

# CHEMISTRY

The Wabash College Chemistry Department believes in a challenging curriculum, which thoroughly investigates all areas of modern chemistry, and in a significant hands-on laboratory experience in which students become progressively more independent as they proceed through the curriculum. We believe that such an education prepares chemistry majors for a variety of career outcomes, including those in research, medicine, teaching, and industry. In recent years, three-fourths of our majors have gone to graduate school in chemistry/biochemistry or to medical school following graduation. Others have chosen to take jobs as chemists or high school teachers or to attend other professional schools (business, law, and physical therapy). We strive to provide chemistry minors and pre-medical students with the knowledge base they need to succeed in their chosen fields. We seek to involve all Wabash students in the study of chemistry through non-majors courses such as CHE-101 Survey of Chemistry and CHE-106 Survey of Biochemistry. We attempt to teach all chemistry students about the relationship between chemistry and the world around them.

## Faculty Advisors

Majors are strongly urged to select an advisor from the Chemistry Department when they declare their major.

## ACS Certified Degree

To meet the certification requirements formulated by the American Chemical Society Committee on Professional Training (CPT) as a chemist and for adequate preparation for graduate school, additional classroom and laboratory work beyond the minimum nine-course major is required. The student should consult with the Chair of the Chemistry Department concerning ways in which the remaining requirements may be fulfilled.

## Advanced Placement

Please refer to the Credit by Examination and Advanced Placement Credit guidelines under Academic Policies - Transfer Credit. Potential chemistry majors and minors who wish to claim advanced placement credit should discuss placement options with the Department Chair. A placement examination will determine if students are eligible to being coursework beyond CHE-111 General Chemistry.

## Student Learning Goals

Students will acquire a broad-based knowledge of general, organic, physical, analytical, inorganic, and biochemistry, and understand how these areas are interconnected.

Students will be able to connect theory with experimental work, including being able to design, execute, and analyze experiments, and to present their results effectively. Students will develop confidence and precision in their laboratory technique.

Students will have the ability to identify, comprehend, evaluate, and discuss primary, secondary, and general chemical literature.

Students will be able to effectively communicate chemical concepts to chemists, scientists, and the general public.

Students will develop as scientists through research, internships, and in-depth course experiences.

Students will engage the chemical and biochemical communities at Wabash and beyond, fostering an inclusive and welcoming environment.

## Requirements for the Chemistry Major

Code	Title	Credits
<b>Core</b>		<b>7.5</b>
CHE-111	General Chemistry	
CHE-241	Inorganic Chemistry	
CHE-221	Organic Chemistry I	
CHE-321	Organic Chemistry II	
CHE-331	Analytical Chemistry	
CHE-351	Physical Chemistry	
CHE-361	Biochemistry	
CHE-491	Integrative Chemistry	

### Electives 1.5

Select 1.5 credits from the following:

CHE-421	Advanced Organic Chemistry <sup>1</sup>	
CHE-431	Advanced Analytical Chemistry	
CHE-441	Advanced Inorganic Chemistry <sup>1</sup>	
CHE-451	Advanced Physical Chemistry	
CHE-461	Advanced Biochemistry <sup>1</sup>	
CHE-462	Biochemistry II	
CHE-471	Advanced Topics in Chemistry <sup>1</sup>	
CHE-487	Independent Study <sup>2</sup>	
CHE-488	Undergraduate Research Methods <sup>2</sup>	

**Total Credits** **9**

### Collateral Requirements Credits

MAT-111	Calculus I	1
MAT-112	Calculus II	1
PHY-111	Physics I - Calculus	1
	or PHY-109 Physics I - Algebra	
	Select one course from the following: PHY-110, PHY-112, CSC-111, MAT-223	1

**Total Credits** **4**

<sup>1</sup> May be repeated when the topics change

<sup>2</sup> No more than one-half course credit of independent study may be used to construct the minimum nine-course major.

CHE-101 Survey of Chemistry, CHE-102 Topics in Chemistry, and CHE-106 Survey of Biochemistry do not count toward the major or minor.

**The mathematics courses are best taken in the freshman year (e.g. MAT-100 and MAT-111 or MAT-111 Calculus I and MAT-112 Calculus II), and the physics sequence are best taken in the sophomore year.** Chemistry majors who intend to pursue a graduate degree are **strongly encouraged** to take the collateral requirements: PHY-111 and PHY-112.

## Suggested order of courses for the chemistry major

Course	Title	Credits
<b>Freshman</b>		
<b>Fall Semester</b>		
CHE-111	General Chemistry	1
MAT-111	Calculus I	1
<b>Credits</b>		<b>2</b>

**Spring Semester**

CHE-241	Inorganic Chemistry	1
MAT-112	Calculus II	1
<b>Credits</b>		<b>2</b>

**Sophomore**

Complete collateral requirement when offered: PHY-110, PHY-112, CSC-111, or MAT-223		1
<b>Credits</b>		<b>1</b>

**Fall Semester**

CHE-221	Organic Chemistry I	1
PHY-111	Physics I - Calculus or PHY-109 or Physics I - Algebra	1

We recommend that students pursuing a graduate degree take PHY-111 this semester.

<b>Credits</b>		<b>2</b>
----------------	--	----------

**Spring Semester**

CHE-321	Organic Chemistry II	1
We recommend that students pursuing a graduate degree take PHY-112 this semester.		

<b>Credits</b>		<b>1</b>
----------------	--	----------

**Junior****Fall Semester**

CHE-351	Physical Chemistry	1
<b>Credits</b>		<b>1</b>

**Spring Semester**

CHE-331	Analytical Chemistry	1
CHE-361	Biochemistry	1

<b>Credits</b>		<b>2</b>
----------------	--	----------

**Senior**

Plus 1.5 additional elective credits taken in the junior or senior year		1.5
---	--	-----

<b>Credits</b>		<b>1.5</b>
----------------	--	------------

**Fall Semester**

CHE-491	Integrative Chemistry	0.5
---------	-----------------------	-----

<b>Credits</b>		<b>0.5</b>
----------------	--	------------

<b>Total Credits</b>		<b>13</b>
----------------------	--	-----------

**Strongly Recommended Supporting Coursework**

Code	Title	Credits
BIO-111	General Biology I	1
BIO-112	General Biology II	1
CSC-111	Intro to Programming	1
More Mathematics, particularly:		
MAT-223	Linear Algebra	1
MAT-224	Differential Equations	1
MAT-225	Multivariable Calculus	1
More Physics, particularly:		
PHY-210	Intro Quantum Theory & Apps	1
PHY-310	Classical Mechanics	1
<b>Total Credits</b>		<b>8</b>

Chemistry majors who wish to transfer chemistry credits from another institution as part of their major must have prior approval of the Department Chair to do so.

**Comprehensive Exams**

The written comprehensive examination for senior majors emphasizes both knowledge of basic chemical concepts and the ability to apply these concepts to new problems. The exam includes written questions over material from the seven core chemistry courses, a laboratory practical, and a primary literature component. Students that fail to complete their seven core chemistry courses by the time of the written examination must petition the Department Chair for a special exam no later than the fall prior to their comprehensive examination.

**Requirements for the Chemistry Minor**

The following courses are required for the chemistry minor:

Code	Title	Credits
CHE-111	General Chemistry	1
CHE-241	Inorganic Chemistry	1
CHE-221	Organic Chemistry I	1
Select one course from the following:		1
CHE-321	Organic Chemistry II	
CHE-331	Analytical Chemistry	
CHE-351	Physical Chemistry	
CHE-361	Biochemistry	
Select one other course credit from the departmental offerings numbered above CHE-221		1
<b>Total Credits</b>		<b>5</b>

No more than one-half course credit of independent study (CHE-487 Independent Study, CHE-488 Undergraduate Research Methods) may be used to construct the minimum five-course minor. Chemistry minors who wish to transfer a chemistry course credit from another institution as part of their minor must have prior approval of the Department Chair to do so; no more than one course credit of transfer credit from another institution may count as part of their minor.

Students who major in Biochemistry are not permitted to minor in Chemistry.

**CHE-101 Survey of Chemistry**

A survey course designed for non-science concentrators, which considers the historical and philosophical developments in chemistry, as well as the application of chemical principles to physical phenomena and social issues. Topics include the development of the atomic theory of matter, atomic structure, chemical bonding, thermodynamics, the chemistry of life (organic and biochemistry), and nuclear energy. Some elementary mathematics will be used. Three lectures and one laboratory each week. Partially fulfills the College laboratory science requirement, but cannot be combined with CHE-111 to complete the laboratory science requirement. This course does not satisfy requirements for the chemistry major or minor. Only CHE-101 or CHE-111, not both, may be counted toward the total number of credits required for graduation.

**Prerequisites:** none

**Corequisites:** CHE-101L

**Credit:** 1

**Distribution:** Science Lab, Quantitative Literacy

**CHE-102 Topics in Chemistry**

An introductory survey course for non-science concentrators that explores chemical principles via a unifying theme. Topics will vary with each scheduled offering. Although presented in the context of a focused application, common fundamentals covered include the scientific method of inquiry, quantitative measurement and calculations, structure and reactivity, applications of chemical principles, and presenting and evaluating scientific evidence. Some elementary mathematics will be used. Class meetings are complemented by a required laboratory activity each week. Partially fulfills the College laboratory science requirement, but cannot be combined with CHE-101 or CHE-111 to complete this distribution requirement. This course does not satisfy major or minor requirements for chemistry or those for the biochemistry major. Only one course from CHE-101, CHE-102, or CHE-111 may be counted toward the total number of credits required for graduation.

**Prerequisites:** none

**Corequisites:** CHE-102L

**Credit:** 1

**Distribution:** Quantitative Literacy, Science Lab

**CHE-106 Survey of Biochemistry**

Foods, medical treatments, and biotechnological applications are important aspects of daily life, both for the individual and society as a whole. This course will focus on the biochemistry of the fundamental building blocks of life: proteins, carbohydrates, lipids, and nucleic acids. It will include a broad overview of general and organic chemistry in the context of biomolecules. Emphases will include structure-function relationships, energy, human health, and societal issues. This course applies toward the lab science requirement, but does not count towards the chemistry, biochemistry, or biology majors or minors.

**Prerequisites:** none

**Corequisites:** CHE-106L

**Credit:** 1

**Distribution:** Science Lab

**CHE-111 General Chemistry**

This is the introductory course for science concentrators. Topics include atomic theory, stoichiometry, thermo chemistry, equilibrium, gas laws, states of matter, solutions, atomic structure, and acid/base chemistry. The laboratory, which emphasizes the basic principles discussed in lecture, includes significant synthetic and analytical work. Three lectures and one laboratory each week. This course is offered in the fall semester.

**Prerequisites:** none

**Corequisites:** CHE-111L

**Credit:** 1

**Distribution:** Science Lab, Quantitative Literacy

**CHE-171 Special Topics**

Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.

**Prerequisites:** none

**Credits:** 0.5

**CHE-201 Survey of Chemistry II**

Enrollment in this course is reserved solely for those students who took and passed CHE 101 and desire to prepare for further study in chemistry, such as organic chemistry. Topics include chemical bonding, thermodynamics and kinetics, chemical equilibrium, and electrochemistry. The laboratory will feature experiments and activities that reinforce and expand upon the fundamental principles explored in lecture. Three lectures and one laboratory each week. Partially fulfills the College laboratory science requirement. This course is offered in the spring semester.

**Prerequisites:** CHE-101 and permission of instructor

**Corequisites:** CHE-201L

**Credit:** 1

**CHE-221 Organic Chemistry I**

A study of the structure and reactions of simple organic compounds. Included as topics are molecular conformations, stereochemistry, and a discussion of some types of modern spectroscopic techniques. The laboratory work emphasizes techniques frequently used by the organic chemist, including distillation, crystallization, sublimation, chromatography, and spectroscopy. Three lectures and one laboratory each week. This course is offered in the fall semester.

**Prerequisites:** CHE-111

**Corequisites:** CHE-221L

**Credit:** 1

**Distribution:** Science Lab

**CHE-241 Inorganic Chemistry**

A study of the bonding and reaction chemistry of transition metal species, main group compounds, and solid state materials. Topics include coordination compounds, organometallic complexes, reaction kinetics and thermodynamics, molecular orbital theory, and a discussion of modern characterization techniques. Investigative work in the laboratory will feature a multi-week project involving the synthesis and characterization of a coordination compound, as well as experiments in descriptive inorganic chemistry, catalysis, and nanoscale structures. Three lectures and one laboratory each week. This course is offered in the spring semester.

**Prerequisites:** CHE-111

**Corequisites:** CHE-241L

**Credit:** 1

**Distribution:** Science Lab, Quantitative Literacy

**CHE-302 Electron Microscopy**

Electron microscopes employ a focused beam of highly energetic electrons to examine sample morphology and topography on a very fine scale. This information is essential to the characterization of a wide range of biological and inorganic specimens including microorganisms, cells, crystals, metals, microelectronics, and nanomaterials. The initial classroom portion of this course focuses on fundamental topics in instrument design, applications, limitations, and sample preparation methods. Subsequent laboratory work involves hands-on instrument training and a substantial microscopy project.

**Prerequisites:** none

**Credits:** 0.5

**Equated Courses:** PHY-302

**CHE-321 Organic Chemistry II**

Characteristic reactions and syntheses of organic molecules will be covered in this course. Spectroscopic techniques not covered in CHE 221 will also be surveyed. Emphasis is placed on the utility of organic chemistry in today's world; class discussions and laboratory work will present many biologically interesting illustrations. Also included is an introduction to the use of the chemical literature. Three lectures and one laboratory each week. This course is offered in the spring semester.

**Prerequisites:** CHE-221

**Corequisites:** CHE-321L

**Credit:** 1

**CHE-331 Analytical Chemistry**

An integrated survey of the application of instrumental methods (spectroscopy, mass spectrometry, chromatography) and modern data analysis methods to the analysis of chemical systems. Electronics and statistical methods of data analysis are also covered. The laboratory emphasizes basic analytical technique, instrument design and function, chemical characterization and separation, and data analysis. Three lectures and one laboratory each week. This course is offered in the spring semester.

**Prerequisites:** CHE-241

**Corequisites:** CHE-331L

**Credit:** 1

**CHE-351 Physical Chemistry**

An introduction to quantum mechanics through the study of exactly soluble models of chemical significance is followed by a statistical mechanical development of chemical thermodynamics. Topics include the postulates of quantum mechanics, the Schrodinger equation, the Heisenberg uncertainty principle, equations of state, partition functions, laws of thermodynamics, and the thermodynamics of ideal and non-ideal solutions. The laboratory applies concepts studied in lecture and emphasizes laboratory report writing skills. Three lectures and one laboratory each week. This course is offered in the fall semester.

**Prerequisites:** CHE-241 and MAT-112 (must be completed prior to taking this course).

**Corequisites:** CHE-351L (must be taken at the same time as this course)

**Credit:** 1

**CHE-361 Biochemistry**

Basic chemical concepts such as intermolecular forces, equilibria, energetics, and reaction mechanisms will be used to study biological systems. The class will be divided into three major foci: biomolecular structures, metabolism, and information transfer. The laboratory will familiarize students with common biochemical techniques and will integrate current areas of biochemical research. Three lectures and one laboratory each week. This course is offered in the spring semester.

**Prerequisites:** CHE-211, CHE-241, or CHE-321, or permission of instructor

**Corequisites:** CHE-361L

**Credit:** 1

**Distribution:** Science Lab, Quantitative Literacy

**CHE-371 Advanced Chemical Instrumentation**

Developments in modern instrumentation enable advanced exploration into fundamental and applied research in chemistry. This course engages students with an in-depth and hands-on approach to a major instrument associated with one of the traditional subdisciplines of chemistry. The classroom portion of this course focuses on fundamental topics specific to instrument design, applications, limitations, and sample preparation methods. Subsequent laboratory work involves hands-on instrumentation and a substantial independent project. Topics vary from year to year and are announced prior to registration for each semester. Refer to Student Planning for topics and descriptions of current offerings.

**Prerequisites:** CHE-331 (must be completed prior to taking this course)

**Credits:** 0.5-1

**CHE-388 Special Problems**

The content for this course varies from semester to semester. It may be repeated for credit upon the instructor's approval. Topics vary with each scheduled offering. Refer to Student Planning's section information for descriptions of individual offerings, and applicability to distribution requirements.

**Prerequisites:** none

**Credits:** 0.5-1

**CHE-421 Advanced Organic Chemistry**

Topics covered vary from year to year. Examples of recent topics include advanced synthesis, medicinal chemistry, and the chemistry of dyes. Refer to Student Planning for topics and descriptions of current offerings. This course is offered either in the fall or spring semester.

**Prerequisites:** CHE-321

**Credits:** 0.5

**CHE-431 Advanced Analytical Chemistry**

A laboratory-based, research-focused exploration of advanced topics in instrument design, function, and data analysis. Experiments dealing with basic analog and digital electronics will stress measurement techniques and data acquisition figures of merit. The use of computers and programming will be considered, with emphasis on data collection (interfacing) and manipulation. These topics will be integrated into discussion and experiments dealing with instrumental analysis. Individual research projects will involve the construction/characterization of instruments and techniques. This course is offered on an occasional basis.

**Prerequisites:** CHE-331

**Credits:** 0.5

**CHE-441 Advanced Inorganic Chemistry**

An advanced study of inorganic chemistry topics beyond those explored in CHE-241, including group theory, molecular spectroscopy, and advanced concepts in organometallics, catalysis, and nanomaterials. This course is important for students interested in attending graduate school in chemistry or materials engineering.

**Prerequisites:** CHE-241

**Credits:** 0.5

**CHE-451 Advanced Physical Chemistry**

This course offers further study of special topics in physical chemistry beyond the topics covered in CHE-351. Examples of recent topics include time-dependent quantum mechanics and laser-based spectroscopies. This course is typically offered in the spring semester.

**Prerequisites:** CHE-351 (must be completed prior to taking this course)

**Credits:** 0.5

**CHE-461 Advanced Biochemistry**

Topics vary from year to year. Examples of recent topics include the chemistry of cancer, determining structures of biomolecules, the RNA world, fermentation and brewing, and the mechanisms of enzyme action. Refer to Student Planning and the Course Descriptions document on the Registrar's webpage for topics and descriptions of current offerings.

**Prerequisites:** CHE-361

**Credits:** 0.5

**CHE-462 Biochemistry II**

This capstone course for the biochemistry major will use primary literature to examine DNA replication, transcription, and translation on a molecular level, and will include a primary literature research project. This course is offered in the fall semester.

**Prerequisites:** CHE-361

**Credits:** 0.5

**CHE-471 Advanced Topics in Chemistry**

This in-depth experience builds technical expertise, provides a more sophisticated view of chemical concepts, fosters critical thinking, promotes skill development, and gives the student an opportunity for the intellectual growth and rigorous thinking that comes from engaging in topics at a high level. An in-depth study of topics selected from the areas of analytical, physical, inorganic, organic, and biochemistry. Focused study of modern research areas of current interest for advanced students; topics vary from year to year and are announced prior to registration for each semester. Refer to Student Planning for topics and descriptions of current offerings.

**Prerequisites:** CHE-241 (must be completed prior to taking this course)

**Credits:** 0.5-1

**CHE-487 Independent Study**

Individual library, coding, or fabrication projects under the supervision of faculty on selected problems for qualified students. Independent projects related to this course do not typically involve significant laboratory research activities. Enrolled students are committed to a minimum 60 hours of work related to their project (0.5 credit earned via ~4 hours a week) and will produce a final report documenting their accomplishments. Topics vary and are determined in collaboration with a faculty member in the chemistry department prior to registration. Instructor permission is required for enrollment.

**Prerequisites:** none

**Credits:** 0.5-1

**CHE-488 Undergraduate Research Methods**

Individual laboratory research projects under the supervision of individual faculty on selected problems for qualified students. Projects in this course involve significant laboratory work and are intended to provide opportunities for students to become involved in ongoing research projects with chemistry faculty. Enrolled students are committed to a minimum 60 hours of laboratory work (0.5 credit earned via ~4 hours a week) and will produce a final research report documenting their accomplishments. Topics vary and are determined in collaboration with a faculty member in the chemistry department prior to registration. Instructor permission is required for enrollment.

**Prerequisites:** none

**Credits:** 0.5-1

**CHE-491 Integrative Chemistry**

The study of chemistry builds upon a progressive investigation of the field's traditional subdisciplines. While a strong preparation in these areas is established through rigorous foundation level coursework, many of the most significant and innovative topics in modern research emerge through meaningful integration of several subdisciplines. This half-semester course focuses on an advanced research field that challenges students to apply knowledge from a combination of foundational courses within the major. While topics may vary each offering, critical engagement with the primary literature, small-group discussion, guided inquiry, and diverse modes of oral and written presentation will be emphasized. This course is required of all majors and is offered during the first half of the fall semester. Instructor permission is required for enrollment.

**Prerequisites:** none

**Credits:** 0.5

## Chemistry Faculty

Scott E Feller

Annah E Kalb

Lynn Krushinski

Walter Ray Pendola Novak

Lon A Porter (chair)

Joseph David Scanlon

Ann Theresa Taylor

Laura Wysocki, *Sabbatical*