CHEMISTRY (CHEM)

Faculty

Professors: Karen J. Castle (Associate Dean of Natural Sciences and Mathematics), Charles H. Clapp, David Rovnyak, Robert A. Stockland, Timothy G. Strein, Brian W. Williams

Associate Professors: Dee Ann Casteel (Chair), William D. Kerber, Molly M. McGuire

Assistant Professors: Hasan Arslan, Douglas Collins, Dabrina Dutcher, Michael R. Krout, Brian Jacob Smith, Sarah Smith, Rebecca L. Switzer

Visiting Assistant Professor: Courtney Thomas

Laboratory Directors: Patrick Martino, Erica Merriett, Neluni Perera

GC/MS Specialist: Peter M. Findeis

Computer, Instrument and NMR Specialist: Brian Breczinski

Chemistry is the science that seeks to understand the structure and composition of matter and the changes that it undergoes. The atomic/molecular perspective of chemistry provides fundamental insight into the macroscopic world of materials and organisms. Chemists apply this insight in many ways, such as the synthesis of new substances with useful technological or therapeutic properties and the discovery of new analytical methods that can be used in medicine and environmental science. Coursework in chemistry introduces students to fundamental chemical principles, teaches students to apply these principles broadly and effectively, and enables students to evaluate critically the impact of chemistry on society.

In addition to providing a working knowledge of chemical principles, a major in chemistry offers experience in critical thinking, data analysis, and experimental design. Chemistry graduates pursue a variety of careers in which these skills are important. Many work as chemists in chemical or pharmaceutical companies or in government labs. Others apply their chemical skills to careers in medicine, law, business, chemical or pharmaceutical sales, biotechnology, pharmacology, toxicology, or environmental science. Many chemistry graduates pursue careers in education at the secondary, college or university level.

The department emphasizes the importance of research experience. The opportunity to engage in an original research investigation, in collaboration with a faculty member, is a distinctive feature of this program.

The chemistry major may be pursued under the Bachelor of Arts or the Bachelor of Science degree programs. Students interested in biochemistry should consider either the Bachelor of Science in chemistry curriculum with biochemistry and biology electives or the Bachelor of Science program in cell biology/biochemistry offered jointly by the chemistry and biology departments.

Bachelor of Arts Major

A **Bachelor of Arts major** consists of ten course credits and a Culminating Experience.

Required Courses		
CHEM 205	Principles of Chemistry	1
or CHEM 207	Explorations in Chemistry	
CHEM 211	Organic Chemistry I	1
CHEM 212	Organic Chemistry II	1
CHEM 231	Analytical Chemistry	1
CHEM 321	Inorganic Chemistry I	1
CHEM 340	Biological Physical Chemistry	1
or CHEM 341	Physical Chemistry I	
MATH 201	Calculus I [1]	1
PHYS 211	Classical and Modern Physics I [2]	1
Culminating Experience [3]		.25-.5
Electives		
2 CHEM courses numbered 300-level or above [4]		2

1 MATH 202 Calculus II is strongly recommended.

2 PHYS 212 Classical and Modern Physics II is strongly recommended.

3 Satisfying Disciplinary Depth Component of the College Core Curriculum.

4 A maximum of one course credit of CHEM 375 Undergraduate Research or CHEM 376 Undergraduate Research may count toward the major.

Bachelor of Science Major

A **Bachelor of Science major** consists of 17 course credits and a Culminating Experience.

Required Courses		
CHEM 205	Principles of Chemistry	1
or CHEM 207	Explorations in Chemistry	
CHEM 211	Organic Chemistry I	1
CHEM 212	Organic Chemistry II	1
CHEM 231	Analytical Chemistry	1
CHEM 321	Inorganic Chemistry I	1
CHEM 322	Inorganic Chemistry II	1
CHEM 332	Analytical Chemistry II	1
CHEM 341	Physical Chemistry I	1
CHEM 342	Physical Chemistry II	1
MATH 201	Calculus I	1
MATH 202	Calculus II	1
MATH 211	Calculus III	1
PHYS 211	Classical and Modern Physics I	1
PHYS 212	Classical and Modern Physics II	1
Science elective		1
Culminating Experience [1]		.25-.5
Electives		
2 CHEM courses numbered 300-level or above		2

[1] Satisfying Disciplinary Depth Component of the College Core Curriculum.

The sequence of chemistry courses indicated below is strongly recommended; exceptions to this sequence are rare, and each must be negotiated with the student's adviser on the merits of the particular case.

The recommended sequence for the Bachelor of Science major is as follows:

First Year

First Semester	Credits	Second Semester	Credits
CHEM 205 or 207	1	CHEM 211	1
MATH 201	1	MATH 202	1
	2		2

Sophomore

First Semester	Credits	Second Semester	Credits
CHEM 212	1	CHEM 231	1
MATH 211	1	PHYS 212	1
PHYS 211	1		
	3		2

Junior

First Semester	Credits	Second Semester	Credits
CHEM 321	1	CHEM 322	1
CHEM 341	1	CHEM 342	1
Science elective (see table below)	1		
	3		2

Senior

First Semester	Credits	Second Semester	Credits
CHEM 332	1	Elective in chemistry	1

Elective in chemistry	1	
	2	1

Total Credits: 17

Science Electives

BIOL 205	Introduction to Molecules and Cells	1
CHEG 450	Polymer Science	1
CSCI 203	Introduction to Computer Science I	1
ECEG 205	Electrical and Computer Engineering Fundamentals	1
ENGR 240	Science of Materials	1
GEOL 305	Introduction to Geochemistry	1
MATH 212	Differential Equations	1
PHYS 235	Applied Electronics	1
PHYS 310	Experimental Physics	1
PHYS 317	Thermodynamics and Statistical Mechanics	1
PHYS 332	Quantum Mechanics	1
PHYS 333	Electromagnetic Theory I	1
Other courses with department approval		1

Electives in chemistry during the senior year may be chosen from any of the 300-level undergraduate courses in chemistry.

No more than two credits of research, CHEM 375 Undergraduate Research or CHEM 376 Undergraduate Research, may be applied toward the major.

Advanced placement credit accepted by the University will count as a credit toward graduation, but will not replace the number of chemistry courses above 205 that are required for a major in chemistry.

Transfer students who are given at least 1.5 transfer credits toward graduation based on two semesters of general chemistry taken prior to transfer will be given an adjustment such that those two courses will replace the specific requirement for CHEM 205 Principles of Chemistry and will count as one of the chemistry courses required for the chemistry degree.

Bachelor of Science graduates will not automatically achieve the American Chemical Society's certification. To fulfill these requirements, Bachelor of Science chemistry students should take the equivalent of at least two additional laboratory or research courses, and CHEM 351 Biochemistry I.

Of the 11 electives to be taken during the four undergraduate years, an additional mathematics course is desirable.

Students interested in coordinating graduate with undergraduate work should consult the department chair before the end of the sophomore year. The department offers a combined B.S./M.S. program for students who desire both more research and more advanced chemistry courses than are obtainable under the Bachelor of Science program. The B.S./M.S. program normally is elected in the sophomore year and is completed in the summer following the senior year.

Satisfying Disciplinary Depth Component of the College Core Curriculum

Culminating Experience

Chemistry majors (B.S. and B.A.) will meet the Culminating Experience requirement in one of the following ways.

- Carry out a research or independent study project in the chemical sciences and take CHEM 371 Chemistry Lecture Series, a 0.25-credit research seminar in the senior year. Each student enrolled in the research seminar will give a formal presentation on the research or independent study project that s/he has undertaken. The research or independent study component can be any one of the following:
  a. at least one credit of undergraduate research (CHEM 375 Undergraduate Research or CHEM 376 Undergraduate Research),
  b. a summer research project carried out either at Bucknell or elsewhere (research projects carried out elsewhere must have prior approval by the department),
  c. an independent study project that involves some form of scholarly work in the chemical sciences other than a laboratory research project.
- Take, during the senior year, one of the 0.5-credit special topics seminar courses (CHEM 385 Seminar or CHEM 386 Seminar) that the department offers. These seminars apply principles that students have learned in their core chemistry courses to topics of current interest, and require each student to give a formal presentation.

Writing Within the Major

The writing requirement within the major can be satisfied with CHEM 332 Analytical Chemistry II or CHEM 342 Physical Chemistry II. All chemistry majors are required to take either CHEM 340 Biological Physical Chemistry or CHEM 341 Physical Chemistry I, both of which involve writing formal lab reports.

Formal Presentation Experience

Each of the ways in which B.A. and B.S. chemistry majors can satisfy the Culminating Experience requirement will require formal presentation(s) under the guidance of the research mentor or seminar course instructor.

Information Literacy

Any 0.5 or 1.0 credit chemistry course at the 300 level will satisfy this requirement.

Two **minors** are available in the department of chemistry:

Chemistry Minor

The minor in chemistry requires six chemistry course credits.

Select one of the following: [1]		1
CHEM 160	Introduction to Environmental Chemistry	
CHEM 205	Principles of Chemistry	
CHEM 207	Explorations in Chemistry	
AP chemistry credit		
Five chemistry courses numbered 211 or higher, including:		5
CHEM 375	Undergraduate Research [2]	
CHEM 376	Undergraduate Research [2]	

[1] No more than one course may count toward the minor.

[2] A maximum of one course credit may be applied toward a chemistry minor.

Biochemistry Minor

The chemistry (biochemistry) minor requires:

Required Courses		
CHEM 351	Biochemistry I	1
CHEM 352	Biochemistry II	1
Electives		
4 CHEM courses numbered 211 or above [3]		4

[3] A maximum of one course credit in research (CHEM 375/376) may be applied toward a biochemistry minor.

Learning Outcomes for Undergraduate Chemistry Majors

(Mapped to Bucknell University Education Goals)

Students will:

1. Demonstrate proficiency in the traditional core areas of chemistry (organic, inorganic, analytical, and physical). (1, 4, 6, 9)
2. Demonstrate proficiency in at least new or specialty areas of chemistry and/or chemical research. (1, 4, 6, 8, 9)
3. Apply quantitative or qualitative theories of molecular behavior to chemical problems. (1, 4, 6, 9)
4. Competently perform analytical and/or synthetic procedures and critically evaluate the results. (1, 4, 6)
5. Find, retrieve, and evaluate information from the chemical literature and use it properly. (1, 4, 6, 8)
6. Communicate scientific information through writing. (7)
7. Communicate scientific information through oral presentation. (7)

Numbers in parentheses reflect related Educational Goals of Bucknell University.

Courses

CHEM 105. Introduction to Chemistry. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:3
A terminal elementary course covering in-depth selected topics, which may vary from year to year. Satisfies science requirement for Bachelor of Arts students not majoring in science or engineering. Not open to students who have taken CHEM 160 or any 200-level CHEM course. Prerequisite: seniors by permission only.

CHEM 160. Introduction to Environmental Chemistry. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Other:4
One semester terminal course in chemistry. Introduction to the basic chemistry principles that govern natural processes and anthropogenic effects on the environment. Satisfies laboratory science requirement for Bachelor of Arts students not majoring in science or engineering. Not open to students who have taken CHEM 105 or any 200-level CHEM. Crosslisted as ENST 160.

CHEM 203. General Chemistry for Engineers. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:4
Fundamental principles in inorganic chemistry including aqueous reactions, atomic and molecular structure, coordination compounds, solids, liquids, and gases, and basic equilibrium. Laboratory experiments are both qualitative and quantitative.

CHEM 205. Principles of Chemistry. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3,Other:4
First college chemistry course for most students. Introduction to chemical principles. Prerequisite: high school chemistry or equivalent. Credit not given for both CHEM 205 and CHEM 207.

CHEM 207. Explorations in Chemistry. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:4
Advanced introductory chemistry course for students with a strong chemistry background. Inquiry based projects and lab experiences. Students seeking permission to take CHEM 207 (instead of CHEM 205) must take the online placement test. Credit not given for both CHEM 207 and CHEM 205.

CHEM 211. Organic Chemistry I. 1 Credit.
Offered Spring Semester Only; Lecture hours:4,Other:5
First-year, second-semester course for students majoring in chemistry, biochemistry, and biology. Bonding and structure in organic compounds, resonance, organic acid/base reactions, basic nomenclature, conformational analysis, stereochemistry, properties and reactions of functional groups. Prerequisite: CHEM 205, CHEM 207 or permission of instructor.

CHEM 212. Organic Chemistry II. 1 Credit.
Offered Fall Semester Only; Lecture hours:4,Other:5
A continuation of CHEM 211 with focus on properties and reactions of functional groups, synthesis, and spectroscopic analysis. Prerequisite: CHEM 211.

CHEM 230. Principles of Chemistry 2. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Other:4
Quantitative topics in chemistry including chemical equilibria, especially acid-base chemistry, thermodynamics, kinetics, and separations. Especially appropriate for life-science students. Prerequisite: CHEM 203, or CHEM 205, or CHEM 207.

CHEM 231. Analytical Chemistry. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Other:5
Chemical equilibrium and modern analysis with an emphasis on acid-base systems, solubility, metal ion determinations, electroanalytical chemistry, spectrophotometry, and separation methods. Prerequisite: CHEM 203, or CHEM 205, or CHEM 207.

CHEM 233. Analytical Chemistry for Engineers. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:4
Chemical equilibrium and modern analysis with an emphasis on acid-base systems, solubility, metal ion determinations, electroanalytical chemistry, and spectrophotometry. College of Engineering students only. Prerequisite: CHEM 205, CHEM 207, CHEM 1AP by permission. Students may take only one of these for credit: CHEM 230, CHEM 231, or CHEM 233.

CHEM 2NT. Chemistry Non-traditional Study. 1-2 Credits.
Offered Fall, Spring, Summer; Lecture hours:Varies,Other:Varies
Non-traditional study in chemistry. Prerequisite: permission of the instructor.

CHEM 313. Synthetic Organic Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3,Recitation:1
Modern synthetic organic chemistry, with examples involving complex natural products. Application of organic mechanism, synthetic strategy, and advanced transformations to total synthesis. Prerequisite: CHEM 212. Crosslisted as CHEM 613.

CHEM 314. Mechanistic Organic Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4,Recitation:2
Thermal and kinetic aspects of organic reactions are discussed along with the effect of substituents, solvents, and stereochemistry on reaction pathways. Qualitative molecular orbital theory of organic compounds is covered in depth. Weekly problem sessions are held. Prerequisite: CHEM 212. Crosslisted as CHEM 614.

CHEM 317. Special Topics in Organic Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4; Repeatable
Available by independent study. Prerequisites: CHEM 212 and permission of the instructor.

CHEM 321. Inorganic Chemistry I. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:4
Structures and reactivity of inorganic systems. Emphasizes hands-on, experiential learning in workshops and laboratory. Prerequisite: CHEM 231 or permission of the instructor.

CHEM 322. Inorganic Chemistry II. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Lab:4
Survey course in modern inorganic chemistry covering transition metal, coordination, organometallic, and bioinorganic chemistry. Laboratory will consist of synthetic and physical measurements as well as the manipulation of air sensitive materials. Prerequisite: CHEM 321 or permission of instructor. Crosslisted as CHEM 622.

CHEM 327. Special Topics in Inorganic Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4; Repeatable
Topics vary. Available by independent study. Prerequisite: CHEM 221. Crosslisted as CHEM 627.

CHEM 332. Analytical Chemistry II. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:4
Theory and practice of techniques of instrumental analysis including spectrophotometry, fluorescence, mass spectrometry, atomic absorption, chromatography, capillary electrophoresis, and dynamic electrochemistry. Prerequisite: CHEM 231. Crosslisted as CHEM 632.

CHEM 337. Special Topics in Analytical Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Available by independent study. Prerequisite: CHEM 231 and permission of the instructor. Crosslisted as CHEM 637.

CHEM 340. Biological Physical Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3,Other:6
Introduction to physical chemistry for life science students, with emphasis on thermodynamics, hydrodynamics and spectroscopy. Not open to B.S. chemistry majors. Prerequisites: CHEM 231, MATH 201, and PHYS 211. MATH 202 and PHYS 212 are recommended. Crosslisted as CHEM 640.

CHEM 341. Physical Chemistry I. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:5
Introductory physical chemistry with emphasis on thermodynamics, kinetics and electrochemistry. Prerequisites: CHEM 231, MATH 211, and PHYS 212. Not open to engineering majors. Crosslisted as CHEM 641.

CHEM 342. Physical Chemistry II. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Other:5
Introductory physical chemistry with emphasis on quantum mechanics, structure and bonding, molecular spectroscopy and statistical mechanics. The customized laboratory experience will emphasize applications of spectroscopy and computational methods. Prerequisite: CHEM 341. Crosslisted as CHEM 642.

CHEM 343. Physical Chemistry for Engineers. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Recitation:1
Introductory physical chemistry for engineers, with emphasis on thermodynamics, chemical kinetics and electrochemistry. Prerequisites: CHEM 231, MATH 211, PHYS 211. Only open to engineering majors.

CHEM 347. Special Topics in Physical Chemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Available by independent study. Prerequisites: CHEM 231 and permission of the instructor. Crosslisted as CHEM 647.

CHEM 351. Biochemistry I. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Recitation:1
Introduction to biological chemistry with emphasis on the structure and function of proteins, lipids, carbohydrates and nucleic acids, kinetics and mechanisms of enzymes, bioenergetics, and metabolism. Prerequisites: CHEM 212 and either CHEM 230 or CHEM 231. Crosslisted as CHEM 651.

CHEM 352. Biochemistry II. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Recitation:1
Advanced topics in protein structure and function, protein folding, enzyme mechanisms, electron transport and free-energy coupling mechanisms, biosynthesis, metabolic regulation, and supramolecular assemblies. Prerequisite: CHEM 351 or permission of the instructor. Crosslisted as CHEM 652.

CHEM 357. Special Topics In Biochemistry. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3,Other:1
Structure/function relationships and dynamics of biomolecules. Prerequisite: permission of the instructor.

CHEM 358. Biochemical Methods. 1 Credit.
Offered Spring Semester Only; Lecture hours:2,Other:6
A course in laboratory techniques including cell fractionation, protein, and nucleic acid analysis. Spectrophotometry, chromatography, centrifugation, electrophoresis, and mass spectrometry are emphasized. Prerequisites: BIOL 205 and CHEM 351 and permission of the instructor. Crosslisted as BIOL 340.

CHEM 360. Advanced Environmental Chemistry. 1 Credit.
Offered Fall Semester Only; Lecture hours:4
Chemistry of the atmosphere, hydrosphere, and lithosphere. Natural processes and anthropogenic effects will be discussed. Prerequisite: CHEM 230 or CHEM 231 or permission of the instructor. Crosslisted as CHEM 660.

CHEM 365. Atmospheric Chemistry and Physics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Addresses the relationships of chemistry, physics, and engineering principles in understanding processes in the Earth's atmosphere. Topics include overview of the Earth's atmospheric history and problems of current environmental concerns including urban ozone, acid rain, particulate pollution, and global change. Crosslisted as CHEG 455.

CHEM 371. Chemistry Lecture Series. .25 Credits.
Offered Both Fall and Spring; Lecture hours:1; Repeatable
Formal oral presentations on current research will be given by students, faculty and visiting scientists. Prerequisites: participation in an approved research project or independent study for seniors or second term juniors only.

CHEM 375. Undergraduate Research. .5-2 Credits.
Offered Both Fall and Spring; Lecture hours:Varies,Other:Varies; Repeatable
Original investigations in analytical, biological, organic, physical, environmental or inorganic chemistry.

CHEM 376. Undergraduate Research. .5-2 Credits.
Offered Both Fall and Spring; Lecture hours:Varies,Other:Varies; Repeatable
Original investigations in analytical, biological, organic, physical, environmental or inorganic chemistry.

CHEM 385. Seminar. .5 Credits.
Offered Both Fall and Spring; Lecture hours:2; Repeatable
Topics vary. Crosslisted as CHEM 685.

CHEM 386. Seminar. .5 Credits.
Offered Both Fall and Spring; Lecture hours:2; Repeatable
Topics vary. Crosslisted as CHEM 686.