

# CHEMISTRY and BIOCHEMISTRY

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The Chemistry and Biochemistry Program is approved by the Committee on Professional Training of the American Chemical Society. This approval means that the program has the faculty, curriculum and instrumentation necessary to provide a quality education for undergraduate students.

### Learning Outcomes for Chemistry and Biochemistry

Upon successful completion of the chemistry or biochemistry major, students will:

1. Understand the basic definitions, concepts and relationships of chemistry.
2. Develop advanced skills in evaluating library searches for primary and other literature.
3. Understand fundamental laboratory analyses and safety protocols.
4. Perform quantitative and qualitative scientific analyses.
5. Understand the basic theory of and use of modern instrumentation.
6. Use computers for chemical applications including technical writing, modeling, data collecting and processing, and database searching.
7. Prepare effective written scientific reports and oral presentations for professional audiences.
8. Work cooperatively in problem solving situations.
9. Understand the benefits and problems of modern chemistry for our society.

Recognizing the individuality of students and that chemistry can be a strong preparation for a variety of careers, the program offers two majors, chemistry and biochemistry, each with multiple emphases. Each of these majors offers courses in the basic areas of inorganic, organic, analytical, physical, and biochemistry, and can be supplemented by special opportunities such as industrial internships and independent research. Modern scientific instrumentation is available and incorporated into all courses of the curriculum. Students are encouraged to consult with chemistry and biochemistry faculty about the various emphases and opportunities associated with each.

### **Chemistry Major**

1. ACS-Approved Emphasis is especially suited for students planning on graduate work or desiring the best preparation for industrial employment.  
Upon completion of this emphasis, students will:
  - Develop an advanced understanding in multiple fields of chemistry.
  - Develop an independent research project, acquire and analyze data, and present the results at an off-campus professional meeting.
2. Forensic Science Emphasis is a multidisciplinary program designed to train students in the analysis of physical and chemical case evidence and the associated legal implications.  
Upon completion of this emphasis, students will:
  - Understand the basic definitions, concepts and relationships of criminalistics.
  - Understand intake, transport and biochemical processes of toxins in the human body.
  - Gain expertise in the collection and analysis of evidence specific to forensic science.
  - Develop an independent research project, acquire and analyze data, and present the results at Celebrate Carroll.
3. Pre-Health Science/Professional Emphasis is for those students who plan to pursue professional work in an allied health field such as medicine, dentistry, optometry, or veterinary science or pursue an industrial career.  
Upon completion of this emphasis, students will:
  - Develop an advanced understanding in a particular field of chemistry.
  - Be able to obtain work-related career experience in an industrial, corporate or medical setting.

### **Chemistry Major Bachelor of Science**

#### **Chemistry Major Core Courses**

Chemistry 109/109L, Principles of Chemistry I  
Chemistry 110/110L, Principles of Chemistry II  
Chemistry 201/201L, Analytical Chemistry  
Chemistry 203/203L, Organic Chemistry I  
Chemistry 204/204L, Organic Chemistry II  
Chemistry 303/303L, Quantum Mechanics and Spectroscopy  
Chemistry 308/308L, Biochemistry I  
Chemistry 401/401L, Advanced Chemical Analysis and Instrumentation  
Chemistry 402, Capstone: Modern Chemistry

#### **Required Support Courses:**

Computer Science 107 or higher  
Mathematics 160 and 161, Calculus  
Physics 203/203L and 204/204L, General Physics

#### **ACS-Approved Emphasis**

##### **Core Courses plus**

Chemistry 302/302L, Advanced Inorganic Chemistry  
Chemistry 304/304L, Thermodynamics and Kinetics

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To receive recognition of completion of this emphasis, students must earn a C or better in all chemistry major core courses and emphasis specific courses, and present results of a research project at a national chemistry meeting.

### Pre-Health Science Professional Emphasis

#### Core Courses plus

One chemistry courses numbered 300 or greater (4 credits)

### Forensic Science Emphasis

#### Core Courses plus

Biology 100/100L, Introductory Human Biology (Recommended) or  
any 100 level biology course

Chemistry 104/104L, Forensic Science

Sociology 103, Introduction to Criminal Justice

Sociology 303, Criminal Procedure, Evidence and Investigation

### Forensic Science Professional Emphasis

#### Core Courses plus

Biology 120, General Biology I

Biology 131, Human Genetics

Chemistry 104/104L, Forensic Science

Chemistry 310/310L, Advanced Forensic Science

Sociology 103, Introduction to Criminal Justice

Sociology 303, Criminal Procedure, Evidence and Investigation

Choose three from the following:

Chemistry 302, Advanced Inorganic Chemistry

Chemistry 304, Thermodynamics and Kinetics

Chemistry 306, Synthesis and Structure

Chemistry 309, Biochemistry II

Chemistry 480, Internship in Chemistry

Graphic Communication 230, Digital Photography

Mathematics 112, Introduction to Statistics

Sociology 212, Criminology

Sociology 304, Introduction to Criminal Law

### Chemistry Minor<sup>1</sup>

#### Courses in the Minor

Chemistry 109/109L, Principles Chemistry I

Chemistry 110/110L, Principles Chemistry II

Chemistry 201/201L, Analytical Chemistry

Chemistry 203/203L, Organic Chemistry I

Chemistry 308/308L, Biochemistry I

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<sup>1</sup> Satisfies secondary teaching education minor for Department of Public Instruction.

### **Biochemistry Major**

1. ACS-Approved Emphasis is designed to prepare students for graduate school in chemistry or biochemistry, medical school, or employment in biomedical sciences.  
Upon completion of this emphasis, students will:
  - Develop an advanced understanding in multiple fields of chemistry and biological chemistry.
  - Develop an independent research project, acquire and analyze data, and present the results at an off-campus professional meeting.
2. Pre-Health Science / Professional Emphasis provides a mixture of chemistry and biology courses and is designed for students who are interested in biology but want to solidify their understanding of the molecular view of it. Graduates will be prepared for professional school, graduate school, medical school or employment in biological and biomedical sciences.  
Upon completion of this emphasis, students will:
  - Develop an advanced understanding in a particular field of biological chemistry.
  - Develop an advanced understanding of medical biology.
3. Pre-Pharmacy Emphasis is a 3+1 program designed to prepare students for direct admission to a pharmacy program. While this emphasis contains courses required for admission to most Pharmacy Programs in the US during the student's first three years, a matriculation agreement with Rosalind Franklin University of Medicine and Science (RFUMS) allows students who are admitted to RFUMS to transfer first year coursework completed at RFUMS back to Carroll and receive a Bachelor of Science in biochemistry with Pre-Pharmacy Emphasis from Carroll University. Students not attending RFUMS may add a fourth year at Carroll to complete a chemistry degree.

### **Biochemistry Major Bachelor of Science**

#### **Biochemistry Major Core Courses**

Biology 120/120L, General Biology I  
Biology 125/125L, General Biology II  
Chemistry 109/109L, Principles of Chemistry I  
Chemistry 110/110L, Principles of Chemistry II  
Chemistry 203/203L, Organic Chemistry I  
Chemistry 204/204L, Organic Chemistry II  
Chemistry 308/308L, Biochemistry I  
Chemistry 309, Biochemistry II

#### **Required Support Courses**

Computer Science 107 or higher  
Mathematics 160 and 161 Calculus  
Physics 203 and 204 General Physics

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## ACS-Approved Emphasis

### Core Courses plus

Biology 220/220L, Genetics  
Biology 332/332L, Gene Manipulation and Genomics or  
Biology 452/452L, Advanced Cell Biology  
Chemistry 201/201L, Analytical Chemistry  
Chemistry 302/302L, Advanced Inorganic Chemistry  
Chemistry 303/303L, Quantum Mechanics and Spectroscopy  
Chemistry 304/304L, Thermodynamics and Kinetics  
Chemistry 401/401L, Advanced Chemical Analysis and Instrumentation  
Chemistry 402, Capstone: Modern Chemistry

To receive recognition of completion of this emphasis, students must earn a C or better in all biochemistry major core courses and emphasis specific courses, and present results of a research project at a national chemistry meeting.

## Pre-Health Science / Professional Emphasis

### Core Courses plus

Biology 220/220L, Genetics  
Biology 452/452L, Advanced Cell Biology  
Chemistry 201/201L, Analytical Chemistry  
Chemistry 401/401L, Advanced Chemical Analysis and Instrumentation  
Chemistry 402, Capstone: Modern Chemistry or  
Chemistry 480, Internship in Chemistry (4 credits)

Choose one course from the following:

Biology 225/225L, Organismal Physiology  
Biology 271/271L, Clinical Immunology  
Biology 312/312L, Microbiology  
Biology 332/332L, Gene Manipulation and Genomics  
Biology 350, Endocrinology

## Pre-Pharmacy Emphasis

### Core Courses plus

Biology 402, Human Anatomy or  
Biology 130, Introduction to Human Anatomy and Physiology I and  
Biology 140, Introduction to Human Anatomy and Physiology II  
Economics 124, Principles of Economics I – Microeconomics  
History 103, Roots of the Western World or  
History 104, Europe and the Modern World  
Psychology 101, Introductory Psychology  
RFUMS YPHS504, Biochemical Principles for Pharmacy  
RFUMS PBBS 505A, Microbiology and Immunology

**Biochemistry Minor**

Biology 130/130L and Biology 140/140L, Human Anatomy and Physiology I & II or  
Biology 120/120L and Biology 125/125L, General Biology I and II  
Chemistry 109/109L, Principles of Chemistry I  
Chemistry 110/110L, Principles of Chemistry II  
Chemistry 203/230L, Organic Chemistry I  
Chemistry 308/308L, Biochemistry I

**Fees**

Specific courses that require use of equipment and disposable supplies are assigned a fee.

**098. Introduction to Chemistry****No credit**

A course designed to provide students with an introduction to the fundamental mathematics and chemistry necessary for CHE 101 or CHE 109. This is an appropriate starting point for students who need a review of high school chemistry. (*Su*)

**101. General Chemistry<sup>1</sup> and****4 credits****101L. General Chemistry Laboratory**

A health science oriented survey course that introduces the basic concepts of inorganic and organic chemistry. Specific topics include: atomic theory, nuclear chemistry, compounds, chemical reactions, energy and organic functional groups. CHE 101 and 101L must be taken simultaneously. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa, Sp*) Prerequisite: CHE 098 or demonstrated proficiency in high school chemistry and algebra.

**102. Biological Chemistry<sup>1</sup> and****4 credits****102L. Biological Chemistry Laboratory**

A survey of organic chemistry and biochemistry that considers the structure and function of biomolecules (carbohydrates, lipids, proteins and nucleic acids) and their metabolism. CHE 102 and 102L must be taken simultaneously. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Sp, Su*) Prerequisite: CHE 101/101L with a grade of C or better.

**104. Forensic Science****NI****4 credits****104L. Forensic Science Laboratory**

A course that focuses on the application of scientific principles to the analysis of forensic data. The analysis and interpretation of physical, chemical, and biological tests is discussed utilizing a firm grounding in basic science. The laboratory utilizes simulated crime data and includes both basic and instrumental analyses. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Sp*)

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<sup>1</sup> Both Chemistry 101 and 102 are survey courses, which cover a wide range of topics but lack the depth of the more traditional chemistry courses; therefore, they do not count toward the major or minor in chemistry.

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- 106. Drug Discovery** NI 4 credits  
**106L. Drug Discovery Laboratory**  
A general survey of drug design and development of pharmaceuticals. This course examines the methods used in drug discovery. Topics include: the role of the FDA, clinical trials, drug action, and the pharmaceutical industry. Various sources of new drugs will be explored and several case studies will be discussed. Laboratory work will introduce students to methods and instrumentation used to develop new drugs. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa*)
- 109. Principles of Chemistry I** 4 credits  
**109L. Principles of Inorganic Chemistry Laboratory**  
An introduction to the basic concepts of modern inorganic chemistry. The topics in this course include units and measurements, stoichiometry, behavior of gases, liquids, and solids, atomic structure, the periodic table, chemical bonding and kinetics. CHE 109 and 109L must be taken concurrently. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa, Su*)
- 110. Principles of Chemistry II** 4 credits  
**110L. Principles of Chemistry II Laboratory**  
A continuing discussion of modern chemistry with a focus on quantitative analysis of chemical problems. Topics include thermodynamics, equilibrium, acid-base theory, and oxidation-reduction reactions. Modern instrumentation is utilized in the laboratory. CHE 110 and 110L must be taken concurrently. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Sp, Su*) Prerequisite: CHE 109/109L.
- 201. Analytical Chemistry** 4 credits  
**201L. Analytical Chemistry Laboratory**  
This course introduces students to the theory and practice of chemical analysis. The principles of titrimetric, spectroscopic, chromatographic and electrochemical methods are examined in terms of chemical equilibrium theory. Topics discussed include ionic equilibrium, gravimetric analysis, solubility/precipitation, acid-base titrations, complexation, potentiometry, UV-visible and atomic absorption spectrophotometry, and gas and liquid chromatography. Laboratory experiments are designed to illustrate the chemical principles discussed in class and to provide hands-on experience with modern analytical methods and instrumentation. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa*) Prerequisite: CHE 110/110L.
- 203. Organic Chemistry I** 4 credits  
**203L. Organic Chemistry I Laboratory**  
An introduction to the study of carbon and its compounds. Emphasis is placed on the simpler aliphatic and aromatic compounds, and functional groups. The course examines the underlying chemical principles and the mechanistic nature of organic reactions. Associated laboratory work is devoted to chemical and physical properties, as well as synthetic techniques. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa, Su*) Prerequisite: CHE 110/110L.

**204. Organic Chemistry II****4 credits****204L. Organic Chemistry II Laboratory**

A continuation of Chemistry 203. Major emphasis is placed upon carbonyl chemistry. The use of spectroscopic techniques is explored. The latter part of the course is devoted to the study of carbonyl compounds and modern synthetic strategies. Laboratory work consists of synthetic techniques, chromatography, and structural analysis. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Sp, Su*) Prerequisite: CHE 203/203L.

**208. Nutrition****3 credits**

This course investigates the biochemistry of food, that is, the chemical structures and functions of the six classes of nutrients: carbohydrates, lipids, proteins, vitamins, minerals, and water. The study of these nutrients will be extended to human physiological requirements, energy balance, food sources and labeling, and deficiency symptoms. Students will be expected to apply their nutrition knowledge to their own lives (or a patient's life) to assess dietary adequacy and compatibility with optimal health. Three hours of lecture/discussion. (*Fa, Sp*) Prerequisite: CHE 102/102L and BIO 140/140L.

**302. Advanced Inorganic Chemistry****4 credits****302L. Advanced Inorganic Chemistry Laboratory**

This course emphasizes structure, bonding, reactivity, and periodicity of inorganic compounds. The laboratory includes the preparation of metal and non-metal compounds and their characterization by chemical and physical methods. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Sp, odd years*) Prerequisite: CHE 204/204L, and 303/203L or 304/304L.

**303. Quantum Mechanics and Spectroscopy****4 credits****303L. Quantum Mechanics and Spectroscopy Laboratory**

Thorough introduction to the principles of physical chemistry providing the theoretical basis of reaction dynamics, quantum chemistry, and atomic and molecular spectroscopy. Laboratory experiments incorporate modern instrumental design and data analysis. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Sp*) Prerequisite: MAT 160, PHY 204/204L and CHE 110/110L.

**304. Thermodynamics and Kinetics****4 credits****304L. Thermodynamics and Kinetics Laboratory**

Study of reaction kinetics and the thermodynamic treatment of equilibrium in chemical systems. Topics include kinetic theory of gases, classical and statistical thermodynamics, phase equilibria, reaction rates and mechanisms. The laboratory relies on original student experimental design and data analysis of physical measurements that yield quantitative results of chemical interest. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa, even years*) Prerequisite: MAT 161, PHY 204/204L and CHE 110/110L.

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### 306. Synthesis and Structure

4 credits

The course will consider advanced topics in organic chemistry including selected topics from advanced spectroscopy, reaction mechanisms, synthetic methodology and photochemistry. Emphasis will be on reading, understanding, and orally presenting articles from the original literature. Four hours of lecture/discussion. (*Fa, odd years*)  
Prerequisite: CHE 204/204L.

### 308. Biochemistry I

4 credits

#### 308L. Biochemistry Laboratory

The course investigates the properties of buffers and the related chemistry of amino acids, the structure and function of proteins including an intensive look at hemoglobin, and the structure of lipids and carbohydrates. The course also focuses on the kinetics, thermodynamics, and mechanisms of enzymatic reactions, the structure of nucleic acids, and the regulation of nucleotide biosynthesis. The laboratory serves to strengthen the understanding of these topics and includes the purification and/or characterization of several classes of biomolecules. Four hours of lecture/discussion and one three-hour laboratory. (Required course fee) (*Fa*) Prerequisite: CHE 203/203L.

### 309. Biochemistry II

4 credits

The course focuses on the investigation of basic topics in metabolism, including bioenergetics, carbohydrate metabolism, and lipid metabolism. Additional topics include the biosynthesis of amino acids, nucleotides, and heme. Four hours of lecture/discussion. (*Sp*) Prerequisites: CHE 204/204L and 308/308L.

### 310. Advanced Forensic Science

4 credits

#### 310L. Advanced Forensic Science Laboratory

An advanced course in forensic science designed for, but not limited to, those hoping to pursue careers in criminalistics. Some of the topics will have been addressed in the survey class CHE104 but will now be discussed in greater detail. There will be an emphasis placed on the use of primary literature. (Required course fee) (*Fa, even years*)  
Prerequisites: CHE 104/104L and CHE 204/204L.

### 390. Projects in Chemistry

1-4 credits

Students work on a project under the direction of a faculty member. It is highly advisable for every student to participate in research projects during their educational experience. Course credit is assigned on the basis of one credit per 40 hours of laboratory work. (Required course fee) (*Fa, Sp*) Prerequisite: Approval of the program chair and the consent of the instructor.

### 391. Special Topics in Modern Chemistry

#### 401. Advanced Chemical Analysis and Instrumentation

4 credits

#### 401L. Advanced Chemical Analysis and Instrumentation Laboratory

This course will complete the student's introduction to modern chemical analysis and instrumentation. The theory and applications of chromatography and separation science will be emphasized, to include gas and liquid chromatographic instrumentation.

The laboratory focuses on configuring, operating, and maintaining instruments while conducting quantitative and qualitative analyses. The course will also serve to initiate student research projects that are completed and presented in CHE 402. The course meets for two 3-hour periods per week. (Required course fee) (*Sp*) Prerequisites: CHE 201/201L and CHE 308/308L.

**402. Capstone: Modern Chemistry****4 credits**

This capstone course will involve the implementation and completion of a research project proposed and approved in CHE 401. The research project will involve the development of an experimental plan, the use of integrative laboratory analysis using a wide range of equipment and instrumentation, the collection, analysis, and interpretation of data, and the presentation of results in written and oral formats. The course will also formally review current trends in chemical research and the future of the chemical enterprise. The course meets for two 3-hour periods per week. (Required course fee) (*Fa*) Prerequisite: CHE 401 or consent of instructor.

**480. Internship in Chemistry****1-4 credits**

A cooperative arrangement with industries or governmental organizations that provides students with “real world” experiences in chemistry. The student must spend time at the company working on a specific project. The student must also be involved in answering some educational questions regarding industrial chemistry. This experience is strongly recommended for students who will be seeking an industrial position after graduation. Plans should be discussed with the instructor during the junior year. (*Fa, Sp, Su*) Prerequisite: Senior standing and consent of the instructor.