CHEMISTRY, DOCTOR OF PHILOSOPHY (Ph.D.)

Program goal
The Department of Chemistry is committed to the dual mission of teaching and research at the bachelor’s, master’s and doctoral level. In teaching, the purpose is to provide high quality education in chemistry to students in preparation for professional careers at all levels. In research, the goals are to advance the science of chemistry, to keep faculty on the forefront of the field and to maintain an educational program consistent with the latest technology and development of the discipline. Service to the chemical profession is also an important aspect of the department’s activities.

Student learning outcomes
1. Demonstrate expertise (breadth and depth) in chemistry
2. Demonstrate appropriate ability to design and conduct experimental research
3. Demonstrate ability to analyze data critically and to design experiments independently
4. Develop competency in the responsible conduct of research
5. Develop effective oral and written communication skills

VCU Graduate Bulletin, VCU Graduate School and general academic policies and regulations for all graduate students in all graduate programs

The VCU Graduate Bulletin website documents the official admission and academic rules and regulations that govern graduate education for all graduate programs at the university. These policies are established by the graduate faculty of the university through their elected representatives to the University Graduate Council.

It is the responsibility of all graduate students, both on- and off-campus, to be familiar with the VCU Graduate Bulletin as well as the Graduate School website (http://www.graduate.vcu.edu) and academic regulations in individual school and department publications and on program websites. However, in all cases, the official policies and procedures of the University Graduate Council, as published on the VCU Graduate Bulletin and Graduate School websites, take precedence over individual program policies and guidelines.

Visit the academic regulations section for additional information on academic regulations for graduate students. (http://bulletin.vcu.edu/academic-reggs)

Degree candidacy requirements
A graduate student admitted to a program or concentration requiring a final research project, work of art, thesis or dissertation, must qualify for continuing master’s or doctoral status according to the degree candidacy requirements of the student’s graduate program. Admission to degree candidacy, if applicable, is a formal statement by the graduate student’s faculty regarding the student’s academic achievements and the student’s readiness to proceed to the final research phase of the degree program.

Graduate students and program directors should refer to the following degree candidacy policy as published in the VCU Graduate Bulletin for complete information and instructions.

Visit the academic regulations section for additional information on degree candidacy requirements. (http://bulletin.vcu.edu/academic-reggs/grad/candidacy)

Graduation requirements
As graduate students approach the end of their academic programs and the final semester of matriculation, they must make formal application to graduate. No degrees will be conferred until the application to graduate has been finalized.

Graduate students and program directors should refer to the following graduation requirements as published in the Graduate Bulletin for a complete list of instructions and a graduation checklist.

Visit the academic regulations section for additional information on graduation requirements. (http://bulletin.vcu.edu/academic-reggs/grad/graduation-info)

Other information
The Department of Chemistry graduate handbook is available at chemistry.vcu.edu/graduate-programs/graduate-handbook. Apply online at graduate.admissions.vcu.edu (http://www.graduate.admissions.vcu.edu).

Admission requirements

<table>
<thead>
<tr>
<th>Degree</th>
<th>Semester(s) of entry</th>
<th>Deadline dates:</th>
<th>Test requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph.D.</td>
<td>Fall</td>
<td>Mar 15</td>
<td>GRE-General</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Nov 15</td>
<td></td>
</tr>
</tbody>
</table>

In addition to the general admission requirements of the VCU Graduate School (http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements), the following requirements represent the minimum acceptable standards for admission:

1. Have a bachelor’s degree from an accredited college or university with 30 credit hours in chemistry.
2. Admission on a provisional basis is possible for a student temporarily lacking this expected chemistry background.

Degree requirements

In addition to general VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-reggs/grad/graduation-info), students are required to complete course work in core and elective courses and to conduct significant research.

1. Credit hour requirements: Students in the Ph.D. in Chemistry program are required to earn a minimum of 60 graduate-level credit hours beyond the baccalaureate. At least one-half of the credit hours presented for graduation must be at the 600 level or higher.
2. Proficiency exams: Students must demonstrate competency in analytical, inorganic, organic and physical chemistry by satisfactory performance on the proficiency exams or with a minimum grade of B in the appropriate course. These examinations are at the level of sound undergraduate courses and are offered preceding the start.
of the school's fall and spring semesters. These tests are used to evaluate the student's strengths and weaknesses, and the student's program is planned accordingly.

3. Doctoral candidacy: The student is required to complete written and oral examinations in his/her major field to become a doctoral candidate. The written examinations consist of a series of cumulative exams based on the chemistry literature. The oral examination includes the presentation and defense of the proposed dissertation research.

4. Dissertation: Students must conduct a substantial original investigation under the supervision of their adviser. Students who wish to include a chemical education component in their research will choose two advisers, one in the cognate area, and one in the area of chemical education. All formal requirements for the degree are otherwise the same as for any doctoral student. Students must prepare dissertations reporting the results of the research and analyzing its significance in relation to existing scientific knowledge. An oral defense of the dissertation will be held. Full-time students should complete the degree requirements in four to five years.

## Curriculum requirements

### Required didactic courses

Select three core courses of the following four areas: analytical, inorganic, organic and physical.

- **CHEM 504**: Advanced Organic Chemistry I
- **CHEM 510** or **CHEM 511**: Atomic and Molecular Structure
- **CHEM 620**: Advanced Inorganic Chemistry I
- **CHEM 63xx** or **ENGR 691**: (courses in analytical area)

Course completed twice:

- **CHEM 698**: Investigations in Current Chemistry Literature (0.5 credit hour)

Select eight credit hours of the following recommended electives, in consultation with adviser:

- **BIOM 500-level** (except BIOM 505, BIOM 506 and BIOM 507)
- **BIOM 530**: Biochemistry, Cell and Molecular Biology Module 1: Protein Structure and Function
- **BIOM 531**: Biochemistry, Cell and Molecular Biology Module 2: Basic Metabolism
- **BIOM 532**: Biochemistry, Cell and Molecular Biology Module 3: Central Dogma of Molecular Biology
- **BIOM 533**: Biochemistry, Cell and Molecular Biology Module 4: Lipids/Membranes and Bioenergetics
- **BIOM 602**: Physical Properties of Macromolecules
- **BIOS 543** or **STAT 543**: Graduate Research Methods I or Statistical Methods I
- **BIOS 544** or **STAT 544**: Graduate Research Methods II or Statistical Methods II
- **CHEM 601**: Chemical Biology I
- **CHEM 602**: Chemical Biology II
- **CHEM 500-level**
- **CHEM 600-level**
- **CHEM 610**: Applied Quantum Chemistry
- **CHEM 611**: Molecular Spectroscopy
- **CHEM 612**: Modern Statistical Mechanics: Fundamentals and Applications
- **CHEM 615**: Chemical Thermodynamics
- **CHEM 616**: Chemical Kinetics
- **CHEM 620**: Advanced Inorganic Chemistry I
- **CHEM 621**: Advanced Inorganic Chemistry II
- **CHEM 630**: Electroanalytical Chemistry
- **CHEM 631**: Separation Science
- **CHEM 632**: Chemometrics
- **CHEM 633**: Mass Spectrometry
- **CHEM 634**: Surface Science
- **CHEM 635**: Spectrochemical Analysis
- **CHEM 691**: Topics in Chemistry
- **CHEM 698**: Investigations in Current Chemistry Literature
- **ENGR 591**: Special Topics in Engineering
- **ENGR 691**: Special Topics in Engineering
- **MEDC 541**: Survey of Molecular Modeling Methods
- **MEDC 609**: Advanced Organic Synthesis: A Target-oriented Approach
- **MEDC 670**: Advanced Molecular Modeling Theory and Practice
- **NANO 570**: Nanoscale Physics
- **NANO 571**: Nanoscale Chemistry
- **NANO 650**: Experimental Techniques in Nanoscience I
- **NANO 651**: Experimental Techniques in Nanoscience II
- **NANO 660**: Theoretical Studies of Nanostructures
- **NANO 661**: Computational Nanoscience
- **PHYS 550**: Techniques in Material Research
- **PHYS 573**: Analytical Methods in Physics
- **PHYS 576**: Electromagnetic Theory
- **PHYS 580**: Quantum Mechanics
- **PHYS 591**: Topics in Physics
- **PHYS 661**: Surface and Materials Physics
- **PHYS 691**: Special Topics

### Other required courses

- **CHEM 690**: Research Seminar in Chemistry
- **CHEM 692**: Chemistry Seminar Presentation
- **CHEM 693**: Chemistry Perspectives and Ethics
- **CHEM 697**: Directed Research

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1. Students must earn a minimum of 18 credit hours in eight didactic graduate courses, not including credit for CHEM 690, CHEM 692, CHEM 693 or CHEM 697.
2. One of these courses may be waived upon satisfactory proficiency exam scores. The number of required credit hours for the degree does not change.
3. The ENGR 691 topics course must be materials characterization.
4. In some cases, students may be required to enroll in both CHEM 510 and CHEM 511 because of proficiency exam scores.
Students are expected to enroll in CHEM 698 (.05 credit hour) twice during their graduate studies, including the semester preceding their literature seminar presentation (CHEM 692). Note: A maximum of two credit hours of CHEM 698 may be presented toward the didactic course graduation requirements to count as one course.

Students are expected to participate in the department's seminar program by enrolling in CHEM 690 or CHEM 692 every spring and fall semester. At least two formal talks are to be presented in the seminar program by enrolling twice in CHEM 692 (one credit hour).

Students are expected to enroll in CHEM 693 within the first year of study.

Students must enroll in CHEM 697 (one credit hour minimum) every spring and fall semester for a minimum of 30 total credit hours. If the required minimum of 60 credit hours for the degree is not fulfilled after completion of all other course requirements, then additional credit hours of CHEM 697 may satisfy remaining credit hours for the degree.

**Total graduate credit hours required (minimum) 60**

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