

## Ph.D. REQUIREMENTS FOR CHEMISTRY GRADUATE STUDENTS

### **Department of Chemistry Graduate Education Mission**

The Department of Chemistry graduate program strives to endow Ph.D. students with a breadth of chemistry knowledge, help them develop the ability to critically analyze the chemical literature, and foster in them the capacity for 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/graduate>). 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 (<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 to assess fundamental knowledge in the chemistry disciplines. 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, one of which, or both, may be used by the student: (1) take 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. Any individual qualifying exam is only re-administered once per student. The generally recommended courses are:

Analytical:	CHEM 221
Inorganic:	CHEM 231
Organic:	CHEM 241
Physical:	CHEM 260

If the student enrolls in the recommended course and does not earn at least a grade of B-, the failed qualifying exam must be re-taken and passed by June 15 of the student's first full year. Failure to satisfy the qualifying-exam requirement in any of the four areas via options (1) or (2) above automatically places a student into the Master's track. Failure to satisfy this requirement in two areas automatically leads to dismissal from the graduate program.

Students entering the program in the spring semester must take all qualifying exams upon arrival. For these students, the "graduate progress clock" starts with the next fall's entering class of

graduate students.

## II. General Course Requirements

### Graduate College Requirements

The Graduate College requires that a minimum of 30 course credits must be obtained for *any* advanced degree. Of these 30 course credits, 15 must be *graded* credits (i.e., credits contributing to the GPA). 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, 45 of which may be accumulated as research credits under CHEM 491 (Doctoral Dissertation Research). A full-time graduate student will generally register for a *total* of 9 credit hours in the fall and spring semesters and 5 credit hours of either Chem380, Chem484, Chem491, Grad901, Grad902, or Grad903 in the summer. *Following completion of all credit requirements (i.e., 75 credits), students should enroll for Continuing Registration (GRAD 90X).*

### Chemistry Department Requirements

Ph.D. students are required to take a minimum of three 3-credit core courses within their area of chemistry specialization (division). In addition, Ph.D. students must meet a distribution requirement by taking a *minimum* of three 3-credit elective courses *outside of their division*. The Graduate College requires that Ph.D. students maintain a minimum GPA of 3.00.

### Divisional Core Courses

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.

Division	Ph.D. Core Course Requirements
Analytical	CHEM 221, and six credits of CHEM 227
Biological	BIOC 301, 302 and <i>one</i> 300-level BIOC course
Inorganic	CHEM 231, 234 and 236
Organic	CHEM 241; 242; and <i>one</i> of the following: CHEM 214, 251, 257, or 258
Physical	CHEM 260, 274, and 275

If a particular 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 student's Graduate Studies Committee (see Section III), subject to approval by the departmental Graduate Affairs Committee (a departmental committee that monitors the progress of all graduate students).

### 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.

Division	Ph.D. Distribution Courses
Analytical	CHEM 221, 227
Biological	BIOC 301, 302

Inorganic	CHEM 231, 234, 236, 237
Organic	CHEM 214, 241, 242, 251, 257
Physical	CHEM 260, 274, 275

Graduate courses offered outside the Department may also be counted as distribution courses 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 Affairs Committee. Courses not enumerated above must be approved by the Graduate Affairs Committee.

### ***Annual Checklist***

All enrolled graduate students are expected to complete an annual checklist in August of each year. The purpose of the Annual Checklist is to promote timely completion of the requirements for graduation. The student should submit their annual checklist through the designated online portal no later than August 31. Students that have not submitted their annual report will not be permitted to complete Chem380, Chem381, Chem484, Chem488, advance to candidacy, or receive GTA funding from the Department.

### ***Individual Development Plans***

In accord with Graduate College and federal guidelines, all graduate students must complete an individual development plan (IDP) in May of each year. The purpose of the individual development plan is professional development of the graduate student, and preparation for a post-graduate career. Enrolled graduate students should prepare an IDP using the departmental template and submit the plan to their research advisor no later than the Friday following the last day of final exams of the spring semester. The research advisor and graduate student will then schedule a meeting for a date no later than May 31 to discuss the IDP.

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

### ***CHEM 379 – Intro to Graduate Research***

A graduate degree in chemistry is primarily research-based, and this course will serve as an introduction to that process. All students must register for CHEM 379 in the fall semester of their first year. CHEM 379 will guide new graduate students through the processes of choosing a research advisor and selecting a graduate studies committee. The course will also provide an introduction to research laboratory safety, an overview of institutional research facilities, and strategies for managing the chemical literature.

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

As part of CHEM 379, each faculty member gives a short presentation describing their research interests, which must be 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 indicate their 1<sup>st</sup> and 2<sup>nd</sup> choice for research advisor to the Department Chair in writing *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 Graduate Studies Committee will also act as 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, two additional Chemistry faculty members, and one faculty member not in the Chemistry Department. Of the three Chemistry faculty, one must be outside of the student's division. The Chair of the Graduate Affairs Committee must be notified *in writing* of the composition of the student's Graduate Studies Committee, by the student, once the committee has been established.

The four-member Graduate Studies Committee is sufficient to provide oversight and academic advising for students. It should be noted that 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. If desired, a graduate student, in consultation with their research advisor, may add an extra faculty member to their Graduate Studies Committee and/or the 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 also a research and educational resource, serving as an "extended research advisor". 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***

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. Students must submit their proposed literature article to the Chem 318 instructor and their research advisor at least two weeks in advance of their presentation, and receive final approval at least one week in advance of their presentation. 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. The course grade will be determined by the Chem 318 instructor in consultation with the other faculty in the research division. When enrolled with zero credits, the grade will be based on attendance and participation. Completion of 3-5 credits of CHEM 318, or 3-5 presentations, is required by the end of the 3<sup>rd</sup> year. Students who choose to only complete 3-4 credits of CHEM 318 will need to take an additional 2-3 credit course in order to meet the Graduate College's 30 course credit requirement.

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

In the summer I semester following their first year, all students will register for CHEM 380, Chemical Investigations (1 credit). The foundation of CHEM 380 is the first checkpoint towards an advanced degree. This document is a brief (4–5 pages) progress summary report to the student's Graduate Studies Committee, which encompasses the proposed project and the initial results obtained in the laboratory. The CHEM 380 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 CHEM 484 dossier.

The CHEM 380 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 CHEM 380 instructor of record must be informed by the student of the intent to present, with one week's warning so that the public portion of the presentation may be attended by those who are interested.

Annual Reports are to be submitted to the members of the Graduate Studies Committee at least one week in advance of their presentation, and presentations must be given prior to the end of the summer I semester. The Graduate Studies Committee collaborates on a written evaluation of the Annual Report and presentation, as well as the student's first-year progress. It is the responsibility of the student's research advisor to submit the written evaluation to the Chair of the Chemistry Graduate Affairs Committee.

#### ***IV. Continuation in the Ph.D. Program***

By the end of June, the Graduate Affairs Committee will have reviewed the progress of all first-year graduate students in the Ph.D. program. Sections I, II, and III each contain one requirement that must be met in order to remain in the Ph.D. program.

*Qualifying Exams.* If a student is not able to rectify a deficiency in one or more of the four fundamental areas, the Graduate Affairs Committee shall move the student to the Master's track, and inform the Graduate College of such by the end of June. If the student is not able to meet the requirement in more than one area, the student will be informed that he/she cannot matriculate in the Chemistry Department's graduate program.

*Course Work.* If a student fails to maintain a 3.00 GPA, the Graduate Affairs Committee shall put the student on notice that their progress will be monitored, and that the GPA deficiency is expected to be remedied by the end of the second year.

*Research Progress.* The CHEM 380 report contains a judgement by the three faculty members most closely aware of the student's research progress. If the report is not a positive validation of the student's research progress, the Graduate Affairs Committee shall put the student on notice that a major improvement in research progress is expected to occur by the second-year review (CHEM 484).

The Graduate Affairs Committee will send each first-year student a letter by the end of June, summarizing the student's performance in the above three areas, with pertinent recommendations.

## **V. The Second Year**

### ***CHEM 318 – Current Topics in Chemistry***

All students will continue to enroll in the ‘Current Topics’ course relevant to his or her division. If not presenting, they must still attend departmental seminars and contribute to divisional presentations in order to receive a grade of S in the ‘Current Topics’ course.

### ***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 short synopsis with annotated bibliography 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 to C-, or F. A grade of "F" on the 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 S in the ‘Current Topics’ course.

### ***CHEM 484 – Advanced Topics in Chemistry***

In the summer III semester following their 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 (20-30 minutes) 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 switching to M.S. program), B- (recommend switching to the M.S. program with additional requirements) or C (recommend dismissal from the program). The dossier and Advancement Exam must be completed by the end of the summer III semester.

The Advancement to Candidacy Exam is part of a comprehensive two-year review by the Graduate

Affairs 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 Affairs 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 Affairs 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.

### ***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 consists of the following 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 (CHEM 484). 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. Participation in the 'Current Topics' course provides a comprehensive overview of current issues of relevance.

Upon completion of these requirements, the Ph.D. student must schedule a meeting with the Chair of the Graduate Affairs Committee to review the records and transcripts. Immediately following, formal notification of the student's passing of the Comprehensive Examination will then be communicated to the Graduate College by the Chair of Graduate Affairs via a memo.

### ***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.

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

## ***VI. 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 487 – Research Problem Conception***

After successful completion of CHEM 484, all Ph.D. students must register for CHEM 487 (Research Problem Conception - 1 credit), in the first semester of the third year. In this course, the candidate must write a 1-2 page document outlining the specific aims or objectives of your 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. In order to complete CHEM 487, the student must receive approval of their written specific aims or objectives 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.

### ***CHEM 488 – Research Problem Solution***

After successful completion of CHEM 487, all Ph.D. students must register for CHEM 488 (Research Problem Solution - 1 credit), in the second semester of the third year. In this course, the candidate must write and orally defend an original research proposal.

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 identified 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, rather 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 10 pages (single-spaced, 1-inch margins, 11 font) excluding 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 that 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.

The CHEM 488 instructor of record must be informed by the student of the intent to present, with one week's warning so that the presentation may be attended by those who are interested.

## ***VII. 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.

### ***Presentation of Research***

All Ph.D. students are required to present their research at a national or regional professional



meeting.

### **VIII. Dissertation Defense**

Ph.D. students are required to write and defend an original dissertation. The Graduate Studies Committee will have been formed, and will act as the dissertation defense committee (with the faculty member from outside the Chemistry Department serving as its 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 Graduate Studies Committee for their review. The outline is subsequently modified, if necessary, by the student. The dissertation is distributed 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 Graduate Studies Committee.

The Chairperson of the dissertation defense committee is charged with communicating the outcome of the defense by submitting the Defense Examination Record Form and any Change of Grade forms to the Graduate College Dean's Office within 3 days of the defense. The student should, as a courtesy, inform the Chair of the Graduate Affairs Committee of the outcome as well, so that such can be noted in the official files.

The Graduate College maintains specific requirements for the format of the dissertation and timetable for submission. Please refer to <https://www.uvm.edu/graduate/resources> for more information.

### **IX. 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.

**X. Suggested Roadmap for Chemistry Ph.D. Requirements**

<b>Year</b>	<b>Fall (Credits)</b>	<b>Spring (Credits)</b>	<b>Summer (Credits)</b>
<b>1</b>	Core Course (3) Elective Course (3) CHEM 379 (1) CHEM 491 (3)	Core Course (3) Elective Course (3) CHEM 318 (1) CHEM 491 (2)	CHEM 380 (1) CHEM 491 (4)
<b>2</b>	Core Course (3) CHEM 318 (1) CHEM 381 (1) CHEM 491 (4)	Elective Course (3) CHEM 318 (1) CHEM 491 (5)	CHEM 484 (2) CHEM 491 (3)
<b>3</b>	CHEM 318 (1) CHEM 487 (1) CHEM 491 (7)	CHEM 318 (1) CHEM 488 (1) CHEM 491 (7)	CHEM 491 (5)
<b>4</b>	CHEM 318 (0) CHEM 491 (6) GRAD 901 (3)	CHEM 318 (0) GRAD 903 (9)	GRAD 903 (9)
<b>5</b>	CHEM 318 (0) GRAD 903 (9)	CHEM 318 (0) GRAD 903 (9)	GRAD 903 (9)