

Chemistry Graduate Student Handbook
September 2009 (pending faculty approval)

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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, the Departmental Graduate Registrar, 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 September, and registration for Spring semester courses is conducted in January. At the beginning of January, the Chemistry Department will provide schedules and forms to register for the Spring semester courses.

Each student who registers for courses is required to discuss the course schedule with his or her course advisor before completing the on-line registration form. Approval of the courses by the

advisor is then conducted online. A designated member of the Graduate Committee serves as the course advisor for first-year students. The course advisor will be asked to initial a hard copy of the form to confirm that a discussion about courses has occurred. All upper-year students must register for research and group/departmental seminars, in addition to any course that is being taken for credit.

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

B. Course Schedules.

In conjunction with the course advisor, a program of coursework for the first year is chosen based on the student's field of interest, previous education and experience, and need for some breadth of study.

Graduate students must complete six courses prior to graduation, a majority of which should be completed in the first year. The courses are graded on a scale of Honors (H), High Pass (HP), Pass (P) and Fail (F). The Chemistry Department requires that 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. Permission to complete fewer than six courses prior to the end of the second year requires approval of the Director of Graduate Studies.

Each sub-discipline has specific course recommendations that are outlined on the following pages. In some cases, recommended courses are not offered every year, and you should take advantage of the course when it is offered. The course requirements have been designed for students with a primary interest in some form of preparative chemistry or in physical chemistry. The physical chemistry course curriculum is slightly different for those interested in biophysical chemistry and for those interested in physical chemistry and chemical physics.

1. Course Requirements in Preparative Chemistry. A student who will be conducting research in areas of preparative chemistry, such as coordination chemistry, bioinorganic chemistry, chemical biology, synthetic organic chemistry, physical organic chemistry, organometallic chemistry, materials synthesis or catalysis, must complete six courses during the first three semesters. 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, and one course in theory or reaction mechanisms. In addition, it is recommended that each student complete a course in physical and spectroscopic methods. These courses can be completed with several possible distributions to fit your background and the schedule of course offerings. You may enroll in three courses each of the two semesters of the first year, four courses the first semester and two the second, or three courses the first semester, two the second semester and one course the first semester of the second year.

The following table provides guidelines on which courses would provide an exposure to synthesis, biological chemistry, transition-metal chemistry and reaction mechanisms.

Synthetic Chemistry	Transition Metals	Biological Chemistry	Theory and Mechanism
Synthetic Methods 523	Organometallics 552	Chemical Biology 521	Advanced Organic 519
Organometallics 552	Modern Coordination Chemistry 557	Bioinorganic Chemistry 554	[Transition Metal Reaction Mechanisms 555]
	Bioinorganic Chemistry 554	Enzyme Reaction Mechanisms	Enzyme Reaction Mechanisms
Natural Product Synthesis 528	Theoretical and Inorganic Chemistry 550b	[Structure and Chemistry of Proteins and Nucleic Acids MBB741]	[Computational Chemistry and Biochemistry 526]
	[Transition Metal Reaction mechanisms 555]		

Chemistry/Biology Interface Training Program

Those chemical biology students supported by the Chemistry/Biology Interface (CBI) training grant are expected to take three full-semester courses for credit each term of their first year. Specific courses will be chosen in consultation with a designated faculty advisor. It is expected that by the end of the second year in residence, students supported by the Chemistry/Biology Interface (CBI) training grant will possess a solid background in both organic and biological chemistry, as well as a sophisticated understanding of important methodologies in cell and molecular biology. These requirements may, however, be fulfilled in whole or in part through courses taken as an undergraduate.

Selection of Elective Courses

In addition to fulfilling the core requirements for Preparative Chemistry, students supported by the Chemistry/Biology Interface (CBI) Training Grant will take one elective from each of the two course listings below. In addition, all CBI students will participate in Responsible Conduct of Research MB&B 676, in their first year. All students will audit the Current Topics in Organic Chemistry Seminar Series (Chem 720) throughout their residence at Yale.

CBI Electives (One elective from each list is required):

Biochemistry/Structural Biology	Cell and Molecular Biology
MBB600 Principles of Biochemistry I	MCDB603 Cell Biology
MBB601 Principles of Biochemistry II	MCDB625 Genetic Analysis
MBB720 Macromolecular Structure and Biophysical Analysis	MBB705 Mol Genetic Prokaryotes
MBB721 Macromolecular Interactions and Dynamic Properties	MBB734 Advanced Eukaryotes Molecular
Chem556 Biochemical Kinetics and Dynamics	MCDB570 Biotechnology
MCDB630 Biochemical and Biophysical Approaches	PHAR502 Pharmacology I/II

2. Course Requirements in Biophysical Chemistry. Students are expected to carry three full-semester courses for credit each term of their first year. Programs will be designed in consultation with a designated faculty advisor using the following guidelines.

By the end of the second year in residence, it is expected that students will have obtained a solid background in physical and biological chemistry and an understanding of the major molecular biophysical methods (magnetic resonance and X-ray crystallography). The specific course

requirements are listed below. Requirements may, however, be fulfilled in whole or in part through courses taken as an undergraduate.

In addition, students supported by the Biophysics Training Grant will take the Biophysics Research Rotations and Ethics course, Chem 700, in their first year. Other Biophysical Chemistry students are encouraged to audit Chem 700. All students will audit the Molecular Science Seminar Series (Chem 730) throughout their residence at Yale.

Course requirements:

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

- Molecules and Radiation 1 (normally Chem 540a),
- Biochemical Kinetics & Dynamics (normally Chem 556a),
- Statistical Methods and Thermodynamics (normally Chem 530b),
- [Biophysical Chemistry (Chem 549b).]

(2) Two elective one-semester courses. We recommend that one be an advanced biological course (molecular biology, cell biology, chemical biology or bioinorganic chemistry) and the other an advanced course on physical methods (spectroscopy, X-ray crystallography or computational chemistry).

A typical first-year program of study is as follows

Fall Term: Chem 540a, Chem 556a, elective, Chem 700a, Chem. 730a

Spring Term: Chem 530b, Chem 549b, elective, Chem 700b, Chem 730b

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

3. Course Requirements in Physical Chemistry. Students are expected to take three courses for credit each term of their first year. Students will arrange their schedules in consultation with a designated faculty advisor, taking into account their undergraduate experience. By the end of the second year of residence it is expected that students will have completed at least six courses for credit and will have completed or demonstrated proficiency in the following 7 core courses:

Introductory Quantum Chemistry (Chem 570a)

Advanced Quantum Mechanics (Chem 572a)

Statistical Mechanics and Thermodynamics (Chem 530b)

Molecules and Radiation (Chem 540a and 542b)

Advanced Physical Methods in Molecular Science (Chem 560La and 561Lb)

Entering students who have previously completed courses with substantially the same content as those listed above need to complete a total of only 6 courses for credit. In addition to fulfilling the remaining core requirements, their courses may be selected from the list below. Alternative courses not on the list may be considered, where appropriate, with approval of the advisor.

[Research Topics in Physical Chemistry (Chem 535a)]

[Nuclear Magnetic Resonance in Liquids (Chem 548b)]

Advanced Organic Chemistry I (Chem 518a) Advanced Organic Chemistry II (CHEM 519b)

Spectroscopic Methods of Structure Determination (Chem 525b)
Theoretical and Inorganic Chemistry (Chem 550b)
Organometallic Chemistry (Chem 552a)
Modern Coordination Chemistry (Chem 557a)
Classical Mechanics (Phys 410 a or b)
Solid State Physics I & II (Phys 448a & 449b)
Electromagnetic Fields and Optics (Phys 430b)
[Introduction to Atomic Physics (Phys 522a)]
Mathematical Methods of Physics (Phys 460a or 506a)
Mathematical Methods in Engineering (ENAS 397b)

With agreement of their designated faculty advisor, a student may replace one or more of the core courses by an appropriate alternative course, including but not limited to those on the above list.

The mathematical background of Physical Chemistry students should include linear algebra and calculus at least to the level of differential equations. Courses appropriate for strengthening mathematical background include Math 222a or b, ENAS 194a or b, and Phys 301a.

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

II. Choice of Research Advisor

The choice of research advisor is the most important decision in graduate school and should be made with information from several sources: attendance at research presentations during the first weeks of the first year, multiple discussions with the 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 gathering of this information, Yale Chemistry has a system of 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. All students, regardless of their research interests, are required to attend these meetings. These seminars provide the best opportunity during your graduate career to gain an overview of research occurring in the department and the interests of each faculty member. Times and places for these seminars will be posted on the graduate student bulletin board.

Beginning with the fourth week of the Fall term, participation in a formal laboratory rotation is required. Rotation schedules vary between subdivisions (see below). By the end the third week (Sept. 19), students in areas of preparative chemistry should submit to the Department Registrar a list of at least four research groups with which they will rotate and students in areas of physical chemistry and chemical biology should submit a list of three (biophysical, chemical biology) or four (physical chemistry and chemical physics) research groups with which they will rotate. The schedule for rotations will be posted on the following Monday.

1. Rotation Schedules and Deadlines for Research Group Choices. The content of the rotation depends on you and the faculty member, but one is expected at a minimum to visit with the faculty member for an introduction, to meet a second time to follow-up on the initial

discussions, to read key publications from the group, to attend group meetings, and to discuss projects with the graduate students and postdocs of the group. You should have established this type of contact with several research groups and faculty members prior to the deadline for choosing a group.

a. Rotation Schedule in Preparative Chemistry. Students in preparative chemistry will conduct rotations during three three-week periods of rotations. A student may choose to conduct two rotations simultaneously, allowing for a total of six rotations. A rank-ordered list of three research groups is due one week after the end of the three rotations, though an extension of this deadline may be requested. Chemical Biology students supported on the CBI training grant are required to register for Chem 700-02 for Credit (Sat/Unsat), which will include three long rotations and a formal presentation of the results from each rotation. [First-year students interested in chemical biology not supported by a training grant should register for Chem 720, Current Topics in Organic Chemistry for Audit. The schedule of the rotations and choice of advisor is the same as given below for Biophysical Chemistry students.

b. Rotation Schedule in Physical Chemistry. Students in physical chemistry will conduct four three-week rotations. A rank-ordered list of three research groups is due one week after the end of the four rotations, though an extension of this deadline may be requested.

c. Rotation Schedule in Biophysical Chemistry. Biophysics students supported on the biophysics training grant are required to register for Chem 700-01 for Credit (Sat/Unsat), which will include three long rotations and a formal presentation of the results from each rotation. [First-year biophysics students not supported on a training grant should register for Chem 700-01 for audit.] Four short rotations are required for all other students. The following lists a schedule of the rotations and choice of advisor.

A summary of the schedule for events related to group selection follows:

All First-Year Students:

Sept. 9 - Sept. 16	Evening presentations by faculty
Sept. 18	Submission of selection of rotations.

Chem 700 Students:

Sept. 21 - Nov. 13	First rotation
Nov. 16 - Feb. 19	Second rotation
Feb. 22 – April 30	Third rotation
May 3	Submission of top three choices for advisor by the biophysical and CBI students.

All Other Students:

Sept. 21 - Oct. 9	First rotation
Oct. 12 - Oct. 30	Second rotation
Nov. 2 – Nov. 20	Third rotation
Jan. 11 – Jan. 29	Fourth rotation

November 30	Submission of three choices of advisors by students in preparative chemistry
February 1	Submission of top three choices for advisor by students in physical 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.

B. Advisor Selection.

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

C. 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 grant can be selected as a research advisor without restriction. It is also possible to join a research group of a faculty member who is not affiliated with the Chemistry Department provided that the student works on a thesis project that has sufficient chemical content. If a student wishes to join a group outside of the Chemistry Department, the student 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 proposed thesis project. This committee must approve the proposed project prior to joining the research group.

D. Changing of Research Advisors.

Because of the obvious disruption of progress toward the Ph.D. degree from changing research advisors, students are strongly urged to gather information to make informed and careful choices of research advisors. A desire to change research groups should be discussed with the Director of Graduate Studies and with the current and proposed new research advisors. Prior to a change in group, the student must clean his/her equipment and lab, and a comprehensible research report, lab notebooks, and data must be provided to the advisor.

III. Second-Year Oral Examinations and Cumulative Examinations.

A. General Information on Second-Year Oral Examinations.

Oral exams are conducted by a three-member faculty committee that is comprised of 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 his or her research advisor, may suggest appropriate members. Suggestions should be submitted to the department registrar by the end of September of the second year. The committee that administers the second-year oral examination normally forms the student's final thesis committee.

Results of the oral examination are provided immediately after a brief discussion of the examination among the members of the thesis committee. A student who does not pass one or both of the oral examinations should consult with members of the exam committee for advice and, if applicable, options for additional opportunities to fulfill the oral examination requirements. Such options often include: retaking the oral exam 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 Oral Examinations.

1. Oral Examinations in Preparative Areas of Chemistry. The oral examinations in preparative chemistry consist of two parts that will be administered on the same day. One part consists of a proposal for research on the topic of your thesis work, and the second part consists of a proposal on a topic separate from the thesis research. You 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 of the project. Both sections of the exam will emphasize fundamental chemistry, including the material of your course work. In addition to your performance during the oral and written part of the exam, you will be judged on progress in research. The chair of the examining committee will provide to the student and Registrar a written summary of recommendations. You should obtain a form for this purpose from the Registrar and bring it to the examination. The examination must be taken by May 31.

Both proposals must be written with the structure of an NIH grant proposal. Details of this format can be found under “Research Plan Format and Page Distribution” at http://grants.nih.gov/grants/funding/phs398/section_1.html#page_limits. This format consists of the following parts. For a ten-page proposal, the suggested lengths are given in parentheses.

- A. Specific Aims (0.5 pages)
- B. Background and Significance (two pages)
- C. Preliminary Results (two pages; you should summarize your own results)
- D. Experimental Design and Methods (Proposed Research, five pages)

The research proposal, covered in the second part of the exam, must be original and conceived by the student. The topic chosen should fall outside the area of thesis research, differ significantly from work currently being carried out within the department, and should be unrelated to previous undergraduate or industrial research or a trivial derivative thereof. In general, a proposal will be considered to lie outside the thesis area if the advanced literature survey required for its preparation shows, at most, minor overlap with that required for the thesis. You should begin the process of obtaining approval of your proposal topic no later than early January. Members of the thesis committee should approve the proposal topic prior to beginning an in-depth investigation of the area. This independent research proposal should be written with a structure and balance of an NIH grant but with a length no longer than 4000 words, excluding references. This is the length of a PRF starter (G-type) grant. As a guideline for the scope of a PRF-G grant, it provides resources for roughly one student for two to three years.

2. Second-Year Oral Exams in Physical Chemistry. Two oral exams with accompanying written reports must be passed during the second year: a thesis-area exam in the Fall term and an in-depth progress report in the Spring term. The thesis-area exam covers the area of proposed thesis research and is intended to be more an advisory procedure than an academic hurdle. The second oral examination evaluates your progress in the initial stages of research, including knowledge of the relevant literature.

For the first oral exam, it is expected that each student will think through, in detail, the particular research project about to be pursued. Students are encouraged to consult with other members of the faculty prior to making a long-term commitment to their research project. The examination

will be administered by the two members of the student's thesis committee and chaired by a third member substituting for the advisor. The written report is due on October 15, and the oral exam must take place before November 1.

It is the student's responsibility to verify with his or her committee members their availability for the oral exam three to four weeks in advance. Once a date and time has been established, a room should be reserved with the Main Office personnel. The written report should be approximately 10 printed pages and should be in the format of a grant proposal as follows:

- a. Specific Aims. State the objectives of the specific research described in the proposal. One page is recommended.
- b. Background. Briefly describe the existing knowledge relevant to the proposed research and identify the gaps that the proposed work is intended to fill. Two to three pages are recommended.
- c. Preliminary Results. Summarize your own studies.
- d. Experimental Plan. Outline the experimental design and the procedures to be used to accomplish the specific aims of the project. Five to six pages are recommended.
- e. Literature Cited. List literature citations at the end of the research plan. See *J. Am. Chem. Soc.* for style.

Oral examinations should begin with no more than a ten-minute oral presentation by the student of the topic under question. Questions and responses that follow should probe the student's knowledge of necessary background material and go beyond that specifically related to the thesis.

The second oral examination will be carried out in two steps. First, a written summary detailing the project goals and the steps taken to achieve them is submitted to the committee by the first Monday after spring break of the second year of residence. The report is typically limited to about 6 pages and will outline the student's research objectives, relation to results found in the literature, accomplishments to date, difficulties encountered, and next steps to be taken. Comments from the committee will be returned to the candidate the following week along with a list of references to both chapters from standard textbooks and to current papers from the literature. Prior to the second oral examination, the student should study the textbook material and the literature references in light of committee's comments. The candidate must schedule the second oral examination before or during the week *prior* to final examinations. In addition to assessing the student's progress in research, it is expected that the oral exam will explore questions of basic physical or biophysical chemistry to establish the broader context of the specific research plan. The focus of these broader issues will be drawn from the list of references explicitly stated in advance as part of the committee's comments on the written progress report.

The committee should meet immediately before the second oral examination to discuss the student's performance thus far in graduate school. The research supervisor should bring all of

the student's records kept by the graduate secretary to this meeting. In both exams, the committee chairman should provide to the student and registrar a written summary of recommendations. A form for this purpose should be obtained by the student from the registrar and brought to the examination.

2. Second-Year Oral Exams in Biophysical Chemistry. Two oral exams with accompanying written reports must be passed during the second year: a thesis-area exam in the Fall term and an independent research proposal exam in the Spring term. The thesis-area exam covers the area of proposed thesis research and is intended to be more an advisory procedure than an academic hurdle. The second oral examination evaluates your design and research of a research project that is outside of your thesis research area.

For the first oral exam, it is expected that each student will think through, in detail, the particular research project about to be pursued. Students are encouraged to consult with other members of the faculty prior to making a long-term commitment to their research project. The examination will be administered by the two members of the student's thesis committee and chaired by a third member substituting for the advisor. The written report is due on October 15, and the oral exam must take place before November 1.

It is the student's responsibility to verify with his or her committee members their availability for the oral exam three to four weeks in advance. Once a date and time has been established, a room should be reserved with the Main Office personnel. The written report should be approximately 10 printed pages and should be in the format of a grant proposal as follows:

- a. Specific Aims. State the objectives of the specific research described in the proposal. One page is recommended.
- b. Background. Briefly describe the existing knowledge relevant to the proposed research and identify the gaps that the proposed work is intended to fill. Two to three pages are recommended.
- c. Preliminary Results. Summarize your own studies.
- d. Experimental Plan. Outline the experimental design and the procedures to be used to accomplish the specific aims of the project. Five to six pages are recommended.
- e. Literature Cited. List literature citations at the end of the research plan. See *J. Am. Chem. Soc.* for style.

The first Oral examinations should begin with no more than a ten-minute oral presentation by the student of the topic under question. Questions and responses that follow should probe the student's knowledge of necessary background material and go beyond that specifically related to the thesis.

The second oral examination will be carried out in two steps. First, a written one paragraph summary detailing the project goals and the steps taken to achieve them is submitted for approval to the committee by the first Monday after spring break of the second year of residence.

The final proposal is typically limited to about 10 pages and will follow the outline for an NIH-style grant application as for the first exam, except 'Preliminary Results' will, of course, not be included. This proposal is designed to test the student's ability to assess the literature and successfully develop an independent project. The second oral must be original with the student, should be outside the area of thesis research, not too closely related to work currently being carried out within the department, and should not include a student's previous undergraduate or industrial research or a trivial derivative thereof. In general, a proposal will be deemed to lie outside the thesis area if the advanced literature survey required for its preparation shows, at most, minor overlap with that required for the thesis. The candidate must schedule the second oral examination before or during the week *prior* to final examinations. In addition to assessing the student's progress in research, it is expected that the oral exam will explore questions of basic physical or biophysical chemistry to establish the broader context of the specific research plan. The focus of these broader issues will be drawn from the list of references explicitly stated in advance as part of the committee's comments on the written progress report.

The committee should meet immediately before the second oral examination to discuss the student's performance thus far in graduate school. The research supervisor should bring all of the student's records kept by the graduate secretary to this meeting. In both exams, the committee chairman should provide to the student and registrar a written summary of recommendations. A form for this purpose should be obtained by the student from the registrar and brought to the examination.

C. Cumulative Exams in Areas of Preparative Chemistry.

Sixteen cumulative exams covering areas of preparative chemistry will be held during the academic year, two exams given the same night each of eight months. A total of three passes must be accumulated by the end of the second year, and a total of eight passes must be gained before obtaining the Ph.D degree. Scores of full pass and half-pass can be achieved on any single exam. You may complete more than one exam when two exams are administered. The cumulative exams will be administered on the first Tuesday of the month, and topics of the cumulative exams will be posted at 4:30 on Friday afternoon prior to the exam.

D. Advancement to Candidacy.

At the end of the second year of study, qualified students will be advanced to candidacy for the Ph.D. degree. At this time a student's progress is judged thoroughly. Students who are advanced to candidacy at this time can be reasonably assured that they will be able to complete the degree requirements.

To advance to candidacy, you must have:

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.
2. passed the oral exams and, if applicable, three written cumulative exams.

3. passed the SPEAK test or equivalent if you are an International student.
4. made satisfactory research progress, as judged by the thesis committee.
5. provided a thesis prospectus to the registrar. Normally, the written report of thesis work for the oral examination is the thesis prospectus.

A student who has not satisfied these requirements by the end of the second year will be reviewed by the Department. If the Department feels that this student cannot complete the requirements for the Ph.D., he or she will be asked to withdraw, but if the Department feels that this student can achieve the degree, he or she will be given a deadline for the completion of the requirements for advancement to candidacy.

E. Master's Degrees.

Students are accepted into the chemistry Ph.D. program. There is little value to a master's degree if you successfully obtain a Ph.D degree. However, you may apply for a Master of Science degree when the necessary requirements are met or if you decide to leave the Ph.D. program. The requirements for the M.S. are:

1. Residence: A student must have one full year of residence.
2. Courses: A student must pass at least five one-semester courses at the graduate level in the Chemistry Department, excluding seminars and research. The Director of Graduate Studies may approve substitution of graduate-level courses in other departments.
3. Honors: The student must obtain at least one semester grade of "honors" or three of "high pass" in graduate-level courses (excluding seminars and research).

IV. Requirements beyond the Second Year.

A. Advanced-Year Seminars and Reports.

Each year every student in the third, fourth and fifth year must present a written report and meet with the thesis committee. By the end of the fourth year, the student must make at least one public presentation of his or her research progress. Before final approval of the Ph.D. dissertation, the student must, in addition, present a public thesis seminar.

1. Annual Progress Reports. During April, you must prepare for the thesis committee a written summary of research progress and plans and meet with the committee to discuss your research progress.

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 and you should provide this written report to your thesis committee members at least one week prior to the meeting on research progress.

By the end of May, you must meet with your thesis committee to discuss research progress. If it is impossible to schedule a meeting with the entire thesis committee, at least two members must attend, and within any two-year period every member must attend at least one meeting. After the

meeting, the student must file with the departmental registrar the Annual Committee Meeting form signed by the members of the thesis committee.

In any year when you present your research progress in public (see below) in a forum attended by at least two members of the thesis committee, the requirement of an annual meeting will be waived. You must file a Public Research Presentation form that indicates approval of the presentation by all committee members. You may still request a committee meeting and at a minimum you should make at least informal contact with your committee annually.

2. Public Presentation of Research Progress. By the end of the fourth year, and at least six months before the final thesis defense, you must present in public a report on your ongoing research and file the public research presentation form with the departmental 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, Club Med, and Metal Mania), the annual Graduate Research Symposium and Poster Session, and regional or national scientific meetings approved by the research advisor. The deadline for this public presentation is September 15. 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 Director of Graduate Studies to allow this presentation to satisfy the requirement even though committee members cannot attend.

B. Time Required for Completion of Degree.

Although it is difficult to stipulate the exact time required for completion of the Ph.D. degree, 4-5 years is considered normal. Progress toward a degree after advancement to candidacy is evaluated largely on the basis of research potential. Yearly reports from the student are reviewed by the thesis advisor and submitted to the Graduate School. During the third or fourth year, if a student's advisor feels 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. In all cases, an open seminar to present the thesis work to the department should culminate your research activities. At least two of the thesis committee members must attend. It is on the basis of this review and presentation that the Department recommends a Ph.D. degree. At least two weeks prior to the thesis seminar, you 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. A list is available from the Chemistry Main Office. After all of the changes recommended by the thesis committee have been made, two copies of the final thesis are submitted to the Chemistry Department registrar in the following format: one hard-bound copy with the title, the author's name and year of degree award printed on the cover and spine; and one unbound copy to be submitted in either a large envelope or some other secure method. The "readers" and the graduate school degree committee make the final acceptance of a thesis.

3. Thesis Deadlines and Tuition Bills. All Ph.D. candidates in years one through four will be charged full tuition. These charges are normally covered by research grants of their advisors and/or University Fellowships. Once a student has met the four-year tuition requirement, he or she will be charged a continuing registration fee (CRF) of \$256 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 a December and May degree are:

October 1, 2008	December degree
March 16, 2009	May degree

V. Teaching and English Language Requirements.

A. Teaching Requirements.

Students are required to serve as teaching assistants at the level of a Teaching Fellow III 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 "TF III" assignment.

A few TF I (~ 5 hours per week) and TF II (~ 10 hours per week) positions are available to graduate students in chemistry. These positions provide supplemental support to students with external fellowships or research assistantships. The duties vary according to the assignments and may be modified at the discretion of the instructor in charge of the course.

B. English Language Requirements.

International students must demonstrate proficiency in spoken English prior to completing the teaching requirement. 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 each 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 a course in spoken English is mandatory during each academic term and 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. All incoming graduate students are required to complete the WEB based chemical safety training program (<http://info.med.yale.edu/chemhaz/>) prior to beginning any lab work. Each year on the morning of the Graduate Student Symposium (currently called the Bristol-Myers Squibb symposium), the department holds a safety meeting at which attendance by all graduate students and postdocs is required. In addition, questions about safety can be addressed to the Chemistry Department Safety Committee or the University Safety office. Please follow all instructions provided by these people.

B. Waste Disposal. The U.S. Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) has strict regulations on the handling of chemicals and waste. After an inspection by EPA several years ago, Yale incurred fines in excess of a million dollars. A violation of a regulation, such as improper labeling of a single waste bottle, can incur a fine of \$10,000. The Yale safety and waste management offices conduct periodic inspections of the laboratories, and laboratories found to violate the EPA and OSHA regulations during these inspections may be closed for a period of time.

Without exception, your chemical waste must be placed in a waste container in a blue tray provided by the safety office in a hood. It is absolutely critical that the bottle is labeled with a proper waste tag provided by the Yale Safety Office and that the contents of the bottle be listed in English words, not formulas or structures. It is also absolutely critical that the cap is always on, except when you are actively adding material to the bottle.

C. 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 Director of Graduate Studies. Generally, only limited hours will be approved.

D. 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 state, "Study toward the Ph.D. degree is expected to be a full-time activity. Accordingly, part-time employment for compensation, at the University or elsewhere, should not conflict with the obligations of the Ph.D. program or interfere with academic progress. Part-time employment beyond an average of ten hours per week requires permission of the director of graduate studies, who will inform the appropriate associate dean." Outside employment of any type by students in chemistry must be approved by the Director of Graduate Studies, the appropriate Associate Dean of the Graduate School, and the student's research director.

E. Vacations. Thesis research is the heart of the graduate program. In order to complete studies successfully in four years, it is usually necessary to work long hours and make judicious use of time. Four weeks of vacation time per year (including University holidays) is generally acceptable, but regulations about vacation time fall under the jurisdiction of the research advisor.

F. Pets. Non-research animals (e.g., dogs) are not to be kept in the building or courtyard.

G. Noise. Excessive noise, such as loud music, will not be tolerated within the Chemistry buildings.

H. 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 decide to leave the Ph.D. program should schedule a discussion with the Director of Graduate Studies prior to their departure.