Chemistry

http://www.und.edu/dept/chem/mainpage.html

FACULTY: H. Abrahamson (Chair), Chu, Delhommelle, Du, Hoffmann, Kozliak, Kubatova, Pierce, Smoliakova, Stahl, Thomasson (Graduate Director) and Zhao

Associate Members of the Graduate Faculty: J. Abrahamson

Degrees Granted: Master of Science (M.S.) and Doctor of Philosophy (Ph.D.)

The Department of Chemistry offers graduate programs leading to the degrees of Master of Science and Doctor of Philosophy with majors in inorganic chemistry, organic chemistry, physical chemistry, and analytical chemistry. The department offers a B.S./M.S. program (using the non-thesis M.S. option) for students who meet the admission criteria listed below.

Current areas of research specialization are synthetic and structural Organometallic Chemistry, Photochemistry, Theoretical Chemistry, Environmental Chemistry, Electroanalytical Chemistry, X-ray Crystallography, Synthetic Inorganic and Organic Chemistry, Optical Spectroscopy, Analytical Instrumentation, Inorganic Compounds for Materials Science, Carbohydrate Chemistry, Physical Biochemistry and Biocatalysis, Theoretical Biophysical Chemistry and Bionanotechnology.

Details pertaining to admission requirements, degree requirements and courses offered can be found in the Degree section.

Master of Science (M.S.)

Thesis Option

Mission Statement and Program Goals

The mission of the Department of Chemistry graduate M.S. program is to provide quality learning experiences in both hands-on laboratory research and classroom settings to post-baccalaureate students. These experiences will establish critical thinking and communication skills based on the theory, principles, and techniques of chemistry. Graduates will be prepared to become professional research chemists essential contributors technically competent to undertake any important task (under strategic guidance of a Ph.D. Chemist).

Goal 1: Learning Chemistry: Students will increase their knowledge of chemistry facts and relationships, both theoretical and practical, improve their logical and critical thinking skills, including the interpretation of experiments designed by Ph.D. chemists.

Goal 2: Communicating Chemistry: Students will learn to communicate effectively in writing and in oral presentations on technical topics.

Goal 3: Acting Professionally: Students will learn the most appropriate way to get a job done by acting ethically and professionally.

Combined Degree Bachelor of Science/ Master of Science (B.S./M.S.)

Non-Thesis Option

Mission Statement and Program Goals

The mission of the Department of Chemistry combined B.S./M.S. program is to provide quality learning experiences in classroom and hands-on laboratory research and classroom settings to post-baccalaureate students. These experiences will establish critical thinking based on the theory, principles, and techniques of chemistry. Graduates will be prepared to become professional chemist in a variety of situations.

Goal 1: Learning Chemistry: Students will increase their knowledge of chemistry facts, relationships, and laboratory skills, improve their critical thinking skills, and learn to work as professional chemists.

Goal 2. Acting Professionally: Students will learn the most appropriate way to get a job done by acting ethically and professionally.

Doctor of Philosophy (Ph.D.)

Mission Statement and Program Goals

The mission of the Department of Chemistry Ph.D. program is to provide quality learning experiences, primarily, in hands-on laboratory research and also in classroom settings to post-baccalaureate students. These experiences will establish independent critical thinking and professional communication skills based on the theory, principles, and techniques of chemistry. Graduates will be prepared to work as independent professional researchers in chemistry capable of contributing to the original literature.

Goal 1: Learning Chemistry: Students will increase their knowledge of chemistry facts and relationships, both theoretical and practical, significantly develop their logical and critical thinking skills, including the design and interpretation of experiments.

Goal 2: Communicating Chemistry: Students will learn to communicate effectively in writing and in oral presentations on technical topics.

Goal 3: Acting Professionally: Students will learn the most appropriate way to get a job done by acting ethically, professionally, and becoming an independent scholar.

Master of Science (M.S.)

Thesis Option

Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

1. A baccalaureate degree with a major in chemistry.
2. A cumulative Grade Point Average (GPA) of at least 2.75 for all undergraduate work or a GPA of at least 3.0 for the junior and senior years of undergrad work.
3. Undergraduate credit in mathematics through integral calculus.
4. One year of physics.
5. Graduate Record Examination General test for all students. (Chemistry subject test also required for all applicants without a baccalaureate degree in Chemistry.)
6. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog.

Degree Requirements

Students seeking the Master of Science (Thesis Option) Degree at the University of North Dakota must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Chemistry Department.

Thesis Option (32 credits total):

1. A minimum of 32 semester credits in a major field, including the credits granted for the thesis and the research leading to the thesis.
2. At least one-half of the credits must be at or above the 500-level.
3. A maximum of one-fourth of the credit hours required for the degree may be transferred from another institute.
4. Required Courses:
   a. CHEM 509 Graduate Seminar – 1 credit
   b. Six (6) credit hours from major sequence
   c. **Analytical**

Select two of the following:		6
CHEM 541	Analytical Spectroscopy	
CHEM 542	Electrochemical Methods	
CHEM 543	Chromatography	
Inorganic		
CHEM 510	Intermediate Inorganic Chemistry	3

Select one of the following:		3
CHEM 511	Advanced Inorganic Chemistry	
CHEM 512	Organometallic Chemistry	
Organic		
CHEM 520	Advanced Organic Chemistry I	3
Select one of the following:		3
CHEM 521	Advanced Organic Chemistry II	
CHEM 522	Advanced Organic Chemistry III	
Physical		
Select two of the following:		6
CHEM 530	Chemical Thermodynamics	
CHEM 531	Chemical Dynamics	
CHEM 532	Quantum Mechanics in Chemistry	

d. Six (6) credit hours of 500-level chemistry courses from two divisions other than the major.
e. Three (3) credit hours of additional elective coursework
f. CHEM 599 Research 10-12 credits
g. CHEM 998 Thesis 4-6 credits.

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Combined Degree Bachelor of Science/ Master of Science (B.S./M.S.)

Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

1. Completed the junior year (95 semester credits) in a Chemistry baccalaureate program with cumulative and chemistry GPAs of 3.0 or better in upper division courses in an American Chemical Society (ACS) certified program.+ International degrees will be evaluated for ACS certification equivalency.
2. One year general chemistry, one year organic chemistry, one semester analytical chemistry, and one semester physical chemistry.
3. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog.
4. International applicants who have received their bachelor's or master's degree in the United States or English-speaking Canada are not required to submit the TOEFL or IELTS.
5. At least one letter of recommendation must be from a chemistry faculty member.
6. + Students will be admitted to School of Graduate Studies upon completion of 125 credits.
   * Applicants being considered for Graduate Teaching Assistantships must achieve these minimum TOEFL scores, but have a minimum score of 26/30 on the Speaking subtest.

Degree Requirements

Students seeking the Bachelor of Science combined with the Master of Science (Non-Thesis Option) Degree at the University of North Dakota must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Chemistry Department.

Non-Thesis Option (32 credits total):

1. Twelve (12) credits of graduate chemistry from area of specialization. May include one 400-level course from the list below.*+
2. Nine (9) elective credits (may come from departments other than chemistry).+
3. One (1) credit of CHEM 509 Graduate Seminar or CHEM 488 Undergraduate Seminar (taken for graduate credit).
4. Eight (8) credits from either Co-op track or Research Track.
5. A maximum of one-fourth of the credit hours required for the degree may be transferred from another institution.
6. Two (2) credits of CHEM 997 Independent Study. Preparation of a written independent study and oral presentation of results to the advisor and interested faculty are required for successful completion of this course.
7. A written Comprehensive Examination in area of chemistry specialization will be taken while in residence. Students will be required to pass the nationally normalized ACS exam in their area of specialization at a proficient level.
8. Required Courses:
   a. One (1) CHEM 509 Graduate Seminar or CHEM 488 Undergraduate Seminar (taken for graduate credit)
   b. Two (2) credits of CHEM 997 Independent Study. Preparation of a written independent study and oral presentation of results to advisor and interested faculty are required for successful completion of this course.
   c. Eight (8) credit hours from either Co-op tract or Research Track
   d. **Co-op Track**

CHEM 537	Graduate Coopertive Education	6
CHEM 599	Research	2
Research Track		
CHEM 599	Research	8

   e. Twelve (12) credits of graduate chemistry from area of specialization. May include one 400-level course.
   f. **Analytical**

CHEM 541	Analytical Spectroscopy	3
CHEM 542	Electrochemical Methods	3
CHEM 543	Chromatography	3
CHEM 441	Instrumental Analysis I - Spectroscopy	2
CHEM 442	Instrumental Analysis II - Electrochemistry	2
CHEM 443	Instrumental Analysis III - Chromatography/Mass Spectrometry	2
Inorganic		
CHEM 510	Intermediate Inorganic Chemistry	3
CHEM 511	Advanced Inorganic Chemistry	3
CHEM 512	Organometallic Chemistry	3
CHEM 454	Inorganic Chemistry II	3
CHEM 455	Spectroscopy and Structure	3
CHEM 463	Advanced Synthesis Laboratory	3
Organic		
CHEM 520	Advanced Organic Chemistry I	3
CHEM 521	Advanced Organic Chemistry II	3
CHEM 522	Advanced Organic Chemistry III	3
CHEM 455	Spectroscopy and Structure	3
CHEM 463	Advanced Synthesis Laboratory	3
Physical		
CHEM 530	Chemical Thermodynamics	3
CHEM 531	Chemical Dynamics	3
CHEM 532	Quantum Mechanics in Chemistry	3
CHEM 470	Thermodynamics & Kinetics	3
CHEM 471	Quantum Mechanics & Spectroscopy	3

   g. Nine (9) elective credits (may come from departments other than chemistry).+
   h. * The following undergraduate courses are eligible for inclusion on graduate programs of study as long as they are NOT required for the B.S. degree. Additional assignments and higher standards of accomplishment are required of students taking these courses for graduate credit: CHEM 441 Instrumental Analysis I - Spectroscopy; CHEM 442 Instrumental Analysis II - Electrochemistry; CHEM 443 Instrumental Analysis III - Chromatography/Mass Spectrometry; CHEM 454 Inorganic Chemistry II; CHEM 455 Spectroscopy and Structure; CHEM 463 Advanced Synthesis Laboratory; CHEM 470 Thermodynamics & Kinetics; and CHEM 471 Quantum Mechanics & Spectroscopy. See the Undergraduate catalog for course descriptions.

+ Requires prior approval of student's committee.

Doctor of Philosophy (Ph.D.)

Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

1. A baccalaureate degree with a major in chemistry.
2. Undergraduate credit in mathematics through integral calculus.
3. One year of physics.
4. Graduate Record Examination General test for all students. (Chemistry subject test also required for all applicants without a baccalaureate degree in Chemistry).
5. Students with a bachelor's degree may be directly admitted into the Ph.D. program.
6. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog.

Degree Requirements

Students seeking the Doctor of Philosophy degree at the University of North Dakota must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Chemistry Department.

The degree of Doctor of Philosophy with a major in chemistry is a research degree and is conferred only in recognition of high achievement in independent scientific research and scholarship.

A candidate for the Ph.D. degree with a major in chemistry must complete a research problem in one of the four fields of chemistry. The scope of the doctoral dissertation will be such as to require the equivalent of at least one full-time academic year of research. Some doctoral research will require a substantially longer time. This research is expected to make a significant contribution to the candidate's chosen field of chemistry. When the major professor decides that the candidate has satisfactorily completed the research problem, the candidate, in accordance with the regulations of the University, is required to prepare a dissertation covering the research.

1. Completion of 90 semester credits beyond the baccalaureate degree
2. Maintenance of at least a 3.0 GPA for all classes completed as a graduate student.
3. Required Courses:
   a. Two (2) credits of CHEM 509 Graduate Seminar
   b. Nine (9) credits of 500-level courses from major sequence
   c.

Analytical		
CHEM 541	Analytical Spectroscopy	3
CHEM 542	Electrochemical Methods	3
CHEM 543	Chromatography	3
Inorganic		
CHEM 510	Intermediate Inorganic Chemistry	3
CHEM 511	Advanced Inorganic Chemistry	3
CHEM 512	Organometallic Chemistry	3
Organic		
CHEM 520	Advanced Organic Chemistry I	3
CHEM 521	Advanced Organic Chemistry II	3
CHEM 522	Advanced Organic Chemistry III	3
Physical		
CHEM 530	Chemical Thermodynamics	3
CHEM 531	Chemical Dynamics	3
CHEM 532	Quantum Mechanics in Chemistry	3

   d. Twelve (12) credits of elective courses (at least nine must be 500-level Chemistry courses; six of these nine must be taken in two divisions other than the major).
   e. CHEM 599 Research 55-57 credits
   f. CHEM 999 Dissertation 10-12 credits

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Courses

CHEM 508. Departmental Lecture. 1 Credit.
S/U grading.

CHEM 509. Graduate Seminar. 1 Credit.
Student presentation of a seminar based on current peer-reviewed literature.

CHEM 510. Intermediate Inorganic Chemistry. 3 Credits.
Review of atomic concepts, molecular topologies, and symmetry. Theories of bonding including directed and undirected atomic orbital view. An introduction to the chemistry of transition metals. Prerequisite: CHEM 454 or an equivalent approved by the department.

CHEM 511. Advanced Inorganic Chemistry. 3 Credits.
Structure of coordination compounds, mechanisms of inorganic reactions, biochemical applications of inorganic chemistry. Three hours lecture per week. Prerequisite: CHEM 510.

CHEM 512. Organometallic Chemistry. 3 Credits.
Preparation, bonding and reactivity of organometallic compounds, both main group and transition metal. Prerequisite: CHEM 454.

CHEM 519. Special Topics in Inorganic Chemistry. 1-3 Credits.
Topic of current interest to be considered each semester; may be repeated for credit if topic is different. Prerequisite: CHEM 510. Repeatable.

CHEM 520. Advanced Organic Chemistry I. 3 Credits.
Reaction mechanisms. Carbanions and radicals. Substitution, elimination and addition reactions. Carbonyl chemistry. Three hours lecture per week. Prerequisite: CHEM 352 or an equivalent approved by the department.

CHEM 521. Advanced Organic Chemistry II. 3 Credits.
Carbocations and carbenes. Oxidations and reductions. Alkylations. Carbonyl additions. Substitution and addition reactions. Three hours lecture per week. Prerequisite: CHEM 352 or an equivalent approved by the department.

CHEM 522. Advanced Organic Chemistry III. 3 Credits.
Photochemistry. Concerted reactions and cycloadditions. Aromatic and heterocyclic chemistry. Transition metals in organic chemistry. Three hours lecture per week. Prerequisite: CHEM 520 or CHEM 521.

CHEM 529. Special Topics in Organic Chemistry. 1-3 Credits.
Topic of current interest. May be repeated for credit if topic is different. Prerequisite: CHEM 520 or CHEM 521. Repeatable.

CHEM 530. Chemical Thermodynamics. 3 Credits.
Application of classical and statistical thermodynamics to chemical equilibrium, phase equilibrium and the physical properties of solutions. Three hours lecture. Prerequisite: CHEM 465 or an equivalent approved by the department.

CHEM 531. Chemical Dynamics. 3 Credits.
Study of the kinetics of complex, coupled chemical reactions in gas and solution phases; dynamics of gas phase reactions. Three hours lecture. Prerequisite: CHEM 465 or equivalent or consent of instructor.

CHEM 532. Quantum Mechanics in Chemistry. 3 Credits.
Application of the time-dependent Schroedinger equation to rotational, vibrational and magnetic spectroscopy; selection rules. Relation of molecular structural parameters and spectroscopic measurements; principles of group theory. 3 hours lecture. Prerequisite: CHEM 464 or an equivalent approved by the department.

CHEM 534. Quantum and Computational Chemistry. 3 Credits.
Study of the electronic structure of atoms and molecules using modern approximation methods; formal aspects of various perturbation and variational techniques as applied to chemical problems. 3 hours lecture. Prerequisite: CHEM 532.

CHEM 537. Graduate Coopertive Education. 1-9 Credits.
Practical experience of applying advanced concepts in chemistry. Experience will vary from student to student and must be coordinated with co-op host. Prerequisites: Permission of Department Chair is required, MS students must have minimum of 26 credits and PhD students must have a minimum of 52 credits.

CHEM 539. Special Topics in Physical Chemistry. 1-3 Credits.
Topic of current interest. May be repeated for credit if topic is different. Prerequisite: Consent of department. Repeatable.

CHEM 541. Analytical Spectroscopy. 3 Credits.
Fundamentals of analytical spectroscopy including principles of emission spectroscopy, flame photometry, atomic absorption, infrared and Raman spectroscopy, ultraviolet/visible spectroscopy, and fluorescence. 3 hours lecture. Prerequisite: CHEM 461 or an equivalent approved by the department.

CHEM 542. Electrochemical Methods. 3 Credits.
Topics ranging from the fundamentals of electrochemistry (including thermodynamics, kinetics, and mass transfer) to applications of contemporary electroanalytical techniques such as cyclic voltammetry, digital simulation, and spectroelectrochemistry are discussed. Three hours lecture. Prerequisite: CHEM 461 or an equivalent approved by the department.

CHEM 543. Chromatography. 3 Credits.
Fundamentals of modern chromatographic techniques including principles of band broadening, gas chromatography, liquid chromatography, and representative sampling problems. Three hours lecture. Prerequisite: CHEM 461 or an equivalent approved by the department.

CHEM 549. Special Topics in Analytical Chemistry. 1-3 Credits.
Topic of current interest to be considered each semester; may be repeated for credit if topic is different. Prerequisite: CHEM 540. Repeatable.

CHEM 561A. Foundations of Chemistry for Teacher Development. 3 Credits.
Second of a chemistry course sequence intended for: a) teachers planning to qualify to teach high school chemistry; or b) teachers looking to enrich their content knowledge in chemistry for professional development. Topics include elementary principles and theories of chemistry, matter, measurement, atoms, ions, molecules, reactions, chemical calculations, thermochemistry, bonding, molecular geometry, periodicity, gases. May not be used in Ph.D. or Master's programs.

CHEM 561B. Foundations of Chemistry for Teacher Development. 3 Credits.
Continuation of CHEM 561A. Prerequisite: CHEM 561A. On demand.

CHEM 561L. Introduction to Guided Learning in Chemistry. 2 Credits.
First of a chemistry course sequence intended for: a) teachers planning to qualify to teach high school chemistry; or b) teachers looking to enrich their content knowledge in chemistry for professional development. Topics include: chemical nomenclature and structure; periodicity; aqueous reactions; chemical stoichiometry; ionic and covalent bonding; solutions; thermochemistry; gases, liquids and solids; and pedagogical issues. May not be used in Ph.D. or Master's programs.

CHEM 562A. Intermediate Chemistry for Teacher Development. 3 Credits.
Fourth of a chemistry course sequence intended for: a) teachers planning to qualify to teach high school chemistry; or b) teachers looking to enrich their content knowledge in chemistry for professional development. Topics include: Equilibrium and kinetic principles of chemistry; behavior of solutions; rates of reactions; thermodynamics; aqueous equilibria (acid/base, solubility); electrochemical cells; chemical behavior of main-group elements; nuclear chemistry. May not be used in Ph.D. or Master's programs. Prerequisite: CHEM 562L.

CHEM 562B. Intermediate Chemistry for Teacher Development. 3 Credits.
Continuation of CHEM 562A. Prerequisite: CHEM 562A.

CHEM 562L. Intermediate Guided Inquiry Learning in Chemistry. 2 Credits.
Third of a chemistry course sequence intended for: a) teachers planning to qualify to teach high school chemistry; or b) teachers looking to enrich their content knowledge in chemistry for professional development. Topics include: colligative properties; chemical kinetics and equilibrium; acid/base chemistry; thermodynamics; electrochemistry; and pedagogical issues. May not be used in Ph.D. or Master's programs. Prerequisites: CHEM 561L and CHEM 561B.

CHEM 563A. Organic and Biochemistry for Teacher Development. 3 Credits.
Sixth of a chemistry course sequence intended for: a) teachers planning to qualify to teach high school chemistry; or b) teachers looking to enrich their content knowledge in chemistry for professional development. Topics include: hydrocarbons; alcohols; amines; aldehydes and ketones; carboxylic acids and their derivatives; proteins; carbohydrates, lipids; nucleic acids, enzymes; generation of biochemical energy; and pedagogical issues. May not be used in Ph.D. or Master's programs. Prerequisite: CHEM 563L.

CHEM 563B. Organic and Biochemistry for Teacher Development. 3 Credits.
Continuation of CHEM 563A. Prerequisite: CHEM 563A.

CHEM 563L. Guided Inquiry Learning in Organic and Biochemistry. 2 Credits.
Fifth of a chemistry course sequence intended for: a) teachers planning to qualify to teach high school chemistry; or b) teachers looking to enrich their content knowledge in chemistry for professional development. Topics include: hydrocarbons; alcohols; amines; aldehydes and ketones; carboxylic acids and their derivatives; proteins; carbohydrates, lipids; nucleic acids, enzymes; and pedagogical issues. May not be used in Ph.D. or Master's programs. Prerequisites: CHEM 562L and CHEM 562B.

CHEM 599. Research. 1-15 Credits.
Maximum of 15 credits each semester. May be repeated for credit. Repeatable.

CHEM 996. Continuing Enrollment. 1-12 Credits.
Repeatable. S/U grading.

CHEM 997. Independent Study. 2 Credits.

CHEM 998. Thesis. 1-9 Credits.
Repeatable to 9 credits.

CHEM 999. Dissertation. 1-18 Credits.
Repeatable to 18 credits.

Undergraduate Courses for Graduate Credit

CHEM 471. Quantum Mechanics & Spectroscopy. 3 Credits.
Theory and nature of bonding and structure, spectroscopy, and optics. Prerequisites: CHEM 466, MATH 265, and PHYS 252. S.