CHEMISTRY PH.D.

All students must meet the Requirements for the Doctor of Philosophy Degree

OVERVIEW

A Ph.D. degree in chemistry prepares students for careers in chemical sciences and related disciplines including biomedical sciences, biotechnology, catalysis, energy, environment, materials science, or nanotechnology. Individuals having earned a Ph.D. in chemistry at UVM have gone on to careers in academics, the chemical industry, and national research laboratories. Graduate study at UVM is research intensive, and a description of research by chemical subdivision follows.

Analytical chemistry involves developing and applying instrumentation and chemical methods to solve problems across a range of chemistries and scientific disciplines. The department currently has 3 research foci: 1) development of innovative methods and instruments to study the formation and chemistry of organic aerosols in the atmosphere. This work bridges the gap between analytical chemistry and atmospheric science, contributing to the understanding of the impact of aerosols on global climate through direct scattering of solar radiation and the formation of ice and water clouds; 2) developing new chemical imaging methods to study biological processes. This work will enable direct imaging of the structural dynamics and interactions of biomolecules and lead to new insights into protein folding dynamics in cells, understanding the molecular origins of neurodegenerative diseases, and aide in the rational design of new nanoparticle drug delivery vehicles; and, 3) development of a suite of electrochemical sensors and sampling/separation techniques to make quantitative measurements of various neurochemicals in the brain. This work will enable elucidate underlying mechanisms of various neuropsychiatric (i.e. PTSD, depression, etc.) and neurodevelopmental disorders (i.e. autism spectrum) to reveal more efficacious treatments.

Biological chemistry is an interdisciplinary area that incorporates organic, analytical, physical, and inorganic chemistry into biological research and has several focus areas. One focus area integrates physical chemistry with biochemistry and utilizes single molecule fluorescence microscopy to investigate how DNA repair enzymes recognize oxidatively damaged DNA bases. A second focus area is the study of antioxidant enzymes, peptides, nucleic acid, and vitamin-like small molecules that contain sulfur and selenium. Here the tools of organic, physical, and analytical chemistry are used for synthesis, characterization, and determination of the mechanism of action of both small molecules and macromolecules. Several other bioanalytical, bioinorganic, bioorganic, and biophysical research opportunities exist within the program as noted above and below.

Inorganic chemistry at UVM involves the study of main-group elements and transition metals in a variety of contexts, with applications in catalysis, energy, environment, and medicine. One example is the synthesis and characterization of inorganic particles, which can be functionalized for broad applications in heterogeneous catalysis, targeted drug delivery, and biological imaging. A second focus area employs biochemical, spectroscopic, and computational tools to elucidate and manipulate the enzymatic mechanisms of metalloproteins. Finally, a third example is the design of metal-based catalysts for chemical bond formation, which can be applied to the preparation of useful small molecules and novel polymeric materials.

Current research in organic chemistry includes the development of novel synthetic methodologies to prepare oxygen- and nitrogen-containing heterocyclic compounds, new ring fragmentation reactions and their applications in synthesis, development of efficient and stereoselective tandem/cascade reaction sequences, natural products, mechanistic studies of organic chemical reactions, development of 1,3-diaza-Claisen rearrangements and applications toward the synthesis of guanidine-containing natural products, and studies in bioorganic chemistry. Additional projects involve the methodological development of syntheses for π-conjugated small molecules, molecular cages, non-planar aromatics, and polymeric systems as functional materials with applications ranging from mesoscale synthesis to renewable energy harvesting and storage.

Physical chemistry research areas include two major areas of focus. The first area is the development of multiscale modeling approaches to understand complex chemical systems, with the aims of elucidating the critical structure-mechanism-function relationships of chemical and biological compounds and providing rational guides to help drug discovery and materials design. The second area is the use of low-frequency vibrational spectroscopies, combined with quantum mechanical calculations, to understand how collective atomic motions are related to bulk material properties, with the aim of harnessing these vibrations to selectively drive processes related to mechanochemistry of energy storage materials, pharmaceutical stability, biomolecular function, and semiconducting potential.

SPECIFIC REQUIREMENTS

Requirements for Admission to Graduate Studies for the Degree of Doctor of Philosophy

An undergraduate major in an appropriate field, minimally with course work in the 4 classic subdisciplines of chemistry (analytical, inorganic, organic, and physical). This is most commonly satisfied with a B.A., B.S., or equivalent degree in chemistry. Applicants with prior research experience are preferred.

Minimum Degree Requirements

Requirement Description		Credits
CHEM 6010	Intro to Graduate Research	1
CHEM 6020	Grad Seminar	1
CHEM 7010	Research Problem Conception	1
CHEM 7015	Research Problem Solution	1

Current Topics in Chemistry (CHEM 6050) must be taken at least 3 times	3-5
Between 20 and 45 credits hours of Doctoral Dissertation Research (CHEM 7491)	20-45
Demonstration of basic competence in four fields of chemistry (analytical, inorganic, organic, and physical) through the biannual qualifying examinations or completion of prescribed courses at the University of Vermont	
1 year of teaching	
1 year of residence	
At least 18 credits of formal course work including:	
9 credits of graduate level courses in the chemical field of specialization	
9-12 credits of graduate-level chemistry courses not in the area of specialization	
Maintenance of an overall grade point average of 3.00	

Comprehensive Examination

In the Chemistry Department, the Comprehensive Examination for the Doctorate degree consists of completion of the following three parts:

(1) Passing of the (entrance) qualifying-examinations requirement within the first year, and successful completion of the coursework requirement. The qualifying examinations establish a broad knowledge base in all major areas of chemistry, while the latter requirement is constructed to add breadth to the students' knowledge base in specific areas of chemistry not directly related to their research area.

(2) Successful completion of the Advancement to Candidacy exam.

(3) Completion of a total of 3 credits of Current Topics (CHEM 6050). This course consists of a review of one major article from the current literature (and supporting supplementary articles). The oral presentation is followed by an examination of the student's understanding of the crucial information in that paper by faculty in the student's major area.

Requirements for Advancement to Candidacy for the Degree of Doctor of Philosophy

It is expected that a student will ordinarily complete the following requirements for admission to candidacy by the end of the second year of residence:

Requirement Description		Credits
CHEM 6010	Intro to Graduate Research	1
CHEM 6015	Chemical Investigations	1
CHEM 6020	Grad Seminar	1

Current Topics in Chemistry (CHEM 6050) must be taken 3 times	3
Demonstration of basic competence in 4 fields of chemistry (analytical, inorganic, organic, and physical) through the biannual qualifying examinations or completion of prescribed courses at the University of Vermont	
1 year of teaching	
1 year of residence	
At least 18 credits of formal course work (at least 9 of which must be at the 6000-level) including:	18
9 credits of graduate-level courses in the chemical field of specialization	
9 credits of graduate-level chemistry courses not in the area of specialization	
Maintenance of an overall GPA of 3.00	