Chemistry and Biochemistry

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The Department of Chemistry and Biochemistry offers bachelor of arts and bachelor of science degrees with majors in chemistry or biochemistry. The department enjoys a strong national reputation.

The curriculum in chemistry provides broad knowledge of the field as a part of the liberal education offered by the College of Arts and Sciences. Chemistry course work is a sound foundation for students interested in advanced work in chemistry or related sciences, particularly such fields as biochemistry, geochemistry, materials science, and molecular biology.

Faculty

Shannon W. Boettcher, associate professor (inorganic, materials science). BA, 2003, Oregon; PhD, 2008, California, Santa Barbara. (2010)

Jeffrey A. Cina, professor (physical). BS, 1979, Wisconsin, Madison; PhD, 1985, California, Berkeley. (1995)

Victoria J. De Rose, professor (bioinorganic). BA, 1983, Chicago; PhD, 1990, California, Berkeley. (2006)

Kenneth M. Doxsee, professor (organic, materials science). BS, 1978, MS, 1979, Stanford; PhD, 1983, California Institute of Technology. (1989)

Deborah B. Exton, senior instructor. BS, 1987, Metropolitan State College of Denver; PhD, 1992, Denver. (1993)

Marina G. Guenza, professor (physical). Laurea, 1985, Università degli Studi di Genova; PhD, 1989, degree granted by consortium of universities of Torino, Genova, and Pavia. (1998)

Julie A. Haack, senior instructor. BS, 1986, Oregon; PhD, 1991, Utah. (2000)

Michael M. Haley, Richard M. and Patricia H. Noyes Professor in Chemistry (organic, materials science). BA, 1987, PhD, 1991, Rice. (1993)

Diane K. Hawley, professor (biochemistry). BA, 1976, Kansas; PhD, 1982, Harvard. (1986)

James E. Hutchison, Lokey-Harrington Chair in the Department of Chemistry; professor (organic, materials science). BS, 1986, Oregon; PhD, 1991, Stanford. (1994)

Darren W. Johnson, professor (organic). BS, 1996, Texas, Austin; PhD, 2000, California, Berkeley. (2003)

David C. Johnson, Rosaria P. Haugland Foundation Chair in Pure and Applied Chemistry; professor (inorganic, materials science). BA, 1978, Rutgers; MS, 1980, PhD, 1983, Cornell. (1986)

Michael E. Kellman, professor (physical). BS, 1971, California, Berkeley; PhD, 1977, Chicago. (1989)

Michael Koscho, instructor (organic). BS, 1993, Purdue; PhD, 1999, Illinois, Urbana-Champaign. (2006)

Mark Lonergan, professor (physical, materials science); director, Materials Science Institute. BS, 1990, Oregon; PhD, 1994, Northwestern. (1996)

Andrew H. Marcus, professor (physical, materials science). BA, 1987, California, San Diego; PhD, 1993, Stanford. (1996)

George V. Nazin, assistant professor (physical). MS, 1999, Moscow Institute of Physics and Technology; PhD, 2007, California, Irvine. (2010)

Brad J. Nolen, associate professor (biochemistry). BA, 1997, Missouri State; PhD, 2003, California, San Diego. (2008)

Catherine J. Page, associate professor (inorganic, materials science). BA, 1980, Oberlin; PhD, 1984, Cornell. (1986)

Michael D. Pluth, associate professor (organic). BS, 2004, Oregon; PhD, 2008, California, Berkeley. (2011)

Kenneth E. Prehoda, professor (biochemistry). BA, 1991, California State, Sacramento; PhD, 1997, Wisconsin, Madison. (2001)

James Prell, assistant professor (physical). BA, 2005, Washington (St. Louis); PhD, 2011, California, Berkeley. (2014)

Geraldine L. Richmond, professor (physical, materials science); presidential chair. BS, 1975, Kansas State; PhD, 1980, California, Berkeley. (1985)

Tom H. Stevens, Philip H. Knight Professor (biochemistry). BA, 1974, MS, 1976, San Francisco State; PhD, 1980, California Institute of Technology. (1982)

David R. "Randy" Sullivan, senior instructor. BS, 1982, MS, 1989, North Texas. (2001)

David R. Tyler, Charles J. and M. Monteith Jacobs Professor in Chemistry (inorganic, materials science). BS, 1975, Purdue; PhD, 1979, California Institute of Technology. (1985)

Gregory M. Williams, senior professor. BS, 1977, California, Los Angeles; PhD, 1981, Princeton. (2001)

Cathy Wong, assistant professor (physical). BSc, 2004, McMaster; PhD, 2011, Toronto. (2015)

Special Staff

John Hardwick, courtesy senior instructor and senior research associate (molecular physics). AB, 1966, Princeton; PhD, 1972, Georgia Institute of Technology. (1985)

Emeriti

Ralph J. Barnhard, senior instructor emeritus. BS, 1959, Otterbein; MS, 1965, Oregon. (1966)

Bruce P. Branchaud, professor emeritus. BS, 1976, Massachusetts; MA, 1981, Dartmouth; PhD, 1981, Harvard. (1983)

Frederick W. Dahlquist, professor emeritus. BA, 1964, Wabash; PhD, 1969, California Institute of Technology. (1971)

Thomas R. Dyke, professor emeritus. BA, 1966, Wooster; PhD, 1972, Harvard. (1974)

O. Hayes Griffith, professor emeritus. AB, 1960, California, Riverside; PhD, 1964, California Institute of Technology. (1965)

David R. Herrick, professor emeritus. BS, 1969, Rochester; MS, 1971, PhD, 1973, Yale. (1975)

John F. W. Keana, professor emeritus. BA, 1961, Kalamazoo; PhD, 1965, Stanford. (1965)

James W. Long, senior instructor emeritus. BS, 1965, Washington (Seattle); PhD, 1969, California, Berkeley. (1978)

Robert M. Mazo, professor emeritus. AB, 1952, Harvard; MS, 1953, PhD, 1955, Yale. (1962)

Peter H. von Hippel, professor emeritus. BS, 1952, MS, 1953, PhD, 1955, Massachusetts Institute of Technology. (1967)

The date in parentheses at the end of each entry is the first year on the University of Oregon faculty.

- **Bachelor of Arts in Chemistry**
- **Bachelor of Arts in Biochemistry**
- **Bachelor of Science in Chemistry**
- **Bachelor of Science in Biochemistry**
- **Chemistry Minor**
- **Biochemistry Minor**

Undergraduate Studies

One strength of the program is the opportunity undergraduates have to participate in the activities of a dynamic research group that considers problems extending well beyond textbook instruction. Major and nonmajor students alike can enjoy this experience of scientific inquiry. One to two years of preparatory course work typically precede the research experience. The department enrolls twenty to thirty undergraduate students each term in CH 401 Research: [Topic].

Preparation

The high school preparation of a prospective chemistry major should include chemistry, physics, and a minimum of three years of mathematics. Those interested in biochemistry would also profit from biology courses in high school.

Two-year college students planning to transfer to the university to major in chemistry should prepare by taking courses equivalent to those outlined for the freshman and sophomore years.

The department offers two general-chemistry sequences, both of which lead to organic chemistry, the second-year sequence in chemistry.

General Chemistry Sequence Options		
CH 221–223	General Chemistry	12
CH 224H–226H	Honors General Chemistry	12

Each sequence covers the fundamentals of chemistry but uses a different approach and a textbook tailored to suit a student's background in high school chemistry and mathematics.

Careers

Career opportunities for chemists are available in education, government, and industry (see the annual October issue of *Chemical and Engineering News*). A bachelor's degree in chemistry provides a good background for advanced study in such fields as

- atmospheric science
- biochemistry
- biology
- environmental sciences
- forensic science
- geochemistry
- geological sciences
- pharmacy
- pharmacology
- physiology
- materials science
- medicine
- medicinal chemistry
- metallurgy
- molecular biology
- neuroscience
- oceanography

Chemists also find jobs in science writing, public relations, personnel, plant production, sales, management, safety management, market research, patent law, and financial analysis. The alumni newsletter, *Chemistry News*, has examples of careers UO majors have chosen. Follow the links on the department's website.

Chemistry Major

The program described below is the recommended curriculum for chemistry majors. It includes courses in chemistry and related fields. Courses taken to satisfy major requirements must be passed with grades of C– or better. Variations in courses and order may be worked out in consultation with an advisor. Advisors can also provide lists of substitute courses and courses that are recommended but not required.

Students are encouraged to participate in CH 401 Research: [Topic].

Bachelor of Arts Degree Requirements in Chemistry

Code	Title	Credits
CH 224H–226H	Honors General Chemistry	12
or CH 221–223	General Chemistry	
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 337	Organic Chemistry Laboratory	3
CH 348–349	Organic Chemistry Lab for Majors	8
CH 411–413	Physical Chemistry	12
CH 417–419	Physical Chemistry Laboratory	12

Advanced Electives (see Advanced Electives table)		9-12
CH 429	Instrumental Analysis	5
Total Credits		**79-82**

Related Science Requirements

Code	Title	Credits
MATH 251–253	Calculus I-III	12
MATH 256 & MATH 281	Introduction to Differential Equations and Several-Variable Calculus I	8
PHYS 251–253	Foundations of Physics I	12
or PHYS 201–203	General Physics	
PHYS 290	Foundations of Physics Laboratory (three terms)	3-6
or PHYS 204–206	Introductory Physics Laboratory	
Total Credits		**35-38**

Advanced Electives

Code	Title	Credits
Advanced electives (e.g., three courses or 9 credits of research or one course and 6 credits of research) chosen from the following: [1]		9-12
CH 401	Research: [Topic]	
CH 420	Physical Organic Chemistry I	
CH 421	Physical Organic Chemistry II	
CH 431	Inorganic Chemistry	
CH 432	Inorganic Chemistry	
CH 433	Inorganic Chemistry	
CH 441	Quantum Chemistry	
CH 442	Quantum Chemistry and Spectroscopy	
CH 443	Quantum Chemistry and Spectroscopy	
CH 444	Chemical Thermodynamics	
CH 445	Statistical Mechanics	
CH 446	Chemical Kinetics: [Topic]	
CH 447	Computational Chemistry	
CH 452	Advanced Organic Chemistry—Stereochemistry and Reactions	
CH 461	Biochemistry	
CH 462	Biochemistry	
CH 463	Biochemistry	
CH 464	RNA Biochemistry	
CH 465	Physical Biochemistry	
CH 467	Biochemistry Laboratory	
GEOL 471	Thermodynamic Geochemistry	
GEOL 472	Aqueous-Mineral-Gas Equilibria	
GEOL 473	Isotope Geochemistry	
PHYS 412–413	Mechanics, Electricity, and Magnetism	
PHYS 414–415	Quantum Physics	
Total Credits		**9-12**

[1] Other courses may be included with advisor approval.

Sample Program for Chemistry Majors

First Year		**Credits**
CH 224H–226H or 221-223	Honors General Chemistry	12
CH 227–229 or 237-239	General Chemistry Laboratory	6
MATH 251–253	Calculus I-III	12
Select one of the following:		8
WR 121 & WR 122	College Composition I	8
WR 121 & WR 123	College Composition I	8
Electives (general-education, group-satisfying courses)		8-12
	Credits	**46-50**
Second Year		
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 337	Organic Chemistry Laboratory	3
CH 348	Organic Chemistry Laboratory for Majors	4
CH 349	Organic Chemistry Lab for Majors	4
MATH 256	Introduction to Differential Equations	4
MATH 281	Several-Variable Calculus I	4
PHYS 251–253 or 201-203	Foundations of Physics I	12
PHYS 290 or 204-206	Foundations of Physics Laboratory	3-6
Electives (general-education, group-satisfying courses)		8-12
	Credits	**54-61**
Third Year		
Advanced electives (see above) and/or CH 401 Research: [Topic]		8-12
CH 411–413	Physical Chemistry	12
CH 417–419	Physical Chemistry Laboratory	12
Electives		8-12
	Credits	**40-48**
Fourth Year		
Advanced electives (see above) and/or CH 401 Research: [Topic]		8-12
CH 429	Instrumental Analysis	5

Electives		18
	Credits	**31-35**
	Total Credits	**171-194**

Bachelor of Science Degree Requirements in Chemistry

Code	Title	Credits
CH 224H–226H	Honors General Chemistry	12
or CH 221–223	General Chemistry	
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 337	Organic Chemistry Laboratory	3
CH 348–349	Organic Chemistry Lab for Majors	8
CH 411–413	Physical Chemistry	12
CH 417–419	Physical Chemistry Laboratory	12
Advanced Electives (see Advanced Electives table)		9-12
CH 429	Instrumental Analysis	5
Total Credits		**79-82**

Related Science Requirements

Code	Title	Credits
MATH 251–253	Calculus I-III	12
MATH 256 & MATH 281	Introduction to Differential Equations and Several-Variable Calculus I	8
PHYS 251–253	Foundations of Physics I	12
or PHYS 201–203	General Physics	
PHYS 290	Foundations of Physics Laboratory (three terms)	3-6
or PHYS 204–206	Introductory Physics Laboratory	
Total Credits		**35-38**

Advanced Electives

Code	Title	Credits
Advanced electives (e.g., three courses or 9 credits of research or one course and 6 credits of research) chosen from the following: [1]		9-12
CH 401	Research: [Topic]	
CH 420	Physical Organic Chemistry I	
CH 421	Physical Organic Chemistry II	
CH 431	Inorganic Chemistry	
CH 432	Inorganic Chemistry	
CH 433	Inorganic Chemistry	
CH 441	Quantum Chemistry	
CH 442	Quantum Chemistry and Spectroscopy	
CH 443	Quantum Chemistry and Spectroscopy	
CH 444	Chemical Thermodynamics	
CH 445	Statistical Mechanics	
CH 446	Chemical Kinetics: [Topic]	
CH 447	Computational Chemistry	
CH 452	Advanced Organic Chemistry—Stereochemistry and Reactions	
CH 461	Biochemistry	
CH 462	Biochemistry	
CH 463	Biochemistry	
CH 464	RNA Biochemistry	
CH 465	Physical Biochemistry	
CH 467	Biochemistry Laboratory	
GEOL 471	Thermodynamic Geochemistry	
GEOL 472	Aqueous-Mineral-Gas Equilibria	
GEOL 473	Isotope Geochemistry	
PHYS 412–413	Mechanics, Electricity, and Magnetism	
PHYS 414–415	Quantum Physics	
Total Credits		**9-12**

[1] Other courses may be included with advisor approval.

Sample Program for Chemistry Majors

First Year		Credits
CH 224H–226H or 221-223	Honors General Chemistry	12
CH 227–229 or 237-239	General Chemistry Laboratory	6
MATH 251–253	Calculus I-III	12
Select one of the following:		8
WR 121 & WR 122	College Composition I	8
WR 121 & WR 123	College Composition I	8
Electives (general-education, group-satisfying courses)		8-12
	Credits	**46-50**
Second Year		
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 337	Organic Chemistry Laboratory	3
CH 348	Organic Chemistry Laboratory for Majors	4
CH 349	Organic Chemistry Lab for Majors	4
MATH 256	Introduction to Differential Equations	4
MATH 281	Several-Variable Calculus I	4
PHYS 251–253 or 201-203	Foundations of Physics I	12
PHYS 290 or 204-206	Foundations of Physics Laboratory	3-6
Electives (general-education, group-satisfying courses)		8-12
	Credits	**54-61**

Third Year		
Advanced electives (see above) and/or CH 401 Research: [Topic]		8-12
CH 411–413	Physical Chemistry	12
CH 417–419	Physical Chemistry Laboratory	12
Electives		8-12
	Credits	**40-48**
Fourth Year		
Advanced electives (see above) and/or CH 401 Research: [Topic]		8-12
CH 429	Instrumental Analysis	5
Electives		18
	Credits	**31-35**
	Total Credits	**171-194**

Biochemistry Major

Many undergraduate students who are interested in advanced study using molecular approaches to biological problems (e.g., biochemistry, molecular biology, neurochemistry, physical biochemistry, or perhaps medical research) may want to include courses in biologically based subjects. For these students, the Department of Chemistry offers a biochemistry major.

Courses taken to satisfy major requirements must be passed with grades of C– or better. Variations in courses and order may be worked out in consultation with an advisor.

Students who plan to attend graduate school should include research in their advanced work. If chemical research is included as part of the advanced work, at least 6 credits of CH 401 Research: [Topic] must be completed. Students who plan to apply to medical schools should investigate the need for a physics laboratory course that is not included in this curriculum.

Bachelor of Arts Degree Requirements in Biochemistry

Code	Title	Credits
CH 224H–226H	Honors General Chemistry	12
or CH 221–223	General Chemistry	
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 337	Organic Chemistry Laboratory	3
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 348	Organic Chemistry Laboratory for Majors	4
CH 411–412	Physical Chemistry	8
CH 461–463	Biochemistry	12
CH 467	Biochemistry Laboratory	4
Total Credits		**61**

Related Science Requirements

Code	Title	Credits
MATH 251–253	Calculus I-III	12
PHYS 201–203	General Physics	12
or PHYS 251–253	Foundations of Physics I	
BI 281H–282H	Honors Biology I-II	10
BI 320	Molecular Genetics	4
Total Credits		**38**

Physical Laboratory Requirement

Code	Title	Credits
Select one of the following:		3-8
PHYS 204–206	Introductory Physics Laboratory	
PHYS 290	Foundations of Physics Laboratory (three terms)	
CH 417	Physical Chemistry Laboratory	
CH 418	Physical Chemistry Laboratory	
Total Credits		**3-8**

Advanced Laboratory Requirements

Code	Title	Credits
Select one of the following:		4-6
Any 400-level chemistry laboratory course		
CH 401	Research: [Topic] (three terms) [1]	
Total Credits		**4-6**

Advanced Electives

Code	Title	Credits
Five approved 400-level courses in chemistry, biology, and physics. Students may use one approved 300-level biology course (BI 321, 322, 328, or 360) as one of the five advanced electives. [2]		21-21
CH 413	Physical Chemistry	
CH 417	Physical Chemistry Laboratory	
CH 418	Physical Chemistry Laboratory	
CH 419	Physical Chemistry Laboratory	
CH 420	Physical Organic Chemistry I	
CH 421	Physical Organic Chemistry II	
CH 429	Instrumental Analysis	
CH 431	Inorganic Chemistry	
CH 432	Inorganic Chemistry	
CH 433	Inorganic Chemistry	
CH 441	Quantum Chemistry	
CH 442	Quantum Chemistry and Spectroscopy	
CH 443	Quantum Chemistry and Spectroscopy	
CH 444	Chemical Thermodynamics	
CH 445	Statistical Mechanics	
CH 446	Chemical Kinetics: [Topic]	
CH 447	Computational Chemistry	
CH 452	Advanced Organic Chemistry—Stereochemistry and Reactions	

CH 464	RNA Biochemistry	
CH 465	Physical Biochemistry	
BI 322	Cell Biology	
BI 328	Developmental Biology	
BI 360	Neurobiology	
BI 422	Protein Toxins in Cell Biology	
BI 423	Human Molecular Genetics	
BI 424	Advanced Molecular Genetics	
BI 426	Genetics of Cancer	
BI 428	Developmental Genetics	
BI 433	Bacterial-Host Interactions	
BI 461	Systems Neuroscience	
BI 463	Cellular Neuroscience	
BI 466	Developmental Neurobiology	
BI 480		
BI 484	Molecular Evolution	
BI 487	Molecular Phylogenetics	
BI 493	Genomic Approaches and Analysis	
Total Credits		**20-21**

1 Advisor approval and a written report are required for Research.

2 See advisor for complete list. Courses used to satisfy the physical and advanced laboratory requirements cannot also be used as an advanced elective.

Sample Program for Biochemistry Majors

First Year		**Credits**
CH 224H–226H or 221-223	Honors General Chemistry	12
CH 227–229 or 237-239	General Chemistry Laboratory	6
WR 121 & WR 123	College Composition I	8
MATH 251–253	Calculus I-III	12
Electives (general-education, group-satisfying courses)		8-12
	Credits	**46-50**
Second Year		
BI 281H–282H	Honors Biology I-II	10
BI 320	Molecular Genetics	4
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 337	Organic Chemistry Laboratory	3
CH 348	Organic Chemistry Laboratory for Majors	4
Electives (general-education, group-satisfying courses)		8-12
	Credits	**41-45**
Third Year		
CH 461–463	Biochemistry	12
CH 467	Biochemistry Laboratory	4
PHYS 201–203	General Physics	12
PHYS 204–206	Introductory Physics Laboratory	6
General-education electives and advanced chemistry-biology electives		8-12
	Credits	**42-46**
Fourth Year		
CH 411–412	Physical Chemistry	8
CH 401	Research: [Topic] (or advanced laboratory)	4-6
General-education electives and advanced chemistry-biology electives		21-28
	Credits	**32-42**
	Total Credits	**161-183**

Bachelor of Science Degree Requirements in Biochemistry

Code	Title	Credits
CH 224H–226H	Honors General Chemistry	12
or CH 221–223	General Chemistry	
CH 227–229	General Chemistry Laboratory	6
or CH 237–239	Advanced General Chemistry Laboratory	
CH 337	Organic Chemistry Laboratory	3
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 348	Organic Chemistry Laboratory for Majors	4
CH 411–412	Physical Chemistry	8
CH 461–463	Biochemistry	12
CH 467	Biochemistry Laboratory	4
Total Credits		**61**

Related Science Requirements

Code	Title	Credits
MATH 251–253	Calculus I-III	12
PHYS 201–203	General Physics	12
or PHYS 251–253	Foundations of Physics I	
BI 281H–282H	Honors Biology I-II	10
BI 320	Molecular Genetics	4
Total Credits		**38**

Physical Laboratory Requirement

Code	Title	Credits
Select one of the following:		3-8
PHYS 204–206	Introductory Physics Laboratory	
PHYS 290	Foundations of Physics Laboratory (three terms)	

CH 417	Physical Chemistry Laboratory	
CH 418	Physical Chemistry Laboratory	
Total Credits		**3-8**

Advanced Laboratory Requirements

Code	Title	Credits
Select one of the following:		4-6
Any 400-level chemistry laboratory course		
CH 401	Research: [Topic] (three terms) [1]	
Total Credits		**4-6**

Advanced Electives

Code	Title	Credits
Five approved 400-level courses in chemistry, biology, and physics. Students may use one approved 300-level biology course (BI 321, 322, 328, or 360) as one of the five advanced electives. [2]		21-21
CH 413	Physical Chemistry	
CH 417	Physical Chemistry Laboratory	
CH 418	Physical Chemistry Laboratory	
CH 419	Physical Chemistry Laboratory	
CH 420	Physical Organic Chemistry I	
CH 421	Physical Organic Chemistry II	
CH 429	Instrumental Analysis	
CH 431	Inorganic Chemistry	
CH 432	Inorganic Chemistry	
CH 433	Inorganic Chemistry	
CH 441	Quantum Chemistry	
CH 442	Quantum Chemistry and Spectroscopy	
CH 443	Quantum Chemistry and Spectroscopy	
CH 444	Chemical Thermodynamics	
CH 445	Statistical Mechanics	
CH 446	Chemical Kinetics: [Topic]	
CH 447	Computational Chemistry	
CH 452	Advanced Organic Chemistry—Stereochemistry and Reactions	
CH 464	RNA Biochemistry	
CH 465	Physical Biochemistry	
BI 322	Cell Biology	
BI 328	Developmental Biology	
BI 360	Neurobiology	
BI 422	Protein Toxins in Cell Biology	
BI 423	Human Molecular Genetics	
BI 424	Advanced Molecular Genetics	
BI 426	Genetics of Cancer	
BI 428	Developmental Genetics	
BI 433	Bacterial-Host Interactions	
BI 461	Systems Neuroscience	
BI 463	Cellular Neuroscience	
BI 466	Developmental Neurobiology	
BI 480		
BI 484	Molecular Evolution	
BI 487	Molecular Phylogenetics	
BI 493	Genomic Approaches and Analysis	
Total Credits		**20-21**

[1] Advisor approval and a written report are required for Research.

[2] See advisor for complete list. Courses used to satisfy the physical and advanced laboratory requirements cannot also be used as an advanced elective.

Sample Program for Biochemistry Majors

First Year		Credits
CH 224H–226H or 221-223	Honors General Chemistry	12
CH 227–229 or 237-239	General Chemistry Laboratory	6
WR 121 & WR 123	College Composition I	8
MATH 251–253	Calculus I-III	12
Electives (general-education, group-satisfying courses)		8-12
	Credits	**46-50**
Second Year		
BI 281H–282H	Honors Biology I-II	10
BI 320	Molecular Genetics	4
CH 341–343	Majors Track Organic Chemistry I-III	12
CH 337	Organic Chemistry Laboratory	3
CH 348	Organic Chemistry Laboratory for Majors	4
Electives (general-education, group-satisfying courses)		8-12
	Credits	**41-45**
Third Year		
CH 461–463	Biochemistry	12
CH 467	Biochemistry Laboratory	4
PHYS 201–203	General Physics	12
PHYS 204–206	Introductory Physics Laboratory	6
General-education electives and advanced chemistry-biology electives		8-12
	Credits	**42-46**
Fourth Year		
CH 411–412	Physical Chemistry	8
CH 401	Research: [Topic] (or advanced laboratory)	4-6

General-education electives and advanced chemistry-biology electives		21-28
	Credits	**32-42**
	Total Credits	**161-183**

Honors Program

The criteria used for the selection of students who graduate with departmental honors in chemistry or biochemistry are as follows:

1. Grade point average (GPA) of at least 3.50 in all graded courses
2. Suitable accomplishment in undergraduate chemical or related research. Specifically, the student must pursue a research problem for one academic year or longer and be recommended as worthy of honors by the faculty supervisor. Positive accomplishment and publishable results are expected but not required
3. Endorsement for a major with honors by a member of the university faculty
4. Completion of all course requirements for the BS degree in chemistry. Waivers or substitutions allowed with the chemistry faculty's approval

Chemistry Minor

A minor in chemistry may be designed from course work in general chemistry, including the laboratory sequence, and at least four additional upper-division courses. University requirements for the minor include a total of 24 credits in chemistry, 15 of which must be in upper-division courses and 12 of which must be completed at the University of Oregon. All courses for the minor must be completed with grades of C– or better. Credits earned in CH 407 Seminar: [Topic], CH 405 Reading and Conference: [Topic], and CH 409 Special Laboratory Problems may not be applied as required course work for the minor.

Biochemistry Minor

Lower Division		
General chemistry sequence		12
General chemistry laboratories		6
Upper Division		
CH 331 & CH 335	Organic Chemistry I and Organic Chemistry II	8
CH 461 & CH 462	Biochemistry and Biochemistry	8
CH 463 or CH 467	Biochemistry Biochemistry Laboratory	4
Total Credits		**38**

Other courses may be submitted for consideration and approval by the department. At least 12 credits for the biochemistry minor must be completed at the University of Oregon. All courses applied to the minor must be completed with grades of C– or better. Credits earned in CH 407 Seminar: [Topic], CH 405 Reading and Conference: [Topic], and CH 409 Special Laboratory Problems may not be applied to required course work for the biochemistry minor.

Academic Minors for Chemistry Majors

A carefully chosen minor can complement and enhance undergraduate study in chemistry. Following is a selection of academic minors that chemistry majors might want to consider:

- biology
- business administration
- computer and information science
- economics
- environmental studies
- geological sciences
- human physiology
- mathematics
- physics

Kindergarten through Secondary Teaching Careers

Students who complete the BA or BS degree with a major in chemistry or biochemistry are eligible to apply for the College of Education's fifth-year licensure program in middle-secondary teaching or the fifth-year licensure program to become an elementary teacher. More information is available from the department's K–12 education advisors, Catherine Page and Julie Haack; see also the **College of Education** section of this catalog.

Graduate Studies

Graduate work in chemistry is a research-oriented PhD program with options in

- biochemistry and molecular biology
- biophysics
- bioorganic and medicinal chemistry
- environmental chemistry
- inorganic and organometallic chemistry
- materials chemistry
- optics and spectroscopy
- organic synthesis
- polymer chemistry
- physical chemistry
- solid-state chemistry
- statistical mechanics of liquids and complex fluids
- surfaces and interfaces
- theoretical chemical physics

Master of science (MS) and master of arts (MA) degrees are also offered.

A strength of the University of Oregon program is its interdisciplinary approach to research and teaching. Many important advances in chemistry occur at the junctions of classically defined divisions of science. Collaborative interaction between these divisions is fostered through interdisciplinary research institutes. Chemical scientists may be interested in the Institute of Molecular Biology, the Institute of Theoretical Science, the Materials Science Institute, the Oregon Center for Optics, and the programs in cell biology and in molecular synthesis, structure, and dynamics.

First-year students are offered financial assistance through graduate teaching fellowships (GTFs). Research assistantships are typically

available for students with advanced standing. These research appointments are funded through grants to the university by federal agencies and private (industrial) sources for support of the basic research programs in the department. Students are selected for these positions based on their interest in a particular research area and by mutual agreement of the student and the faculty member directing the work.

An illustrated publication, *University of Oregon Doctoral Program in Chemistry*, may be requested from the department. The booklet presents information about the program, facilities, financial support, faculty members and their individual research interests, housing, and the local environment. People who request the booklet also receive information about admission and application forms for admission and graduate teaching fellowships.

Biochemistry, Molecular Biology, Cell Biology

One of the most active areas of research is the study of the molecular bases of cell function, including synthesis of macromolecules, regulation of gene expression, development, cell movement, and the structure and function of biological membranes. Research in these areas has been fostered by close collaboration among biologists, chemists, and physicists. The interdisciplinary nature of these programs has been greatly strengthened by the Institute of Molecular Biology and the program in cell biology. Eight members of the chemistry department are affiliated with these programs. Entering graduate students are in an excellent position to take advantage of the molecular-oriented avenues to study biological problems.

Biophysical Chemistry

Biophysical chemistry provides close collaboration and educational interaction among faculty members and students. Research groups that are developing and applying physical methods work closely with molecular and cellular biologists, neurobiologists, biochemists, and synthetic organic chemists. Most of the research programs in biophysical chemistry are interdisciplinary.

Another area of general interest is the nature of the excited electronic states of biopolymer components. This includes the use of the optical properties of biopolymers, such as their circular dichroism, as a probe of their conformational state; the relationship of excited state conformation changes to their resonance Raman spectra; and a fundamental interest in the nature of excited states.

Materials Science

The discipline of materials science seeks to understand the structures, properties, and structure-property relationships of condensed phase materials. It is by nature interdisciplinary, combining expertise from the fields of chemistry, physics, geology, and molecular biology. Most areas of chemistry can make an important contribution to materials science in the synthesis and characterization of various materials. Here the word materials generally means bulk crystalline solids but also includes low-dimensional materials such as thin solid films or nanoscopic "wires" as well as amorphous solids and some aspects of liquids. Much of the excitement of the research in this area derives from the discovery and the improved understanding of new materials that have potential technological applications.

The Materials Science Institute was created to foster collaboration among the materials-oriented research groups at the University of Oregon. Members of the institute are active in the study of the structure, reactivity, and thermodynamics of materials in addition to the characterization of their electronic, magnetic, and optical properties. The chemistry and physics departments, dominant members of the institute, offer courses and seminars on the chemistry and physics of materials to foster the educational and research aspects of materials science. The list of active research topics includes the application of novel synthetic strategies toward the preparation of metastable phases (including the use of thin-film superlattice composites, sol-gel synthesis, self-assembly, and electron beam lithography), ultra-high vacuum surface science, laser-induced dynamics at surfaces, nonlinear optics of interfaces, characterization of electronic materials and devices, studies on the properties of amorphous and glassy materials, quantum size effects and fundamental limits of microelectronic devices, scanning force and scanning tunneling microscopy of modified surfaces and biological molecules, and electron transport across protein assemblies and biotechnological materials. Sharing of facilities and expertise among the various research groups is an important and valued aspect of the Materials Science Institute. Collaboration between institute members and industrial and national research laboratories is also an important dimension of the program. See also Materials Science Institute in the **Research Institutes and Centers** section of this catalog.

Organic, Bioorganic, Inorganic, Organometallic, and Materials Chemistry

The synthesis of new chemical substances and the study of their fundamental chemical and physical properties is at the heart of organic, bioorganic, organometallic, inorganic, and materials chemistry. Research and teaching in these traditionally distinct subareas is unified through a single, cohesive organic-inorganic area in the chemistry department.

Undergraduate students, graduate students, and postdoctoral researchers in organic-inorganic chemistry enjoy an especially broad education emphasizing the fundamental aspects of chemical synthesis, structural characterization, and mechanisms of chemical reactions and processes. Formal course work is organized around these interdisciplinary themes. Many research projects are interdisciplinary.

Weekly organic-inorganic seminars cover recent advances in organic, organometallic, inorganic, and materials research. Of foremost importance is the contiguous location of research laboratories. This proximity results in an open and active atmosphere that encourages spontaneous discussions of day-to-day research activities and problems, providing a chemical education unsurpassed by any textbook or formal course.

Organic-inorganic researchers have direct access to state-of-the-art instrumentation in the shared organic-inorganic instrumentation facility adjoining the research laboratories. Most faculty members in this area have varied research interests and expertise. Collaboration with researchers working in physics, materials science, biochemistry, and medicinal chemistry enhances the program.

Physical Chemistry

Physical chemistry focuses on understanding the physical basis of chemical phenomena. This goal is pursued through the concerted efforts of experimentalists and theorists. While experimentalists design and carry out laboratory investigations of chemical systems, theorists conceive and develop theoretical tools to explain and predict system properties. Ultimately, physical chemistry is about understanding the mysteries of chemical phenomena at a deep, fundamental level. The discipline

draws from and contributes to many areas of chemistry, physics, biology, materials science, engineering, and mathematics.

At the University of Oregon, research in physical chemistry focuses on a variety of topics.

Experimental spectroscopy includes pulsed laser techniques to probe the molecular structure at wet interfaces; the development of new optical techniques to study the motions of intracellular species and macromolecules in liquids; and novel ultrafast, nonlinear spectroscopic methods to study the dynamics of excited states in molecules.

On the theoretical front, topics of interest include dynamics of highly excited molecules using quantum and semiclassical techniques, the development of a formal description of wave-packet interferometry, elucidation of molecular structure through theoretical studies of electronic potential energy surfaces, and theoretical statistical mechanics and simulation.

Much work at Oregon combines frontier experimental and theoretical approaches in tandem on particular topics. Theoretical and experimental studies in statistical mechanics concentrate on soft condensed matter and complex fluids. Another focus is quantum control using coherent and ultrafast laser pulses, pursued along both experimental and theoretical lines.

The physics of chemical systems at interfaces includes spectroscopic studies of organic, inorganic, and biomolecules at surfaces and interfaces as well as electrochemical and electrical investigations of charge transfer at molecular or nanoparticle-based semiconducting interfaces.

The research on semiconductor interfaces aims at identifying and controlling novel systems that enhance or mimic the behavior of conventional semiconductor interfaces.

Industrial Internships for Master’s Degrees in Chemistry

These internships, sponsored by the Materials Science Institute, are described in the Research Centers and Institutes (http://catalog.uoregon.edu/archive/2016-2017/research) section of this catalog. Information and application materials are available through the institute.

Courses

CH 111. Introduction to Chemical Principles. 4 Credits.
Chemical concepts for students in health care, biological applications, and environmental studies. Topics include atomic structure, solutions, acids, bases, stoichiometry, equilibrium, biomolecules, and organic functional groups. Lecture, demonstration.
Prereq: MATH 095.

CH 113. The Chemistry of Sustainability. 4 Credits.
Illustrates how chemistry provides innovative materials, processes, and consumer products that support sustainable solutions related to energy utilization, global warming and pollution prevention.
Prereq: Math 095 or higher; high school chemistry.

CH 114. Green Product Design. 4 Credits.
Illustrates how green chemistry, product design, advertising, and sustainable business practices are used to design greener consumer products and accelerate their adoption in the market.

CH 157M. Information, Quantum Mechanics, and DNA. 4 Credits.
A non-science major's introduction to the physical and chemical concepts explaining how information is stored in and transmitted by physical objects and molecules, including DNA. Multilisted with PHYS 157M.

CH 196. Field Studies: [Topic]. 1-2 Credits.
Repeatable.

CH 198. Workshop: [Topic]. 1-2 Credits.
Repeatable.

CH 199. Special Studies: [Topic]. 1-5 Credits.
Repeatable.

CH 221. General Chemistry I. 4 Credits.
First term of the three-term university chemistry sequence: components of matter, quantitative relationships, atomic structure, thermochemistry, and major classes of chemical reactionsof the elements. Lectures. Students cannot receive credit for both CH 221 and CH 224H.
Prereq: high school chemistry; pre- or coreq: MATH 111. Concurrent CH 227 or 237 recommended.

CH 222. General Chemistry II. 4 Credits.
Second term of the three-term university chemistry sequence: molecular structure, chemical bonding, gases and kinetic molecular theory, intermolecular forces, solutions and kinetics.Lectures. Students cannot receive credit for both CH 222 and CH 225H.
Prereq: CH 221 or CH 224H; pre- or coreq: MATH 112. Concurrent CH 228 or CH 238 recommended.

CH 223. General Chemistry III. 4 Credits.
Third term of the three-term university chemistry sequence: thermodynamics, equilibrium, electrochemistry, nuclear chemistry. Lectures. Students cannot receive credit for both CH 223 and CH 226H.
Prereq: CH 222 or CH 225H and MATH 112. Concurrent CH 229 or CH 239 recommended.

CH 224H. Honors General Chemistry. 4 Credits.
First-year university chemistry for students with excellent backgrounds in high school chemistry, physics, and mathematics. Chemical structure, reactions, stoichiometry, thermochemistry, and an introduction to quantum chemistry. Students cannot receive credit for both CH 221 and CH 224H.
Prereq: high school chemistry; MATH 112 or equivalent; pre- or coreq: MATH 241 or 246 or 251 or 261. Concurrent CH 237 recommended.

CH 225H. Honors General Chemistry. 4 Credits.
First-year university chemistry for students with excellent backgrounds in high school chemistry, physics, and mathematics. Chemical bonding, states of matter, solutions, kinetics, and nuclear chemistry. Students cannot receive credit for both CH 222 and CH 225H.
Prereq: CH 221 or 224H; pre- or coreq: MATH 242 or 247 or 252 or 262. Concurrent CH 238 recommended.

CH 226H. Honors General Chemistry. 4 Credits.
First-year university chemistry for students with excellent backgrounds in high school chemistry, physics, and mathematics. Chemical equilibrium, acid-base chemistry, thermodynamics, and electrochemistry. Students cannot receive credit for both CH 223 and CH 226H.
Prereq: CH 222 or 225H; pre- or coreq: MATH 243 or 247 or 253 or 263. Concurrent CH 239 recommended.

CH 227. General Chemistry Laboratory. 2 Credits.
First term of the three-term laboratory sequence: basic laboratory skills, quantitative relationships, qualitative analysis, calorimetry.
Pre- or coreq: CH 221 or 224H; MATH 111.

CH 228. General Chemistry Laboratory. 2 Credits.
Second term of the three-term laboratory sequence: graphical analysis, spectroscopy, spectrophotometry, gas laws, chromatography, kinetics.
Prereq: CH 227 or 237; pre- or coreq: CH 222 or 225H; MATH 112.

CH 229. General Chemistry Laboratory. 2 Credits.
Third term of the three-term laboratory sequence: synthesis, equilibrium, acids and bases, volumetric analyses, electrochemistry, nuclear chemistry.
Prereq: CH 228 or 238; pre- or coreq: CH 223 or 226H.

CH 237. Advanced General Chemistry Laboratory. 2 Credits.
First-year university laboratory course for students with a strong high school laboratory experience. Projects in analytical and inorganic chemistry emphasize the use of quantitative glassware, gravimetric and volumetric analysis, acid-base and precipitation reactions.
Prereq: MATH 112; Pre- or coreq: CH 221 or 224H.

CH 238. Advanced General Chemistry Laboratory. 2 Credits.
Projects in inorganic and biochemistry with a focus on absorption spectroscopy, synthesis of coordination compounds, and measuring initial rates of reaction.
Prereq: CH 227 or 237; pre- or coreq: CH 222 or 225H.

CH 239. Advanced General Chemistry Laboratory. 2 Credits.
Projects in biochemistry and inorganic chemistry involving enzymology, mechanisms of reactions, kinetics, and visible absorption spectroscopy.
Prereq: CH 228 or 238; pre- or coreq: CH 223 or 226H.

CH 331. Organic Chemistry I. 4 Credits.
Structure, properties, and bonding of organic molecules.
Prereq: CH 223 or 226H. Concurrent CH 337 recommended.

CH 335. Organic Chemistry II. 4 Credits.
Reactions and mechanisms of organic chemistry.
Prereq: CH 331 or 341. Concurrent CH 338 recommended.

CH 336. Organic Chemistry III. 4 Credits.
Organic chemistry of biomolecules with a focus on chemical aspects.
Prereq: CH 335 or 342. Concurrent CH 339 recommended.

CH 337. Organic Chemistry Laboratory. 3 Credits.
Principles and techniques of laboratory practice in organic chemistry.
Prereq: CH 229 or 239; pre- or coreq: CH 331.

CH 338. Organic Chemistry Laboratory. 3 Credits.
Principles and techniques of laboratory practice in organic chemistry.
Prereq: CH 331 or 341, 337; pre- or coreq: CH 335.

CH 341. Majors Track Organic Chemistry I. 4 Credits.
Structure, properties, and bonding of organic molecules. Provides a rigorous foundation appropriate for chemistry and biochemistry majors as they become chemical practitioners. Sequence with CH 342, 343.
Prereq: CH 223 or CH 226H. Concurrent CH 337 recommended.

CH 342. Majors Track Organic Chemistry II. 4 Credits.
Focuses on mechanisms and reactions of common organic functional groups. Sequence with CH 341, 343.
Prereq: CH 331 (with grade of B– or better) or CH 341. Concurrent CH 348 recommended.

CH 343. Majors Track Organic Chemistry III. 4 Credits.
Incorporates topics from the recent chemistry literature. Sequence with CH 341, 342.
Prereq: CH 335 (with grade of B– or better) or CH 342. Concurrent CH 349 recommended.

CH 348. Organic Chemistry Laboratory for Majors. 4 Credits.
Problem solving in the organic chemistry laboratory. Sequence with CH 337, 349.
Prereq: CH 337; CH 331 or 341; coreq: CH 342.

CH 349. Organic Chemistry Lab for Majors. 4 Credits.
Organic chemistry laboratory projects. Two-dimensional nuclear magnetic resonance techniques. Sequence with CH 337, 348.
Prereq: CH 348; coreq: CH 343.

CH 360. Physiological Biochemistry. 4 Credits.
For preprofessional health science students. Topics include protein structure and function, enzyme mechanisms, central metabolism and bioenergetics, integration and regulation of metabolism by hormone action. Students cannot receive credit for both CH 360 and 462.
Prereq: CH 336 or 343; BI 214 or 282H recommended.

CH 399. Special Studies: [Topic]. 5 Credits.
Repeatable.

CH 401. Research: [Topic]. 1-21 Credits.
Repeatable. Introduction to methods of chemical investigation. For advanced undergraduates by arrangement with individual faculty members.

CH 403. Thesis. 1-12 Credits.
Repeatable. Open to students eligible to work for a bachelor's degree with honors in chemistry or biochemistry.
Prereq: Honors majors.

CH 405. Reading and Conference: [Topic]. 1-21 Credits.
Repeatable.

CH 406. Field Studies: [Topic]. 1-21 Credits.
Repeatable.

CH 407. Seminar: [Topic]. 1-5 Credits.
Repeatable. Biochemistry seminar for undergraduates who have completed or are enrolled in CH 461, 462, 463. No graduate credit.

CH 408. Workshop: [Topic]. 1-21 Credits.
Repeatable.

CH 409. Special Laboratory Problems. 1-21 Credits.
Repeatable. Nonresearch-oriented laboratory instruction and off-campus research and laboratory experience.

CH 410. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CH 411. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to chemical thermodynamics.
Prereq: two years of college chemistry (except for physics majors), PHYS 201, 202, 203; MATH 253; MATH 256, 281, 282 strongly recommended.

CH 412. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to statistical mechanics and rate processes.
Prereq: two years of college chemistry (except for physics majors); CH 411; PHYS 201, 202, 203; MATH 253; MATH 256, 281, 282 strongly recommended.

CH 413. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to quantum chemistry.
Prereq: two years of college chemistry (except for physics majors), PHYS 201, 202, 203; MATH 253; MATH 256, 281, 282 strongly recommended.

CH 417. Physical Chemistry Laboratory. 4 Credits.
Experiments in thermodynamics, modern electronic measurements, computer modeling, and data reduction.
Pre or coreq: CH 411.

CH 418. Physical Chemistry Laboratory. 4 Credits.
Experiments in statistical mechanics, chemical kinetics, plasma chemistry, and mass spectrometry.
Prerequisite CH 417; Pre or coreq: CH 412.

CH 419. Physical Chemistry Laboratory. 4 Credits.
Experiments molecular spectroscopy, quantum chemistry, and laser-excited chemical and physical processes to illustrate theoretical principles.
Prereq: CH 417; pre or coreq: CH 413.

CH 420. Physical Organic Chemistry I. 4 Credits.
Modern physical organic chemistry including chemical bonding, acid-base chemistry, thermochemistry, noncovalent interactions, and introduction to computational chemistry. Sequence with CH 421/521.
Prereq: CH 336.

CH 421. Physical Organic Chemistry II. 4 Credits.
Modern physical organic chemistry including tools to study reaction mechanisms, kinetic analysis, isotope effects, and qualitative molecular orbital theory. Sequence with CH 420/520.
Prereq: CH 420/520.

CH 429. Instrumental Analysis. 5 Credits.
Use of instrumental methods for quantitative determinations of unknown chemical samples.
Prereq: CH 417.

CH 431. Inorganic Chemistry. 4 Credits.
Introduction to group theory for molecular symmetry; syntheses, structures, reactions, and reaction mechanisms of coordination complexes and organometallic complexes.

CH 432. Inorganic Chemistry. 4 Credits.
Bioinorganic chemistry: metals in biological systems; coordination chemistry, reactions, spectroscopy, metalloclusters, and synthetic modeling.
Prereq: CH 431 recommended.

CH 433. Inorganic Chemistry. 4 Credits.
Solid-state inorganic chemistry: solid-state structure and its determination; the electrical, magnetic, and mechanical properties of materials and their physical description.
Prereq: CH 431 recommended.

CH 441. Quantum Chemistry. 4 Credits.
The principles of time-independent quantum mechanics and their application to model atomic and molecular systems.
Prereq: CH 413 or equivalent.

CH 442. Quantum Chemistry and Spectroscopy. 4 Credits.
Molecular structure theory, perturbation theory, time-dependent quantum mechanics, theory of spectra, selection rules.
Prereq: CH 441 or equivalent.

CH 443. Quantum Chemistry and Spectroscopy. 4 Credits.
Experimental spectra of atomic and molecular systems and surfaces.
Prereq: CH 442 or equivalent.

CH 444. Chemical Thermodynamics. 4 Credits.
The laws of thermodynamics and their applications, including those to nonideal chemical systems.
Prereq: CH 413 or equivalent.

CH 445. Statistical Mechanics. 4 Credits.
Molecular basis of thermodynamics. Applications to the calculation of the properties of noninteracting and weakly interacting systems.
Prereq: CH 413 or equivalent.

CH 446. Chemical Kinetics: [Topic]. 4 Credits.
Repeatable. Description and interpretation of the time evolution of chemical systems.
Prereq: CH 413 or equivalent.

CH 447. Computational Chemistry. 4 Credits.
Introduction to modern computational methods used to understand the properties of molecules.
Prereq: CH 411, 412; or PHYS 353.

CH 451. Advanced Organic-Inorganic Chemistry. 4 Credits.
Principles of organic-inorganic reaction dynamics; kinetics and mechanisms, linear free-energy relationships, isotope effects, substitution reactions, dynamic behavior of reactive intermediates, electron transfer chemistry.
Prereq: CH 336 or equivalent.

CH 452. Advanced Organic Chemistry—Stereochemistry and Reactions. 4 Credits.
Principles and applications of stereochemistry; reagents and reactions, with mechanisms, used in contemporary organic synthesis; examples taken from the current literature.

CH 454. Advanced Electrochemistry. 4 Credits.
Advanced topics in electrochemistry including fundamental concepts (thermodynamics, kinetics, transport) and applications (analytical techniques, electrolysis, batteries).
Prereq: CH 411.

CH 461. Biochemistry. 4 Credits.
Structure and function of macromolecules. Exposure to calculus and physical chemistry recommended.
Prereq: CH 336 or 343.

CH 462. Biochemistry. 4 Credits.
Metabolism and metabolic control processes. Energy and sensory transduction mechanisms.
Prereq: CH 461.

CH 463. Biochemistry. 4 Credits.
Mechanisms and regulation of nucleic acid and protein biosynthesis. Other current topics in biochemical genetics.
Prereq: CH 461/561; or CH 360 with a grade of B- or better.

CH 464. RNA Biochemistry. 4 Credits.
Introduction to the diverse field of RNA biochemistry.
Prereq: CH 463 or BI 320.

CH 465. Physical Biochemistry. 4 Credits.
Physical chemical properties of biological macromolecules; forces and interactions to establish and maintain macromolecular conformations; physical bases of spectroscopic, hydrodynamic, and rapid-reaction investigative techniques. Offered alternate years.
Prereq: CH 461.

CH 466. Structural Biochemistry. 4 Credits.
Protein and nucleic acid structures and energetics. Structure determination by x-ray crystallography and nuclear magnetic resonance. Computational methods for structural analysis. Offered alternate years.
Prereq: CH 461.

CH 467. Biochemistry Laboratory. 4 Credits.
Methods of modern molecular biology and protein purification.
Prereq: CH 461

CH 503. Thesis. 1-16 Credits.
Repeatable.

CH 507. Seminar: [Topic]. 1-5 Credits.
Repeatable. Biochemistry seminar for undergraduates who have completed or are enrolled in CH 461, 462, 463. No graduate credit.

CH 508. Workshop: [Topic]. 1-21 Credits.
Repeatable.

CH 510. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CH 511. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to chemical thermodynamics.

CH 512. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to statistical mechanics and rate processes.

CH 513. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to quantum chemistry.

CH 517. Physical Chemistry Laboratory. 4 Credits.
Experiments in thermodynamics, modern electronic measurements, computer modeling, and data reduction.
Pre- or coreq: CH 411/511.

CH 518. Physical Chemistry Laboratory. 4 Credits.
Experiments in statistical mechanics, chemical kinetics, plasma chemistry, and mass spectrometry.
Pre or coreq: CH 412/512.

CH 519. Physical Chemistry Laboratory. 4 Credits.
Experiments in molecular spectroscopy, quantum chemistry, and laser-excited chemical and physical processes to illustrate theoretical principles.
Pre or coreq: CH 413/513.

CH 520. Physical Organic Chemistry I. 4 Credits.
Modern physical organic chemistry including chemical bonding, acid-base chemistry, thermochemistry, noncovalent interactions, and introduction to computational chemistry. Sequence with CH 421/521.

CH 521. Physical Organic Chemistry II. 4 Credits.
Modern physical organic chemistry including tools to study reaction mechanisms, kinetic analysis, isotope effects, and qualitative molecular orbital theory. Sequence with CH 420/520.
Prereq: CH 420/520.

CH 531. Inorganic Chemistry. 4 Credits.
Introduction to group theory for molecular symmetry; syntheses, structures, reactions, and reaction mechanisms of coordination complexes and organometallic complexes.

CH 532. Inorganic Chemistry. 4 Credits.
Bioinorganic chemistry: metals in biological systems; coordination chemistry, reactions, spectroscopy, metalloclusters, and synthetic modeling.
Prereq: CH 531 recommended.

CH 533. Inorganic Chemistry. 4 Credits.
Solid-state inorganic chemistry: solid-state structure and its determination; the electrical, magnetic, and mechanical properties of materials and their physical description.
Prereq: CH 531 recommended.

CH 541. Quantum Chemistry. 4 Credits.
The principles of time-independent quantum mechanics and their application to model atomic and molecular systems.
Prereq: CH 4/513 or equivalent.

CH 542. Quantum Chemistry and Spectroscopy. 4 Credits.
Molecular structure theory, perturbation theory, time-dependent quantum mechanics, theory of spectra, selection rules.
Prereq: CH 4/541 or equivalent.

CH 543. Quantum Chemistry and Spectroscopy. 4 Credits.
Experimental spectra of atomic and molecular systems and surfaces.
Prereq: CH 4/542 or equivalent.

CH 544. Chemical Thermodynamics. 4 Credits.
The laws of thermodynamics and their applications, including those to nonideal chemical systems.
Prereq: CH 4/513 or equivalent.

CH 545. Statistical Mechanics. 4 Credits.
Molecular basis of thermodynamics. Applications to the calculation of the properties of noninteracting and weakly interacting systems.
Prereq: CH 413/513 or equivalent.

CH 546. Chemical Kinetics: [Topic]. 4 Credits.
Repeatable. Description and interpretation of the time evolution of chemical systems.
Prereq: CH 4/513 or equivalent.

CH 547. Computational Chemistry. 4 Credits.
Introduction to modern computational methods used to understand the properties of molecules.

CH 551. Advanced Organic-Inorganic Chemistry. 4 Credits.
Principles of organic-inorganic reaction dynamics; kinetics and mechanisms, linear free-energy relationships, isotope effects, substitution reactions, dynamic behavior of reactive intermediates, electron transfer chemistry.
Prereq: CH 336 or equivalent.

CH 552. Advanced Organic Chemistry—Stereochemistry and Reactions. 4 Credits.
Principles and applications of stereochemistry; reagents and reactions, with mechanisms, used in contemporary organic synthesis; examples taken from the current literature.

CH 554. Advanced Electrochemistry. 4 Credits.
Advanced topics in electrochemistry including fundamental concepts (thermodynamics, kinetics, transport) and applications (analytical techniques, electrolysis, batteries).

CH 561. Biochemistry. 4 Credits.
Structure and function of macromolecules.

CH 562. Biochemistry. 4 Credits.
Metabolism and metabolic control processes. Energy and sensory transduction mechanisms.
Prereq: CH 461/561.

CH 563. Biochemistry. 4 Credits.
Mechanisms and regulation of nucleic acid and protein biosynthesis. Other current topics in biochemical genetics.
Prereq: CH 461/561.

CH 564. RNA Biochemistry. 4 Credits.
Introduction to the diverse field of RNA biochemistry.

CH 565. Physical Biochemistry. 4 Credits.
Physical chemical properties of biological macromolecules; forces and interactions to establish and maintain macromolecular conformations; physical bases of spectroscopic, hydrodynamic, and rapid-reaction investigative techniques. Offered alternate years.

CH 566. Structural Biochemistry. 4 Credits.
Protein and nucleic acid structures and energetics. Structure determination by x-ray crystallography and nuclear magnetic resonance. Computational methods for structural analysis. Offered alternate years.
Prereq: CH 561.

CH 567. Biochemistry Laboratory. 4 Credits.
Methods of modern molecular biology and protein purification.

CH 601. Research: [Topic]. 1-16 Credits.
Repeatable.

CH 602. Supervised College Teaching. 1-5 Credits.
Repeatable.

CH 603. Dissertation. 1-16 Credits.
Repeatable.

CH 605. Reading and Conference: [Topic]. 1-16 Credits.
Repeatable.

CH 606. Field Studies: [Topic]. 1-16 Credits.
Repeatable.

CH 607. Seminar: [Topic]. 1-5 Credits.
Repeatable. Seminars offered in biochemistry, chemical physics, materials science, molecular biology, neuroscience, organic-inorganic chemistry, and physical chemistry.

CH 608. Workshop: [Topic]. 1-16 Credits.
Repeatable.

CH 609. Terminal Project. 1-16 Credits.
Repeatable.

CH 610. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CH 613. Organic Chemistry: [Topic]. 1-4 Credits.
Repeatable. Topics include bioorganic and bioinorganic chemistry, computational chemistry, green chemistry, medicinal chemistry, natural products, organometallic chemistry, polymers, catalysis, molecular motors, and spectroscopic methods for structure determination. Repeatable when topic changes.

CH 623. Organic-Inorganic Chemistry Journal Club. 1 Credit.
Repeatable. Preparation and delivery of colloquium-style lectures in organic-inorganic chemistry based on papers from the literature. Repeatable for maximum of 12 credits.

CH 624. Physical Chemistry Journal Club. 1 Credit.
Repeatable. Preparation and delivery of colloquium-style lectures in physical chemistry based on papers from the literature. Repeatable for maximum of 12 credits.

CH 662. Advanced Biochemistry. 4 Credits.
Detailed consideration of enzyme mechanisms, macromolecular structure, protein-nucleic acid interactions, and selected aspects of biological synthesis.

CH 667. Polymers: Synthesis, Characterization, Processing. 4 Credits.
Methods of polymer synthesis and characterization; kinetics and mechanisms of the principal polymerization reactions. Introduction to mechanical properties and fabrication techniques.

CH 668. Physical Chemistry of Polymers and Coatings. 4 Credits.
Statistical and thermodynamic models for the equilibrium configuration, conformation, structure, mechanical properties, and phase transitions of polymer solutions, dense melts, liquid crystals.

CH 669. Polymer Synthesis and Characterization Laboratory. 4 Credits.
Preparation and physical characterization of polymers; emphasis on polymers of commercial interest.

CH 670. Industrial Polymer Projects Laboratory. 4 Credits.
Polymer industry–focused projects with emphasis on formulation and optimization of adhesives, coatings, thermoplastics, thermosets, drug delivery systems, biopolymers, personal care products.
Prereq: CH 667, CH 668, CH 669.

CH 677M. Semiconductor Device Physics. 4 Credits.
Introduction to the theory behind semiconductors. Elementary theory of inorganic solids; electronic structures and transport properties. Basic theory of devices including diodes, transistors, mosfets, and optoelectronic devices. Offered only in summer. Sequence with PHYS 678M, PHYS 679M. Multilisted with PHYS 677M.

CH 678M. Semiconductor Processing and Characterization Technology. 4 Credits.
Introduction to the techniques required to make semiconductors and test their properties. Solid-state and surface chemistry of inorganic semiconductors as it pertains to microelectronic devices. Offered only in summer. Multilisted with PHYS 678M.
Prereq: CH 677M.

CH 679M. Device Processing and Characterization Laboratory. 4 Credits.
Students use theory and techniques learned to design, fabricate, and test a device that performs a specific function, with an emphasis on wafer processing and device realization. Offered only in summer. Sequence with CH 677M, CH 678M. Multilisted with PHYS 679M.
Prereq: CH 678M.

CH 680. Electronics and Vacuum Systems. 4 Credits.
Introduction to modern electronic components, circuits, basic vacuum theory, vacuum failure modes, measurement systems, and troubleshooting.

CH 681. Introduction to Electron Microscopy. 4 Credits.
Introduction to theory and best practices for applying scanning electron (SEM) and transmission electron microscopy (TEM) in materials science.

CH 682. Electron Microprobe Analysis. 4 Credits.
Introduction to the theory and operation of instrumentation for electron microprobe analysis (EPMA) in materials science and geochemistry.

CH 683. Surface Analysis. 4 Credits.
Introduction to theory and best practices for surface analysis techniques (XPS and ToF-SIMS), with focus on applications for materials science.