Bachelor of Science in Biochemistry

Program Description

Chemistry is a field of science focused on the physiochemical behavior of atoms, molecules, and ions that ultimately determine the sort of environment we live in; the cars we drive, the energy we use, and even how we feel on a given day. Chemists investigate multiple phenomena, in order to understand the behavior and properties of matter, the reactions and transformations that dictate chemical processes, and the creation of new substances. Through all this, it is no surprise that chemistry is often considered the central science linking the physical sciences with engineering, medicine, and life sciences. Pedagogically, chemistry is typically organized into subdisciplines, including organic chemistry, physical chemistry, inorganic chemistry, biochemistry, analytical chemistry, theoretical/computational chemistry, environmental/geochemistry, nuclear chemistry and materials chemistry. The BS Chemistry degree at Mines is approved by the American Chemical Society (ACS) and includes chemistry tracks that can be tailored to optimize preparation consistent with a student's individual career goals. The specific curricular tracks available emphasize chemistry, biochemistry and/or environmental chemistry. Additionally, a separate non-ACS BS Biochemistry degree is offered, which is designed to educate professionals for career opportunities in medicine, veterinary science, biotechnology, etc. All the degrees in the Chemistry program are designed to educate professionals for the varied career opportunities this central scientific discipline affords.

Student Learning Outcomes

By the end of the chemistry curriculum, students should be able to:

1. Apply chemistry fundamentals in solving open-ended problems
2. Understand the results from modern state-of-the-art tools of chemical analysis and synthesis
3. Locate and use pertinent information from the chemical literature
4. Interpret and use experimental data to advance the knowledge base of chemical or biochemical systems
5. Effectively communicate in both written and oral formats
6. Prepare strong applications for, and succeed in, professional careers or graduate school
7. Make responsible contributions to society

Primary Contact

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Chemistry Department
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https://chemistry.mines.edu/
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Bachelor of Science in Biochemistry

Program Educational Objectives

In addition to contributing toward achieving the educational objectives described in the Mines Graduate Profile and the ABET accreditation criteria, the BS curricula in chemistry are designed to:

- Impart mastery of chemistry fundamentals.
- Develop ability to apply chemistry fundamentals in solving open-ended problems.
- Impart knowledge of and ability to use modern tools of chemical analysis and synthesis.
- Develop ability to locate and use pertinent information from the chemical literature.
- Develop ability to interpret and use experimental data for chemical systems.
- Develop ability to effectively communicate in both written and oral formats.
- Prepare students for entry to and success in professional careers.
- Prepare students for entry to and success in graduate programs.
- Prepare students for responsible contribution to society.

Curriculum

The BS chemistry curricula, in addition to the strong basis provided by the common core, contain three components: chemistry fundamentals, laboratory and communication skills, and applications courses.

Chemistry fundamentals

- Analytical chemistry – sampling, method selection, statistical data analysis, error sources, theory of operation of analytical instruments (atomic and molecular spectroscopy, mass spectrometry, nuclear magnetic resonance spectroscopy, chromatography and other separation methods, electroanalytical methods, and thermal methods), calibration, standardization, stoichiometry of analysis, equilibrium, and kinetic principles in analysis.
- Inorganic chemistry – atomic structure and periodicity, crystal lattice structure, molecular geometry and bonding (VSEPR, Lewis structures, VB and MO theory, bond energies, and lengths), metals structure and properties, acid-base theories, main-group element chemistry, coordination chemistry, term symbols, ligand field theory, spectra and magnetism of complexes, organometallic chemistry, and nanomaterials chemistry and design.
- Organic chemistry – bonding and structure, structure- physical property relationships, reactivity-structure relationships, reaction mechanisms (nucleophilic and electrophilic substitution, addition, elimination, radical reactions, rearrangements, redox reactions, photochemical reactions, and metal-mediated reactions), chemical kinetics, catalysis, major classes of compounds and their reactions, and design of synthetic pathways.
- Physical chemistry – thermodynamics (energy, enthalpy, entropy, equilibrium constants, free energy, chemical potential, non-ideal systems, standard states, activity, phase rule, phase equilibria, phase diagrams), electrochemistry, kinetic theory (Maxwell-Boltzmann distribution, collision frequency, effusion, heat capacity, equipartition of energy), kinetics (microscopic reversibility, relaxation processes, mechanisms and rate laws, collision and absolute rate theories), quantum mechanics (Schroedinger equations, operators and matrix elements, particle-in-a-box, simple harmonic oscillator, rigid rotor, angular momentum, hydrogen atom, hydrogen wave functions, spin, Pauli principle, LCAO method, MO theory, bonding), spectroscopy (dipole selection rules, rotational spectra, term symbols, atomic and molecular electronic spectra, magnetic spectroscopy, Raman spectroscopy, multiphoton selection rules, lasers), statistical thermodynamics (ensembles, partition functions, Einstein crystals, Debye crystals), group theory, surface chemistry,

X-ray crystallography, electron diffraction, dielectric constants, dipole moments, and elements of computational chemistry.

Laboratory and communication skills

- Analytical methods – gravimetry, titrimetry, sample dissolution, quantitative spectroscopy, GC, HPLC, GC/MS, potentiometry, NMR, AA, ICP-AES
- Synthesis techniques – batch reactor assembly, inert-atmosphere manipulations, vacuum line methods, high-temperature methods, high-pressure methods, distillation, recrystallization, extraction, sublimation, chromatographic purification, product identification
- Physical measurements – refractometry, viscometry, colligative properties, FTIR, NMR
- Information retrieval – Chemical Abstracts online searching, CA registry numbers, Beilstein, Gmelin, handbooks, organic syntheses, organic reactions, inorganic syntheses, primary sources, ACS Style Guide
- Reporting – lab notebook, experiment and research reports, technical oral reports
- Communication – scientific reviews, seminar presentations, publication of research results

Applications

- Elective courses – application of chemistry fundamentals in chemistry elective courses or courses in another discipline e.g., chemical engineering, environmental science, materials science.
- Internship – summer or semester experience in an industrial or governmental organization working on real-world problems.
- Undergraduate research – open-ended problem solving in the context of a research project.

Degree Requirements for Bachelor of Science in Chemistry

Degree Requirements (Chemistry Track)

First Year

		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
EDNS151	CORNERSTONE - DESIGN I			3.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
S&W	SUCCESS AND WELLNESS			1.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
HASS100	NATURE AND HUMAN VALUES			3.0
PHGN100	PHYSICS I - MECHANICS			4.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
				32.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.0
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I			3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY			1.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
HASS215	FUTURES			3.0
CHGN222	ORGANIC CHEMISTRY II			3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY			1.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
CHGN335	INSTRUMENTAL ANALYSIS			3.0
TECH ELECT	Technical Elective*			3.0
				16.0

Junior

Fall		**lec**	**lab**	**sem.hrs**
CHGN336	ANALYTICAL CHEMISTRY			3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY			1.0
CHGN341	INORGANIC CHEMISTRY I			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I			4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH			1.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II			4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY			2.0
CHGN428	BIOCHEMISTRY			3.0
TECH ELECT	Technical Elective*			3.0

EBGN321	ENGINEERING ECONOMICS*For the 2023 Catalog EBGN321 replaced EBGN201 as a Core requirement. EBGN321 was added to the core, but has a prerequisite of 60 credit hours. Students whose programs that required EBGN201 the sophomore year may need to wait to take EBGN321 until their junior year. For complete details, please visit: https://www.mines.edu/registrar/core-curriculum/	3.0
		15.0

Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				6.0

Senior				
Fall		**lec**	**lab**	**sem.hrs**
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
CHGN ELECT	Chemistry Elective**			3.0
TECH ELECT	Technical Elective*			3.0
TECH ELECT	Technical Elective*			3.0
FREE	Free Elective			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
ELECTIVE	CULTURE AND SOCIETY (CAS) 400-Level Restricted Elective			3.0
CHGN401	INORGANIC CHEMISTRY II			3.0
CHGN ELECT	Chemistry Elective**			2.0
TECH ELECT	Technical Elective*			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
				17.0

Total Semester Hrs: 131.0

* Technical electives are courses in any technical field. HASS, PAGN, Military Science, ROTC, McBride and most courses in EBGN are ***not*** accepted technical electives. Examples of possible electives that are acceptable are:

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CHGN411	APPLIED RADIOCHEMISTRY	3.0
CHGN420	PHYSICAL ORGANIC CHEMISTRY	3.0
CHGN430	INTRODUCTION TO POLYMER SCIENCE	3.0
CHGN462	MICROBIOLOGY	3.0
EBGN305	SURVEY OF ACCOUNTING	3.0
EBGN308	PRINCIPLES OF MARKETING	3.0
EBGN309	FUNDAMENTALS OF MANAGEMENT	3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3.0
EBGN346	INTRODUCTION TO INVESTMENTS	3.0
EBGN351	INTRODUCTION TO DECISION SCIENCE	3.0
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3.0
EBGN453	PROJECT MANAGEMENT	3.0
MATH201	INTRODUCTION TO STATISTICS	3.0
MATH332	LINEAR ALGEBRA	3.0
MNGN210	INTRODUCTORY MINING	3.0
MTGN211	STRUCTURE OF MATERIALS	3.0
PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0

** Chemistry electives are non-required courses taught within the Chemistry Department. In addition, graduate-level Chemistry and Geochemistry courses taught within the department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter PhD programs in Chemistry or related fields are strongly advised to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495.

Degree Requirements (Environmental Chemistry Track)

First Year				
		lec	**lab**	**sem.hrs**
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
HASS100	NATURE AND HUMAN VALUES			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
				32.0

Sophomore				
Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.0

CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I			3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY			1.0
HASS215	FUTURES			3.0
				18.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN222	ORGANIC CHEMISTRY II			3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY			1.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
CHGN335	INSTRUMENTAL ANALYSIS			3.0
EDNS151	CORNERSTONE - DESIGN I			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
				16.0
Junior				
Fall		**lec**	**lab**	**sem.hrs**
CHGN336	ANALYTICAL CHEMISTRY			3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY			1.0
CHGN341	INORGANIC CHEMISTRY I			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I			4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH			1.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
CHEV ELECT	Environmental Elective**			3.0
				18.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II			4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY			2.0
CHGN428	BIOCHEMISTRY			3.0
CHEV ELECT	Environmental Elective**			3.0
TECH ELECT	Technical Elective*			3.0
				15.0
Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				6.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
CHEV ELECT	Environmental Elective**			3.0
CHEV ELECT	Environmental Elective**			3.0
CHGN ELECT	Chemistry Elective**			3.0
FREE	Free Elective			3.0
EBGN321	ENGINEERING ECONOMICS*For the 2023 Catalog EBGN321 replaced EBGN201 as a Core requirement. EBGN321 was added to the core, but has a prerequisite of 60 credit hours. Students whose programs that required EBGN201 the sophomore year may need to wait to take EBGN321 until their junior year. For complete details, please visit: https://www.mines.edu/registrar/core-curriculum/			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN ELECT	Chemistry Elective**			2.0
CHGN406	INTRODUCTION TO GEOCHEMISTRY			3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) 400-Level Restricted Elective			3.0
S&W	SUCCESS AND WELLNESS			1.0
FREE	Free Elective		3.0	3.0
				15.0

Total Semester Hrs: 135.0

* Technical electives are courses in any technical field. HASS, PAGN, Military Science, ROTC, McBride and most courses in EBGN are ***no***t accepted technical electives. Examples of possible electives that are acceptable are:

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER	3.0
CHGN411	APPLIED RADIOCHEMISTRY	3.0
CHGN420	PHYSICAL ORGANIC CHEMISTRY	3.0
CHGN430	INTRODUCTION TO POLYMER SCIENCE	3.0
CHGN462	MICROBIOLOGY	3.0
EBGN305	SURVEY OF ACCOUNTING	3.0
EBGN308	PRINCIPLES OF MARKETING	3.0
EBGN309	FUNDAMENTALS OF MANAGEMENT	3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3.0
EBGN346	INTRODUCTION TO INVESTMENTS	3.0
EBGN351	INTRODUCTION TO DECISION SCIENCE	3.0
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3.0
EBGN453	PROJECT MANAGEMENT	3.0
MATH201	INTRODUCTION TO STATISTICS	3.0
MATH332	LINEAR ALGEBRA	3.0
MNGN210	INTRODUCTORY MINING	3.0

MTGN211	STRUCTURE OF MATERIALS	3.0
PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0

** Chemistry electives are non-required courses taught within the Chemistry department. In addition, graduate-level Chemistry and Geochemistry courses taught within the department are acceptable.

Environmental electives are courses that are directly or indirectly related to Environmental Chemistry. Examples of possible electives that are acceptable are:

CHGN406	INTRODUCTION TO GEOCHEMISTRY	3.0
CHGN411	APPLIED RADIOCHEMISTRY	3.0
CHGN462	MICROBIOLOGY	3.0
CEEN302	FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT	3.0
CEEN460	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT	3.0
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES	3.0
CEEN479	AIR POLLUTION	3.0
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT	3.0
GEOC407	ATMOSPHERE, WEATHER AND CLIMATE	3.0
GEOC408	INTRODUCTION TO OCEANOGRAPHY	3.0
GEGN466	GROUNDWATER ENGINEERING	3.0

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter PhD programs in Chemistry or related fields are strongly advised to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495.

Degree Requirements (Biochemistry Track)

First Year

		lec	lab	sem.hrs
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
HASS100	NATURE AND HUMAN VALUES			3.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
PHGN100	PHYSICS I - MECHANICS			4.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
				32.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.0
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I			3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY			1.0
				15.0

Spring		**lec**	**lab**	**sem.hrs**
CHGN222	ORGANIC CHEMISTRY II			3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY			1.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
CHGN335	INSTRUMENTAL ANALYSIS			3.0
EDNS151	CORNERSTONE - DESIGN I			3.0
HASS215	FUTURES			3.0
				16.0

Junior

Fall		**lec**	**lab**	**sem.hrs**
TECH ELECT	Technical Elective*			4.0
CHGN336	ANALYTICAL CHEMISTRY			3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY			1.0
CHGN341	INORGANIC CHEMISTRY I			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I			4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH			1.0
				16.0

Spring		**lec**	**lab**	**sem.hrs**
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II			4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY			2.0
CHGN428	BIOCHEMISTRY			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II			4.0
				16.0

Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				6.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
CHGN429	BIOCHEMISTRY II			3.0
CHGN ELECT	Chemistry Elective**			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			3.0
EBGN321	ENGINEERING ECONOMICS*For the 2023 Catalog EBGN321 replaced EBGN201 as a Core requirement. EBGN321 was added to the core, but has a prerequisite of 60 credit hours. Students whose programs that required EBGN201 the sophomore year may need to wait to take EBGN321 until their junior year. For complete details, please visit: https://www.mines.edu/registrar/core-curriculum/			3.0
S&W	SUCCESS AND WELLNESS			1.0
				16.0

Spring		**lec**	**lab**	**sem.hrs**
ELECTIVE	CULTURE AND SOCIETY (CAS) 400-Level Restricted Elective			3.0
CHGN401	INORGANIC CHEMISTRY II			3.0
CHGN ELECT	Chemistry Elective**			2.0
FREE	Free Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
TECH ELECT	Technical Elective			3.0
				17.0

Total Semester Hrs: 134.0

* Technical electives are courses in any technical field. HASS, PAGN, Military Science, ROTC, McBride and most courses in EBGN are not accepted technical electives. Examples of possible electives that are acceptable are:

CHGN Electives:

CHGN311	INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY	3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CHGN409	BIOLOGICAL INORGANIC CHEMISTRY	3.0
CHGN441	THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS	3.0
CHGN445	CHEMICAL BIOLOGY	3.0
CHGN462	MICROBIOLOGY	3.0
CHGN495	UNDERGRADUATE RESEARCH	1-5

Tech Electives:

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN311	NEUROSCIENCE	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	GENETICS	4.0
CBEN322	BIOLOGICAL PSYCHOLOGY	3.0
CBEN411	NEUROSCIENCE, MEMORY, AND LEARNING	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0

Chemistry electives are non-required courses taught within the Chemistry department. In addition, graduate-level Chemistry and Geochemistry courses taught within the department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are strongly advised to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495.

Degree Requirement for Bachelor of Science in Biochemistry

First Year

		lec	**lab**	**sem.hrs**
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
HASS100	NATURE AND HUMAN VALUES			3.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
				32.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.0

CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I			3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY			1.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
MATH225	DIFFERENTIAL EQUATIONS			3.0
CHGN335	INSTRUMENTAL ANALYSIS			3.0
CHGN222	ORGANIC CHEMISTRY II			3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY			1.0
EDNS151	CORNERSTONE - DESIGN I			3.0
HASS215	FUTURES			3.0
				16.0
Junior				
Fall		**lec**	**lab**	**sem.hrs**
CHGN341	INORGANIC CHEMISTRY I			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I			4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH			1.0
CHGN336	ANALYTICAL CHEMISTRY			3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY			1.0
TECH ELECT	Technical Elective			4.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN428	BIOCHEMISTRY			3.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY			2.0
CHGN431	INTRODUCTORY BIOCHEMISTRY LABORATORY			2.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective I			3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II			4.0
CHGN ELECT	Chemistry Elective			3.0
				17.0
Summer		**lec**	**lab**	**sem.hrs**
CHGN490	CHEMISTRY FIELD SESSION			6.0
				6.0
Senior				
Fall		**lec**	**lab**	**sem.hrs**
CHGN429	BIOCHEMISTRY II			3.0
CHGN ELECT	Chemistry Elective			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective II			3.0
FREE ELECT	Free Elective			3.0
EBGN321	ENGINEERING ECONOMICS*For the 2023 Catalog EBGN321 replaced EBGN201 as a Core requirement. EBGN321 was added to the core, but has a prerequisite of 60 credit hours. Students whose programs that required EBGN201 the sophomore year may need to wait to take EBGN321 until their junior year. For complete details, please visit: https://www.mines.edu/registrar/core-curriculum/			3.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
CHGN ELECT	Chemistry Elective			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) 400-Level Restricted Elective III			3.0
FREE ELECT	Free Elective			3.0
FREE ELECT	Free Elective			3.0
S&W	SUCCESS AND WELLNESS			1.0
TECH ELECT	Technical Elective			3.0
				16.0

Total Semester Hrs: 133.0

CHGN Electives:

CHGN311	INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY	3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CHGN409	BIOLOGICAL INORGANIC CHEMISTRY	3.0
CHGN441	THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS	3.0
CHGN445	CHEMICAL BIOLOGY	3.0
CHGN462	MICROBIOLOGY	3.0
CHGN495	UNDERGRADUATE RESEARCH	1-5

* Technical electives are courses in any technical field. HASS, PAGN, Military Science, ROTC, McBride and most courses in EBGN are ***not*** accepted technical electives. Examples of possible elective that are acceptable are:

Tech Electives:

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN305	ANATOMY AND PHYSIOLOGY LAB	1.0
CBEN311	NEUROSCIENCE	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	GENETICS	4.0
CBEN322	BIOLOGICAL PSYCHOLOGY	3.0
CBEN411	NEUROSCIENCE, MEMORY, AND LEARNING	3.0

CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0

Major GPA

During the 2016-2017 academic year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CHGC100 through CHGC599 inclusive
- CHGN100 through CHGN599 inclusive

COURSES

CHGN1XX. Chemistry Elective. 0-6 Semester Hr.

CHGN111. INTRODUCTORY CHEMISTRY. 3.0 Semester Hrs.
(S) Introductory college chemistry. Elementary atomic structure and the periodic chart, chemical bonding, chemical reactions and stoichiometry of chemical reactions, chemical equilibrium, thermochemistry, and properties of gases. Must not be used for elective credit. Does not apply toward undergraduate degree or g.p.a. 3 hours lecture and 3 hours lab; 3 semester hours.

CHGN121. PRINCIPLES OF CHEMISTRY I. 4.0 Semester Hrs.
Study of matter and energy based on atomic structure, correlation of properties of elements with position in periodic chart, chemical bonding, geometry of molecules, phase changes, stoichiometry, solution chemistry, gas laws, and thermochemistry. 3 hours lecture, 3 hours lab; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.
Course Learning Outcomes

- Design and conduct experiments to predict and explain simple chemical and physical processes.
- Calculate or measure quantities using the correct precision and units.
- Explain the general quantum mechanical model for an atom and perform simple spectroscopy calculations.
- Predict the products and calculate amounts of substances in a chemical reaction.
- Describe the trends in periodic properties of elements and explain why they occur.
- Identify the primary types of bonds in a substance, and types of intermolecular forces, if present.
- Explain molecular-level differences between solids, liquids, gases for pure ionic and covalent substances.
- Calculate amount of energy flow during a chemical reaction or phase change, classifying it as heat or work.
- Determine 3D shape and polarity of small molecules and polyatomic ions to predict trends in properties.
- Explain in basic terms how each concept above applies to modern science or engineering issues.

CHGN122. PRINCIPLES OF CHEMISTRY II (SC1). 4.0 Semester Hrs.
Continuation of CHGN121 concentrating on chemical kinetics, gas laws, thermodynamics, electrochemistry and chemical equilibrium (acid- base, solubility, complexation, and redox). Laboratory experiments emphasizing quantitative chemical measurements. 3 hours lecture; 3 hours lab, 4 semester hours. Prerequisite: Grade of C- or better in CHGN121.
Course Learning Outcomes

- Predict physical properties of pure substances & solutions resulting from chemical bonding & intermolecular forces.
- Compare/contrast the direction & spontaneity of chemical & physical processes based on energy & entropy changes.
- Construct chemical rate laws from sequences of molecular collisions; Analyze the factors that determine reaction rates.
- Predict the extend & direction of chemical reactions approaching equilibrium; Assess the impact of stresses to a system at equilibrium.
- Determine the properties & composition of aqueous systems by applying equilibrium concepts & acid/base theory.
- Design experiments & clearly communicate your findings to scientists & non-scientists.
- Explain how each concept above applies to modern science & engineering challenges.

CHGN125. MOLECULAR ENGINEERING & MATERIALS CHEMISTRY. 4.0 Semester Hrs.
Studies of the interactions of matter and energy in chemical reactions and physical processes. Building on principles from CHGN121, the course systematically explores the relationships between processes, structures and properties, starting from the atomic and molecular level. It provides a framework to apply knowledge of chemical bonding and material properties to engineering design, with an emphasis on the Engineering Grand Challenges and the discovery of new process-structure-property relationships. There is a strong focus on the underlying principles of kinetics and equilibrium, and their general applicability, strongly rooted in the first and second law of thermodynamics. Examples of these principles come primarily from solid-state systems. Laboratory experiments emphasize conceptual understanding of structure-property relationships through both hands-on and computational analysis, reinforced by quantitative chemical measurements. Prerequisite: Grade of C- or better in CHGN121. 3 hours lecture; 3 hours lab; 4 semester hours.
Course Learning Outcomes

- Knowledge: A student will be able to:
- Comprehension: A student will be able to:
- Application: A student will be able to:
- Analysis: A student will be able to:

CHGN198. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.

CHGN198. SPECIAL TOPICS. 0-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN198. SPECIAL TOPICS. 0-6 Semester Hr.

CHGN198. SPECIAL TOPICS. 0-6 Semester Hr.

CHGN198LA. SPECIAL TOPICS. 0-6 Semester Hr.

CHGN198LB. SPECIAL TOPICS. 0-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

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CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENTY STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.

CHGN209. INTRODUCTION TO CHEMICAL THERMODYNAMICS. 3.0 Semester Hrs.
Introduction to the fundamental principles of classical thermodynamics, with particular emphasis on chemical and phase equilibria. Volume-temperature-pressure relationships for solids, liquids, and gases; ideal and non-ideal gases. Introduction to kineticmolecular theory of ideal gases and the Maxwell-Boltzmann distributions. Work, heat, and application of the First Law to closed systems, including chemical reactions. Entropy and the Second and Third Laws; Gibbs Free Energy. Chemical equilibrium and the equilibrium constant; introduction to activities & fugacities. One- and two-component phase diagrams; Gibbs Phase Rule. May not also receive credit for CBEN210 or GEGN330. Prerequisites: CHGN121, CHGN122 or CHGN125, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Analyze and identify thermodynamic concepts involving spontaneous vs. non-spontaneous processes.
- Describe heat and work on the atomic/molecular level.
- Predict the heat capacities of gases using molecular degrees of freedom and the Equipartition Principle.
- Explain the temperature-dependence of heat capacities, including the effect of phase changes.
- Differentiate and relate heat vs. temperature.
- Quantitatively utilize the First Law and explain internal energy and enthalpy changes.
- Distinguish between real and ideal gases and explain the role of the intermolecular potential.
- Interpret and explain (both qualitatively and using calculations) the thermodynamics of phase changes and chemical reactions.
- Interpret various phase diagrams (and their important projections) for both pure substances and binary mixtures.
- Interpret the Second and Third Laws of Thermodynamics at the atomic level.
- Predict and explain spontaneity using entropy and free energy calculations.
- Analyze and interpret heat engines and heat pumps involving ideal gases, especially regarding the Second Law.

CHGN221. ORGANIC CHEMISTRY I. 3.0 Semester Hrs.
Structure, properties, and reactions of the important classes of organic compounds, introduction to reaction mechanisms. Prerequisites: Grade of C- or better in CHGN122 or CHGN125. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Gain an in-depth understanding of chemical bonding.
- Be able to name, draw, and determine the structures of organic molecules.
- Understand the properties of organic molecules.
- Understand chemical reactions and reactivity.

CHGN222. ORGANIC CHEMISTRY II. 3.0 Semester Hrs.
Continuation of CHGN221. 3 hours lecture; 3 semester hours. Prerequisite: Grade of C- or better in CHGN221.

CHGN223. ORGANIC CHEMISTRY I LABORATORY. 1.0 Semester Hr.
Laboratory exercises including purification techniques, synthesis, and characterization. Experiments are designed to support concepts presented in the CHGN221. Students are introduced to Green Chemistry principles and methods of synthesis and the use of computational software. 3 hours laboratory, 1 semester hour. Prerequisite: CHGN221 or concurrent enrollment.

CHGN224. ORGANIC CHEMISTRY II LABORATORY. 1.0 Semester Hr.
Laboratory exercises using more advanced synthesis techniques. Experiments are designed to support concepts presented in CHGN222.

CHGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN298. SPECIAL TOPICS. 1-6 Semester Hr.

CHGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN299. INDEPENDENT STUDY. 1-6 Semester Hr.

CHGN311. INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY. 3.0 Semester Hrs.
The primary objective of this course is to provide all students a suitable background to understand the role nanotechnology will play in future technologies and the underpinning principals involved. 3 hours lecture; 3 semester hours. Prerequisite: CHGN121.

Course Learning Outcomes

- Understanding of the phenomena and properties arising from nanoscale materials as a function of changing size and shape.
- Understanding of the terminology and techniques associated with assembling, manipulating and measuring properties at the nanoscale.
- Understanding the different classes of nanoscale materials, their properties and applications.
- Ability to read and assess the landmark nanotechnology papers in the literature.
- Utilizing the above developed knowledge to identify and interpret literature in state of the art applications interfacing nanotechnology with your field of interest.

CHGN323. QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY. 2.0 Semester Hrs.
Identification, separation and purification of organic compounds including use of modern physical and instrumental methods. 1 hour lecture; 3 hours lab; 2 semester hours. Prerequisite: Grade of C- or better in CHGN222, CHGN224.

CHGN335. INSTRUMENTAL ANALYSIS. 3.0 Semester Hrs.
Principles of AAS, AES, Visible-UV, IR, NMR, XRF, XRD, XPS, electron, and mass spectroscopy; gas and liquid chromatography; data interpretation. Prerequisite: CHGN122 with a grade of C- or better or CHGN125 with a grade of C- or better.
Course Learning Outcomes

- Understand what is happening at an atomic/molecular level for each grouping of techniques. What characteristic is being measured?
- Understand when a technique is (not) applicable.
- Compare subtechniques within a family.
- List/sketch components of an instrument and explain the importance of each.
- Understand how to optimize instruments.
- Differentiate good and poor results.
- Use the techniques for qualitative and/or quantitative analyses.
- Determine performance characteristics such as accuracy, precision, selectivity, sensitivity, limit of detection, and calibration methods.

CHGN336. ANALYTICAL CHEMISTRY. 3.0 Semester Hrs.
Theory and techniques of gravimetry, titrimetry (acid-base, complexometric, redox, precipitation), electrochemical analysis, chemical separations; statistical evaluation of data. Prerequisite: CHGN221, CHGN122 with a grade of C- or better or CHGN125 with a grade of C- or better.
Course Learning Outcomes

- Choose appropriate analytical samples, perform correct measurements, understand sources of errors.
- Perform basic statistical data analyses and understand the principles behind them.
- Write mathematical expressions for different kinds of chemical equilibria (including acid-base, precipitation, complexation, and redox equilibria) and use them to calculate species concentrations in solution and to design and understand chemical analyses.
- Apply basic principles of electrochemistry to design and understand chemical analyses involving potentiometry and electroanalytical techniques.
- (With CHGN 337 Analytical Chemistry Laboratory) apply quantitative laboratory skills and techniques.

CHGN337. ANALYTICAL CHEMISTRY LABORATORY. 1.0 Semester Hr.
Laboratory exercises emphasizing sample preparation and instrumental methods of analysis. Prerequisite: CHGN221 (C- or better), CHGN 223. Co-requisite: CHGN336.
Course Learning Outcomes

- Reinforce, through laboratory exercises, the principles of analytical chemistry that are presented in CHGN 336 Analytical Chemistry and CHGN 335 Instrumental Analysis.
- Train students in the principles and practice of sample preparation and quantitative chemical measurements.
- Provide students with the opportunity to work with modern analytical instrumentation.
- By the end of the course, students should be able to select the most appropriate techniques for specific analyses and know how to determine the practical limitations of each method.

CHGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) Supervised, full-time, chemistry-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

CHGN341. INORGANIC CHEMISTRY I. 3.0 Semester Hrs.
The chemistry of the elements and periodic trends in reactivity is discussed. Particular concepts covered include group theory, symmetry, bonding in ionic and metallic crystal, acid-base theories, coordination chemistry, ligand field theory and radioactivity. 3 hours lecture; 3 semester hours. Prerequisite: CHGN222 and CHGN209 or CBEN210.
Course Learning Outcomes

- Students should be able to assess, evaluate or apply periodic trends, group theory, coordination chemistry, molecular orbital theory and crystal field theory.

CHGN351. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I. 4.0 Semester Hrs.
A study of chemical systems from a molecular physical chemistry perspective. Includes an introduction to quantum mechanics, atoms and molecules, spectroscopy, bonding and symmetry, and an introduction to modern computational chemistry. Prerequisites: MATH225, PHGN200, CHGN209 with a grade of C- or better or CBEN210.
Course Learning Outcomes

- Demonstrate basic knowledge of quantum mechanics and its application.
- Demonstrate basic knowledge of spectroscopic methods that are used to detect molecules and to investigate their properties.
- Demonstrate knowledge and intuition of molecular-scale processes that allow rationalization of how molecular-scale parameters can affect macroscopic properties.
- Use the methods of chemical kinetics to determine and analyze the rates of chemical reactions.
- Interpret and discuss reaction equilibria in terms of free energies and chemical potentials.

- Explain the origin and need of activity; apply these concepts to ideal and real solutions of electrolytes and non-electrolytes.

CHGN353. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II. 0-4 Semester Hr.
A continuation of CHGN351. Includes statistical thermodynamics, chemical kinetics, chemical reaction mechanisms, electrochemistry, and selected additional topics. 3 hours lecture; 3 hours laboratory; 4 semester hours. Prerequisite: CHGN351.
Course Learning Outcomes

- Develop an understanding of the molecular basis of properties.
- Synthesize material you've seen in earlier physical chemistry courses into a coherent perspective on chemical systems.

CHGN395. INTRODUCTION TO UNDERGRADUATE RESEARCH. 1.0 Semester Hr.
(I) (WI) Introduction to Undergraduate Research is designed to introduce students to the research endeavor. Topics include ethics, hypothesis testing, critical evaluation of the scientific literature, scientific writing, bibliographic software, and proposal preparation. Prerequisites: Completion of the chemistry curriculum through the Spring semester of the sophomore year. Credit: 1 semester hour.

CHGN396. UNDERGRADUATE RESEARCH. 1-5 Semester Hr.
(I,II,S) Individual research project for freshman, sophomores or juniors under direction of a member of the departmental faculty. Prerequisites: None. Variable credit; 1 to 5 credit hours. Repeatable for credit. Seniors should take CHGN495 instead of CHGN396.

CHGN398. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN398LA. SPECIAL TOPICS LAB. 1-6 Semester Hr.

CHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.

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CHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.

CHGN401. INORGANIC CHEMISTRY II. 3.0 Semester Hrs.
The chemistry of the elements and several applications are related to inorganic chemistry are considered in this course. Particular concepts covered include experimental techniques, chemistry specific to groups of elements, catalysis and industrial processes, inorganic materials and nanotechnology, and other applications of inorganic chemistry. Prerequisite: CHGN341. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Students should be able to apply fundamental considerations of inorganic chemistry to "real world" scenarios.

CHGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY. 3.0 Semester Hrs.
Equivalent with CHGC505,
Processes by which natural and anthropogenic chemicals interact, react and are transformed and redistributed in various environmental compartments. Air, soil and aqueous (fresh and saline surface and groundwaters) environments are covered, along with specialized environments such as waste treatment facilities and the upper atmosphere. Prerequisites: CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- NA

CHGN406. INTRODUCTION TO GEOCHEMISTRY. 3.0 Semester Hrs.
A comprehensive introduction to the basic concepts and principles of geochemistry, coupled with a thorough overview of related principles of thermodynamics and kinetics. Topics covered include: chemical bonding, key chemical reactions, mineral chemistry, soils and nanogeoscience, differentiation of the earth, controls on natural waters, stable and radiogenic isotopes and organic and biogeochemistry. Equivalent with CHGC503. Prerequisite: CHGN122 or CHGN125, GEGN101.
Course Learning Outcomes

- None

CHGN409. BIOLOGICAL INORGANIC CHEMISTRY. 3.0 Semester Hrs.
This course starts with a short introduction to inorganic chemistry and biology. The course then focuses on core bioinorganic chemistry topics, including metalloprotein structure and function; characterization of bioinorganic systems; metal assimilation, metabolism, and homeostasis; and metals in medicine. We also briefly cover special topics, such as metallo-endocrinology, extremophiles, biomineralization, and supramolecular bioinorganic chemistry. We investigate recent advances in the field of bioinorganic chemistry, introduce many leading scientists in the field, and explore scientific literature. Students are assessed through two open-resource, take-home exams (midterm and final) covering course material. Students also explore a topic of their choice through a class presentation and a writing assignment. Students will benefit from having taken at least one of the following courses: organic chemistry, inorganic chemistry, or biochemistry.

CHGN410. SURFACE CHEMISTRY. 3.0 Semester Hrs.
Equivalent with MLGN510,
Introduction to colloid systems, capillarity, surface tension and contact angle, adsorption from solution, micelles and micro - emulsions, the solid/gas interface, surface analytical techniques, van der Waal forces, electrical properties and colloid stability, some specific colloid systems (clays, foams and emulsions). Students enrolled for graduate credit in MLGN510 must complete a special project. Prerequisite: CHGN209 or CBEN210.

CHGN411. APPLIED RADIOCHEMISTRY. 3.0 Semester Hrs.
This course is designed for those who have a budding interest radiochemistry and its applications. A brief overview of radioactivity and general chemistry will be provided in the first three weeks of the course. Follow-on weeks will feature segments focusing on the radiochemistry in the nuclear fuel cycle, radioisotope production, nuclear forensics and the environment. Prerequisite: CHGN122 or CHGN125.

CHGN413. CHEMISTRY OF THE LANTHANIDES AND ACTINIDES. 3.0 Semester Hrs.
This course is designed to introduce students to the chemistry and properties lanthanide and actinide elements, collectively known as the

f-block. These elements are key components of nearly all electronic devices, and you are currently using about eight of them if you are reading this on a cellphone or computer. They also possess fascinating and complex chemistry that can be quite different from transition metals. The course will start with a history of their discovery and the developments that took place during the Manhattan Project. The course will then continue with fundamentals of f-block chemistry with a focus on electronic structure and thermodynamics. Following this, other core topics will include: 1) environmental chemistry including efforts to remediate Cold War legacy nuclear sites and how chemistry plays a role in this. 2) Aqueous Chemistry. 3) Coordination chemistry. 4) Optical and magnetic properties and the selection rules that determine these phenomena. 5) Catalysis, including small molecule activation and polymerization. 5) Separations and recycling. 6) Nuclear Medicine. Each year the course will be partially tailored to recent discoveries and adjusted in focus based on class interests.

Course Learning Outcomes

- Students will have an understanding of why f-block elements are fundamentally different from elements in other parts of the periodic table.
- Students will understand why the unique electronic properties of f-block elements play key roles in numerous technologies
- Students will understand the pros and cons of nuclear energy including the recycling and storage of nuclear waste

CHGN420. PHYSICAL ORGANIC CHEMISTRY. 3.0 Semester Hrs.
This course will introduce students to the fundamental chemical and physical principles that underly mechanistic organic chemistry with a basis in frontier orbital theory, combining valence bond and molecular orbital theories. Topics covered will include thermochemistry, conformational analysis, bond dissociation energies and acidity, kinetics, linear free energy relationships, bonding and molecular orbital theory, and non-covalent interactions. A broad goal of this course is to teach students the underlying principles behind the content introduced in Organic Chemistry I and II. What do we mean when we say that a molecule or conformation is more or less stable than another? What factors control the rate and selectivity of a chemical reaction? What experiments can be used to probe an organic reaction mechanism? These are all questions that we will aim to address by the end of this course. Prerequisites: CHGN222, CHGN351.

Course Learning Outcomes

- Correlate composition and structure of molecules with their reactivity.
- Compare and contrast the spatial and energetic relationships of frontier orbitals.
- Relate organic molecule frontier orbitals with the molecule's structure and reactivity.
- Evaluate the thermodynamics of organic molecule reactivity based on molecular structure.
- Correlate reaction mechanisms with kinetics using transition state theory.
- Design experiments for measuring and correlating thermodynamics and kinetics.

CHGN422. POLYMER CHEMISTRY LABORATORY. 1.0 Semester Hr.
Prerequisites: CHGN221, CHGN223. 3 hours lab; 1 semester hour.

CHGN423. SOLID-STATE CHEMISTRY. 3.0 Semester Hrs.
Dependence of properties of solids on chemical bonding and structure; principles of crystal growth, crystal imperfections, reactions and diffusion in solids, and the theory of conductors and semiconductors Prerequisite: CHGN 121.

Course Learning Outcomes

- 1. Develop foundational understanding of the atomic structure of crystalline solid-state materials, including symmetry, crystal systems, Bravais lattices, space groups, and Miller indices. Connect these concepts to diffraction and scattering
- 2. Connect bonding and electronic structure to functional properties, i.e. electronic transport, light absorption and emission, phonons/lattice dynamics, etc.
- 3. Develop the ability to critically read, synthesize, and discuss the literature corpus surrounding concepts in solid-state materials chemistry.

CHGN428. BIOCHEMISTRY. 3.0 Semester Hrs.
Introductory study of the major molecules of biochemistry: amino acids, proteins, enzymes, nucleic acids, lipids, and saccharides- their structure, chemistry, biological function, and biosynthesis. Stresses bioenergetics and the cell as a biological unit of organization. Discussion of classical genetics, molecular genetics, and protein synthesis. Co-requisite: CHGN222.

CHGN429. BIOCHEMISTRY II. 3.0 Semester Hrs.
A continuation of CHGN428. Topics include: nucleotide synthesis; DNA repair, replication and recombination; transcription, translation and regulation; proteomics; lipid and amino acid synthesis; protein target and degradation; membranes; receptors and signal transduction. Prerequisite: CHGN428.

Course Learning Outcomes

- The learning objectives involve a detailed study of the synthetic reactions for biochemical building blocks and biopolymers. This starts with the integration of CO2 and N2 into synthetic pathways. The construction of the primary 20 amino acids, nucleic acids, fatty acids and carbohydrates will be studied in detail. The light capture and CO2 fixation pathways in photosynthetic organisms will be covered extensively. The breakdown of fatty acids, nucleic acids and amino acids to central metabolites will be covered. The incorporation of building blocks into biopolymers (proteins, DNA/RNA, oligosaccharides) will be incorporated. DNA repair mechanisms and gene regulation will also be studied. General chemical themes regarding equilibria, redox processes, protein structure/function, reaction kinetics and thermodynamics will be extensively reinforced. Biopolymer formation through DNA/RNA polymerase and ribosome functions will be detailed.

CHGN430. INTRODUCTION TO POLYMER SCIENCE. 3.0 Semester Hrs.
Equivalent with MLGN530,
An introduction to the chemistry and physics of macromolecules. Topics include the properties and statistics of polymer solutions, measurements of molecular weights, molecular weight distributions, properties of bulk polymers, mechanisms of polymer formation, and properties of thermosets and thermoplastics including elastomers. Pre requisite: CHGN222. 3 hour lecture, 3 semester hours.

Course Learning Outcomes

- Draw chemical structures, name, and determine synthetic procedures for representative polymers.
- Describe the methods for the polymerization of different polymers and the benefits and drawbacks of different methods.

- Describe the kinetics associated with different polymerization methods as well as the statistics governing the syntheses.
- Describe molecular weight characterization techniques.
- Describe the solution properties of polymeric materials with an understanding of the Flory-Huggins theory (furthermore, relate this to the phase behavior of blends).
- Describe the fundamental principles that govern the morphology of polymers.
- Express an understanding of the principles that govern the glass transition temperature.
- Understand and describe the origin of the mechanical and rheological response of polymeric materials.
- Interview successfully for a job in the polymer industry by expressing the knowledge gained from this course.

CHGN431. INTRODUCTORY BIOCHEMISTRY LABORATORY. 2.0 Semester Hrs.
The link between the structure of a material and its properties is ubiquitous across all fields. Throughout the Biochemistry lab course, we will have the opportunity to explore both protein and nucleic acids through various techniques and analyses that probe the structure-property relationship of biomolecules that subsequently allows us to tap into molecular function. The selection of experiments is intentionally designed to provide exposure to a broad range of modern experimental strategies to enrich and solidify material covered within the CHGN428/429 sequence. Co-requisite: CHGN428.
Course Learning Outcomes

- Students will gain proficiency in basic biochemistry laboratory techniques.
- Students will generate hypotheses and analyze data.

CHGN435. PHYSICAL BIOCHEMISTRY. 3.0 Semester Hrs.
Apply physical chemical principles to understand property-function relationships of biochemical molecules, and investigate biochemical instrumentation and quantitative analyses common to biochemistry. Methods discussed include light/fluorescence microscopy, biomolecular structure determination, i.e., X-ray crystallography, cryo-electron microscopy and NMR, scattering techniques, biomolecular motors, and more. Prerequisite: CHGN 428 + CHGN 209 or equivalent (CBEN 210 or BIOL 301) Co-requisite: N/A.
Course Learning Outcomes

- 1) Demonstrate basic knowledge of thermodynamics and statistical mechanics, and their applications in biochemistry
- 2) Demonstrate basic knowledge of quantum mechanics and its applications in biochemistry
- 3) Demonstrate basic knowledge of common spectroscopic and imaging methods used in biochemistry
- 4) Develop grant-writing skills, particularly in relation to explaining scientific concepts clearly and concisely
- 5) Develop oral presentation skills when disseminating scientific information

CHGN441. THE CHEMISTRY AND BIOCHEMISTRY OF PHARMACEUTICALS. 3.0 Semester Hrs.
This course will examine a broad range of pharmaceuticals, including but not limited to controlled substances, treatments for cardiovascular, respiratory, and infectious diseases, as well as cannabinoids and performance-enhancing substances. The history, pharmacology, and, in some cases, the synthesis of these pharmaceuticals will be covered. Prerequisite: CHGN222, CHGN428.
Course Learning Outcomes

- Students will be able to describe different general mechanisms of action of pharmaceuticals
- Describe different chemical treatments to specific ailments and diseases along with side effects
- Differentiate site and mechanism of action and how agonists and antogonist drugs interact at drug receptor sites
- Explain nomenclature used to name and classify drugs

CHGN445. CHEMICAL BIOLOGY. 3.0 Semester Hrs.
The analysis of biological systems from the perspective of organic/inorganic and physical chemistry, including chemical reactions for the synthetic preparation of biomolecules and the chemistry behind different biotechnological developments and tools. A strong emphasis on the mechanistic basis of biochemical transformations is included. Strategies for directing pharmaceuticals or diagnostics to different subcellular locales will be presented. A survey of key advancements in the field of chemical biology will be drawn from the primary literature. Prerequisite: CHGN 222, CHGN 428.
Course Learning Outcomes

- 1. Understand the molecular-level and atomistic origins of how structure imparts reactivity, based on principles from organic and physical organic chemistry.
- 2. Develop a working knowledge of strategies to direct chemical reagents to different subcellular locales.
- 3. Become familiar with the primary literature describing key advances in the field of chemical biology.
- 4. Be able to use the theories, concepts, and tools of chemical biology to predict how compounds may interact with biological systems.
- 5. Propose novel research to address an outstanding question in the field.

CHGN462. MICROBIOLOGY. 3.0 Semester Hrs.
Equivalent with CHGN562,
(II) This course will cover the basic fundamentals of microbiology, such as structure and function of prokaryotic versus eukaryotic cells; viruses; classification of microorganisms; microbial metabolism, energetics, genetics, growth and diversity, microbial interactions with plants, animals, and other microbes. Special focus will be on pathogenic bacteriology, virology, and parasitology including disease symptoms, transmission, and treatment. 3 hours lecture, 3 semester hours. Prerequisite: CBEN120.

CHGN475. COMPUTATIONAL CHEMISTRY. 3.0 Semester Hrs.
This class provides a survey of techniques of computational chemistry, including quantum mechanics (both Hartree-Fock and density functional approaches) and molecular dynamics. Emphasis is given to the integration of these techniques with experimental programs of molecular design and development. Prerequisites: CHGN351, CHGN401. 3 hours lecture; 3 semester hours.

CHGN490. CHEMISTRY FIELD SESSION. 6.0 Semester Hrs.
(WI) Professional-level chemistry experience featuring modules including organic/polymer synthesis and characterization, inorganic nanomaterial investigations, computational chemistry, environmental chemical analysis , biochemistry and technical report writing. 6-week summer session; 6 semester hours. Prerequisite: CHGN323, CHGN341, and CHGN351.

CHGN495. UNDERGRADUATE RESEARCH. 1-5 Semester Hr.
(I, II, S) (WI) Individual research project under direction of a member of the Departmental faculty. Prerequisites: selection of a research topic and advisor, preparation and approval of a research proposal, completion of chemistry curriculum through the junior year. Variable credit; 1 to 5 credit hours. Repeatable for credit.

CHGN496A. SPECIAL SUMMER COURSE. 0-16 Semester Hr.

CHGN497. INTERNSHIP. 1-6 Semester Hr.
(I, II, S) Individual internship experience with an industrial, academic, or governmental host supervised by a Departmental faculty member. Prerequisites: Completion of chemistry curriculum through the junior year. Variable credit; 1 to 6 credit hours.

CHGN498. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN498. SPECIAL TOPICS. 1-6 Semester Hr.

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CHGN499. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN499. INDEPENDENT STUDY. 1-6 Semester Hr.

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Professors

Thomas Albrecht, University Distinguished Professor

Thomas Gennett

Richard C. Holz

Mark P. Jensen, Grandey University Chair in Nuclear Science & Engineering

Daniel M. Knauss

Matthew C. Posewitz

Svitlana Pylypenko

James F. Ranville

Ryan M. Richards, University Distinguished Professor

Alan S. Sellinger

Jenifer C. Shafer

Brian G. Trewyn, Interim Department Head

Bettina M. Voelker

Shubham Vyas

Associate professors

Dylan Domaille

C. Michael McGuirk

Assistant professors

David Halat

Samantha Johnson

Annalise Maughan

Teaching Professors

Renee Falconer

Angela Sower

Teaching Associate Professors

Christian Beren

Amanda Jameer

Erik Menke, Associate Department Head

Teaching Assistant Professors

Amanda Furness

Jonathan Miorelli

Megan Moyer

Research Professors

Mark E. Eberhart

Kim R. Williams

Research Associate Professors

Jessica Jackson

Joseph Sperling

Yuan Yang

Research Assistant Professors

Aaron Goodman

Rebecca Smaha

Joint Appointees

Mark Allendorf

Eric Bauer

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Daniel Ruddy

Paul Tobash

Affiliate Appointees

Judah Friese

Joseph Meyer

Nicholas Strange

John Stringer

Derek Vardon

Liz Ware

Emeriti Professor

Scott W. Cowley

Ronald W. Klusman

Donald Langmuir

Donald L. Macalady

Patrick MacCarthy

Michael J. Pavelich

Mark R. Seger

E. Craig Simmons

Kent J. Voorhees

Thomas R. Wildeman

David Wu