

# Chemistry-Biochemistry

## PROGRAM OBJECTIVES

The chemistry-biochemistry degree offered by the Department of Chemistry-Biochemistry prepares chemistry majors for graduate work in pure and applied chemistry, for employment as research chemists and chemical technicians, for entrance into schools for education in the health science and environmental fields, for governmental civil service and teaching positions.

## LEARNING OUTCOMES

Chemistry-biochemistry graduates will be able to apply pertinent chemical knowledge to the solution of diverse scientific, environmental, and social problems in the following learning outcomes:

- *Content Knowledge:* Students will understand the basic chemical/biochemical principles and content in the major specialty areas, which include inorganic, organic, physical, analytical, and biochemistry.
- *Applied Learning Skills:* Students will acquire safe chemical/biochemical laboratory practices and techniques including the use of instrumentation and computers.
- *Inquiry and Integrated Learning:* Students will be able to design and conduct chemical/biochemical research with appropriate documentation including literature searches.
- *Communication and Critical Thinking:* Students will understand the importance of the discipline to modern society and be able to communicate chemical/biochemical information both orally and in writing to their peers and the public.

## MEANS OF ASSESSMENT

To assess student learning, the faculty will employ traditional evaluation techniques such as homework assignments, quizzes, examinations, and evaluation of laboratory experiments. The American Chemical Society (ACS) offers standardized exams in every field of chemistry, including biochemistry, and these will be administered to our students upon completion of their coursework for comparison to national averages. In addition, a service learning component will be incorporated in selected courses. Finally, students will be required to fulfill two capstone projects. One will be an independent undergraduate research project under the supervision of a chemistry faculty member and the second will be a seminar that will conclude with the student's oral and written presentation to the faculty and to his/her peers. Most chemistry-biochemistry students will also present their research at national meetings of scientific societies, such as the ACS.

## REQUIREMENTS FOR THE BACHELOR OF ARTS OR THE BACHELOR OF SCIENCE IN CHEMISTRY-BIOCHEMISTRY

The degree consists of a common core of required courses. Students choose to pursue a chemistry or biochemistry pathway by completing additional coursework in math, physics, biology, and/or chemistry.

- Complete EOU graduation requirements with at least a "C-" in each course required for the Chemistry-Biochemistry degree and have a grade point average of 2.00 or better.
- Complete 48 credits of chemistry required courses.

- Complete 20 credits of math and physics required courses.
- A minimum of 20 chemistry credit hours must be completed at Eastern Oregon University. The designated capstone courses are CHEM 401 and CHEM 407.

## CHEMISTRY REQUIRED COURSES

**CHEM 204+L, 205+L, 206+L** General Chemistry (15)  
**CHEM 285** Chemical Safety (1)  
**CHEM 320** Analytical Chemistry (3) (UWR)  
**CHEM 321** Analytical Chemistry Laboratory (2)  
**CHEM 334** Organic Chemistry I (4)  
**CHEM 335** Organic Chemistry II (4)  
**CHEM 336** Organic Chemistry III (4)  
**CHEM 338** Organic Chemistry I Laboratory (1)  
**CHEM 339** Organic Chemistry II Laboratory (1)  
**CHEM 340** Physical Chemistry (4)  
**CHEM 401** Research (1)  
**CHEM 407** Seminar (1) (UWR)  
**CHEM 407** Seminar (1) (UWR)  
**CHEM 407** Seminar (1) (UWR)  
**CHEM 421** Instrumental Analysis (3)  
**CHEM 422** Instrumental Analysis Laboratory (2)  
**Total: 48 credits**

## MATH & PHYSICS REQUIRED COURSES

**MATH 251** Calculus I (4)  
**MATH 252** Calculus II (4)  
**PHYS 201+L** General Physics (4)  
**PHYS 202+L** General Physics (4)  
**PHYS 203+L** General Physics (4)  
**Total: 20 credits**

## CHEMISTRY PATHWAY OPTION

- Students pursuing the CHEMISTRY PATHWAY will complete a minimum of 103 credits in chemistry and related fields as outlined below:

## CHEMISTRY PATHWAY REQUIRED COURSES

**CHEM 360** Environmental Chemistry (4)  
**CHEM 361** Environmental Chemistry Lab (1)  
**CHEM 411** Inorganic Chemistry (4)  
**CHEM 437** Organic NMR Spectroscopy (2)  
**MATH 253** Calculus III (4)  
**CS 161** Foundations of CS I (4)  
**Total: 19 credits**

## CHEMISTRY PATHWAY ELECTIVE COURSES

Choose 4 of the following courses:

**MATH 321** Differential Equations (4)

**MATH 341** Linear Algebra (4)

**STAT 327** Stats & Experimental Design (5)

**STAT 352** Statistics (4)

**CHEM 412** Inorganic Chemistry Lab (1)

**CHEM 450** Structural Biochemistry (4)

**CHEM 451** Metabolic Biochemistry (4)

**Total: 16-17 credits**

## BIOCHEMISTRY PATHWAY OPTION

- Students pursuing the BIOCHEMISTRY PATHWAY will complete a minimum of 108 credits in chemistry and related fields as outlined below:

## BIOCHEMISTRY PATHWAY REQUIRED COURSES

**BIOL 211+L** Prin of Biology + Lab (4+1)

**BIOL 212+L** Prin of Biology + Lab (4+1)

**BIOL 213+L** Prin of Biology + Lab (4+1)

**BIOL 341+L** Genetics (4)

**BIOL 342+L** Genetics (4)

**BIOL 431** Cell Struct & Funct (5)

**CHEM 450** Structural Biochemistry (4)

**CHEM 451** Metabolic Biochemistry (4)

**CHEM 454** Biochemistry Lab (2)

**Total: 38 credits**

## BIOCHEMISTRY PATHWAY ELECTIVE COURSES

Choose one of the following courses:

**BIOL 323+L** General Microbiology (5)

**BIOL 345** Molecular Biology (3)

**BIOL 432+L** Animal Physiology (5) (UWR)

**BIOL 433+L** Plant Physiology (5)

**CHEM 411** Inorganic Chemistry (4)

**CHEM 437** Organic NMR Spectroscopy (2)

**Total: 2-5 credits**

## CHEMISTRY-BIOCHEMISTRY DEGREE

### TYPICAL FIRST YEAR CURRICULUM

(Non-Calculus Ready)

#### Fall

**CHEM 204** General Chemistry (5) ①

**MATH 111** College Algebra (4) ②

Electives (6) ③

#### Winter

**CHEM 205** General Chemistry (5) ①

**MATH 112** Pre-Calculus (4) ②

Electives (6) ③

#### Spring

**CHEM 206** General Chemistry (5)

**CHEM 285** Chemical Safety (1)

Electives (9) ③

## TYPICAL SECOND YEAR CURRICULUM

#### Fall

**CHEM 334** Organic Chemistry I (4)

**CS 161** Foundations of CS I (4) **chem pathway only**

**BIOL 211** Prin of Biology (5) **biochem pathway only**

**CHEM 401** Research (1)

**MATH 251** Calculus I (4)

Electives (2) ③

#### Winter

**CHEM 335** Organic Chemistry II (4)

**CHEM 338** Organic Chemistry I Lab (1)

**MATH 252** Calculus (4)

**BIOL 212** Prin of Biology (5) **biochem pathway only**

Electives (5) ③ **chem pathway only**

#### Spring

**CHEM 336** Organic Chemistry III (4)

**CHEM 339** Organic Chemistry II Laboratory (1)

**MATH 253** Calculus (4) **chem pathway only**

**BIOL 213** Prin of Biology (5) **biochem pathway only**

Electives (6) ③ **chem pathway only**

Electives (5) ③ **biochem pathway only**

## TYPICAL THIRD YEAR CURRICULUM

#### Fall

**PHYS 201** General Physics (4)

**chem pathway only**

**CHEM 320** Analytical Chemistry (3)

**CHEM 321** Analytical Chemistry Lab (2)

Electives (6) ③

**biochem pathway only**

**BIOL 341** Genetics (4)

**CHEM 450** Structural Biochem (4)

**CHEM 454** Biochem Lab (2)

Electives (1) ③

#### Winter

**PHYS 202** General Physics (4)

**chem pathway only**

**CHEM 421** Instrumental Analysis (3)

**CHEM 422** Instrumental Analysis Lab (2)

Electives (6) ③

**biochem pathway only**

**BIOL 342** Genetics (4)

**CHEM 451** Metabolic Biochem (4)

Electives (3) ③

#### Spring

**PHYS 203** General Physics (4)

**CHEM 340** Physical Chemistry (4)

Electives (2-7) ③

**chem pathway only**

**CHEM 360** Environmental Chem (4) ⑤

**CHEM 361** Environmental Chem Lab (1) ⑤

## TYPICAL FOURTH YEAR CURRICULUM

### Fall

**CHEM 407** Seminar (1)  
**chem pathway only**  
Math/Stat/Chem Options (8) ④  
Electives (6) ③

### biochem pathway only

**CHEM 320** Analytical Chemistry (3)  
**CHEM 321** Analytical Chemistry Lab (2)  
**BIOL 431** Cell Structure & Function (5)  
Electives (4) ③

### Winter

**CHEM 407** Seminar (1)  
**chem pathway only**  
Math/Stat/Chem Options (9) ④  
**CHEM 437** Organic NMR Spec (2) ⑤  
Electives (3) ③

### biochem pathway only

**CHEM 421** Instrumental Analysis (3)  
**CHEM 422** Inst Anal Lab (2)  
Upper-Div CHEM/BIOL Options (5)  
Electives (4) ③

### Spring

**CHEM 407** Seminar (1)  
**chem pathway only**  
**CHEM 411** Inorganic Chemistry (4) ⑤  
Electives (10) ③  
**biochem pathway only**  
Upper-Div CHEM/BIOL Options (4)  
Electives (10) ③

## CHEMISTRY-BIOCHEMISTRY DEGREE

### TYPICAL FIRST YEAR CURRICULUM

(Calculus Ready)

### Fall

**CHEM 204** General Chemistry (5) ①  
**MATH 251** Calculus I (4)  
Electives (6) ③

### Winter

**CHEM 205** General Chemistry (5) ①  
**MATH 252** Calculus (4)  
Electives (6) ③

### Spring

**CHEM 206** General Chemistry (5)  
**MATH 253** Calculus (4) chem pathway only  
**CHEM 285** Chemical Safety (1)  
Electives (5-9) ③

### TYPICAL SECOND YEAR CURRICULUM

### Fall

**CHEM 334** Organic Chemistry I (4)  
**CHEM 401** Research (1)  
Electives (2-5) ③  
**chem pathway only**

**CS 161** Foundations of CS I (4)  
Math/Stat/Chem Options (4) ④

### biochem pathway only

**BIOL 211** Prin of Biology (5)

### Winter

**CHEM 335** Organic Chemistry II (4)  
**CHEM 338** Organic Chemistry I Lab (1)  
Electives (5-6) ③  
**Math/Stat/Chem Options** (4) ④ **chem pathway only**  
**BIOL 212** Prin of Biology (5) **biochem pathway only**

### Spring

**CHEM 336** Organic Chemistry III (4)  
**CHEM 339** Organic Chemistry II Laboratory (1)  
Electives (5-6) ③  
**Math/Stat/Chem Options** (4) ④ **chem pathway only**  
**BIOL 213** Prin of Biology (5) **biochem pathway only**

## TYPICAL THIRD YEAR CURRICULUM

### Fall

**PHYS 201** General Physics (4)  
**chem pathway only**  
**CHEM 320** Analytical Chemistry (3)  
**CHEM 321** Analytical Chemistry Lab (2)  
Electives (6) ③  
**biochem pathway only**  
**BIOL 341** Genetics (4)  
**CHEM 450** Structural Biochem (4)  
**CHEM 451** Biochem Lab (2)  
Electives (1) ③

### Winter

**PHYS 202** General Physics (4)  
**chem pathway only**  
**CHEM 421** Instrumental Analysis (3)  
**CHEM 422** Instrumental Analysis Lab (2)  
Electives (6) ③  
**biochem pathway only**  
**BIOL 342** Genetics (4)  
**CHEM 451** Metabolic Biochem (4)  
Electives (3) ③

### Spring

**PHYS 203** General Physics (4)  
**CHEM 340** Physical Chemistry (4)  
Electives (2-7) ③  
**chem pathway only**  
**CHEM 360** Environmental Chem (4) ⑤  
**CHEM 361** Environmental Chem Lab (1) ⑤

## TYPICAL FOURTH YEAR CURRICULUM

### Fall

**CHEM 407** Seminar (1)  
**chem pathway only**  
**Math/Stat/Chem Options** (5) ④  
Electives (9) ③  
**biochem pathway only**

**CHEM 320** Analytical Chemistry (3)  
**CHEM 321** Analytical Chemistry Lab (2)  
**BIOL 431** Cell Structure & Function (5)  
Electives (4) ③

#### Winter

**CHEM 407** Seminar (1)  
**chem pathway only**  
**CHEM 437** Organic NMR Spec (2) ⑤  
Electives (12) ③  
**biochem pathway only**  
**CHEM 421** Instrumental Analysis (3)  
**CHEM 422** Inst Anal Lab (2)  
Upper-Div **CHEM/BIOL** Options (5)  
Electives (4) ③

#### Spring

**CHEM 407** Seminar (1)  
**chem pathway only**  
**CHEM 411** Inorganic Chemistry (4) ⑤  
Electives (10) ③  
**biochem pathway only**  
Upper-Div **CHEM/BIOL** Options (4)  
Electives (10) ③

#### Note:

- ① Students not meeting admission requirements to CHEM 204, 205 should enroll in CHEM 101, 102.
- ② Students may need to enroll in lower level math sequence as determined by an EOU evaluation.
- ③ Selected to meet general education requirements.
- ④ Selected from 300 or 400 level physics, mathematics, statistics, or computer science to meet the chemistry program requirements.
- ⑤ Alternate year course

#### REQUIREMENTS FOR THE MINOR IN CHEMISTRY

- A minimum of 30 graded credits in chemistry  
REQUIRED:

**CHEM 206** General Chemistry (5)

Select 15 hours from the courses listed below:

**CHEM 204** General Chemistry (5)  
**CHEM 205** General Chemistry (5)  
**CHEM 285** Chemical Safety (1)  
**CHEM 320** Analytical Chemistry (3) (UWR)  
**CHEM 321** Analytical Chemistry Laboratory (2)  
**CHEM 334** Organic Chemistry I (4)  
**CHEM 335** Organic Chemistry II (4)  
**CHEM 336** Organic Chemistry III (4)  
**CHEM 338** Organic Chemistry I Laboratory (1)  
**CHEM 339** Organic Chemistry II Laboratory (1)  
**CHEM 340** Physical Chemistry (4)  
**CHEM 360** Environmental Chemistry (4)  
**CHEM 361** Environmental Chemistry Lab (1)  
**CHEM 411** Inorganic Chemistry (4)  
**CHEM 412** Inorganic Chemistry Lab (1)

**CHEM 421** Instrumental Analysis (3)  
**CHEM 422** Instrumental Analysis Laboratory (2)  
**CHEM 437** Organic NMR Spectroscopy (2)  
**CHEM 450** Structural Biochemistry (4)  
**CHEM 451** Metabolic Biochemistry (4)  
**CHEM 454** Biochemistry Laboratory (2)  
**CHEM 310/410** Selected Topics (1-5)

- At least 15 credit hours must be upper division courses.
- A minimum grade of "C-" required for each course with an average GPA of 2.00 or more for all courses counting toward the minor.
- A minimum of 10 hours counting toward the minor must be completed at Eastern Oregon University.

#### REQUIREMENTS FOR THE MINOR IN ENVIRONMENTAL CHEMISTRY

- A minimum of 30 graded credits in chemistry and biology as follows.

Required:

**CHEM 206** General Chemistry (5)  
**CHEM 320** Analytical Chemistry (3) (UWR)  
**CHEM 321** Analytical Chemistry Lab (2)  
**CHEM 360** Environmental Chemistry (4)  
**CHEM 361** Environmental Chemistry Lab (1)

Electives: Select 5 credit hours from the following courses:

**CHEM 204** General Chemistry (5)  
**CHEM 205** General Chemistry (5)  
**CHEM 285** Chemical Safety (1)  
**CHEM 421** Instrumental Analysis (3)\*\*  
**CHEM 422** Instrumental Analysis Laboratory (2)\*\*  
**BIOL 357** General Ecology (4)\*\*  
**BIOL 358** General Ecology Lab (1)\*\*

\*\*Lab course must be taken as well as the associated lecture courses to be counted as credits toward this minor.

- A minimum grade of "C-" required for each course with an average GPA of 2.00 or more for all courses counting toward the minor.
- A minimum of 10 hours counting toward the minor must be completed at Eastern Oregon University.

## CHEMISTRY COURSE DESCRIPTIONS

### **CHEM 101 - Intro to Chem\*SMI (Credits: 4)**

#### **Gen Ed Core-Natural, Math & Info Sciences**

Service and general education course covering basic principles of general chemistry. Designed for students without previous chemistry experience. Lab required. Prerequisite: MATH 095 (or equivalent, may be taken concurrently).

### **CHEM 101L - Intro Chem Lab (Credits: 0)**

Must be taken concurrently with CHEM 101.

### **CHEM 102 - Intro to Chem\*SMI (Credits: 4)**

#### **Gen Ed Core-Natural, Math & Info Sciences**

Service and general education course covering basic principles of general chemistry and the elements of organic chemistry. Lab required. Prerequisite: CHEM 101 (or equivalent).

### **CHEM 102L - Intro Chem Lab (Credits: 0)**

Must be taken concurrently with CHEM 102.

### **CHEM 103 - Intro to Chem\*SMI (Credits: 4)**

#### **Gen Ed Core-Natural, Math & Info Sciences**

Service and general education course providing a survey of biochemistry. Lab required. Prerequisite: CHEM 102 (or equivalent).

### **CHEM 103L - Intro Chem Lab (Credits: 0)**

Must be taken concurrently with CHEM 103.

### **CHEM 110 - Selected Topics (Credits: 1 to 6)**

Topics designed to meet current needs of students. Specific titles to be selected by the chemistry staff. Prerequisite: None.

### **CHEM 204 - Gen Chemistry\*SMI (Credits: 5)**

#### **Gen Ed Core-Natural, Math & Info Sciences**

Principles of chemistry for chemistry/biochemistry majors and related fields: Topics covered include chemical periodicity, constructing and balancing chemical equations, stoichiometry, gas laws and the quantum structure of atoms. Lab required. Prerequisite: High school chemistry or consent of instructor. MATH 111 (may be taken concurrently) or equivalent.

### **CHEM 204L - Gen Chem Lab (Credits: 0)**

Must be taken concurrently with CHEM 204.

### **CHEM 205 - Gen Chemistry\*SMI (Credits: 5)**

#### **Gen Ed Core-Natural, Math & Info Sciences**

Principles of chemistry for chemistry/biochemistry majors and related fields: Topics covered include Lewis structures, VSEPR theory, thermochemistry, intermolecular forces, colligative properties, and chemical kinetics. Lab required. Prerequisite: CHEM 204 or consent of instructor. MATH 112 or equivalent recommended.

### **CHEM 205L - Gen Chem Lab (Credits: 0)**

Must be taken concurrently with CHEM 205.

### **CHEM 206 - General Chemistry\*SMI (Credits: 5)**

#### **Gen Ed Core-Natural, Math & Info Sciences**

Principles of chemistry for chemistry/biochemistry majors and related fields. Topics covered include chemical equilibria of inorganic systems, acids and bases, solubility, thermodynamics and electrochemistry. Lab required. Prerequisite: CHEM 205 or equivalent.

### **CHEM 206L - Gen Chemistry Lab (Credits: 0)**

Must be taken concurrently with CHEM 206.

### **CHEM 210 - Selected Topics (Credits: 1 to 6)**

Topics designed to meet current needs of students. Specific titles to be selected by the chemistry staff. Must have at least sophomore standing or consent of instructor.

### **CHEM 285 - Chemical Safety (Credits: 1)**

A course that emphasizes current, safe practices in the undergraduate chemical laboratory. Designed for students in chemistry and related fields. Provides training in the safe use and disposal methods for chemicals, for containers of chemicals, and in the handling of specialized equipment required for doing chemistry. A required course for our laboratory assistants. Prerequisite: None, but undergraduate experience in chemistry recommended.

### **CHEM 310 - Selected Topics (Credits: 1 to 6)**

Topics designed to meet current needs of students. Specific titles to be selected by the chemistry staff. Prerequisite: Junior standing or consent of instructor.

### **CHEM 320 - Analytical Chemistry (Credits: 3)**

#### **Institutional Graduation Requirement - UWR**

Fundamental principles of quantitative analysis with emphasis on volumetric and instrumental methods. Prerequisite: CHEM 206 or equivalent. Student must have at least sophomore standing to register for this course.

### **CHEM 321 - Analytical Chem Lab (Credits: 2)**

Quantitative analytical laboratory experiments with emphasis on volumetric analysis and the use of several instrumental methods. Prerequisite: CHEM 320 or concurrent. Student must have at least sophomore standing to register for this course.

### **CHEM 334 - Organic Chem I (Credits: 4)**

Introductory study of the molecular structure, chemical properties and reaction mechanisms of organic substances. Includes problems in organic synthesis. Prerequisite: CHEM 205 or equivalent. Student must have at least sophomore standing to register for this course.

### **CHEM 335 - Organic Chem II (Credits: 4)**

Studies of the molecular structure, chemical properties and reaction mechanisms of organic compounds. Includes problems in organic synthesis. Prerequisite: CHEM 334 or equivalent. Student must have at least sophomore standing to register for this course.

**CHEM 336 - Organic Chem III (Credits: 4)**

Studies of the molecular structure, chemical properties and reaction mechanisms of organic and biochemical substances. Prerequisite: CHEM 335 or equivalent. Student must have at least sophomore standing to register for this course.

**CHEM 338 - Organic Chem I Lab (Credits: 1)**

Selected techniques of organic analysis, separation and synthesis. Offers experience in performing organic reactions and in using instruments that pertain to organic compounds. Prerequisite: CHEM 334 or equivalent; Co-requisite: CHEM 335. Student must have at least sophomore standing to register for this course.

**CHEM 339 - Organic Chem II Lab (Credits: 1)**

Selected techniques of organic and biochemical analysis, separation and synthesis. Offers experience in performing organic and biochemical reactions and in using apparatuses and instruments that pertain to organic and biochemistry. Prerequisite: CHEM 335 and 338 or equivalent; Co-requisite: CHEM 336. Student must have at least sophomore standing to register for this course.

**CHEM 340 - Physical Chemistry (Credits: 4)**

Survey of physical chemistry including an overview of thermodynamics, chemical kinetics, quantum mechanics, and spectroscopy. Prerequisite: CHEM 206, MATH 252 or MATH 241, PHYS 201 and 202 or consent of instructor. Student must have at least sophomore standing to register for this course.

**CHEM 360 - Environmental Chemistry (Credits: 4)**

Introduction to environmental chemistry covering both fundamental chemical principles and societal implications. Emphasis will be placed on air chemistry and air pollution, chemistry of natural waters and water pollution, soils and sediments, and toxicity of organic and inorganic chemicals. Prerequisite: CHEM 206. Student must have at least sophomore standing to register for this course.

**CHEM 361 - Environmental Chem Lab (Credits: 1)**

Laboratory work will cover aspects of sampling, instrumental and automated analysis, and regulatory requirements. Prerequisite: CHEM 360 or concurrent.

**CHEM 401 - Research (Credits: 1 to 3)**

(Capstone) Individual research project selected with and supervised by a member of the chemistry faculty. Prerequisite: Consent of instructor. Student must have at least junior standing to register for this course.

**CHEM 405 - Reading & Conference (Credits: 1 to 6)**

Individual or small group study of a chemistry topic not included in the regular curriculum, supervised by a member of the chemistry faculty. Prerequisite: Consent of instructor. Student must have at least junior standing to register for this course.

**CHEM 407 - Seminar (Credits: 1)****Institutional Graduation Requirement - UWR**

(Capstone) During this three-term sequence student select and research topics in chemistry (fall term); prepare and peer-review a research paper (winter term); and deliver a 50 minute final, polished technical presentation on their topic. Must have at least senior standing or consent of instructor.

**CHEM 410 - Selected Topics (Credits: 1 to 6)**

Topics designed to meet current needs of students. Specific titles to be selected by the chemistry staff. Student must have at least junior standing to register for this course.

**CHEM 411 - Inorganic Chemistry (Credits: 4)**

Chemical bonding, symmetry, coordination chemistry, molecular orbitals, solid state and materials chemistry, descriptive chemistry of transition metals. Prerequisite: CHEM 206. Student must have at least junior standing to register for this course.

**CHEM 412 - Inorganic Chemistry Lab (Credits: 1)**

Survey of laboratory techniques to study inorganic molecules through synthesis, characterization, and model construction. Prerequisite: CHEM 206; Co-requisite: CHEM 411. Student must have at least junior standing to register for this course.

**CHEM 421 - Instrumental Analysis (Credits: 3)**

The theory and practice of analytical chemistry as applied to instrumental methods of analysis. Advantages and limitation of instrumental methods will be discussed. Prerequisite: CHEM 320, PHYS 203 recommended. Student must have at least junior standing to register for this course.

**CHEM 422 - Instrumental Analysis Lab (Credits: 2)**

Laboratory experiments focus on instrumental methods of analysis, optimization of instrumental parameters and data analysis. Prerequisite: CHEM 421 or concurrent. Student must have at least junior standing to register for this course.

**CHEM 437- Organic NMR Spectroscopy (Credits: 2)**

An advanced lecture and laboratory based course focused on the operation of NMR instrumentation and the interpretation of organic compound NMR spectroscopic results. Prerequisite: CHEM 336 and CHEM 339 or equivalent, or consent of instructor. Student must have at least junior standing to register for this course.

**CHEM 450 - Structural Biochemistry (Credits: 4)**

The structures and functions of the major classes of biologically important molecules, and the study of enzyme kinetics and catalysis. Prerequisite: CHEM 336 or equivalent, or consent of instructor. Student must have at least junior standing to register for this course.

**CHEM 451 - Metabolic Biochemistry (Credits: 4)**

Exploration of metabolic pathways in living organisms from a chemical perspective. Specific topics, discussed at the molecular level, are selected from, but not limited to the following: Anabolic and catabolic pathways, electron transport, proton pumping, ATP production and biosignaling. Prerequisite: CHEM 450 Structural Biochemistry. Student must have at least junior standing to register for this course.

**CHEM 454 - Biochemistry Lab (Credits: 2)**

Introduction of standard biochemical laboratory techniques and their application to solving biochemical and biochemically- related problems. Prerequisite: CHEM 336 or equivalent or consent of instructor. Student must have at least junior standing to register for this course.