CHEMISTRY

Undergraduate Study

For undergraduate curricula in liberal arts and sciences leading to the degrees Bachelor of Science and Bachelor of Arts, see Liberal Arts and Sciences, Curriculum.

Graduates holding the B.S. degree in Chemistry qualify in many fields as: teachers of Chemistry, supervisors in industry, technical sales personnel, and research chemists in federal, state, municipal, academic, or industrial laboratories. Students with high scholastic standing often continue with graduate work, where they may explore more thoroughly the specialized areas of chemistry in which they are interested.

The B.A. degree is useful for students who intend to pursue studies in parallel areas, such as secondary school teaching, or to obtain additional majors or strong minors. The B.A. degree does not prepare students as well for graduate study or professional employment in chemistry.

Graduates have firm foundations in the fundamentals and application of current chemical theories. They are able to design, carry-out, record, and analyze the results of chemical experiments. They are able to use modern instrumentation and classical techniques to identify and solve chemical problems as well as explore new areas of research. Graduates are able to communicate the results of their work to chemists, as well as non-chemists. They understand the ethical and environmental dimensions of problems and issues facing chemists. They follow the proper procedures and regulations for safe storage, labeling, use of chemicals, and disposal of chemicals. Graduates are skilled in problem solving, critical thinking, and analytical reasoning. These skills may be applied to careers in education and industry; in professions such as law, medicine, environmental sciences, and forensic sciences.
The curricula in Chemistry are approved by the American Chemical Society (ACS). Students who complete the program obtain an ACS certified baccalaureate degree provided they also take one Biochemistry course, typically BBMB 301 Survey of Biochemistry, BBMB 316 (http://catalog.iastate.edu/azcourses/bbmb) Principles of Biochemistry or BBMB 404 Biochemistry I and BBMB 405 (http://catalog.iastate.edu/azcourses/bbmb) Biochemistry II.

Liberal arts majors who wish to transfer into Chemistry at the end of their second year may still complete all degree requirements and graduate within five years.

Undergraduate students seeking the B.S. degree in Chemistry usually take courses essential to the degree program according to the following schedule:

First year

CHEM 101	Chemistry Learning Community Orientation	1
CHEM 177 & CHEM 178	General Chemistry I and General Chemistry II	5-7
or CHEM 201	Advanced General Chemistry	
CHEM 177L	Laboratory in General Chemistry I	1
or CHEM 177N	Laboratory in General Chemistry I	
or CHEM 201L	Laboratory in Advanced General Chemistry	
CHEM 211	Quantitative and Environmental Analysis	2
CHEM 211L	Quantitative and Environmental Analysis Laboratory	2
MATH 165	Calculus I	4
MATH 166	Calculus II	4
ENGL 150	Critical Thinking and Communication	3
LIB 160	Information Literacy	1

Second year

CHEM 110	Cutting-Edge Chemistry: Research and Career Opportunities	1
CHEM 331	Organic Chemistry I	3
CHEM 332	Organic Chemistry II	3
CHEM 333L	Laboratory in Organic Chemistry I (for Chemistry and Biochemistry Majors)	2
CHEM 334L	Laboratory in Organic Chemistry II (for Chemistry and Biochemistry Majors)	2
MATH 265	Calculus III	4
PHYS 221	Introduction to Classical Physics I	5
PHYS 222	Introduction to Classical Physics II	5
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
or ENGL 250H	Written, Oral, Visual, and Electronic Composition: Honors	

Third year

CHEM 324	Introductory Quantum Mechanics	3
CHEM 325	Chemical Thermodynamics	3
CHEM 322L	Laboratory in Physical Chemistry	3
CHEM 316	Instrumental Methods of Chemical Analysis	2
CHEM 316L	Instrumental Analysis Laboratory	2
CHEM 301	Inorganic Chemistry	2
CHEM 550	Safety in the Chemical Laboratory	1

Plus a foreign language requirement.

Fourth year

CHEM 402	Advanced Inorganic Chemistry	3
CHEM 401L	Inorganic Chemistry Laboratory	1
ENGL 314	Technical Communication	3
Two advanced Chemistry courses (min 4 credits)		4-6

Communication Proficiency requirement: The LAS College requires a C or better in ENGL 250. The Department requires a grade of C– or better in ENGL 314.

ENGL 150 & ENGL 250	Critical Thinking and Communication and Written, Oral, Visual, and Electronic Composition	3-6
or ENGL 250H	Written, Oral, Visual, and Electronic Composition: Honors	
ENGL 314	Technical Communication	3

CHEM 399 Undergraduate Research or CHEM 499 Senior Research is strongly recommended. Credits earned in 399/499/490 may only be used to meet one of the advanced course requirements.

Chemistry majors seeking certification to teach Chemistry in secondary schools must meet the requirements of the College of Human Sciences as well as those of the Chemistry program. In addition, they must apply formally for admission to the teacher education program.

Undergraduate students seeking the B.A. degree in Chemistry have the following courses in their degree programs as minimum requirements:

One of the following sequences:		6-8
CHEM 177 & CHEM 178 & 177L	General Chemistry I and General Chemistry II and Laboratory in General Chemistry I	
or CHEM 177	Laboratory in General Chemistry I	
CHEM 167 & CHEM 178 & 167L	General Chemistry for Engineering Students and General Chemistry II and Laboratory in General Chemistry for Engineering	
CHEM 201 & 201L	Advanced General Chemistry and Laboratory in Advanced General Chemistry	
CHEM 211	Quantitative and Environmental Analysis	2
CHEM 211L	Quantitative and Environmental Analysis Laboratory	2
CHEM 301	Inorganic Chemistry	2
CHEM 316	Instrumental Methods of Chemical Analysis	2
CHEM 316L	Instrumental Analysis Laboratory	2
CHEM 324	Introductory Quantum Mechanics	3
CHEM 321L	Laboratory in Physical Chemistry	2-3
or CHEM 322L	Laboratory in Physical Chemistry	
CHEM 325	Chemical Thermodynamics	3
CHEM 331	Organic Chemistry I	3
CHEM 331L	Laboratory in Organic Chemistry I	1
CHEM 332	Organic Chemistry II	3
CHEM 332L	Laboratory in Organic Chemistry II	1
The following are required as supporting work:		12
MATH 165	Calculus I	
MATH 166	Calculus II	
PHYS 221	Introduction to Classical Physics I	
PHYS 222	Introduction to Classical Physics II	

Minor

The Department offers a minor in chemistry which may be earned by credit in:

CHEM 177	General Chemistry I	4
CHEM 177L	Laboratory in General Chemistry I	1
or		
CHEM 167 & 167L	General Chemistry for Engineering Students and Laboratory in General Chemistry for Engineering	5
CHEM 178	General Chemistry II	3
CHEM 211	Quantitative and Environmental Analysis	2
CHEM 211L	Quantitative and Environmental Analysis Laboratory	2
CHEM 324	Introductory Quantum Mechanics	3
CHEM 331	Organic Chemistry I	3
CHEM 331L	Laboratory in Organic Chemistry I	1
And one of the following:		2-5
CHEM 301	Inorganic Chemistry	
CHEM 316 & 316L	Instrumental Methods of Chemical Analysis and Instrumental Analysis Laboratory	
CHEM 325 & CHEM 321L	Chemical Thermodynamics and Laboratory in Physical Chemistry	
or CHEM 322	Laboratory in Physical Chemistry	
CHEM 332 & 332L	Organic Chemistry II and Laboratory in Organic Chemistry II	

The total minimum credits in Chemistry thus will be 20 to 23 depending on which advanced courses are selected.

Chemistry, B.A.

Freshman

Fall	Credits	Spring	Credits
CHEM 177(F) or CHEM 201(F)[1,2]	4-5	CHEM 178[2]	3
CHEM 177N or CHEM 201L[2,F]	1	CHEM 101	1
CHEM 101[3]	1	CHEM 211	2
MATH 165	4	CHEM 211L	2
ENGL 150	3	MATH 166	4

LIB 160	1	Electives	3
Electives			
	14-15		15

Sophomore

Fall	Credits	Spring	Credits
CHEM 331	3	CHEM 332	3
CHEM 333L[F,2]	2	CHEM 334L[2,5]	2
PHYS 221[2]	5	PHYS 222[2]	5
CHEM 110	1	ENGL 250	3
Electives	3	Electives	3
	14		16

Junior

Fall	Credits	Spring	Credits
CHEM 324 (or CHEM 325)	3	CHEM 325 (or CHEM 324)	3
Foreign Language - first semester of any foreign language accepted[4]	4	CHEM 321L[S]	2
Electives	9	CHEM 301[S]	2
		Foreign Language - second semester[4]	4
		CHEM 550 (strongly recommended)[S]	1
		Electives	3
	16		15

Senior

Fall	Credits	Spring	Credits
CHEM 316[F]	2	BBMB 301 (strongly recommended)	3
CHEM 316L[F]	2	CHEM 399 (strongly recommended)	
ENGL 314	3	Electives	12
Electives	8		
	15		15

1 Advanced high school chemistry and strong algebra skills are necessary for success in CHEM 201. Math ACT of 24 or greater is strongly recommended.

2 Students may substitute the following courses, if necessary:

- CHEM 201 for 177 and 178;
- CHEM 177L for 177N or 201L.
- CHEM 331L and 332L for 333L and 334L; however, this substitution may result in a program which is deficient in the laboratory experience recommended by the American Chemistry Society.
- CHEM 321L for 322L; however this substitution may result in a program which is deficient in the laboratory experience recommended by the American Chemistry Society.
- PHYS 111 and 112 for PHYS 221 and 222, however PHYS 221 and 222 are highly recommended.

3 Required of Chemistry Learning Community Members.

4 Completion of three years of foreign language in high school fulfills this requirement.

F Class offered Fall Semester only.

S Class offered Spring Semester only.

Individuals earning a B.A. degree in Chemistry who have taken 331L, 334L and 322L can obtain American Chemical Society certification by taking an additional advanced chemistry lecture course of BBMB 301 or 404. CHEM 550 may not be used to satisfy the Advanced Chemistry requirement.

Chemistry, B.S.

Freshman

Fall	Credits	Spring	Credits
CHEM 177 or CHEM 201(F)[1,2]	4-5	CHEM 178[1,2]	3
CHEM 177N or CHEM 201L[2,F]	1	CHEM 211	2
CHEM 101 (required for LC members)	1	CHEM 211L	2
MATH 165	4	CHEM 101	1
ENGL 150	3	MATH 166	4
LIB 160	1	Electives	3
Electives			
	14-15		15

Sophomore

Fall	Credits	Spring	Credits
CHEM 331	3	CHEM 332	3
CHEM 333L[2,F]	2	CHEM 334L[2,S]	2
CHEM 110[F]	1	PHYS 222	5
MATH 265	4	ENGL 250	3
PHYS 221	5	Electives	3
Electives			
	15		16

Junior

Fall	Credits	Spring	Credits
CHEM 325 or CHEM 324	3	CHEM 325 or CHEM 324	3
CHEM 316[F]	2	CHEM 322L[S]	3
CHEM 316L[F]	2	CHEM 301[S]	2
Foreign Language - first semester of any foreign language accepted[3]	4	Foreign Language - second semester[3]	4
Electives	5	CHEM 550 (strongly recommended)[S]	1
		Electives	3
	16		16

Senior

Fall	Credits	Spring	Credits
CHEM 402[F]	3	CHEM 401L[S]	1
ENGL 314	3	Advanced Chemistry[5,6]	4-5
Electives	9	BBMB 301 (strongly recommended)	3
		CHEM 399 (strongly recommended) crs-variable	
		Electives	6
	15		14-15

1 Advanced high school chemistry and strong algebra skills are necessary for success in CHEM 201. Math ACT of 24 or greater is strongly recommended.

2 Students may substitute the following courses, if necessary:

- CHEM 201 for 177 and 178;
- CHEM 177l for 177N or 201L
- CHEM 331l and 332L for 333L and 334L; however, this substitution may result in a program which is deficient in the laboratory experience recommended by the American Chemistry Society.

3 Completion of three years of foreign language in high school fulfills this requirement.

4 The completion of two courses (minimum of 2 credits each) are required to meet this requirement. (In addition to advanced Chemistry courses, certain courses in Biochemistry-Biophysics, Chemical Engineering, Computer Science, Mathematics and Materials Science and Engineering are acceptable.) Up to four credits in undergraduate research (CHEM 339 and/or 499) can be counted as one of the two advanced chemistry courses. CHEM 550 may not be used to satisfy the Advanced Chemistry requirement.

5 The program as listed above meets the standard for a certified degree of the American Chemical Society's Committee on Professional Training if BBMB 301 or 404 is one of the Advanced Chemistry Courses.

F Class offered Fall Semester only.

S Class offered Spring Semester only.

Graduate Study

The Department offers work for the degrees Master of Science and Doctor of Philosophy with majors in Chemistry, Analytical, Inorganic, Organic, and Physical chemistry. Co-majors may be taken between areas within Chemistry or between one of the areas in Chemistry and another department. Courses in other areas of Chemistry as well as courses in other departments may be used to satisfy the requirement for coursework outside the major field. A Ph.D. student in Chemistry may choose an additional specialty in one of six areas: Materials Chemistry, Industrial Chemistry, Biomolecular Sciences, Chemistry Education, Chemical Instrumentation, and Forensic Chemistry. A minimum of ten credits is required for each additional specialty. A course which counts towards an additional specialty may also count toward the outside course requirement. A minor in Chemistry is available to students in other departments. The Department participates in the interdepartmental major in Toxicology.

The Department of Chemistry requires all graduate students majoring in Chemistry to teach as part of their training for an advanced degree. Prerequisite to major graduate work is the completion of undergraduate work in Chemistry, Mathematics, and Physics substantially equivalent to that required of undergraduate Chemistry majors at this institution.

The course numbers for general Chemistry courses include 163-178, and 201.

Index to field of work for 200 level courses and above is given by the second and third digits of course numbers:

1. Inorganic Chemistry 00-09
2. Analytical Chemistry 10-19
3. Physical Chemistry 20-29 and 60-69
4. Organic Chemistry 30-39
5. Chemical Education 50-59
6. Interdisciplinary Chemistry 70-89
7. Research 99

Courses primarily for undergraduates:

CHEM 050: Preparation for College Chemistry
(3-0) Cr. 0. F.S.
Prereq: 1 year high school algebra
An in-depth active learning experience designed to impart the fundamental concepts and principles of chemistry, with an emphasis on mathematics skills and logical thinking. For students intending to enroll in general chemistry and who have not taken high school chemistry or who have not had a high school college preparatory chemistry course who need a review of chemical problem solving and chemical concepts. Credit for Chem 50 does not count toward graduation.

CHEM 101: Chemistry Learning Community Orientation
(1-0) Cr. 1. F.S.
Prereq: Member of the Chemistry Learning Community.
Integration of first year and transfer students into the chemistry program. Introduction and overview of degree requirements and support services on campus, assistance with transition to college and community life, and team-building and leadership activities. Offered on a satisfactory-fail basis only.

CHEM 101A: Chemistry Learning Community Orientation: On-Campus Orientation
(1-0) Cr. 1. F.
Prereq: Member of the Chemistry Learning Community.
Integration of first year and transfer students into the chemistry program. Introduction and overview of degree requirements and support services on campus, assistance with transition to college and community life, and team-building and leadership activities. Offered on a satisfactory-fail basis only.

CHEM 101B: Chemistry Learning Community Orientation: Professional Development Opportunities
(1-0) Cr. 1. S.
Prereq: Member of the Chemistry Learning Community.
Integration of first year and transfer students into the chemistry program. Introduction and overview of degree requirements and support services on campus, assistance with transition to college and community life, and team-building and leadership activities. Offered on a satisfactory-fail basis only.

CHEM 102L: Physical Sciences for Elementary Education
(Cross-listed with PHYS). (1-4) Cr. 3. F.S.
Prereq: MATH 195 or MATH 140
Physical science principles for future elementary teachers. Emphasis on experiments that address current elementary science education standards and that are appropriate for their future students to do, such as measurements of mass, length, time, light from atoms, charge and current, motion due to forces, energy and work, heat, waves, optics, building bridges and making musical instruments, studying states of matter and chemical reactions.

CHEM 110: Cutting-Edge Chemistry: Research and Career Opportunities
(1-0) Cr. 1. F.
Overview of careers in chemistry: industrial, governmental, and academic careers; literature and compound search instruction; professional ethics; and an introduction to joining a research lab. For students majoring or minoring in chemistry or chemistry-related fields. Offered on a satisfactory-fail basis only.

CHEM 160: Chemistry in Modern Society
(3-0) Cr. 3. F.S.
Aspects of chemistry visible to a non-scientist in our society. A survey of selected areas of chemistry with emphasis on the interface between chemistry and other fields of human activity.

CHEM 163: College Chemistry
(4-0) Cr. 4. F.S.SS.
Prereq: 1 year of high school algebra and geometry and Chem 50 or 1 year of high school chemistry; and credit or enrollment in CHEM 163L
A general survey of chemistry with an emphasis on conceptual problems for those who are not physical and biological science or engineering majors. Nomenclature, chemical reactions, stoichiometry, atomic structure, periodic properties, chemical bonding, states of matter, solutions, thermochemistry, acid-base theory, oxidation-reduction reactions, basic chemical kinetics, and chemical equilibrium. Only one of Chem 163, 167, 177, or 201 may count toward graduation.

CHEM 163L: Laboratory in College Chemistry
(0-3) Cr. 1. F.S.SS.
Prereq: Credit or enrollment for credit in CHEM 163
Laboratory to accompany CHEM 163. Must be taken with CHEM 163. Only one of Chem 163L, CHEM 167L, and CHEM 177L may count toward graduation.

CHEM 167: General Chemistry for Engineering Students
(4-0) Cr. 4. F.S.
Prereq: 1 year of high school chemistry or CHEM 50 and Math 143 pre-calculus or high school equivalent.
Principles of chemistry and properties of matter explained in terms of modern chemical theory with emphasis on topics of general interest to the engineer. Only one of Chem 163, 167, 177, or 201 may count toward graduation.

CHEM 167L: Laboratory in General Chemistry for Engineering
(0-3) Cr. 1. F.S.
Prereq: Credit or enrollment for credit in CHEM 167
Laboratory to accompany 167. Only one of Chem 163L, 167L, and 177L may count toward graduation.

CHEM 177: General Chemistry I

(4-0) Cr. 4. F.S.SS.

Prereq: MATH 140 or high school equivalent, and CHEM 50 or 1 year high school chemistry, and credit or enrollment in CHEM 177L. Chemistry and biochemistry majors may consider taking CHEM 201

The first semester of a two semester sequence which explores chemistry at a greater depth and with more emphasis on concepts, problems, and calculations than 163. Recommended for physical and biological science majors, chemical engineering majors, and all others intending to take 300-level chemistry courses. Principles and quantitative relationships, stoichiometry, chemical equilibrium, acid-base chemistry, thermochemistry, rates and mechanism of reactions, changes of state, solution behavior, atomic structure, periodic relationships, chemical bonding. Only one of Chem 163, 167, 177, or 201 may count toward graduation.

CHEM 177L: Laboratory in General Chemistry I

(0-3) Cr. 1. F.S.SS.

Prereq: Credit or enrollment for credit in CHEM 177

Laboratory to accompany 177. 177L must be taken with 177. Only one of Chem 163L, 167L, and 177L may count toward graduation.

CHEM 177N: Laboratory in General Chemistry I

(0-3) Cr. 1. F.

Prereq: Credit or enrollment for credit in CHEM 177. For chemistry and biochemistry majors

Laboratory to accompany CHEM 177. CHEM 177N must be taken with CHEM 177. Only one of Chem 163L, CHEM 167L, and CHEM 177N may count toward graduation.

CHEM 178: General Chemistry II

(3-0) Cr. 3. F.S.SS.

Prereq: CHEM 177, CHEM 177L

Continuation of 177. Recommended for physical or biological science majors, chemical engineering majors, and all others intending to take 300-level chemistry courses.

CHEM 178L: Laboratory in College Chemistry II

(0-3) Cr. 1. F.S.SS.

Prereq: CHEM 177L and credit or enrollment for credit in CHEM 178

Laboratory to accompany 178. 178L is not a necessary co-requisite with 178.

CHEM 201: Advanced General Chemistry

(5-0) Cr. 5. F.

Prereq: Co-enrollment in MATH 165 or credit, one year of high school chemistry, and one year high school physics or advanced chemistry. Co-enrollment in CHEM 201L.

A one-semester course in general chemistry designed to give students an in-depth, broad-based view of modern chemistry, and, in part, to facilitate participation in independent undergraduate research. Topics include stoichiometry, atomic and molecular structure, chemical bonding, kinetics, chemical equilibria, and thermodynamics. Discussion of current trends in various chemical disciplines, which may be given by guest experts in chemistry, biochemistry, and chemical engineering, will help the student appreciate the scope of the chemical sciences and how research is carried out. Only one of Chem 163, 167, 177, or 201 may count toward graduation.

CHEM 201L: Laboratory in Advanced General Chemistry

(0-3) Cr. 1. F.

Prereq: Credit or enrollment for credit in CHEM 201

Laboratory to accompany 201. Introductory lab experience in synthesis and analysis to prepare students for research activities. 201L must be taken with 201. Only one of 163L, 167L, 177L, 177N or 201L may count toward graduation.

CHEM 211: Quantitative and Environmental Analysis

(2-0) Cr. 2. F.S.

Prereq: CHEM 163 and CHEM 163L, CHEM 201 and CHEM 201L; or credit or enrollment in CHEM 178; and concurrent enrollment in CHEM 211L

Theory and practice of elementary volumetric, chromatographic, electrochemical and spectrometric methods of analysis. Chemical equilibrium, sampling, and data evaluation. Emphasis on environmental analytical chemistry; the same methods are widely used in biological and materials sciences as well.

CHEM 211L: Quantitative and Environmental Analysis Laboratory

(0-6) Cr. 2. F.S.

Prereq: Credit or enrollment for credit in CHEM 211

Introductory laboratory experience in volumetric, spectrometric, electrochemical and chromatographic methods of chemical analysis.

CHEM 231: Elementary Organic Chemistry
(3-0) Cr. 3. F.S.SS.
Prereq: CHEM 163, CHEM 163L, or CHEM 177, CHEM 177L; credit or enrollment in CHEM 231L
A survey of modern organic chemistry including nomenclature, structure and bonding, and reactions of hydrocarbons and important classes of natural and synthetic organic compounds. For students desiring only an elementary course in organic chemistry. Students in physical or biological sciences and premedical or preveterinary curricula should take the full year sequence 331 and 332 (with the accompanying laboratories 331L and 332L). Only one of Chem 231 and 331 or BBMB 221 may count toward graduation.

CHEM 231L: Laboratory in Elementary Organic Chemistry
(0-3) Cr. 1. F.S.SS.
Prereq: Credit or enrollment for credit in CHEM 231; CHEM 163L or CHEM 177L
Laboratory to accompany 231. 231L must be taken with 231. Only one of Chem 231L and 331L may count toward graduation.

CHEM 298: Cooperative Education
Cr. R. F.S.SS.
Prereq: Permission of the Department cooperative education coordinator; sophomore classification
Required of all cooperative education students. Students must register for this course prior to commencing each work period.

CHEM 299: Undergraduate Research (for Freshmen and Sophomores)
Cr. arr. Repeatable, maximum of 6 credits.
Prereq: Permission of staff member with whom student proposes to work

CHEM 301: Inorganic Chemistry
(2-0) Cr. 2. S.
Prereq: CHEM 324
Atomic and molecular structure and bonding principles; molecular shapes and symmetry; acids and bases; solid-state structures and properties; inorganic chemistry of H, B, C.

CHEM 316: Instrumental Methods of Chemical Analysis
(2-0) Cr. 2. F.
Prereq: CHEM 211, CHEM 211L, Math 166, and concurrent enrollment in CHEM 316L; PHYS 222 recommended
Quantitative and qualitative instrumental analysis. Operational theory of instruments, atomic and molecular absorption and emission spectroscopy, electroanalysis, mass spectrometry, liquid and gas chromatography, electrophoresis, literature of chemical analysis.

CHEM 316L: Instrumental Analysis Laboratory
(0-6) Cr. 2. F.
Prereq: Credit or enrollment in CHEM 316
Advanced laboratory experience in UV-visible spectrophotometry, atomic absorption and emission spectrometry, electrochemistry, gas and liquid chromatography, electrophoresis, mass spectrometry, and other instrumental methods.

CHEM 321L: Laboratory in Physical Chemistry
(1-3) Cr. 2. S.
Prereq: Credit or enrollment in CHEM 324 or CHEM 325.
Error analysis; use of computers for interfacing to experiments and for data analysis; thermodynamics, infrared and optical spectroscopy, lasers. Not applicable towards the B.S. degree in Chemistry. Only one of Chem 321L and 322L may count toward graduation.

CHEM 322L: Laboratory in Physical Chemistry
(1-6) Cr. 3. S.
Prereq: CHEM 324 or CHEM 325.
Error analysis; use of computers for interfacing to experiments and for data analysis; thermodynamics, surface science, infrared and optical spectroscopy, lasers. Only one of Chem 321L and 322L may count toward graduation.

CHEM 324: Introductory Quantum Mechanics
(3-0) Cr. 3. F.S.
Prereq: CHEM 178, MATH 166; PHYS 222 recommended.
Quantum mechanics, atomic and molecular structure, spectroscopy, kinetic theory of gases, chemical kinetics.

CHEM 325: Chemical Thermodynamics
(3-0) Cr. 3. F.S.
Prereq: CHEM 178, MATH 166; PHYS 222 recommended
Classical thermodynamics 1st, 2nd, and 3rd laws with applications to gases and interfacial systems, multicomponent, multiphase equilibrium of reacting systems, surface chemistry, and electrochemical cells. Students taking a two-semester physical chemistry sequence are advised to take 324 first; in the spring semester, a molecular-based section of this course, stressing statistical thermodynamics, is offered for which knowledge of 324 is useful.

CHEM 331: Organic Chemistry I

(3-0) Cr. 3. F.S.SS.

Prereq: CHEM 178 or CHEM 201, enrollment in CHEM 331L highly recommended

The first half of a two semester sequence. Modern organic chemistry including nomenclature, synthesis, structure and bonding, reaction mechanisms. For students majoring in physical and biological sciences, premedical and pre-veterinary curricula, chemistry and biochemistry. Students desiring only one semester of organic chemistry should take 231 and 231L, not 331. Only one of Chem 231 and 331 may count toward graduation.

CHEM 331L: Laboratory in Organic Chemistry I

(0-3) Cr. 1. F.S.SS.

Prereq: CHEM 177L; credit or enrollment for credit in CHEM 331

Laboratory to accompany 331. Chemistry and biochemistry majors are encouraged to take 333L. Only one of Chem 231L and 331L may count toward graduation.

CHEM 332: Organic Chemistry II

(3-0) Cr. 3. F.S.SS.

Prereq: CHEM 331; enrollment in CHEM 332L highly recommended

Continuation of 331. Modern organic chemistry including nomenclature, synthesis, structure and bonding, reaction mechanisms, natural products, carbohydrates and proteins. For students majoring in physical and biological sciences, premedical and pre-veterinary curricula, chemistry and biochemistry.

CHEM 332L: Laboratory in Organic Chemistry II

(0-3) Cr. 1. F.S.SS.

Prereq: CHEM 331L; credit or enrollment for credit in CHEM 332

Laboratory to accompany 332. Chemistry and biochemistry majors are encouraged to take 334L.

CHEM 333L: Laboratory in Organic Chemistry I (for Chemistry and Biochemistry Majors)

(0-6) Cr. 2. F.

Prereq: Credit or enrollment for credit in CHEM 331

Laboratory to accompany 331 for chemistry and biochemistry majors.

CHEM 334L: Laboratory in Organic Chemistry II (for Chemistry and Biochemistry Majors)

(0-6) Cr. 2. S.

Prereq: CHEM 333L, credit or enrollment for credit in CHEM 332

Laboratory to accompany 332 for chemistry and biochemistry majors.

CHEM 398: Cooperative Education

Cr. R. F.S.SS.

Prereq: Permission of the Department cooperative education coordinator; junior classification

Required of all cooperative education students. Students must register for this course prior to commencing each work period.

CHEM 399: Undergraduate Research

Cr. arr.

Prereq: Permission of instructor with whom student proposes to work and junior or senior classification

Undergraduate research. No more than six total credits of Chem 399 and Chem 499 may count toward graduation. Credits earned in 399/499/490 may only be use to meet one of the advanced course requirements for the B.S. degree.

CHEM 401L: Inorganic Chemistry Laboratory

(0-3) Cr. 1. S.

Prereq: CHEM 402

Preparation and characterization of inorganic and organometallic compounds by modern techniques. For students majoring in chemistry or biochemistry.

CHEM 402: Advanced Inorganic Chemistry

(3-0) Cr. 3. F.

Prereq: CHEM 301; CHEM 331 recommended

Chemistry of the d and f metals. Structure, bonding, electronic spectra, and reaction mechanisms. Aspects of organometallic solid state and bioinorganic chemistry.

CHEM 490: Independent Study

Cr. arr.

Prereq: Completion of 6 credits in chemistry at the 300 level or higher and permission of instructor

No more than 9 credits of Chem 490 may count toward graduation.

CHEM 498: Cooperative Education

Cr. R. F.S.SS.

Prereq: Permission of the Department cooperative education coordinator; senior classification

Required of all cooperative education students. Students must register for this course prior to commencing each work period.

CHEM 499: Senior Research
Cr. 2-3. Repeatable, maximum of 6 credits.
Prereq: Permission of instructor with whom student proposes to work; B average in all chemistry, physics, and mathematics courses
Research in chosen area of chemistry, with final written report as senior thesis. This course should be elected for two consecutive semesters. For students majoring in chemistry. No more than six total credits for Chem 399 and 499 may count toward graduation.

Courses primarily for graduate students, open to qualified undergraduates:

CHEM 501L: Inorganic Preparations
(0-3) Cr. 1. F.
Prereq: CHEM 402
Preparation and characterization of inorganic and organometallic compounds by modern research techniques.

CHEM 502: Advanced Inorganic Chemistry
(3-0) Cr. 3. F.
Prereq: CHEM 402; CHEM 331 recommended
Chemistry of the main group (s, p) and transition (d, f) metals. Structure, bonding, electronic spectra, and reaction mechanisms. Aspects of organometallic, solid state, bioinorganic, and nano chemistry.

CHEM 505: Physical Inorganic Chemistry
(3-0) Cr. 3. F.
Prereq: CHEM 402 or CHEM 502 and CHEM 324
Elementary group theory and molecular orbital theory applied to inorganic chemistry. Spectroscopic methods of characterization of inorganic compounds and organometallic compounds.

CHEM 511: Advanced Analytical Chemistry
(3-0) Cr. 3. F.
Prereq: CHEM 316 and CHEM 316L
General methods of quantitative inorganic and organic analysis. Aqueous and nonaqueous titrimetry; selective reagents; sampling and sample dissolution; modern instrumentation; sensors; atomic and molecular microscopy; bioanalytical methods; data evaluation; chemometrics; and analytical literature.

CHEM 512: Electrochemical Methods of Analysis
(3-0) Cr. 3. F.
Prereq: CHEM 316 and CHEM 316L; Recommended but not Required CHEM 324, and CHEM 322L
Principles of convective-diffusional mass transport in electroanalysis. Applications of potentiometry, voltammetry, and coulometry. Introduction to heterogeneous and homogeneous kinetics in electroanalysis. Analog and digital circuitry. Interfacing.

CHEM 513: Analytical Molecular and Atomic Spectroscopy
(3-0) Cr. 3. S.
Prereq: CHEM 316 and CHEM 316L, CHEM 324, CHEM 322L
Introduction to physical optics and design of photometric instruments. Principles of absorption, emission, fluorescence, and Raman spectroscopy. Error and precision of optical methods. Ultraviolet, visible, and infrared methods of qualitative and quantitative organic and inorganic analysis.

CHEM 516: Analytical Separations
(3-0) Cr. 3. F.
Prereq: CHEM 316 and CHEM 316L, CHEM 324, CHEM 322L
Principles and examples of inorganic and organic separation methods applied to analytical chemistry. Solvent extraction, volatilization, ion exchange, liquid and gas chromatography, and electrophoresis.

CHEM 531: Organic Synthesis I
(2-0) Cr. 2. S.
Prereq: CHEM 332
Survey of organic functional group transformations.

CHEM 532: Organic Synthesis II
(2-0) Cr. 2. F.
Prereq: CHEM 531
Synthesis of complex organic compounds including natural products.

CHEM 537: Physical Organic Chemistry I
(3-0) Cr. 3. F.
Prereq: CHEM 332
Survey of reactive intermediates including cations, anions, carbenes, and radicals.

CHEM 538: Physical Organic Chemistry II
(3-0) Cr. 3. S.
Prereq: CHEM 537
Molecular structure, stereochemistry, introduction to reaction mechanisms, thermodynamic and kinetic data, linear free energy relationships, isotope effects, orbital symmetry.

CHEM 550: Safety in the Chemical Laboratory
(1-0) Cr. 1. S.
Prereq: CHEM 332L
Introduction to laboratory safety and chemical hygiene. Use of engineering controls and personal protective equipment. Chemical storage and waste disposal practices. Handling hazardous chemicals. Radiation safety and laser safety. Offered on a satisfactory-fail basis only.

CHEM 555: Teaching College Chemistry
(2-0) Cr. 2. Alt. S., offered even-numbered years.
Prereq: Graduate or senior classification.
Methods of instruction, strategies and techniques for effective teaching and learning along with practice teaching in undergraduate chemistry recitation and laboratory courses. Cooperative learning, guided-inquiry, learning cycles, conceptual change, models and modeling, concept maps, visualization, computer simulations, web-based delivery systems, and learning theories.

CHEM 561: Fundamentals of Quantum Mechanics
(4-0) Cr. 4. F.
Prereq: CHEM 324
Schroedinger equation and exact solutions; square wells and barriers; harmonic oscillator; the hydrogen atom; atomic orbitals; operators including angular momenta; time-independent and time-dependent perturbation theory; Schroedinger and Heisenberg representations; unitary operators; interaction picture, density matrix.

CHEM 562: Fundamentals of Atomic and Molecular Quantum Mechanics
(3-0) Cr. 3. S.
Prereq: CHEM 561, credit or enrollment in CHEM 583
Variational method, many electron atoms; addition of angular momentum, self-consistent field method for open and closed shells, linear combinations of atomic orbitals, origin of chemical bonding, many-electron diatomic and polyatomic molecules, treatments of electron correlation, approximation methods.

CHEM 563: Statistical Mechanics
(3-0) Cr. 3. S.
Prereq: CHEM 325
Microscopic and macroscopic properties, laws of thermodynamics, ensembles and distribution functions, applications to gases, solids, and chemical equilibrium.

CHEM 564: Molecular Spectroscopy and Structure
(3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: CHEM 505 or CHEM 562
Maxwell's field equations, interaction of light with matter including time-dependent perturbation theory, microwave, vibrational (infra-red, Raman) and electronic spectroscopies, symmetry derived selection rules, special lineshapes and introduction to nonlinear and coherent laser spectroscopies.

CHEM 571: Solid-State Chemistry
(2-0) Cr. 2. Alt. S., offered odd-numbered years.
Prereq: CHEM 301, CHEM 324
Structural principles, synthetic strategies, analytical methods, and chemical bonding issues applied to solids. Atomic packings and networks, short-range vs. long-range order, defects; phase diagrams, reactive fluxes, chemical transport; diffraction, spectroscopy; energy bands and their bonding interpretations.

CHEM 572: Spectrometric Identification of Organic Compounds
(2-3) Cr. 3. F.
Prereq: CHEM 332
Principles of infrared, ultraviolet, nuclear magnetic resonance, and mass spectroscopy as applied to organic chemistry.

CHEM 573: Nanochemistry
(2-0) Cr. 2. Alt. S., offered even-numbered years.
Prereq: CHEM 301, CHEM 324
Synthesis, characterization, properties and applications of nanoscale materials (≈ 0.5-500 nm), relationship with molecular, meso and bulk compounds. Chemistry of solid surfaces, zero-, one- and two-dimensional (0D, 1D, 2D) nanostructures , semiconductor quantum dots, plasmonic nanoparticles, carbon nanomaterials, porous nanomaterials, potential health and safety impacts.

CHEM 574: Organometallic Chemistry of the Transition Metals
(2-0) Cr. 2. Alt. S., offered odd-numbered years.
Prereq: CHEM 301, CHEM 332
Transition metal complexes with ligands such as cyclopentadienyl, olefins, acetylenes, benzenes, and carbon monoxide. Coverage of structure, bonding, reactivity, fundamental mechanisms, and homogeneous catalysis.

CHEM 576: Surface Chemistry
(3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: CHEM 324
Gas-surface interactions and techniques of characterization. Idealized surface lattices, surface tension, Wulff plots, work function, adsorbate-adsorbate interactions, 2D phase diagrams, diffusion, thin film growth, adsorption and desorption mechanisms/energetics/kinetics, adsorption isotherms, vacuum techniques, electron- and ion-based spectroscopies for surface analysis (including AES, FIM, XPS, UPS, EXAFS, EELS, SIMS, LEED and STM).

CHEM 577: Mass Spectrometry
(3-0) Cr. 3. S.
Basic physics, instrumentation, chemical and biological applications of mass spectrometry.

CHEM 578: Chemical Kinetics and Mechanisms
(2-0) Cr. 2. Alt. S., offered even-numbered years.
Prereq: CHEM 324
Rates and mechanisms; reversible, consecutive, and competing reactions; chain mechanisms; kinetic isotope effects; very rapid reactions; acid-base catalysis, theories of unimolecular reactions; transition state and Marcus theories.

CHEM 579: Introduction to Research in Chemistry
Cr. R. F.
Introduction to the various areas of research in chemistry at Iowa State University.

CHEM 580: Introduction to Computational Quantum Chemistry
(3-0) Cr. 3. Alt. F., offered odd-numbered years.
Prereq: CHEM 324
Basic principles of quantum mechanics, schrodinger equation. Hartree-Fock/molecular orbital theory, introduction to group theory, introduction to modern methods of computational chemistry; applications include molecular structure, potential energy surfaces and their relation to chemical reactions; molecular spectroscopy, photochemistry, solvent effects and surface chemistry.

CHEM 583: Chemical Group Theory
(1-0) Cr. 1. F.
Prereq: CHEM 324
Basic concepts and theorems, representation theory; point groups, molecular orbitals, molecular states, molecular vibrations, rotation group and angular momenta; space groups and crystals; permutation group, antisymmetry, and spin states.

CHEM 599: Nonthesis Research
Cr. arr.
Prereq: Permission of instructor concerned

Courses for graduate students:

CHEM 600: Seminar in Inorganic Chemistry
(1-0) Cr. 1. Repeatable, maximum of 3 times. F.S.
Prereq: Permission of instructor

CHEM 601: Selected Topics in Inorganic Chemistry
(2-0) Cr. 1-2. F.S.
Prereq: Permission of instructor
Topics such as molecular structure and bonding; organometallic compounds; physical techniques of structure determination; nonaqueous solutions; Zintl phases; transition-metal oxides; free-radical reactions; electron transfer reactions; metal-metal bonding; and bioinorganic chemistry of nucleic acids.

CHEM 611: Seminar in Analytical Chemistry
(1-0) Cr. 1. Repeatable. F.S.
Prereq: Permission of instructor

CHEM 619: Special Topics in Analytical Chemistry
(2-0) Cr. 1-2. Repeatable. F.S.
Prereq: Permission of instructor
Raman spectroscopy, sensors, spectroelectrochemistry, capillary electrophoresis, analytical plasmas, chemometrics and bioanalytical chemistry.

CHEM 631: Seminar in Organic Chemistry
(1-0) Cr. 1. Repeatable. F.S.
Prereq: Permission of instructor

CHEM 632: Selected Topics in Organic Chemistry
(2-0) Cr. 1-2. Repeatable. F.S.
Prereq: CHEM 537
Topics of current interest in organic chemistry such as spectroscopy, physical organic chemistry, photochemistry, organometallic chemistry, mechanisms of oxidations and reductions, modern organic synthesis, reactive intermediates, bioorganic chemistry, and polymers.

CHEM 660: Seminar in Physical Chemistry
(1-0) Cr. 1. Repeatable. S.
Prereq: Permission of instructor

CHEM 667: Special Topics in Physical Chemistry
(2-0) Cr. 1-2. F.S.
Prereq: Permission of instructor
Advanced and recent developments in physical chemistry are selected for each offering.

CHEM 699: Research
Cr. arr. Repeatable.
Prereq: Permission of instructor