

# Ph.D. REQUIREMENTS FOR CHEMISTRY GRADUATE STUDENTS

## *Department of Chemistry Graduate Education Mission*

The Department of Chemistry programs strive to achieve excellence in breadth of chemistry knowledge, critical analysis of the literature, and original, creative, and independent thinking. This document serves as a supplement to the general requirements for the graduate degree at the University of Vermont, as defined by the Graduate College (<http://www.uvm.edu/~gradcoll/>). The goal for Ph.D. students is to develop mastery of one's research area as well as a comprehensive understanding of all areas in chemistry.

## *Graduate Student Ethics*

Graduate students are required to conduct themselves in an ethical and professional manner. This includes treating fellow students, faculty, staff, and undergraduates with due respect and courtesy at all times. Ethical academic standards are defined by the University of Vermont (UVM; <http://www.uvm.edu/~uvmppg/ppg/student/acadintegrity.pdf>), and contravention of these standards with regard to falsification of data, plagiarism, or misconduct in examinations and/or research will result in disciplinary action and possible dismissal from the Graduate program.

## *The Ph.D. Program in Chemistry: From Admission to Graduation*

### *I. Qualifying Exams*

Prior to registration, new graduate students in chemistry are given the American Chemical Society (ACS) standard examinations in analytical, inorganic, organic, and physical chemistry for qualifying purposes. A passing score for any exam is 50th percentile. The level of each of these examinations is essentially that of the final exam in a good undergraduate course in analytical, inorganic, organic and physical chemistry. The results of these multiple-choice examinations, the extent of undergraduate course work, and specific interests are used to determine a student's initial academic program.

Should a student not earn a passing grade on an exam, there are two mechanisms to rectify the deficiency: 1) Take (or audit, as appropriate) a recommended course in that discipline and receive a grade of B- or better or, 2) re-take the failed ACS exam and receive a passing grade. The generally recommended courses are:

Analytical:	CHEM 221
Inorganic:	CHEM 231
Organic:	CHEM 241
Physical:	CHEM 161 or 162 (audit only, not for graduate credit)

If the student enrolls in the recommended course during the first semester and does not earn at least a grade of B-, the failed qualifying exam must be re-taken and passed by the end of the second semester. If the recommended course is offered only during the second semester (CHEM 221, for example), the student may opt to re-take the qualifying exam at any time before the third semester. A given qualifying exam is only re-administered once per student. **A student must pass all qualifying requirements before the start of the third semester in order to continue**

**in the Ph.D. program.** (Note: Students entering the program in the spring semester are granted a one-semester extension of this rule).

## ***II. Course Requirements***

### Graduate College Requirements

The Graduate College requires that a minimum of 15 *graded* credits (i.e., credits contributing to the GPA) be obtained for *any* advanced degree. These credits must be for courses at the 200-level or above and must be accumulated as *a graduate student in residence at UVM*. A total of 75 hours (graded + ungraded) are required for the Ph.D. degree, most of which are accumulated as research credits under CHEM 491 (Doctoral Dissertation Research). A full-time graduate student will generally register for a *total* of 10 credit hours per semester. *Following completion of all credit requirements (i.e., 75 credits), students should enroll for Continuing Registration (GRAD 900).*

### Chemistry Department Requirements

Ph.D. students are required to take a minimum of three core courses within their area of chemistry specialization (division). In addition, Ph.D. students must meet a distribution requirement by taking a minimum of one course of advanced level work in *each of 2 areas outside of their division*. Note that only one of these distribution courses may be for fewer than 3 credits. Thus, the minimum course load for a Ph.D. student is five graduate courses. The Department of Chemistry requires that Ph.D. students maintain a minimum GPA of 3.25.

### Core Courses (by division)

Each division requires students to take specific upper-level graduate courses in their area of specialization, as detailed below. A grade of B- or better must be obtained for the course to satisfy the core course requirement.

<u>Division</u>	<u>Ph.D. Requirements</u>
Analytical	CHEM 221 and <i>two</i> of the following: CHEM 223, 225 or 226
Inorganic	CHEM 231, 234 and 236
Organic	CHEM 241, CHEM 242 or 251, and <i>one</i> approved 200- or 300-level course
Physical	CHEM 262, 264 and <i>one</i> approved 200- or 300-level course

If a specific required course is not offered during the student's stay at UVM, then an appropriate substitute course must be arranged by the student in consultation with the division faculty members, subject to approval by the Graduate Standards Committee.

### Approved Distribution Courses

Students are required to take graduate-level chemistry courses in areas outside of their chosen division so as to ensure a broad knowledge of chemistry commensurate with a Ph.D. degree. The courses listed below currently satisfy the distribution requirements. A student must earn a B- or better for a course to satisfy the distribution requirement.

<i>Analytical</i>	CHEM 221, 223, 225, 226, 227, 228
<i>Inorganic</i>	CHEM 231, 234, 236, 237, 238
<i>Organic</i>	CHEM 241, 242, 251, 257, 258
<i>Physical</i>	CHEM 262, 264, 267, 268
<i>Related Science</i>	BIOC 301 or 302, CHEM 205, 206, 214

Graduate courses offered outside the Department may also be counted towards the 75 credit hours required for the Ph.D. degree and are often desirable in areas that are interdisciplinary in nature (e.g., medicinal chemistry, solid state chemistry, chemical physics, etc.). The exact program of courses should be determined in consultation with the student's research advisor and Graduate Studies Committee (Section III).

### **III. The First Year**

#### **Choosing a Research Advisor**

In the fall semester (typically in early October), each faculty member gives a short presentation describing their research interests, attended by all new graduate students. Using this information to narrow their research options, students meet individually with faculty members with whom they have common interests. Students are strongly encouraged to discuss research with several members of the chemistry faculty and to not restrict themselves to one area or group. Students need to submit a *written* letter or *e-mail* indicating their 1<sup>st</sup> and 2<sup>nd</sup> choice of research advisor to the Department Chair *before the end of the fall semester*. Students entering in the spring semester should choose their research advisor before the end of the spring semester.

A student's interests may straddle the research of two faculty members. For this reason, a student may develop a joint research project with two research advisors. A student may select a research advisor who is a faculty member in a division other than that in which they propose to take their major coursework.

#### **Graduate Studies Committee**

A multidisciplinary Graduate Studies Committee is formed to provide oversight for the student's progress toward an advanced degree. The members of the Graduate Studies Committee are assembled during the second semester of the student's first year. The Graduate Studies Committee will form the nucleus of the student's annual review, research proposal, and

dissertation defense committees. This committee should be chosen in consultation with the student's research advisor and *shall consist of the research advisor and two additional Chemistry faculty members*, one of whom must be outside of the student's division. The Graduate Standards Committee, a departmental committee that monitors the progress of all graduate students, must be notified *in writing* of the composition of the student's Graduate Studies Committee, once established.

The three-member Graduate Studies Committee is sufficient to provide oversight and academic advising for students. However, the Graduate College requires that a faculty member who does not have an appointment in chemistry serve as chair of a student's Dissertation Committee. It is suggested that the student select this 'outside member' when the Graduate Studies Committee is formed. If desired, a graduate student may add an extra faculty member to their Graduate Studies Committee and/or their Dissertation Defense Committee at a later time.

The Graduate Studies Committee is specifically charged with evaluating the student's annual progress through the program. However, the Graduate Studies Committee is a research and educational resource, serving as an "extended research advisor," and not a judicial body. The members of a student's Graduate Studies Committee are available for consultation regarding research, academic, or other matters relevant to graduate education.

### ***CHEM 318 – Current Topics in Chemistry (spring)***

Following the current chemical literature is an essential component to gaining a deeper understanding of chemistry and for success in research. Beginning in the *spring* semester of the first year, all graduate students will register for CHEM 318 (0-1 credit). This course is a "journal club:" Students and faculty in the division will meet for a semiformal presentation by one of the students on a current article in the literature, followed by informal discussion of that topic. Not every student will present in a given semester, but all students are required to attend and are expected to contribute to the discussion. Students who present in a given semester register for one credit, and those who do not present register for zero credits. The presentations will typically consist of the review of one major article from the literature and supporting supplementary articles. The specific details, such as scheduling and criteria for presentations, are determined by each division, and these details can be found in the course syllabus. An additional requirement for this course is attendance at *all* Departmental Seminars. Students will be given a grade of either Satisfactory (S) or unsatisfactory (U) for the 'Current Topics' course. Note: completion of three (3) credits of CHEM 318, or three presentations, is required by the end of the seventh semester.

### ***CHEM 380 – Chemical Investigations***

In the spring semester of the first year, all students will register for CHEM 380, Chemical Investigations (1 credit). CHEM 380 serves as the student's first Annual Report and is the first checkpoint towards an advanced degree. For CHEM 380, each student presents a brief (4–5 page) report to their Graduate Studies Committee, introducing their proposed project and the initial results obtained in the laboratory. The first Annual Report will include relevant background from the literature, a statement of the relevance of the proposed research, preliminary results, and a general plan for continued research. Submission of this report to the members of the Graduate Studies Committee will be followed by a brief presentation (~20–30 minutes) and a discussion period. The discussion will serve to probe the student's general

knowledge of the research area, and may pose questions that can be addressed in the student's second-year dossier.

The first Annual Report serves as a mechanism for ensuring that the student is in a strong position to obtain significant research results and has embarked on an academic trajectory that will lead to an advanced degree. The presentation is a forum for the student to keep their Graduate Studies Committee informed about their research. As such, the report and presentation should survey the relevant literature but, more importantly, it should give the basic rationale and importance of the work, the specific goals of the project, the methodologies to be employed, and the experimental progress to date. The audience will include, at a minimum, the students and faculty in that student's division, members of the student's Graduate Studies Committee, and other interested people.

Reports are due by the end of the first week of June and presentations are typically given during the following week. The Graduate Studies Committee provides a written evaluation of the annual report and presentation, as well as the student's first-year progress, to the Chair of the Chemistry Graduate Standards Committee.

#### ***IV. The Second Year***

##### ***CHEM 318 – Current Topics in Chemistry (fall and spring)***

All students will continue to enroll in the 'Current Topics' course relevant to his or her division.

##### ***CHEM 381 – Graduate Seminar***

In the fall semester of the second year, all graduate students register for CHEM 381 (1 credit) and present a topical seminar, outside of their principal area of research, to the Department. A topic for a seminar from the chemical literature is chosen by the student in consultation with the CHEM 381 instructor.

While this is an important presentation, students typically spend no more than three weeks in preparation. At the start of the semester, the course instructor will determine a schedule for when the seminars will be presented. A 300-word abstract with annotated bibliography (~10–15 references from refereed journals) is to be distributed to the faculty *at least one week in advance of the presentation to the Department*. The seminar will be graded on a scale of A, B, C or F. A grade of "F" on any seminar will require that it be repeated no later than the following semester. The topic of a repeat seminar will be chosen in consultation with the seminar instructor. Other details of the course can be found in the course syllabus. Students enrolled in both CHEM 381 and 318 will not be required to give a presentation for their 'Current Topics' course, however they must still attend department seminars and contribute to divisional presentations in order to receive a grade of 'Satisfactory' in the 'Current Topics' course.

##### ***CHEM 484 – Advanced Topics in Chemistry – Advancement to Candidacy***

In the spring semester of the second year, Ph.D. students must enroll in CHEM 484 (2 credits) to advance to Ph.D. candidacy. The process of advancement to candidacy provides a student with the opportunity to demonstrate the comprehensive, fundamental knowledge, in the context of

their research, needed to pursue a Ph.D. degree. The process of advancement starts with the preparation of a dossier consisting of an extensive introduction to the dissertation, a detailed record of research progress, and future directions. This culminates in the Advancement to Candidacy Examination: a short (10-15 minute) presentation followed by a comprehensive oral examination. The dossier should be approximately 15 pages in length, and should address key background literature, experimental protocols, results, and expected directions. By this time, the student should have a detailed understanding of the key experiments to be performed and the fundamental questions to be addressed in the dissertation. Although the dossier is similar to the first annual report, it is more comprehensive and should demonstrate a student's aptitude for pursuing Ph.D.-level research.

The Advancement to Candidacy Examination will assess general knowledge in all areas of chemistry with a focus on the student's division. While the advisor may give minimal assistance during a student's preparation for the Advancement Exam, they will serve principally as an observer during the presentation and oral examination. The candidate is graded, based on the dossier and examination, on the following scale: A (recommend promotion to Ph.D. candidacy), B+ (recommend promotion to Ph.D. candidacy with additional requirements), B (recommend switch to M.S. program), B- (recommend switch to the M.S. program with additional requirements) or C (recommend dismissal from the program). The dossier and Advancement Exam must be completed before the beginning of the fall semester of the 3<sup>rd</sup> year.

The Advancement to Candidacy Exam is part of a comprehensive two-year review by the Graduate Standards Committee which, in consultation with the student's Graduate Studies Committee, makes the final recommendation on Ph.D. candidacy. The evaluation will take into consideration the student's placement results, coursework, graduate seminar, and research progress. Based on this evaluation, the Graduate Standards Committee will recommend that the student either be: (1) accepted into the Ph.D. program, (2) accepted into the Ph.D. program pending successful completion of additional requirements as specified by the Committee, (3) asked to complete a Master's degree or, (4) dismissed from the graduate program. The Graduate Standards Committee will notify the student's Graduate Studies Committee, in writing, of the results of their review. Recommendation for dismissal is rare and is only made following discussion by and vote of the entire chemistry faculty.

*Following completion of all credit requirements (i.e., 75 credits), students should enroll for Continuing Registration (GRAD 900).*

### **Time Limits for the Ph.D. Degree**

The Graduate College has established a maximum allowed time of nine (9) years to complete the Ph.D. degree. Students who have not advanced to Ph.D. candidacy after CHEM 484 have one additional year to complete coursework, research, and thesis requirements for the M.S. degree.

## **V. The Third Year**

### **CHEM 318 – Current Topics in Chemistry (fall and spring)**

All students will continue to enroll in the Current Topics course relevant to their division.

## **CHEM 488 – Original Research Proposal**

After successful completion of CHEM 484, all Ph.D. students must register for CHEM 488 (Research Problem Conception and Solution - 1 credit), usually in the first semester of the third year. In this course, the candidate must write and orally defend an original research proposal.

The original research proposal consists of a written formulation of a research problem and methods of solution in a field not directly related to the student's Ph.D. research project. This proposal is dictated entirely by the student; therefore, assistance from the research advisor is to be held to a strict minimum. Prior to finalizing the topic of the proposal, the student must receive approval of the topic from all members of the student's Graduate Studies Committee. In the event that any members of the committee have reservations about the suitability of the topic, the committee shall meet to resolve these differences and report back to the student so that the topic may be modified as needed.

No later than one month prior to the oral presentation/exam, the student shall distribute an outline of the proposal to the members of their Graduate Studies Committee. At least two weeks before the proposal defense, the student distributes copies of the written proposal to all committee members. The defense of the original proposal consists of a public presentation followed by a closed oral examination by the committee. Whereas the oral examination will focus primarily on questions related to the proposed research, the committee may revisit deficiencies established during the Advancement to Candidacy Exam. After the student's oral presentation and examination, the committee meets privately to evaluate the student's performance. Research proposals are graded on a Pass/Conditional Pass/Fail basis. A Conditional Pass requires additional work, specified by the examining committee, which may involve a written report or a repeat of the oral examination at a later date. Successful completion of the research proposal is recorded by a grade of Satisfactory (S) in CHEM 488 and the student will continue on-track for the Ph.D. degree. Students earning a grade of Unsatisfactory (U) in CHEM 488 enter the M.S. track with one additional semester to finish their thesis research.

The Department of Chemistry trains Ph.D. students to become independent scientists. The research proposal should not be viewed as a literature search or as an additional graduate seminar—it is the opportunity to practice that independence. The bulk of the student's effort, both written and oral, are devoted to identifying and solving a chemical problem. Evaluation by the faculty will center upon the validity and importance of the problem and the scientific viability of the proposed solution. The length of the written proposal should be kept to a *maximum of 3000 words* plus figures and references and should present background sufficient to define the problem as well as a reasonably detailed presentation of the methodology proposed to solve it. Students should be prepared to deal with any questions which relate to the both the oral and written presentations of the proposal -- NOTE: chemistry is a cumulative science, so it is assumed that advanced concepts and techniques introduced in the proposal are backed by a solid fundamental understanding of the underlying material. Please refer to the CHEM 488 syllabus for specific details. Preparation and presentation of the original proposal take typically no more than 8 weeks to complete.

## **GRAD 497 – Comprehensive Examination requirement**

The Graduate College mandates that any advanced degree requires completion of a

Comprehensive Examination. In the Department of Chemistry, the Comprehensive Examination is broken into three parts:

- (1) Completion of qualifying examinations and coursework. The course requirements are constructed to add breadth to the student's study in areas of chemistry not directly related to their research area. The qualifying examinations establish a broad knowledge base in all major areas of chemistry.
- (2) Successful completion of the Advancement to Candidacy Exam. The second-year dossier and oral examination is a comprehensive review of the student's fundamental understanding of chemistry
- (3) Completion of a total of three (3) credits of CHEM 318. It is essential for scientists to be able to critically analyze and discuss the chemical literature. The 'Current Topics' course leans on the multidisciplinary nature of research to provide a comprehensive overview of current issues of relevance.

Upon completion of these requirements, Ph.D. students enroll in GRAD 497. This is a zero-credit 'course,' required by the Graduate College, which indicates satisfactory completion of the graduate comprehensive examination requirement. The Graduate Standards Committee is notified prior to enrollment in this course.

## Annual reports

All Ph.D. students submit an Annual Report (5-10 pages) and schedule a meeting with their Graduate Studies Committee by the end of the academic year (defined as the day that 'Classes End' in the spring semester of the official UVM Academic Calendar (<http://www.uvm.edu/~rgweb/calendar/>)). The Annual Report is a written summary of research accomplishments achieved *that academic year*, highlighting key experiments, results, expected progress, and benchmarks for the coming year. It is the responsibility of the student to schedule a suitable time to convene a Graduate Studies Committee meeting at which all of its members will be present.

The Annual Report should be written in as much detail as would be expected in a dissertation, with a high emphasis on experimental results. Here, hypotheses are clearly presented, and conclusions discussed in the context of the results obtained. The Annual Report should be submitted to the student's Graduate Studies Committee at least one week prior to the scheduled meeting. The student then meets privately with their Graduate Studies Committee and gives a brief (10–15 minute) presentation of their research accomplishments (no introductory material necessary), followed by a discussion of research progress and direction. The Annual Report provides three major benefits: (1) it will give the Graduate Studies Committee a chance to act as an experimental advisor, suggesting experiments and identifying pitfalls, (2) it will serve as a 'check' to ensure that students are making significant progress towards their degree and, (3) it allows the student to organize and self-evaluate their progress on a regular basis. If it is determined that the student is not making significant progress, their Graduate Studies Committee may suggest benchmarks that must be achieved in order to remain active within the Ph.D. program.

## **VI. The Fourth+ Years**

### **CHEM 318 – Current Topics in Chemistry (fall and spring)**

All students will continue to enroll in the Current Topics course relevant to their division.

### **Annual Reports**

All Ph.D. candidates are required to submit Annual Reports as outlined above.

Lastly, all Ph.D. students are required to present their research at a national or regional professional meeting.

## **VII. Dissertation Defense**

Ph.D. students are required to write and defend an original dissertation. In the semester when the student intends to defend their Ph.D. dissertation, they must enroll in Grad 499, a zero-credit course required by the Graduate College for graduation. Before the student begins writing their dissertation, the Dissertation Committee must have been formed that now includes a member from outside of the Chemistry Department to serve as the Chairperson. The student's research advisor has the option of requiring additional members, if deemed appropriate. A detailed outline of the dissertation is then presented to the Dissertation Committee for their review. The outline is subsequently modified, if necessary, by the student. The dissertation is presented to the committee members at least two weeks prior to the date of the oral defense. The defense consists of a formal public presentation of the dissertation work followed by a closed oral examination by the Dissertation Committee.

The Graduate College maintains specific requirements for the format of the dissertation and timetable for submission. Please refer to <http://www.uvm.edu/~gradcoll/forms/guidelines.pdf> for more information.

## **VIII. Financial Support**

During the academic year, graduate students typically receive financial support either in the form of a teaching assistantship (T.A.) from the chemistry department or a research assistantship (R.A.) from their research advisor's grant. Graduate students will automatically be considered for T.A. support by the department through either their fifth year (Ph.D.) or second year (M.S.) in the program; T.A. support for third-year M.S. candidates will be considered on an individual basis. Summer support is not guaranteed, but it is unusual for a student not be appointed to a T.A. or R.A. during the summer months. All support, of course, is dependent upon the student's satisfactory performance both as a T.A. and in their research.

## IX. Suggested Timetable for Graduate Requirements

NOTE: The student is responsible for documenting their progress through the program by keeping their Graduate Record Progress (GRP) form up to date.

Year	Fall	Spring
1	<ul style="list-style-type: none"> <li>• (August) Qualifying Exams</li> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ Distribution/Core requirements</li> </ul> </li> <li>• (November) Choose research advisor</li> </ul>	<ul style="list-style-type: none"> <li>• Form Graduate Studies Committee (GSC)</li> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ Distribution/Core requirements</li> <li>○ CHEM 318 (<i>Current Topics</i>)</li> </ul> </li> <li>• Satisfy placement requirements</li> <li>• By June 8<sup>th</sup>: CHEM 380 – <i>Chemical Investigations</i> (Annual Report to GSC)</li> <li>• By June 15<sup>th</sup>: Annual Report presentation to GSC</li> </ul>
2	<ul style="list-style-type: none"> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ Distribution/Core requirements</li> <li>○ CHEM 318</li> </ul> </li> <li>• CHEM 381 – <i>Graduate Seminar</i></li> </ul>	<ul style="list-style-type: none"> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ Distribution/Core requirements</li> <li>○ CHEM 318</li> </ul> </li> <li>• CHEM 484 – <i>Advanced Topics in Chemistry</i> (Advancement to Candidacy Exam)</li> </ul> <p>* Written dossier and oral examination*</p>
3	<ul style="list-style-type: none"> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ CHEM 318</li> </ul> </li> <li>• CHEM 488 – <i>Research Problem Conception and Solution</i></li> </ul>	<ul style="list-style-type: none"> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ CHEM 318</li> </ul> </li> <li>• Annual Report</li> </ul>
4+	<ul style="list-style-type: none"> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ CHEM 318 (a total of three credits are required before the end of the seventh semester)</li> </ul> </li> <li>• Enroll in GRAD 497 after completion of CHEM 484, 3 satisfactory credits of CHEM 318, and at least 6 months prior to submission of dissertation</li> </ul>	<ul style="list-style-type: none"> <li>• <u>Coursework:</u> <ul style="list-style-type: none"> <li>○ CHEM 318</li> </ul> </li> <li>• Annual Report</li> <li>• [Ph.D. Dissertation Defense – GRAD 499]</li> </ul>