Chemistry
Graduate Student
Handbook

Entering Class of 2018

Chemistry Graduate Student Handbook
Approved August 2018

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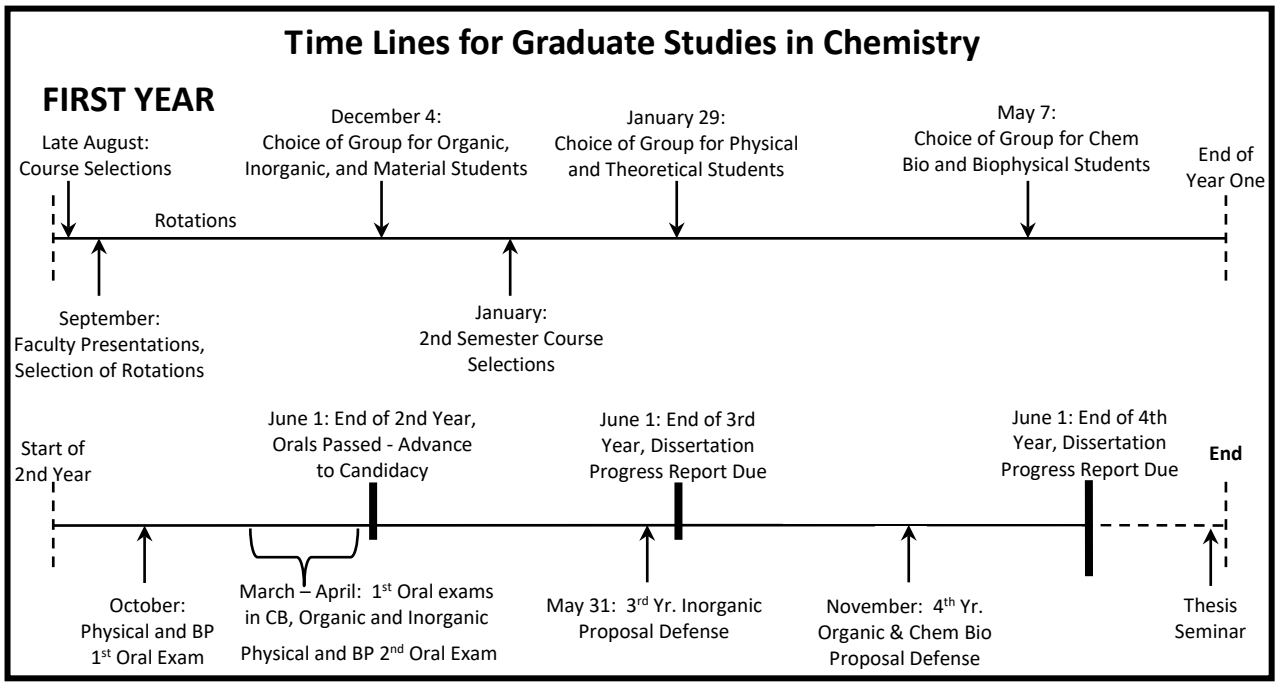

This document provides information on the curriculum choices and degree requirements for a Ph.D. in the Department of Chemistry at Yale University. The Graduate School maintains a set of additional requirements that have been provided to you separately and are not included here. For answers to additional questions, students should consult the Graduate School Bulletin on Programs and Policies, the Director of Graduate Studies (DGS), the Chemistry Department Graduate Registrar, the Chemistry Department website (http://chem.yale.edu), or the appropriate official of the Graduate School.

I. Course Registration and Course Schedules

A. Registration and Departure.

Registration for Fall semester courses is conducted when arriving at Yale in late August and registration for Spring semester courses is conducted in January. During your First Year Orientation, the Chemistry Department will provide schedules and forms within your orientation packets to assist you in selecting courses, and each student will speak with a divisional faculty advisor who will provide guidance about which courses fit you best. The divisional advisor will be asked to initial your packet's course approval form to indicate approval of your course choices. This form must be handed into the Graduate Registrar's office prior to you registering for courses online through Online Course Selection (OCS) at www.yale.edu/SIS.

All upper-year students must register for research and group/departmental seminars, in addition to any course that is being taken for credit. Guidelines for course registration are available separately from the Graduate Registrar. Upper-year students must also register for classes online through Online Course Selection (OCS) at www.yale.edu/SIS.

Students who leave New Haven before January 31 or September 1 but who intend to submit their thesis after these dates should inform the Graduate Registrar. They should return their student I.D. cards and any laboratory keys at that time.

B. Course Schedules.
Each student chooses a program of coursework for the first year in conjunction with the divisional advisor, based on the student's field of interest, previous education, and experience.

Graduate students must successfully complete six full-semester courses prior to the qualifying exam, a majority of which should be completed in the first year (except Chemical Biology and Biophysical Chemistry students, who must complete their course requirements in the first year). Graduate courses are graded on a letter scale of Honors (H), High Pass (HP), Pass (P), and Fail (F). The Chemistry Department requires the average of the top five grades, exclusive of Chem 700, be at least HP for a student to remain in good standing. The Graduate School requires that each student receive at least two semester grades of Honors within the first two years, exclusive of research, seminar, and shop courses. Only one of the required two Honors can be earned in a laboratory course, such as Chem 560L. Chem 700 is a research/seminar course, and Chem 562L and Chem 564L are shop courses. All first-year students are required to take Chem 590 "Ethical Conduct and Scientific Research" in the fall semester, which does not count toward the six required courses.

Some recommended courses are not offered every year, so one should take advantage of the course when it is offered. Permission to complete fewer than six credits prior to the end of the second year requires approval of the DGS. Each sub-discipline has different course recommendations that are outlined on the following pages. Students with interests in Materials chemistry can choose either the Inorganic or the Physical course requirements, in consultation with their advisor, as there are not yet separate requirements for the Materials division.

1. Course Requirements in Preparative Chemistry. A student in the Inorganic, Chemical Biology, or Organic track must complete six course credits during the first three semesters, or receive special permission from the DGS. These courses should reflect the breadth of current research in these areas of chemistry. Thus, the student should strive to complete one course in synthetic chemistry, one course in biological chemistry, one course in transition metal chemistry, one course in theory or reaction mechanisms, and one in physical and spectroscopic methods. The breadth requirement can adjust to fit your background and the schedule of course offerings.

The following table indicates which courses provide an exposure to synthesis, biological chemistry, transition-metal chemistry and reaction mechanisms. Courses in brackets will not be offered during the 2018-2019 academic year but may be offered in subsequent years.

Synthetic Chemistry	Transition Metals	Biological Chemistry	Theory and Mechanism
[Synthetic Methods 523]	Materials Chemistry 549	Chemical Biology 521	[Advanced Organic 519]
[Natural Product Synthesis 528]	Physical Methods in Inorganic Chemistry 550	[Bioinorganic Chemistry 554]	Computational Chemistry and Biochemistry 526
Materials Chemistry 549	Organometallics 552	Biochemical Rates and Mechanisms 556	Inorganic Mechanisms 555
Organometallics 552	[Bioinorganic Chemistry 554]	[Structure and Chemistry of Proteins and Nucleic Acids MBB741]	Biochemical Rates and Mechanisms 556
	Inorganic Mechanisms 555		
	Modern Coordination Chemistry 557		

Special Requirements for Chemical Biology

Chemical Biology students must take three full-semester courses for credit each term of their first year, and this is required to be eligible for support by the Chemistry/Biology Interface (CBI) training grant. Specific courses will be chosen in consultation with a divisional faculty advisor, who can also advise students about eligibility and requirements of the CBI training grant. By the end of the second year in residence, students should possess a solid background in both organic and biological chemistry, as well as a sophisticated understanding of important methodologies in cell and molecular biology. This background may come through a combination of courses at Yale and courses taken as an undergraduate. If a Chemical Biology student is a TF during the first year and is not eligible for the CBI training grant, then it is reasonable to take some of these classes during the second year.

In addition to fulfilling the core requirements for Preparative Chemistry, students in Chemical Biology must take one elective from each of the two course listings below. These students must also audit the Current Topics in Organic Chemistry Seminar Series (Chem 720/721), Seminar in Chemical Biology (Chem 740/741), or Seminar in Inorganic Chemistry (Chem 760/761) throughout their residence at Yale.

Chemical Biology Electives (One elective from each list is required):

Biochemistry/Structural Biology	Cell and Molecular Biology
Chem 556 Biochemical Rates & Mechanisms	[MBB 705 Mol. Genetic Prokaryotes]
MBB 600 Principles of Biochemistry I	[MBB 734 Advanced Eukaryotes Molecular]
MBB 601 Principles of Biochemistry II	MCDB 570 Biotechnology
MBB 720 Macromolecular Structure and Biophysical Analysis	MCDB 603 Cell Biology
[MBB721Macromolecular Interactions and Dynamic Properties]	MCDB 625 Genetic Analysis
[MCDB 630 Biochemical and Biophysical Approaches]	[PHAR 502 Pharmacology I/II]

2. Course Requirements in Biophysical Chemistry. Students must take five full-semester courses for credit by the end of their first year. Specific curricula are designed in consultation with a designated faculty advisor using the following guidelines.

By the end of the second year in residence, students should have obtained a solid background in physical and biological chemistry and an understanding of the major molecular biophysical methods (NMR, spectroscopy and X-ray crystallography). This background may come through a combination of courses at Yale and courses taken as an undergraduate.

In addition, all Biophysical students should take Lab Rotations for First Year Biophysical and Chemical Biology Graduate Students, Chem 700 for credit in their first year. All Biophysical students must audit the Biophysical Chemistry Seminar Series (Chem 750/751) throughout their residence at Yale. The rotation and seminar classes do not count toward the five full-semester courses.

Course requirements:

(1) Three one-semester courses in biophysical/physical chemistry:

- Molecules and Radiation I (Chem 540)
- Biochemical Rates & Mechanisms (Chem 556)
- Biophysical Spectroscopy (Chem 559)

(2) Two elective one-semester courses. We recommend that one be an advanced biological course, such as molecular biology, cell biology, chemical biology, or bioinorganic chemistry, and the other an advanced course on physical chemistry such as Statistical Mechanics (Chem 530) or computational chemistry.

A typical first-year program of study is as follows:

Fall Term: Chem 559, Chem 540, elective, Chem 700, Chem 750
Spring Term: Chem 556, elective, Chem 701, Chem 751

For students who have not taken biochemistry as an undergraduate, MB&B 600/601 is required in addition to the above course requirements.

3. Course Requirements in Physical Chemistry. Students are expected to take three full-semester courses for credit during each term of their first year. Individual programs of study must be arranged in consultation with a designated faculty advisor, taking into account pertinent undergraduate experience. By the end of the second year of residence it is expected that a student will have completed at least six courses for credit, thereby demonstrating proficiency in the material covered by the following seven core classes:

Quantum Chemistry (Chem 570)
Advanced Quantum Mechanics (Chem 572)
Statistical Mechanics and Thermodynamics (Chem 530)
Molecules and Radiation I & II (Chem 540 and Chem 542)
Advanced Instrumentation Laboratory I & II (Chem 560L and [Chem 561L])

Entering students who already have completed classes with substantially the same content as those listed above need to complete a total of only six full-semester courses for credit. In addition to fulfilling the remaining core requirements, their courses may be selected from the list found below. Alternative classes may be considered, where appropriate, with approval of the faculty advisor and the Director of Graduate Studies.

Advanced Organic Chemistry I & II (Chem 518 and [Chem 519])
Computational Chemistry and Biochemistry (Chem 526)
[Research Topics in Physical Chemistry (Chem 535)]
[Nuclear Magnetic Resonance in Liquids (Chem 548)]
Materials Chemistry (Chem 549)
Organometallic Chemistry (Chem 552)
Inorganic Mechanisms (Chem 555)
Modern Coordination Chemistry (Chem 557)
Classical Mechanics (Phys 410)
Electromagnetic Fields and Optics (Phys 430)
Mathematical Methods of Physics (Phys 506)
Solid State Physics I & II (Phys 548 and Phys 549)
[Introduction to Atomic Physics (Phys 522)]
[Mathematical Methods in Engineering (ENAS 397)]

With the agreement of their designated faculty advisor, a student may replace one or more of the core courses by an appropriate alternative course.

The mathematical background of Physical Chemistry students should include linear algebra and calculus at least to the level of differential equations. If this material was not covered in the student's undergraduate curriculum, he or she should consider strengthening their mathematical background through supplementary courses such as Math 222 (Linear Algebra with Applications), ENAS 194 (Ordinary and Partial Differential Equations with Applications), and Phys 301 (Introduction to Mathematical Methods of Physics).

All students are expected to audit the Molecular Science Seminar Series (Chem 730/731) throughout their residence at Yale.

II. Choice of Research Advisor

The choice of research advisor is an extremely important decision and should be made with information from several sources: attendance at research presentations during the first weeks of the first year, multiple discussions with faculty members, reading of manuscripts from the research groups of interest, attendance at group meetings, visiting of group websites, and discussions with students in the research group. To facilitate the process of gathering needed information, Yale Chemistry has instituted a system of research rotations.

A. Research Presentations, Rotations, and Deadlines for Research Group Choices.

During the first three weeks of classes, the faculty will present brief research seminars to provide information on their research groups to first-year graduate students. These seminars afford the best opportunity during your graduate career to gain an overview of research occurring in the department and to note the specific interests of each faculty member. Every first-year student, regardless of their research area, is required to attend all of these meetings. Times and locations of these seminars will be distributed electronically.

Beginning with the third week of the Fall term, participation in a formal laboratory rotation is required. Rotation schedules vary between subdivisions (see below). By Sept. 14th, students in areas of preparative chemistry should submit to the Graduate Registrar a list of at least three

research groups with which they wish to rotate. Students in the areas of physical chemistry and theoretical chemistry should submit a list of four groups for their research rotations. Submissions use an online survey form which can be found on the Chemistry "Useful Links" webpage. The schedule for rotations will be posted on the following Monday (Sept. 17), and the rotations will begin immediately.

B. Rotation Schedules and Deadlines for Research Group Choices.
The content of the rotation depends on the student and the faculty member, but (at a minimum) the former is expected to visit the latter for an introduction and to meet a second time to follow up on the initial discussion. Rotating students should plan to read key publications from the group, to attend scheduled group meetings, and to discuss ongoing projects with the graduate students and the postdoctoral fellows currently in the group.

1. Rotation Schedule in Preparative Chemistry. Organic, Inorganic, and Materials graduate students conduct three-week rotations in three different research groups during the Fall of their first year. Students choose the groups in which they rotate in mid-September, and the three rotations run through late November. During the rotation, students typically attend group meetings, speak one-on-one with members of the laboratory, and have at least one conversation with the proposed advisor regarding potential thesis topics. If a student feels that they need to sample more than three groups, they may choose to conduct two rotations simultaneously. While this allows for more than three rotations, simultaneous rotation experiences are not as impactful. After the end of the third rotation, each student turns in a rank-ordered list of the three research groups that they prefer, with the top lab ranked #1. We recommend that all students speak directly with the adviser of the lab ranked #1 during the days before this deadline. Any student having difficulty choosing a group at that time should immediately contact the Graduate Registrar or DGS.

Chemical Biology students conduct eight-week rotations in three different research groups during their first year. At the end of each rotation, a formal presentation of the results from their rotation is due. Research advisors are selected by providing the Graduate Registrar with a rank-ordered list of the three research groups you would like to join one week after the end of rotations, with the top lab ranked #1. Chemical Biology students are required to register for Chem 700-02/701-02 for Credit (Sat/Unsat).

2. Rotation Schedule in Biophysical Chemistry. Biophysical students conduct eight-week rotations in three different research groups during their first year. At the end of each rotation, a formal presentation of the results from their rotation is due. Research advisors are selected by providing the Graduate Registrar with a rank-ordered list of the three research groups you would like to join one week after the end of rotations. Biophysics students, regardless of funding support, are required to register for Chem 700-01/701-01 for Credit (Sat/Unsat).

3. Rotation Schedule in Physical Chemistry. Students in physical and theoretical chemistry will conduct three-week rotations in four different research groups during their first year. Research advisors are selected by providing the Graduate Registrar with a rank-ordered list of three research groups that the student would like to join for their Ph.D. studies. This form is due one week after the formal end of rotations.

A summary of the schedule for events related to group selection in 2018-19 follows:

All First-Year Students:

Sept. 5 - Sept. 12	Evening presentations by faculty
Sept. 14	Submission of selection of rotations.

Biophysical and Chemical Biology Students:

Sept. 17 - Nov. 16	First rotation
Nov. 26 - Feb. 22	Second rotation
Feb. 25 - May 3	Third rotation
May 7	Submission of top three choices for advisor by the biophysical and chemical biology students

All Other Students:

Sept. 17 - Oct. 5	First rotation
Oct. 8 - Nov. 2	Second rotation
Nov. 5 - Nov. 30	Third rotation
Dec. 3 - Jan. 25	Fourth rotation (Physical and Theoretical students only)
December 4	Submission of top three choices for advisors by students in preparative chemistry
January 29	Submission of top three choices for advisor by students in physical and theoretical chemistry. In addition, any student who has participated in the short rotations and is planning to work in a biophysical group should sign up for the third long rotation at this time.

C. Advisor Selection.

Students should discuss joining a research group with a faculty member before submitting their list of choices to the Graduate Registrar. All agreements for choice of research advisor require review and approval by the Director of Graduate Studies. The Director of Graduate Studies also should be consulted promptly if any difficulties arise in reaching an agreement.

D. Selection of an Advisor Outside of the Chemistry Department.

Faculty members who hold joint appointments in Chemistry or are affiliated with the Chemistry Department through the Biophysics or Chemistry/Biology Interface training grants can be selected as a research advisor. It also is possible to join the research group of a faculty member who is not affiliated formally with the Chemistry Department provided that the student works on a thesis project having sufficient chemical content. If a student wishes to join a group outside of the Chemistry Department, he or she must meet with a committee consisting of the proposed advisor and two faculty members whose primary appointment is in the Chemistry Department to consider the overlap of the proposed thesis project with the field of chemistry. This committee must approve the proposed project prior to joining the research group.

E. Changing of Research Advisors.

Because of the obvious disruption of progress toward the Ph.D. degree from changing research advisors, students strongly are urged to make a well-informed and careful choice of research advisor from the onset of their Ph.D. studies. A desire to change research groups should be discussed with the Director of Graduate Studies and with the current and proposed new research

advisors. If the current advisor is the DGS, the student can consult with the Student Climate Director or the Departmental Chair. Prior to a change in group, the student must clean his/her laboratory equipment and space, and must provide a comprehensible research report, as well as lab notebooks and pertinent research data, to the advisor.

III. Second-Year Candidacy Examination

A. General Information.

The purpose of the candidacy examination is for the student to demonstrate: (*i*) a thorough understanding of the background and methods of their Ph.D. project; (*ii*) significant research progress that indicates the candidate will successfully complete a satisfactory dissertation within a reasonable length of time (4.5-6 years), even if the experimental work so far has not yet been productive in terms of publishable results; (*iii*) an ability to develop independent research ideas from first principles and literature study related to their Ph.D. project; and (*iv*) proficiency in communicating chemistry principles in both a written and oral format. These skills are essential to be an effective chemistry researcher, and the candidacy examination requires the student to exhibit aptitude in all of these areas.

The candidacy examination should be completed before the last day of reading period in the spring semester of a student's second year in the Ph.D. program, with timing details reached through consultation with their advisor. Candidacy examinations are conducted by a three-member committee formed by the student's research advisor and two faculty members familiar with the student's area of research. In all cases, at least two of the committee members must be faculty whose primary appointment is in the Chemistry Department. The student, in consultation with their research advisor, is responsible for selecting appropriate members. Students should ask faculty to be on their committee *at least two months* before they wish to take the examination. The committee that administers the candidacy examination normally forms the student's final thesis committee. It is the student's responsibility to verify with his or her committee members their availability for the candidacy examination one to two months in advance of the proposed date. Once a date and time has been established, the student should reserve a room using 25Live. Written documents (see below) should be provided to the committee at least one week before the scheduled examination date. Students must download an evaluation form from the Chemistry "Useful Links" webpage and bring it to the examination.

In addition to a student's performance in the oral and written components of the examination (see below), candidates will be judged on progress in research. At the close of the candidacy exam, the student leaves the room, and the committee discusses the results in order to come to a decision that is delivered immediately to the student. The possible outcomes are Pass, Conditional Pass, or Fail. The committee will provide to the student and the Chemistry Department Graduate Registrar a written summary of recommendations. A student who does not pass the candidacy examination typically has other opportunities (determined by the examination committee) to fulfill the candidacy examination requirements. Such options often include: retaking the oral examination in the areas in which the student's understanding is deficient, enrolling in additional courses, or submitting a written paper on subjects in which the student's understanding is deficient.

B. Specific Description of the Candidacy Examination.

The candidacy examination consists of both written and oral components. In each component students will be expected to demonstrate a thorough knowledge of the thesis area and related areas of chemistry, and to discuss competently the results that have been obtained and the future direction(s) of the project(s). In the written component students are expected to produce an independent proposal based on their Ph.D. project. The proposal should contain information about results obtained to date and planned future work. A general format for the proposal is provided below with approximate guidelines for section lengths given in parentheses:

1. **Aims:** State the specific objectives of the research project being described in the proposal. (0.5-1 page)
2. **Background and Significance:** Briefly describe existing knowledge relevant to the proposed research and identify any gaps that the proposed work is intended to fill. (1-2 pages)
3. **Preliminary Results:** Summarize your own completed and ongoing studies. (2-3 pages)
4. **Proposed Research:** Outline the experimental design and the procedures to be used to accomplish the specific aims of the project. (3-4 pages)
5. **Conclusions:** Summarize the proposal and describe the impact of the results on the field of study. (<0.5 pages)
6. **References:** List relevant literature citations. For appropriate style, consult either ACS (*e.g., J. Am. Chem. Soc.*) or APS (*e.g., J. Chem. Phys.*) guidelines.

The relative length of the sections does not have to exactly follow the suggestions above, but the final written document is expected to be ten pages or less excluding references. The proposal should be provided to the committee at least one week before the oral examination.

More specific instructions for formatting the proposal are as follows:

1. Type density, including characters and spaces, must be no more than 15 characters per inch with no more than six lines of text per inch. Use one of the following typefaces:
   - Arial, Courier New, or Palatino Linotype at a font size of 11 points or larger.
   - Times New Roman at a font size of 12 points or larger.
   - Computer Modern family of fonts at a font size of 11 points or larger.
2. Set page margins to 0.75 inches.
3. A font size of less than 10 points may be used for mathematical formulas or equations, figure/table/diagram captions, and when using a Symbol font to insert Greek letters or special characters, but it must be in a black font color, readily legible, and follow the font typeface requirement.
4. Color can be used in figures; however, all text must be in a black font color, clear and legible.

The oral examination will consist of a two-hour examination based on the written proposal. For the oral examination, students should plan to arrive with ~45 minutes worth of prepared material summarizing their written proposal (students often choose to use PowerPoint, Keynote, or similar presentation software), but should anticipate being interrupted with questions. In addition to testing the student's knowledge of their Ph.D. project, the examination will emphasize fundamental chemistry and will probe the candidate's comprehension of necessary background

material, including topics that go beyond those specifically related to the thesis. After the examination, students will submit their signed oral exam form to the Graduate Registrar and email a PDF copy of their written report to the Graduate Registrar.

C. Advancement to Candidacy.
At the end of the second year of study, qualified students will be advanced to candidacy for the Ph.D. degree. To advance to candidacy, students must have met the following criteria:

1. Completed the Honors requirement: As noted above, the Graduate School requires that each student must receive at least two term grades of Honors within the first two years, exclusive of those for research, seminar, and shop courses. Only one of the required two Honors can be earned in a laboratory course (*e.g.*, Chem 560L). Note that Chem 700 is a research/seminar course, and Chem 562L and Chem 564L are shop courses, so they do not count toward the Honors requirement.
2. Passed the candidacy examination.
3. Made satisfactory research progress, as judged by the thesis committee.

A student who has not satisfied these requirements by the end of the second year will be reviewed by the Department. If the evaluation indicates that the student is unlikely to complete the requirements for the Ph.D., they will be asked to withdraw from the program and referred to the Dean of the Graduate School. However, if the evaluation indicates that the student is likely to advance with further effort, he or she will be given a deadline for completion of the requirements for advancement to candidacy.

D. Master's Degrees.
Students may apply for a Master of Science degree when the necessary requirements are met or if they decide to leave the Ph.D. program. The requirements for the M.S. are as follows:

1. Residence: A student must have at least one academic year of residence.
2. Courses: A student must pass at least five graduate-level term courses in the Chemistry Department exclusive of seminars and research. In addition, an overall average (exclusive of seminars and research) of High Pass must be maintained across all courses. The DGS may approve substitution of graduate-level courses in other departments.

IV. Requirements beyond the Second Year

A. Annual Progress Reports, Independent Proposal and Public Presentations.
In the third, fourth and fifth year, students should plan to meet with their thesis committee. By the end of the fourth year, the student must make at least one public presentation of his or her research progress and present an independent proposal to their thesis committee. Information about each of these activities is provided below.

1. Annual Progress Reports. During April, each student should prepare a written summary of research progress and plans for the thesis committee and meet with the committee to discuss their research activities. Organizing and scheduling this meeting is the responsibility of the student. The written summary should consist of two or three pages of double-spaced text. A copy

of this report may then be used as the text for the annual dissertation progress report required by the Graduate School. This written report should be provided to thesis-committee members at least one week prior to the meeting on research progress.

By the end of May, each student should meet with their thesis committee to discuss research progress. It is acceptable to meet with the committee members individually, though a coordinated meeting typically is more beneficial for research feedback. After the meeting(s), the student must file with the Chemistry Department Graduate Registrar the Annual Committee Meeting form signed by the members of the thesis committee. Students can download this form from the Chemistry "Useful Links" webpage.

In any year when a student presents their research progress in public (see below), the requirement of an annual meeting will be waived. Students must file with the Chemistry Department Graduate Registrar a Public Research Presentation form that indicates approval of the presentation by at least two committee members, and should seek their feedback. Students can download this form from the Chemistry "Useful Links" webpage. A student still may request a committee meeting and at a minimum should make at least informal contact with their committee annually.

2. Independent Research Proposal Examination. Students are required to write and defend an independent research proposal after candidacy and before the end of the spring semester of their fourth year of graduate studies. The exact timing of the proposal will be determined by the student and their research advisor, in conjunction with the thesis committee.

The format of the independent-research-proposal examination is similar to that used to advance the student to candidacy and involves both a written and oral component. The major difference is that instead of preparing a proposal based on their own research, students now are expected to craft an independent proposal that is not related to their Ph.D. work. This is defined as a proposal based mostly on literature that the student would not normally read to directly support his or her thesis project. Students must consult with their research advisor about the topic of the proposal and approval of the proposal area should occur prior to beginning an in-depth investigation.

Students also must consult with their research advisor about the format of the written proposal. Unless otherwise specified by the advisor, the independent research proposal must follow the guidelines for the NIH Ruth L. Kirschstein National Research Service Award (NRSA), as described on the NIH website.

The essentials of this format are:

1. Specific Aims (Limited to one page): State concisely the goals of the proposed research and summarize the expected outcome(s), including the impact that the results of the proposed research will exert on the research field(s) involved. List succinctly the specific objectives of the research proposed, for example, to test a stated hypothesis, create a novel design, solve a specific problem, challenge an existing paradigm, address a critical barrier to progress in the field, or develop a new technology.
2. Research Strategy (Limited to six pages, including all figures, charts, and tables):

Significance: Explain the importance of the problem or critical barrier to progress in the field that the proposed project addresses. Explain how the proposed project will enhance scientific knowledge. Explain how the approach pursued differs from others, and what will render this approach superior to what has come before. If no related work has been done in the area, discuss the conceptual advances that lead to your approach.

Approach: Describe the overall strategy, methodology, and analyses to be used to accomplish the specific aims of the project. Discuss potential problems, alternative strategies, and benchmarks for success anticipated to achieve the aims.

3. *Literature Cited* (No page limit): Provide a bibliography of any references cited. Each reference must include the names of all authors (in the same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication.

Format specifications are as follows:

1. The page margins must be at least 0.5 inches.
2. Use black Arial, Helvetica, Palatino Linotype, or Georgia typeface, and a font size of 11 points or larger. Type density, including characters and spaces, must be no more than 15 characters per inch with no more than six lines of text per inch.
3. For Figures, Graphs, Diagrams, Charts, Tables, Figure Legends, and Footnotes one may use a smaller type size but it must be in a black font color, readily legible, and follow the font typeface requirement. Color can be used in figures; however, all text must be in a black font color, clear and legible.

The oral part of the proposal assignment will consist of a 60-90-minute examination based on the written proposal. Students should plan to arrive with ~30 minutes worth of prepared material summarizing their written proposal (students often choose to use PowerPoint, Keynote, or similar presentation software), but should anticipate being interrupted with questions.

As with the candidacy examination it is the responsibility of the student to verify with his or her committee members their availability for the independent research proposal examination one to two months in advance of the proposed date. Once a date and time has been established, the student should reserve a room using 25Live.. Written documents should be provided to the committee at least one week before the scheduled examination date. Results of the examination are provided immediately after a brief discussion of the examination among the members of the examining committee. The committee will provide to the student and the Chemistry Department Graduate Registrar a written summary of recommendations. Students should download a form for this purpose from the Chemistry "Useful Links" webpage and bring it to the examination. After the examination, students must submit their signed oral exam form and email a PDF copy of their written report to the Graduate Registrar.

3. Public Presentation of Research Progress. By the end of the fourth year, and at least six months before the final thesis defense, each student must present in public a report on their ongoing research and file the public research presentation form with the Chemistry Department Graduate Registrar. The report may consist of a lecture or a poster presentation. Acceptable forums for this presentation include the departmental seminar series, the student seminar series

(Biophysical Journal Club, Physical Chemistry Club, and Metal Mania), the annual Graduate Research Symposium and Poster Session, and regional or national scientific meetings approved by the research advisor. Whatever the forum, the student should inform the thesis committee of the time of the presentation so that at least two members may attend. A student who makes a public presentation of research outside the department may petition the DGS to allow this presentation to satisfy the requirement even though committee members cannot attend.

B. Time Required for Completion of Degree.
A typical time for completion of the PhD degree is 4.5–6 years, and depends on the progress of the student's research and fulfillment of the thesis requirements (see below). A special petition from the department is required to extend a terminal date beyond the sixth year.

Progress toward a degree after advancement to candidacy is evaluated largely on the basis of research potential. Yearly Dissertation Progress Reports from the student are reviewed by the thesis advisor and submitted to the DGS and Graduate School. During the third or fourth year, if a student's advisor judges that the student is struggling, the thesis committee may be asked to provide an evaluation of the likelihood that the student will complete the thesis research project. On the basis of that report, the student's progress may be deemed inadequate and support beyond the fourth year may not be provided.

C. Thesis Requirements.

1. Thesis Seminar. Each student will conclude their research activities by presenting an open seminar on their thesis work to the department. Exceptions may be made in rare cases of truly extraordinary circumstances, and only with the concurrence of the thesis advisor and the Director of Graduate Studies. At least two of the thesis committee members must attend the thesis seminar, and every effort must be made to ensure the attendance of all committee members. At least two weeks prior to the thesis seminar, the student should provide each committee member with a copy of the thesis that is complete and formatted according to the requirements of the Graduate School (see below).

2. Thesis Format. The Graduate School has a number of detailed requirements for the format of the thesis and such criteria should be consulted by the student prior to beginning to write the thesis. A link to the requirements is available online on the Chemistry "Useful Links" webpage and a list is available from the Chemistry Main Office. After all of the changes recommended by the thesis committee have been made, an electronic PDF copy should be submitted to the Chemistry Department Graduate Registrar. The thesis committee members and the graduate school degree committee determine the final acceptance of a thesis.

3. Thesis Deadlines and Tuition Bills. All Ph.D. candidates in years one through four are charged full tuition. These charges normally are covered by the research grants of their advisors and/or University Fellowships. Once a student has met the four-year tuition requirement, he or she charged a continuing registration fee (CRF) of $650 per term until the dissertation is submitted or the terminal date (end of sixth year) is passed. A special petition from the department is required to extend a terminal date beyond the sixth year.

The dates for submitting the thesis for December and May degrees are as follows:

Monday, October 1, 2018	December degree
Thursday, March 14, 2019	May degree

V. Teaching and English Language Requirements

A. Teaching Requirements.

Students are required to serve as teaching fellows (TFs) at the TF20 level for two semesters during their studies. The workload inevitably varies with the course assignment, but a student should report to the Director of Graduate Studies if his or her duties exceed 225 hours per semester for a TF20 assignment.

In later semesters, graduate students may teach additional semesters, at the discretion of the research advisor. Students should be advised that the Center for Teaching and Learning at Yale offers in-depth instruction on teaching, for students who have teaching in their career aspirations.

B. English Language Requirements.

International students must demonstrate proficiency in spoken English prior to being assigned as a teaching fellow (TF). Proficiency can be demonstrated by obtaining a score of 50 or higher on the SPEAK test, obtaining a score of 50 or higher on the TSE exam, or completing a degree with at least two years of study from a university other than Yale in which the language of instruction is English. The SPEAK test is given at Yale three times each year: in August, just prior to the start of the Fall term, in December, and in May. Any student who has not fulfilled the spoken-English proficiency requirement must take the SPEAK test every time it is offered. Students who have not completed the spoken-English proficiency requirement must enroll in a course in spoken English at the Yale English Language Institute. Attendance of this course is mandatory during each academic term, as well as over the summer, until the spoken-English proficiency requirement is completed.

VI. Safety, Waste Disposal, Conduct and Departure

A. Safety.

Safety should be a primary concern of all students working in a research laboratory. Safety in the laboratories begins, first and foremost, with a sense of responsibility to yourself and your colleagues, because it puts everyone at risk. All incoming graduate students are required to complete the Web-based chemical safety training program (http://ehs.yale.edu/trainings/Lab-Chemical-Training) prior to beginning any laboratory work. Each year during orientation, the department holds a safety meeting at which attendance of all incoming students, lab safety officers, and teaching fellows is required. Departmental safety policies are posted online at www.chem.yale.edu/resources/safety. Individual research groups also have more specific safety policies.

Adherence to the established safety procedures is required for all individuals to remain in good standing. Occasionally there are individuals who are repeatedly unable or unwilling to abide by safety policies. To resolve such cases, the following program has been instituted:

Step 1: Individuals whose research advisors find them to be repeatedly out of compliance with our safety policies will be required to discuss the issues in question with their advisor and the Director of Graduate Studies. This is meant to give both parties an opportunity to articulate their position and basis for behavior, and ideally come to a mutually agreeable solution that addresses all issues. The individual may be reprimanded by

actions including, but not limited to, suspension from laboratory work, assignment of additional laboratory duties, or routine safety inspections. A written summary of this meeting will be kept in the student's file.

Step 2: If the efforts above are unsuccessful, there will be a formal meeting of the student's thesis committee. In cases where a thesis committee has not been formed (*e.g.*, first-year graduate students, postdoctoral fellows, undergraduates, *etc.*), an *ad hoc* committee composed of three faculty members will be established. The committee may recommend additional actions. A summary of this meeting will be recorded.

Step 3: If both of the above meetings are unsuccessful, the individual will be referred to the Dean of the Graduate School with the recommendation that he or she be transferred to an alternative program or dismissed from the University. Other individuals (visiting scientists, postdoctoral fellows, *etc.*) may be terminated at the discretion of their advisor.

Each laboratory has one or more designated Laboratory Safety Officers (LSOs), who help the PI to ensure laboratory members are in compliance with all safety rules on a day-to-day basis. The LSOs also are instructed by the faculty to bring repeated instances of non-compliance to the attention of their faculty advisor.

B. Health and Mental Health.

Research productivity should not be allowed to compromise students' health and safety. Students should obey all University-declared weather emergencies and discourage other students from putting themselves in harm's way (*e.g.*, walking alone at night). Lab-related injuries should be reported immediately to the research advisor and to EHS personnel.

Research and life can be stressful, and students are encouraged to seek professional counseling when needed. Yale Health offers free and confidential mental health screenings.

The Yale Graduate School manages requests for leaves due to physical or mental health, and also offers parental leaves for new parents of either gender. Please consult the GSAS website for more information.

Selected contact information:

Environmental Health & Safety (EHS): 203-785-3550
Safe Ride: 203-432-WALK
Mental Health: 203-432-0290

C. Waste Disposal.

The U.S. Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) have strict regulations on the handling of chemicals and waste. The Yale safety and waste management offices conduct periodic on-site inspections of all laboratories, and facilities found to violate EPA and OSHA regulations during these inspections may be closed for a period of time.

All chemical waste must be placed in a waste container that has been entrained in secondary containment. It is critical that every waste bottle be labeled with a proper waste tag provided by the Yale Safety Office, that the contents of the bottle be listed in English words, not formulas or

structures, and that the cap always be kept on except when actively adding material to the bottle. For additional details, please see http://ehs.yale.edu/chemical-waste.

D. Tutoring.
The Graduate School will allow most graduate students to tutor in courses they are not teaching. However, specific approval must be obtained from the research advisor before committing to other obligations of this sort. Generally, only limited hours will be approved because the focus of each student's Ph.D. work must be research.

E. Graduate School Regulations on Outside Work.
The Graduate School has set rules and regulations regarding employment outside of the chemistry department. The Graduate School regulations (https://gsas.yale.edu/funding-aid/yale-student-employment-office-seo) state, "Unless otherwise noted in the letter of admission, students are expected to register on a full-time basis. Part-time employment at the University or elsewhere should not conflict with the obligations of the degree program or interfere with academic progress. International students must consult the Office of International Students and Scholars (OISS) regarding their eligibility for employment while in the United States. Part-time employment beyond an average of ten hours per week requires permission of the director of graduate studies in consultation with the appropriate associate dean." Outside employment, of any type, by a graduate student also must be approved by the student's research director.

F. Vacations.
Four weeks of vacation time per year (including University holidays) generally is acceptable, but specific regulation of vacation time falls under the jurisdiction of the research advisor.

G. Pets.
Non-research animals (*e.g.*, dogs) are not to be kept in the Chemistry buildings or courtyards.

H. Noise.
Excessive noise, such as loud music, will not be tolerated within the Chemistry buildings because it compromises the effectiveness of safety alarms, and influences the working environment of others.

I. Departure.
Before students leave the Department, it is necessary to certify that all keys, books, and laboratory records have been returned and that the student's research area has been cleaned and left free of hazards. Proper disposal of residual chemicals by each student is required prior to departure because it is tremendously expensive to dispose of unknown chemicals.

Students who are considering leaving the Ph.D. program prior to their terminal degree should schedule a confidential discussion with the Director of Graduate Studies or the Director of Student Climate and Diversity.