEM 2098 (minimum grade C-). Coreq: Requires corequisite course of CHEM 3111. Term offered: fall. Max hours: 2 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 2068 or CHEM 2069 or CHEM 2098 (minimum grade C-). Requires corequisite course of CHEM 3111.
Typically Offered: Fall.

CHEM 3401 - Survey of Organic Chemistry (3 Credits)
This class is designed as a survey course to prepare students for the one semester biochemistry course (CHEM 3810). Throughout this course we will cover the basics of organic reaction processes including acid/base chemistry, isomers and chirality, alkenes, aromaticity, substitution, and elimination reactions. We will then move our focus on functional groups that are common in biomolecules including alcohols, carboxylic acids and derivatives, aldehydes and ketones, and then chemistry next door to the carbonyl carbon. Once we have covered these basics we will survey the chemistry of carbohydrates, amino acids, lipids, and nucleic acids and then close out the semester with a discussion on enzymes and metabolic processes. Prereq: Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-). Max hours: 3 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-).
Typically Offered: Fall, Spring.

CHEM 3411 - Organic Chemistry I (4 Credits)
Lecture course for science majors. Topics covered include Structure and Bonding, Stereochemistry, Alkanes, reactions of alkenes, alkyl halides, alcohols and other functional groups, reaction mechanism and spectroscopy. Prereq: Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (minimum grade C-). No co-credit with CHEM 3481. Term offered: fall, spring, summer. Max hours: 4 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (minimum grade C-).
Typically Offered: Fall, Spring, Summer.

CHEM 3418 - Organic Chemistry Lab I (1 Credit)
Laboratory course for science majors. Topics include methods of purification, separation and analysis of organic compounds; organic reactions and workups and spectroscopy. Emphasis on scientific writing. Prereq: CHEM 2068 or 2069 or 2098 with a C-or higher. Coreq: CHEM 3411 or CHEM 3481. No co-credit with CHEM 3488. Term offered: fall, spring, summer. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: CHEM 2068 or 2069 or 2098 with a C- or higher Coreq: CHEM 3411 or CHEM 3481
Typically Offered: Fall, Spring, Summer.

CHEM 3421 - Organic Chemistry II (4 Credits)
Lecture course for science majors. A continuation of Chem 3411. Topics covered include spectroscopy, aromaticity, reactions of alkynes, conjugated dienes, benzene, benzene derivatives, aldehydes, ketone, carboxylic acids, carboxylic acid derivatives, enols, enolates and amines, reaction mechanisms and syntheses. Prereq: CHEM 3411 or 3481 with a C- or higher. No co-credit with CHEM 3491. Max hours: 4 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3411 or 3481 with a C- or higher.

CHEM 3428 - Organic Chemistry Lab II (1 Credit)
Laboratory course for science majors. A continuation of CHEM 3418. Topics include analysis of organic unknowns, organic reactions and workups and spectroscopy. Emphasis on scientific writing. Prereq: CHEM 3418 or 3488 with a C- or higher. Coreq: CHEM 3421 or CHEM 3491. Note: Students will not receive credit for CHEM 3428 if they take it after successfully completing CHEM 3498. Term offered: fall, spring, summer. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: CHEM 3418 or 3488 with a C- or higher Coreq: CHEM 3421 or 3491
Typically Offered: Fall, Spring, Summer.

CHEM 3481 - Majors Organic Chemistry I (4 Credits)
Lecture course designed for chemistry majors and students interested in other science majors, or the biomedical field, e.g., pre-dental, pre-pharmacy, or premedical; although all interested students are welcome to enroll. Organic chemistry for majors distinguishes from the regular Organic Chemistry course by a lower student-to-faculty ratio. This allows for the implementation of activities that provide a more in-depth view into this fascinating topic; as well as a better outlook into its relationship to everyday life and career opportunities. Activities may include writing and oral presentation exercises, or attending special seminars, among others. The topics covered are those in a general curriculum, such as structure and bonding, molecular representations, reactivity and mechanisms, acid/base reactions, and alkane/alkene/alkyne reactivity, to mention a few. No co-credit with CHEM 3411. Prereq: Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-) or instructor permission. Restriction: Restricted to Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS ACS, BICM-BS, BICM-ADL). Term offered: fall. Max hours: 4 Credits.
Grading Basis: Letter Grade
Restricted to Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS ACS, BICM-BS, BICM-ADL). Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-) or instructor permission.
Typically Offered: Fall.

CHEM 3488 - Majors Organic Chemistry Laboratory I (1 Credit)
Laboratory course for science majors. Honors laboratory class to accompany CHEM 3411 or CHEM 3481. Topics include methods of purification, separation and analysis of organic compounds through extended experiments; organic reactions and workups and spectroscopy. Emphasis on scientific writing. Prereq: Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS ACS, BICM-BS, BICM-ADL) who have completed CHEM 2068 or 2069 or 2098 with a C- or higher and co-enroll in CHEM 3481 or instructor permission. Note: No co-credit with CHEM 3418. Term offered: fall. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS, ACS, BICM-BS, BICM-ADL) who have completed CHEM 2068 or 2069 or 2098 with a C- or higher and co-enroll in CHEM 3481 or instructor permission.
Typically Offered: Fall.

CHEM 3491 - Majors Organic Chemistry II (4 Credits)
Lecture course for science majors, a continuation of CHEM 3481. Majors Organic Chemistry is distinguished from the regular CHEM 3421 by smaller sections size and greater integration with the majors Chemistry and Biochemistry curriculum. Topics are covered with increased depth and organic chemistry topics are presented to highlight and reinforce overlapping idea from physical and biochemistry classes. Presentation is focused on reaction mechanisms, syntheses and introduction to the organic chemistry of metabolism. Intended for chemistry majors and advanced pre-medical, predental, pre-pharmacy and other health related careers requiring a full year of organic chemistry. Instructor permission required. No co-credit with CHEM 3421. Prereq: Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS ACS, BICM-BS, BICM-ADL) who have completed CHEM 3481 or 3411 with a C- or higher or instructor permission. Term offered: spring. Max hours: 4 Credits.
Grading Basis: Letter Grade
Prereq: Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS ACS, BICM-BS, BICM-ADL) who have completed CHEM 3481 or 3411 with a C- or higher or instructor permission.
Typically Offered: Spring.

CHEM 3498 - Majors Organic Chemistry Laboratory II (2 Credits)
Laboratory course for science majors. A continuation of CHEM 3418 or CHEM 3488. Topics include multi-step organic reactions, workups and spectroscopy and an independent research project. Emphasis on use of the chemical literature, scientific writing and scientific presentation. Prereq: Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS-ACS, BICM-BS, BICM-ADL) who have completed CHEM 3481 or 3411 and CHEM 3488 or 3418 with a C- or higher or instructor permission. Term offered: fall, spring. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq: Chemistry and Biochemistry majors (CHEM-BS, CHEM-ADL, CHEM-BS2, CHEM-BS, ACS, BICM-BS, BICM-ADL) who have completed CHEM 3481 or 3411 and CHEM 3488 or 3418 with a C- or higher or instructor permission.
Typically Offered: Fall, Spring.

CHEM 3600 - Topics in Chemistry (1-3 Credits)
Upper-level majors in chemistry or a related discipline explore a special topic in chemistry or biochemistry. A description of topics to be covered in the current semester is maintained on the Chemistry department website. Max hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.

CHEM 3810 - Biochemistry (4 Credits)
Introduces the principles of biochemistry for science and health science-oriented majors. This survey course covers the important aspects of modern biochemistry including macromolecular structure, enzymology, and metabolism in one semester. Prereq: Requires prerequisite courses of BIOL 2010(2061) or BIOL 2030(2097) and CHEM 3401 or CHEM 3411 or CHEM 3481 (minimum grade of C-). Term offered: fall, spring, summer. Max hours: 4 Credits.
Grading Basis: Letter Grade
Requires prerequisite courses of BIOL 2010(2061) or BIOL 2030(2097) and CHEM 3401 or CHEM 3411 or CHEM 3481 (minimum grade of C-).
Typically Offered: Fall, Spring, Summer.

CHEM 3840 - Independent Study (1-3 Credits)
Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the CLAS undergraduate advising office for approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.
Typically Offered: Fall, Spring, Summer.

CHEM 3939 - Internship (1-3 Credits)
Designed experiences involving application of specific, relevant concepts and skills in supervised employment situations. Prereq: Students must have a junior standing and at least a 2.75 GPA and must work with the Experiential Learning Center advising to complete a course contract and gain approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Prereq: Junior standing or higher and at least a 2.75 cumulative GPA
Typically Offered: Fall, Spring, Summer.

CHEM 4000 - Applied Organic Chemistry for Health Sciences (3 Credits)
Tailored for students in health sciences, this comprehensive Organic Chemistry course is meticulously designed to provide a strong foundation in the fundamental principles of organic chemistry, emphasizing key topics crucial for success in the field of health sciences. Prereq: Requires prerequisite course of CHEM 3421 (minimum grade of C-). Term offered: fall, spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 3421 (minimum grade of C-).
Typically Offered: Fall, Spring.

CHEM 4010 - Advanced Inorganic Chemistry (3 Credits)
Covers the fundamental principles of inorganic chemistry. Topics include atomic structure and periodicity, molecular symmetry, bonding, structural chemistry, main-group chemistry, coordination chemistry, and organometallic chemistry. Requisite knowledge in Undergraduate Inorganic and Physical Chemistry assumed. Cross-listed with CHEM 5010. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CHEM 4110 - Advanced Analytical Chemistry (3 Credits)
Explores the fundamental principles of analytical chemistry. Topics will focus on meteorology (the science of making measurements), measurements based on energy transfer (e.g. spectroscopic analysis), and measurements based on mass transfer (e.g. chemical separations and electrochemistry). Requisite knowledge in Undergraduate Instrumental Analysis is assumed. Cross-listed with CHEM 5110. Max hours: 3 Credits.
Grading Basis: Letter Grade

CHEM 4121 - Instrumental Analysis (3 Credits)
Surveys instrumental methods of analysis, emphasizing atomic and molecular spectroscopy, mass spectrometry, surface characterization, and chromatography techniques. Students are introduced to a wide array of powerful and elegant tools for obtaining qualitative and quantitative information about the composition and structure of matter. Prereq: CHEM 3111 or CHEM 3481, CHEM 3421 or CHEM 3491, PHYS 2331 or PHYS 2020 and CHEM 4521 with a C- or higher. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3111 or CHEM 3481, CHEM 3421 or CHEM 3491, PHYS 2331 or PHYS 2020 and CHEM 4521 with a C- or higher.
Typically Offered: Spring.

CHEM 4128 - Instrumental Analysis Laboratory (2 Credits)
CHEM 4128 demonstrates a wide array of powerful and elegant tools for obtaining qualitative and quantitative information about the composition and structure of matter. The post laboratory assignments demonstrate a writing process that follows the guidelines of the American Chemical Society. Note: Required of chemistry majors and open to other students in CHEM 4121. Prereq: CHEM 3118 and 4538 with a C- or higher. Coreq: CHEM 4121. Term offered: spring. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq:CHEM 3118 and 4538 with a C- or higher Coreq: CHEM 4121
Typically Offered: Spring.

CHEM 4221 - Practical Applications of Spectroscopy (3 Credits)
This course surveys spectroscopic methods in order to deduce the structure of organic compounds from an examination of spectra, with an emphasis on infrared spectroscopy, mass spectometry, nuclear magnetic resonance spectroscopy, and ultraviolet spectroscopy. Students will be introduced to a wide array of powerful and elegant tools for obtaining qualitative information about the structure of matter. This course will require a good amount of thought, yet all of the concepts and associated mathematical manipulations are within the reach of a student who has met the prerequisites. Prereq: CHEM 3411 or CHEM 3481 with a C- or higher. Cross-listed with CHEM 5221. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3411 or 3481 with a C- or higher.

CHEM 4310 - Advanced Organic Chemistry (3 Credits)
An exploration of structure, bonding and reactivity in organic modules that includes extensive analysis of the chemical literature, culminating in written and seminar presentations of individual projects. Requisite knowledge in Undergraduate Organic Chemistry and Physical Chemistry is assumed. Restriction: Restricted to degree-granting Graduate programs. Cross-listed with CHEM 5310. Term offered: fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall.

CHEM 4388 - Nucleic Acid Technologies I (2 Credits)
This laboratory is intended to provide hands-on experience on the synthesis, characterization, and analyses of oligonucleotides of DNA and RNA. The laboratory will cover the basics to understand structural aspects of these biopolymers, using UV-vis, circular dichroism, electrophoresis, HPLC and mass spectroscopy. (All students will be expected to prepare, and turn in, three written reports; and three oral presentations. Every class member will also be required to keep an organized laboratory notebook, thus the class will be exposed to basic research aspects and literature searches. The course will also require students to design a successful experiment, that will prepare them for conditions they may likely encounter in an industrial, ,or advanced academic setting. Specifically, each student will choose a DNA sequence and probe their oligonucleotide model towards the recognition of a particular target, e.g., metabolite, protein, or molecular ion. In assessing these concepts, every student will be exposed to the basics of DNA/RNA structure as well as the chemistry of solid-phase chemistry. Every student will be required to present current topics (from recent literature) in front of the class as a way to enhance skills in oral presentation and scientific communication, aspects that will also enrich the scientific writing experience. To enhance the writing experience and provide a broader perspective on contemporary research, that is related to the course, students will be required to attend two seminars (from the departmental seminar series) and prepare a short written report. It is worth noting that this course will provide exposure to techniques that are commonly used in an industrial setting, e.g., in the development of RNA-based drugs and therapeutics, thus preparing them for a successful transition onto their next academic/professional step). Prereq: Requires prerequisite course of CHEM 3421 or CHEM 3491 (all minimum grade C-). Cross-listed with CHEM 5388. Max hours: 2 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 3421 or CHEM 3491 (all minimum grade C-).

CHEM 4411 - Bioconjugate Techniques and Theranostic Nanomedicine (3 Credits)
The selective making of chemical bonds to biological molecules in complex mixtures enables a wide variety of applications in bio- and nano-materials science, bioengineering, and diagnostic and therapeutic (nano-)medicine. This course will discuss theory and practical current methods for chemical modification and conjugation of proteins and other bio- and nano-materials: Topics include permanent and cleavable cross-linkers, protein modification reagents, immobilization of enzymes/DNA, enzyme-antibody conjugates, protein-protein interactions, PEGylation and labeling of proteins, and solid-phase peptide synthesis. Prereq: CHEM 3411 or CHEM 3481 with a B or higher. Cross-listed with CHEM 5411. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3411 or CHEM 3481 with a B or higher
Typically Offered: Fall.

CHEM 4421 - Cannabis Chemistry (3 Credits)
An exploration of the terpene to cannabinoid compounds including biosynthesis pathways; human receptor structures and mechanism; current analytical methods for Quality Assurance and Quality Contorl and current research in medical applications. Prereq: Organic Chemistry I with a C- or higher (Chem 3411 or Chem 3481), and corequisite/prerequisite: Organic Chemistry II (CHEM 3421 or CHEM 3491). Cross-listed with CHEM 5421. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prerequisite: Organic Chemistry I with a C- or higher (Chem 3411 or Chem 3481), and corequisite/prerequisite:Organic Chemistry II (CHEM 3421 or CHEM 3491).
Typically Offered: Spring.

CHEM 4500 - Foundations of Physical Chemistry (3 Credits)
This course prepares students for CHEM 4511 and/or 4521. The goal is to bridge the gap between algebra- and calculus-based physics courses and to introduce essential math concepts and skills in Calculus III that are relevant to the Physical Chemistry course sequence 4511/4521. Prereq: PHYS 2020 or (prereq or coreq) PHYS 2331,CHEM 3421 or CHEM 3491 and MATH 2411 with a C- or higher. Term offered: fall, spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Pre: PHYS 2020 or (prereq or coreq) PHYS 2331,CHEM 3421 or CHEM 3491 and MATH 2411 with a C- or higher.
Typically Offered: Fall, Spring.

CHEM 4510 - Computational Chemistry (3 Credits)
Classical and ab initio molecular dynamics are covered from theory to application. Students have access to high-performance computational resources and cover current topics in the field. Requisite knowledge in Undergraduate Physical Chemistry is assumed. Cross-listed with CHEM 5510. Term offered: fall. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall.

CHEM 4511 - Physical Chemistry: Thermodynamics and Kinetics (3 Credits)
Includes study of the laws of thermodynamics, thermochemistry, chemical equilibria, solutions and statistical mechanics. Prereq: PHYS 2020 or PHYS 2331 with C- or higher and either (pre-requisite MATH 2421 Calculus III -OR- CHEM 4500 Foundations for Physical Chemistry with a C- or higher) OR co-requisite/ pre-requisite MATH 3511 Mathematics of Chemistry with a C- or higher if completed before CHEM 4511. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: PHYS 2020 or PHYS 2331 with C- or higher and either (pre-requisite MATH 2421 -OR- CHEM 4500 with a C- or higher) OR co-requisite/pre-requisite MATH 3511 with a C- or higher.
Typically Offered: Spring.

CHEM 4518 - Physical Chemistry Laboratory: Reaction Analysis (2 Credits)
Instruction in the experimental techniques of physical chemistry with emphasis on the properties of gases, thermodynamics and chemical equilibrium. Prereq or Coreq: CHEM 4511 with a C- or higher if completed before CHEM 4518. Term offered: spring. Max hours: 2 Credits.
Grading Basis: Letter Grade
Pre- or Co-Requisite CHEM 4511 with a C- or higher if completed before CHEM 4518.
Typically Offered: Spring.

CHEM 4521 - Physical Chemistry: Quantum and Spectroscopy (3 Credits)
Includes study of chemical kinetics, quantum mechanics, molecular structure and spectroscopy. Prereq: PHYS 2020 or PHYS 2331 with C- or higher and either (pre-requisite MATH 2421 Calculus III -OR- CHEM 4500 Foundations for Physical Chemistry with a C- or higher) OR co-requisite/ pre-requisite MATH 3511 Mathematics of Chemistry with a C- or higher if completed before CHEM 4521. Term offered: fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: PHYS 2020 or PHYS 2331 with C- or higher and either (pre-requisite MATH 2421 -OR- CHEM 4500 with a C- or higher) OR co-requisite/pre-requisite MATH 3511 with a C- or higher.
Typically Offered: Fall.

CHEM 4530 - Advanced Physical Chemistry (3 Credits)
Explores fundamental properties of molecules (bond length and strength, the potential energy surface, reaction rates, etc.) and examines how these properties are measured, using original literature as the primary source, and culminating in written and seminar presentations of individual projects. Requisite knowledge in Undergraduate Physical Chemistry is assumed. Cross-listed with CHEM 5530. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CHEM 4538 - Physical Chemistry Laboratory: Molecular Structure (2 Credits)
CHEM 4538 explores the central principles of physical chemistry, with emphasis on quantum chemistry, spectroscopy, and computational methods. The post laboratory assignments demonstrate a writing process that follows the guidelines of the American Chemical Society. Prereq or Coreq: CHEM 4511 or CHEM 4521 with a C- or higher if completed before CHEM 4538 . Cross-listed with CHEM 5538 Term offered: fall. Max hours: 2 Credits.
Grading Basis: Letter Grade
Pre or Co-Requisite CHEM 4511 or CHEM 4521 with a C- or higher.
Typically Offered: Fall.

CHEM 4548 - Physical Biochemistry Laboratory (2 Credits)
Experimental techniques of physical chemistry emphasizing thermodynamics, kinetics, and spectroscopy of biological molecules. Fulfills the Physical Chemistry Lab requirement for Biochemistry Emphasis majors. Prereq: CHEM 3498 or CHEM 4828 and PHYS 2020 or PHYS 2331 with a C- or higher. Prereq or Coreq: CHEM 4511 or CHEM 4521 with a C- or higher. Recommended Preparation: CHEM 4810. Cross-listed with CHEM 5548. Term offered: fall, spring. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3498 or CHEM 4828 and PHYS 2020 or PHYS 2331 with a C- or higher. Prereq or Coreq: CHEM 4511 or CHEM 4521 with a C- or higher.
Typically Offered: Fall, Spring.

CHEM 4580 - Molecular Informatics (3 Credits)
This course resides at the intersection between Chemistry, Biochemistry, and Data Science. The course covers fundamental concepts of Chemical and Biochemical Informatics and provides students with hands on experience in using computational tools to manipulate chemical and biochemical data. Students will learn fundamentals of data science, database management, data structure, data representation, data visualization, and data analysis as applied to Chemistry and Biochemistry. The course requires a basic understanding of programming but does not require extensive programming experience. Examples explored in class and in homework will be built using Python code within Jupyter Notebooks or Google Colab notebooks such that students can explore new topics while remaining focused on the underlying molecular concepts and computer methods which allow them to manage large amounts of molecular information and to find relationships between the structure and properties of molecules. Data mining approaches will be explored as will classification algorithms and chemical similarity analysis methods. Students will learn about the applications of cheminformatics in drug discovery, such as compound selection, virtual library generation, virtual high throughput screening which can check for potential molecules that have the potential to be developed into drugs. Note: While this course is not a pre-requisite for 4510 Computational Chemistry, CHEM 4640 AI in Chemistry and Biochemistry, or CHEM 4845 Molecular Modeling and Drug Design, the skills developed in this course will work synergistically with those courses and will allow you to get more from your experiences in those courses or from your experience in a research lab. Prereq: Requires prerequisite courses of (CHEM 3411 or CHEM 3481) AND (CHEM 4630 or MATH 1376 or BIOS 6642 or MOLB 7900 or CSCI 1410) (all minimum grade C-). Cross-listed with CHEM 5580. Max hours: 2 Credits.
Grading Basis: Letter Grade
Requires prerequisite courses of (CHEM 3411 or CHEM 3481) AND (CHEM 4630 or MATH 1376 or BIOS 6642 or MOLB 7900 or CSCI 1410) (all minimum grade C-).

CHEM 4600 - Advanced Topics in Chemistry (1-3 Credits)
Upper-level majors in chemistry or a related discipline explore a special topic in chemistry or biochemistry. A description of topics to be covered in the current semester is maintained on the Chemistry department website. Max hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.

CHEM 4610 - Understanding & Presenting Chemical Research (1-2 Credits)
This course will improve your ability to systematically search for chemical information, help you interpret the information you find, & improve your ability to summarize and present that information. Prereq: Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-).Cross-listed with CHEM 5610. Term offered: fall, spring. Repeatable. Max hours: 2 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 2.
Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-).
Typically Offered: Fall, Spring.

CHEM 4630 - Programming for Data Analysis in the Physical Sciences (1 Credit)
This course will be taught using live coding format (the instructor will code live in the classroom with the students). In this course, you will learn to process data using python scripts that you will write. Data include for example absorption spectra, protein pdb files, coordinate files. You will also learn how to use Python libraries and write functions (for example to create high resolution graphs). Finally, you will learn best coding practices, how to keep track of different versions of your code and share your code using Github. Prereq: Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-). Having completed a semester of Organic Chemestry is recommended preparation for optimal student success. Cross-listed with CHEM 5630. Max hours: 1 Credit.
Grading Basis: Letter Grade
Requires prerequisite course of CHEM 2061 or CHEM 2062 or CHEM 2091 (all minimum grade C-).

CHEM 4640 - Artificial Intelligence in Chemistry and Biochemistry (3 Credits)
Artificial Intelligence (AI) changes every aspect of our lives. In this course, we explore AI and its applications from the perspective of a chemist/biochemist. The role of AI and the latest trends in modern chemistry and biochemistry will be taught. Students will learn how to connect modern AI techniques to their own research projects, using both experimental and computational data. Prereq or Coreq: Requires prerequisite or corequisite courses of (CHEM 3810 or CHEM 4810 or CHEM 5810) AND (CHEM 4630 or 5630) (all minimum grade of C- if prerequisite). Cross-listed with CHEM 5640. Max hours: 3 Credits.
Grading Basis: Letter Grade
Requires prerequisite or corequisite courses of (CHEM 3810 or CHEM 4810 or CHEM 5810) AND (CHEM 4630 or 5630) (all minimum grade of C- if prerequisite).

CHEM 4655 - Teaching Assistant Bootcamp (1 Credit)
This course is 4-5 8-hour days of intensive training in suitable pedagogy for general chemistry and organic chemistry laboratory classes, procedures for teaching laboratory sections, and laboratory techniques. Students must have a teaching assistant contract with the Chemistry Department in order to take this course. Cross-listed with CHEM 5655. Term offered: fall. Repeatable. Max Hours: 1 Credit.
Grading Basis: Letter Grade
Repeatable. Max Credits: 2.
Typically Offered: Fall.

CHEM 4700 - Environmental Chemistry (3 Credits)
A discussion of the sources, reactions, transport, effects, and fates of chemical species in the water, soil, and air environments. Prereq: CHEM 3111 or CHEM 3411 or CHEM 3481 with a C- or higher. Cross-listed with CHEM 5700. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3111 or CHEM 3411 or CHEM 3481 with a C- or higher
Typically Offered: Spring.

CHEM 4810 - General Biochemistry I (3 Credits)
In-depth introductory course for chemistry, science and health science majors. Topics include structure and energetics of proteins; mechanisms and kinetics of enzymes; structure and function of carbohydrates, lipids and nucleic acids. Prereq or Coreq: CHEM 3421 or CHEM 3491 with a grade of C- or higher. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq or Coreq: CHEM 3421 or CHEM 3491 with a grade of C- or higher.

CHEM 4815 - Structural Biology of Neurodegenerative Diseases (3 Credits)
Advanced course in Biochemistry/Biophysics. Principles of Protein Folding, Structure-Function Relationship, and spectroscopic techniques related to characterization of these processes as applied to neurodegenerative diseases such as Parkinson's and Alzheimer's. Prereq: 1) BIOL 2010 (or 2061/2097/2030), BIOL 2011 (or 2081/2098/2031), BIOL 2020 (or 2051/2095/2040), and BIOL 2021 (or 2071/2096/2041), and 2) CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Coreq: PHYS 2020 or PHYS 2331. Cross-listed with CHEM 5815, BIOL 4815, and BIOL 5815. Term offered: spring. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: 1) BIOL 2010 (or 2061/2097/2030), BIOL 2011 (or 2081/2098/2031), BIOL 2020 (or 2051/2095/2040), and BIOL 2021 (or 2071/2096/2041), and 2) CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Coreq: PHYS 2020 or PHYS 2331
Typically Offered: Spring.

CHEM 4820 - General Biochemistry II (3 Credits)
Advanced course for chemistry, science and health science majors. Topics include energetics and pathways for metabolism of carbohydrates, lipids, and amino acids. Prereq: CHEM 3810 or 4810 or 5810 with a C- or higher. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3810 or 4810 or 5810 with a C- or higher

CHEM 4825 - Biochemistry of Metabolic Disease (3 Credits)
Advanced course in biochemistry. An expanded study of selected topics in metabolism and how they relate to diseases, including inflammation, diabetes, obesity, and rare genetic disorders. Prereq: 1) BIOL 2010 (or 2061/2097/2030), BIOL 2011 (or 2081/2098/2031), BIOL 2020 (or 2051/2095/2040), and BIOL 2021 (or 2071/2096/2041), and 2) CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Cross-listed with CHEM 5825, BIOL 4825 and BIOL 5825. Term offered: fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: 1) BIOL 2010 (or 2061/2097/2030), BIOL 2011 (or 2081/2098/2031), BIOL 2020 (or 2051/2095/2040), and BIOL 2021 (or 2071/2096/2041), and 2) CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher.
Typically Offered: Fall.

CHEM 4828 - Biochemistry Lab (2 Credits)
Focuses on modern laboratory techniques for biochemical research, with an emphasis on methods for protein isolation, purification and characterization. Students perform experiments including chromatography, electrophoresis, molecular cloning, spectrophotometry, and enzyme activity assays. Prereq: CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Max hours: 2 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3810 or 4810 or 5810 with a C- or higher

CHEM 4835 - Biochemistry of Gene Regulation and Cancer (3 Credits)
Explores the biochemical and molecular aspects of cancer biology. Topics include DNA mutations and repair, gene regulation, oncogenes and tumor suppressors, stem cells and differentiation, and cancer drug development. Prereq: 1) BIOL 2010 (or 2061/2097/2030), BIOL 2011 (or 2081/2098/2031), BIOL 2020 (or 2051/2095/2040), and BIOL 2021 (or 2071/2096/2041), and 2) CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Cross-listed with CHEM 5835, BIOL 4835, and BIOL 5835. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: 1) BIOL 2010 (or 2061/2097/2030), BIOL 2011 (or 2081/2098/2031), BIOL 2020 (or 2051/2095/2040), and BIOL 2021 (or 2071/2096/2041), and 2) CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher.
Typically Offered: Fall.

CHEM 4840 - Independent Study: Chem (1-6 Credits)
Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the CLAS undergraduate advising office for approval. Prereq: Permission of instructor required. Term offered: fall, spring, summer. Repeatable. Max Hours: 12 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 12.
Typically Offered: Fall, Spring, Summer.

CHEM 4845 - Molecular Modeling and Drug Design (3 Credits)
Advanced course in biochemistry. An introductory course on modern molecular modeling techniques and their applications to computer-aided rational drug design. Prereq: CHEM 3411 or CHEM 3481 with a C- or higher. Cross-listed with CHEM 5845. Term offered: fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3411 or 3481 with a C- or higher.
Typically Offered: Fall.

CHEM 4860 - Bioinorganic Chemistry: Bioinorganic compounds in medicine (3 Credits)
Explore the roles of metals in biochemistry and medicine by studying chemical/physical properties of metal coordinated compounds. The course focus on metal coordination resulting biopolymer folding and the function of macromolecules that is involved into iron cytochromes, zinc and copper enzymes, iron sulfur proteins, oxygen transport, iron storage, electron transfer, inorganic model compounds, metals in medicine, and toxicity of inorganic species. Topic is extended to biomedical application such as chemotherapy. Prereq: CHEM 3810 or CHEM 4810 or CHEM 5810 with a C- or higher. Cross-listed with CHEM 5860. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CHEM 3810 or 4810 or 5810 with a C- or higher

CHEM 4880 - Directed Research (1-6 Credits)
Students will engage in original research projects supervised and mentored by faculty. Students must work with faculty prior to registration to develop a proposal for their project and receive permission to take this course. Note: Students must submit a special processing form completely filled out and signed by the student and faculty member, describing the course expectations, assignments and outcomes, to the CLAS undergraduate advising office for approval. Term offered: fall, spring, summer. Repeatable. Max Hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.
Typically Offered: Fall, Spring, Summer.