

## Chemistry

College of Science, Engineering and Technology

Department of Chemistry & Geology

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Chair: Brian L. Groh

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The department is recognized by the American Chemical Society and offers a BS major that is approved by that organization. Anyone considering a chemistry or biochemistry major or chemistry minor should choose a departmental faculty member as an advisor and consult that advisor often throughout the course of study.

**Admission to Major.** Admission to a program is necessary before enrolling in 300- and 400-level courses. Admission is granted by the department. To be eligible for admission to the chemistry program, a student must have declared Chemistry or Chemistry Teaching as a first major, completed 32 credits including CHEM 201 and CHEM 202 and achieved a minimum GPA of 2.0. Students should also have an assigned chemistry advisor with whom they have discussed the program. Applications for admission to the chemistry program are available in the department office.

### CHEMISTRY BA

Required for major: (57-59 credits)

#### Required General Education (8-9 credits):

MATH 121 Calculus I (4)  
 PHYS 211 Principles of Physics I (4) **OR**  
 PHYS 221 General Physics I (5) **OR**

#### Required Support Courses (4-5 credits):

PHYS 212 Principles of Physics II (4) **OR**  
 PHYS 222 General Physics II (5)

#### Required for Major (Core, 31 credits):

CHEM 201 General Chemistry I (5)  
 CHEM 202 General Chemistry II (5)  
 CHEM 305 Analytical Chemistry (4)  
 CHEM 320 Organic Chemistry I (with lab) (5)  
 CHEM 321 Organic Chemistry II (3)  
 CHEM 331 Organic Chemistry II Lab (1)  
 CHEM 381 Introduction to Research (2)  
 CHEM 412 Intermediate Inorganic (2)  
 CHEM 440 Physical Chemistry (3)  
 CHEM 495 Senior Seminar (1)

#### Required Electives for Major (Chemistry, 6 credits):

Choose a minimum of 6 credits from chemistry or biochemistry courses except CHEM 479 and CHEM 482. These electives must include at least one of the following courses:

CHEM 360	CHEM 407	CHEM 415
CHEM 423	CHEM 424	CHEM 437
CHEM 450	CHEM 451	CHEM 465
CHEM 466	CHEM 474	CHEM 475

CHEM 300/400 Elective  
 CHEM 300/400 Elective

**Required for Bachelor of Arts (BA) degree ONLY:** Language (8)

**Required Minor:** Yes. Any but Chemistry.

### CHEMISTRY BS

The Chemistry BS major offers students a choice of two options: Option I and

Option II: ACS Approved.

#### OPTION I

Option I is for students who want a rigorous preparation in chemistry, but who do not need as comprehensive a program as that prescribed for the A.C.S. option.

MATH 121 Calculus I (4)  
 PHYS 221 General Physics I (5)

Required for Major (Support, 9 credits):

MATH 122 Calculus II (4)  
 PHYS 222 General Physics II (5)

Required for Major (Core, 50-51 credits):

CHEM 201 General Chemistry I (5)  
 CHEM 202 General Chemistry II (5)  
 CHEM 305 Analytical Chemistry (4)  
 CHEM 320 Organic Chemistry I (with lab) (5)  
 CHEM 321 Organic Chemistry II (3)  
 CHEM 331 Organic Chemistry II Lab (1)  
 CHEM 381 Introduction to Research (2)  
 CHEM 413 Advanced Inorganic Chemistry (3)  
 CHEM 415 Inorganic Preparations (2)  
 CHEM 423 Chemical and Spectroscopic Determination of Structure (4)  
 CHEM 440 Physical Chemistry I (3)  
 CHEM 441 Physical Chemistry II (3)  
 CHEM 450 Physical Chemistry Laboratory I (1)  
 CHEM 451 Physical Chemistry Laboratory II (1)  
 CHEM 475 Instrumental Analysis (4)  
 CHEM 495 Senior Seminar (1)  
 CHEM 360 Principles of Biochemistry (4) **OR**  
 CHEM 460 Biochemistry I (3)

Required Electives for Major (1 credit):

Students opting for CHEM 460 must choose at least 1 credit from the following:

CHEM 407	CHEM 312	CHEM 424	CHEM 434	CHEM 461
CHEM 465	CHEM 474	CHEM 485	CHEM 496	CHEM 497
CHEM 498	CHEM 499			

Required Electives (3-4 credits)

PHYS 441 Mechanics (4)  
 PHYS 447 Electricity & Magnetism I (3)  
 PHYS 453 Solid State Physics (3)  
 PHYS 473 Statistical Physics (3)  
 MATH 321 Ordinary Differential Equations (4)  
 MATH 455 Theory of Statistics I (4)

Required Minor: None

#### OPTION II: A.C.S. APPROVED

The BS Chemistry, A.C.S. option approved by the American Chemical Society is intended for professional chemists and provides an excellent preparation for graduate or professional school, industry or business. Any deviations from this program requires prior approval from the department.

#### Required General Education (9 credits):

MATH 121 Calculus I (4)  
 PHYS 221 General Physics I (5)

#### Required Support Courses (9 credits):

MATH 122 Calculus II (4)  
 PHYS 222 General Physics II (5)

#### Required for Major (Core, 50-51 credits):

CHEM 201 General Chemistry I (5)  
 CHEM 202 General Chemistry II (5)  
 CHEM 305 Analytical Chemistry (4)  
 CHEM 320 Organic Chemistry I (with lab) (5)

CHEM 321	Organic Chemistry II (3)
CHEM 331	Organic Chemistry II Lab (1)
CHEM 381	Introduction to Research (2)
CHEM 413	Advanced Inorganic Chemistry (3)
CHEM 415	Inorganic Preparations (2)
CHEM 423	Chemical and Spectroscopic Determination of Structure (4)
CHEM 440	Physical Chemistry I (3)
CHEM 441	Physical Chemistry II (3)
CHEM 450	Physical Chemistry I Lab (1)
CHEM 451	Physical Chemistry II Lab (1)
CHEM 475	Instrumental Analysis (4)
CHEM 495	Senior Seminar (1)
CHEM 360	Principles of Biochemistry (4) <b>OR</b>
CHEM 460	Biochemistry I (3)

**Required Electives for Major (Chemistry, 1 credit):**

Students opting for CHEM 460 must choose at least 1 credit from the following:

CHEM 407	CHEM 312	CHEM 424	CHEM 434	CHEM 461
CHEM 465	CHEM 474	CHEM 485	CHEM 496	CHEM 497
CHEM 498	CHEM 499			

**Required Electives (3-4 credits):**

Choose a minimum of 3 credits from the following courses:

PHYS 441	PHYS 447	PHYS 453	PHYS 473	MATH 321
MATH 455				

**Required Minor: None.**

**CHEMISTRY MINOR****Required for Minor (Core, 22 credits):**

CHEM 201	General Chemistry I (5)
CHEM 202	General Chemistry II (5)
CHEM 305	Analytical Chemistry (4)
CHEM 320	Organic Chemistry I (with lab) (5)
CHEM 321	Organic Chemistry II (3)

**Required Electives for Minor (CHEM, 3 credits)**

Choose a minimum of 3 credits from Chemistry or Biochemistry courses except CHEM 381, CHEM 479, CHEM 482 and CHEM 495.

CHEM XXX	300/400 Elective
CHEM XXX	300/400 Elective

These elective credits must be taken at Minnesota State Mankato for the minor.

**CHEMISTRY TEACHING BS**

Requirements for the Chemistry Teaching BS can be found in the SCIENCE TEACHING section of the bulletin. For information, consult the chemistry education advisor, Jeffrey Pribyl.

**POLICIES/INFORMATION**

**GPA Policy.** Students obtaining a major or minor in chemistry must maintain an overall GPA of 2.0 with no more than 5 credits of "D" work in chemistry courses.

**P/N Grading Policy.** Courses leading to a major or minor in chemistry or biochemistry may not be taken on a P/N basis except where P/N grading is mandatory.

The first year of coursework for all chemistry and biochemistry majors should include two semesters of chemistry (CHEM 201, CHEM 202) and two semesters of mathematics (selection of courses depends on mathematics background). During the second year, the recommended courses include organic chemistry,

advanced mathematics, physics, analytical chemistry. It is important for BS chemistry majors that the calculus and physics sequences be completed by the end of the second year since they are prerequisites for physical chemistry. Physical chemistry and instrumental analysis should be taken during the third year. The advanced courses in chemistry and biochemistry can be taken in the junior and senior years. Participation in chemistry seminar is required of all majors. The coursework in mathematics and physics that is required for a major may be credited toward a major or minors in these areas. For this reason it is often desirable and convenient to choose a joint major or minor with physics or mathematics.

**COURSE DESCRIPTIONS****CHEM 100 (4) Chemistry in Society**

This lecture and laboratory course investigates the world of chemistry, the nature of matter and our interactions with chemicals on a daily basis.

This course is intended for non-science majors and is not a preparation for CHEM 111 or CHEM 201.

Fall, Spring  
GE-3

**CHEM 104 (3) Introduction to Chemistry**

This course is an introduction to general chemistry. It is a non-laboratory class designed to prepare students for CHEM 201 or to be utilized as a general education course. This course will address more mathematical relationships than CHEM 106.

GE-3

**CHEM 106 (3) Introduction to Chemistry (for Allied Health)**

This course is an introduction to general and organic chemistry. This is a non-laboratory class designed to prepare students for CHEM 111 or to be utilized as a general education course.

GE-3

**CHEM 111 (5) Chemistry of Life Processes**

This course is an introduction to organic chemistry and biological chemistry for students in nursing, dental hygiene, dietetics, and athletic training. The laboratory will reinforce lecture concepts.

Pre: CHEM 106 or High School Chemistry

Fall, Spring  
GE-2, GE-3

**CHEM 131 (3) Forensic Science**

This chemistry course explores the scientific methods used in criminal investigations. Course topics will include discussions of different kinds of evidence, how to select and analyze samples, and especially how to interpret results of scientific tests. Specific topics will include the analysis of DNA, drugs, Accelerants and explosives, and other organic and inorganic compounds. Case studies will be used as examples throughout the course. There will also be discussions concerning the ethics analysis, and uses of forensic data.

Variable  
GE-3, GE-9

**CHEM 132 (3) Chemistry of Energy**

This course explores and evaluates energy sources from a chemical perspective. In addition to discussion of chemical processes associated with traditional energy sources such as fossil fuels, alternative sources such as solar energy and "next generation" batteries will be presented. In conjunction with this information the environmental and societal consequences for each alternative will be explored.

Variable  
GE-3

**CHEM 133 (3) Challenges to Our Global Environment**

This course will examine two of the most significant environmental challenges facing modern society: stratospheric ozone depletion and global climate change, from an interdisciplinary perspective. The course will start by examining, with a minimum of mathematics, the scientific basis and evidence for these phenomena, and then go on to consider the potential implications of and solutions to these

challenges. In order to understand these potential implications and solutions, we must realize and understand the interdisciplinary nature of these challenges.

Variable

GE-2, GE-10

**CHEM 134 (3) Mind Altering Substances**

This course will explore the scientific, pharmacological, neurochemical and cultural aspects of psychoactive substances. The material is presented intuitively, with no mathematics. Course topics will include discussions of the major classes of pharmaceutical and psychoactive substances, basic neurochemistry, the role of psychoactive substances in medicine, the ritual use of psychoactive substances by traditional cultures, the FDA approval process, the significance and implications of drug testing, the controversy of drug-induced behavioral modification, national and global perspectives of substance abuse and the ethics of legalization.

Variable

GE-3

**CHEM 135 (3) Science of Sport**

An online course introducing the science related to sports issues including nutrition, movement, equipment selection, and healthy exercising/training.

Summer

GE-3

**CHEM 191 (3) Chemistry for Engineers**

This course covers basic chemistry and applications relevant to students interested in the engineering fields.

Pre: Placement into MATH 115 or MATH 121, high school chemistry or "C" or higher in CHEM 104

Fall, Spring

**CHEM 201 (5) General Chemistry I**

Introduction to the basic principles of chemistry including atomic and molecular structure, bonding, chemical reactions, stoichiometry, thermodynamics and states of matter. Laboratory will reinforce lecture concepts.

Pre: "C" or better in MATH 112 or equivalent; high school Chemistry or CHEM 104.

Fall, Spring

GE-2, GE-3

**CHEM 202 (5) General Chemistry II**

Continuation of the basic principles of chemistry including properties of solutions, kinetics, acids and bases, equilibria, buffers, precipitation reactions, electron transfer reactions, electrochemistry, entropy and free energy. Laboratory will reinforce lecture concepts.

Pre: "C" or better in CHEM 201

Fall, Spring

**CHEM 299 (1-6) Individual Study**

**CHEM 305 (4) Analytical Chemistry**

Introduction to the principles of chemical analysis, with emphasis on classical methods of analysis. Lectures will stress the theory of chemical measurements and sample handling. Laboratory exercises will provide students with opportunities to explore calibration methods, method development, and established procedures for volumetric and gravimetric analyses. Basic atomic spectroscopy is also presented.

Pre: "C" or better in CHEM 202

Fall, Spring

**CHEM 312 (2) Intermediate Inorganic Chemistry**

This course is designed to emphasize the descriptive aspects of inorganic chemistry. Course topics include nuclear chemistry, reactivity patterns of selected s and p block elements and a brief introduction to coordination chemistry.

Pre: A grade of "C" or higher in CHEM 202

Spring

**CHEM 320 (5) Organic Chemistry I**

Introduction to organic structure, bonding, chemical reactivity, reactions as acids and bases, mechanisms and stereochemistry. The chemistry of alkanes, alkyl

halides, alkenes, alkynes, alcohols, ethers, aldehydes and ketones, carboxylic acids and their derivatives, and amines will be covered. Laboratory illustrates synthetic techniques and the preparation and reactions of functional groups discussed during lecture.

Pre: CHEM 202

Fall

**CHEM 321 (3) Organic Chemistry II**

The chemistry of aromatic compounds, free radicals, polyenes, macromolecules, heterocyclic compounds, carbohydrates, amino acids, peptides, and proteins will be covered. This will include a study of mechanisms, synthetic transformations, concerted reactions, and spectroscopy.

Pre: "C" or better in CHEM 320

Spring

**CHEM 331 (1) Organic Chemistry II Lab**

Laboratory illustrating electrophilic aromatic substitutions and other reactions of aromatic compounds, synthetic transformations as well as qualitative organic analysis.

Pre: CHEM 321 previously or concurrently

Spring

**CHEM 360 (4) Principles of Biochemistry**

Analysis of the structure and metabolism of biologically important compounds. This intermediate-level course is designed for students in the medical technology, food science, chemistry education, chemistry and pre-professional health majors. The laboratory teaches basic biochemical techniques.

Pre: "C" or better in CHEM 320

Spring

**CHEM 381 (2) Introduction to Research**

Introduction to the use of chemical literature (in print and electronic media), current departmental faculty research interests, safe and ethical conduct of laboratory research, and proper recording of research results in laboratory notebooks. Students perform a literature search and write a proposal for an undergraduate research project.

Pre: CHEM 321

Fall

**CHEM 407 (3) Environmental Chemistry**

The sources of various elements and chemical reactions between them in the atmosphere and hydrosphere are treated. Current research topics relevant to the field of environmental chemistry will also be addressed. Laboratory exercises will emphasize proper sampling technique and various analytical methods for quantifying environmentally important components.

Pre: "C" or better in CHEM 305

Variable

**CHEM 413 (3) Advanced Inorganic Chemistry**

A survey of topics in inorganic chemistry including quantum mechanics, symmetry and group theory, solid state chemistry, molecular structure and geometry, bonding theories, and coordination chemistry, emphasizing the theoretical foundation.

Pre: "C" or better in CHEM 441

Fall

**CHEM 415 (2) Inorganic Preparations**

The preparation and study of inorganic/organometallic compounds utilizing a variety of synthetic techniques including common Schlenk techniques. The studies will include characterization by common instrumental methods such as IR, NMR and UV-vis spectroscopy. Additional studies using instrumental techniques such as IR, NMR, UV-vis, electrochemistry and magnetic susceptibility will also be conducted.

Pre: "C" or better in CHEM 413

Spring

**CHEM 423 (4) Spectroscopic Determination of Structure**

Spectroscopic techniques including nuclear magnetic resonance, infrared, and mass spectrometry for determining structural features of molecules will be covered. Spectroscopic methods emphasize interpretation of spectra, and also

provide hands-on operation of the corresponding electronic instruments. The laboratory uses these techniques for the determination of the structures of a series of unknown compounds.

Pre: CHEM 321 and CHEM 331

Spring

### **CHEM 424 (3) Advanced Organic Chemistry**

Advanced synthetic organic reactions and their mechanisms. Laboratory will include examples of some of this chemistry, and techniques for reaction monitoring and product purification.

Pre: "C" or better in CHEM 321

Spring-EVEN

### **CHEM 434 (2) Industrial Chemistry**

The synthesis and properties of organic macromolecules, especially industrially important polymers, and the chemistry of other industrially important chemical reactions and processes.

Pre: CHEM 321

Spring-ODD

### **CHEM 437 (4) Food Chemistry**

This lecture laboratory course will cover the fundamental principles of food chemistry. Chemical and physical properties of major and minor food components will be discussed. The laboratory will involve both traditional wet chemical methods and more sophisticated instrumental analyses.

Pre: "C" or better in CHEM 305, CHEM 320;

Pre or Co: CHEM 360 or CHEM 460

### **CHEM 440 (3) Physical Chemistry I**

Detailed treatment of thermodynamics and chemical kinetics. Topics include equations of state, laws of thermodynamics, statistical thermodynamics, phase and reaction equilibrium, thermodynamics of solutions and electrochemistry, transport properties, and reaction kinetics.

Pre: "C" or better in CHEM 305, "C" or better in MATH 121, "C" or better in PHYS 212 or PHYS 221

Fall

### **CHEM 441 (3) Physical Chemistry II**

Detailed treatment of quantum mechanics, spectroscopy, and statistical mechanics. Topics include the foundations of quantum mechanics, application of quantum mechanics to atomic and molecular structure, foundations of spectroscopic techniques and statistical mechanics.

Pre: "C" or better in CHEM 440, "C" or better in MATH 122, "C" or better in PHYS 222

Spring

### **CHEM 445 (2) Advanced Physical Chemistry**

Integrated application of the content from CHEM 440 and CHEM 441 to an applied topic of interest to the instructor. The course will depend heavily on reading and discussion of current primary literature of physical chemistry. Possible topics include: atmospheric chemistry, thermodynamics of protein folding, catalytic processes, or molecular processes at interfaces.

Pre: "C" or better in CHEM 441

Variable

### **CHEM 450 (1) Physical Chemistry Laboratory I**

Laboratory to accompany CHEM 440. An advanced treatment of measurement theory and data analysis precedes a series of thermodynamic and kinetic experiments designed to complement topics treated in lecture to help students' independence and sophistication in planning, performing, and reporting experimental work.

Pre: CHEM 440 previously or concurrently

Fall

### **CHEM 451 (1) Physical Chemistry Laboratory II**

Laboratory to accompany CHEM 441. Experiments and computational projects in quantum mechanics, spectroscopy, and statistical mechanics. The experiments and projects will continue to work toward the goal of increasing the students'

independence and sophistication.

Pre: "C" or better in CHEM 440

Pre or Co: CHEM 441

Spring

### **CHEM 460 (3) Biochemistry I**

Detailed analysis of the structures, properties, and functions of proteins, carbohydrates, and lipids; introduction to carbohydrate metabolism; theory for the purification and analysis of proteins. Concurrent enrollment in CHEM 465 is recommended.

Pre: "C" or better in CHEM 320, and BIOL 106

Fall

### **CHEM 461 (3) Biochemistry II**

Detailed analysis of the reactions involved in intermediary metabolism, translation, transcription, and replication.

Pre: CHEM 460

Spring

### **CHEM 465 (1) Biochemical Techniques I**

A lecture/laboratory course which presents methodology and instrumentation used to purify and analyze biomolecules. Techniques include chromatography, autoradiography and radioisotope techniques, polyacrylamide gel electrophoresis, and spectrophotometry.

Pre: CHEM 460 previously or concurrently. CHEM 305 is recommended.

Fall

### **CHEM 466 (2) Biochemical Techniques II**

Students work in teams to solve biochemical research problems by analyzing data from experiments which they design.

Pre: CHEM 460 and CHEM 465

Spring

### **CHEM 474 (2) Chromatography**

Theory and applications of thin layer, paper, liquid, gas and supercritical fluid chromatography and capillary electrophoresis.

Pre: CHEM 320 previously or concurrently is recommended

Fall-EVEN

### **CHEM 475 (4) Instrumental Analysis**

Theory and practice of modern instrumental methods including basic electronics. Special emphasis placed on sampling methods, analog and digital electronics, electrochemistry, spectrophotometric and chromatographic methods, surface and thin-film analysis and computer acquisition and data processing techniques.

Pre: "C" or better in CHEM 305; PHYS 212 or PHYS 222 is recommended

Spring

### **CHEM 477 (1-3) Special Topics in Instrumental Analytical Chemistry**

Detailed study and focused discussion of a specific analytical technique such as electrochemistry, X-ray analysis, etc. or an area of analysis such as metals, bioanalytical, etc. May be taken more than once for credit.

Pre: CHEM 305

Variable

### **CHEM 479 (4) Teaching Physical Science**

Methods and materials for teaching physical sciences in middle school through high school. Clinical experiences required for the course.

Pre: Consent

Spring

### **CHEM 482 (1-3) Problems in Teaching Science**

Variable

### **CHEM 485 (1-2) Seminar in Environmental Chemistry**

Study of current environmental problems or issues with emphasis on the relevant chemical needs and understanding necessary to monitoring or alleviating the problems.

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## CHEMISTRY

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Pre: CHEM 305

Variable

### **CHEM 490 (1-6) Workshop**

#### **CHEM 495 (1) Senior Seminar**

Capstone course for majors in Chemistry, Biochemistry and Chemistry Teaching. During this course students will present the results of their research in several different forums including oral presentations and poster sessions.

Pre: Consent

Spring

### **CHEM 496 (1-6) Senior Thesis**

### **CHEM 497 (1-16) Internship**

### **CHEM 498 (1-6) Undergraduate Research**

### **CHEM 499 (1-6) Individual Study**