

**SUMMARY OF PROCEDURES AND  
REQUIREMENTS  
FOR GRADUATE DEGREES**

**Department of Chemistry  
and Biochemistry**

The Ohio State University

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# **SUMMARY OF PROCEDURES AND REQUIREMENTS FOR GRADUATE DEGREES**

## ***DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY***

### **GRADUATE DEGREES IN CHEMISTRY**

#### **INTRODUCTION**

The requirements for advanced degrees at The Ohio State University are summarized in the Graduate School Handbook, which can be found on the Graduate School website at <http://gradsch.osu.edu/handbook>. All incoming students should become familiar with the contents of the Handbook and should use it for reference during the tenure of his/her degree program at OSU.

This document summarizes specific requirements for graduate degrees in Chemistry and Biochemistry, as well as additional comments and instructions for students in our programs. A student who seeks a graduate degree in the Department of Chemistry and Biochemistry is expected to expend a major effort on the research problem that culminates in a thesis or dissertation. To reach this goal, the candidate will conduct independent research under the guidance of a faculty advisor, prepare and present a thesis on the study, and demonstrate that it adds significant new knowledge to some area of chemistry. The course requirements are designed to prepare the student for this major challenge of graduate education.

#### **ADMISSION TO THE GRADUATE PROGRAMS IN CHEMISTRY AND BIOCHEMISTRY**

Admission requires demonstration of an acceptable B.S. or B.A. degree, and a reasonable expectation of success in the graduate program. The student should have a minimum overall undergraduate point-hour ratio of at least 3.2 (on a 4.0 basis), strong background in undergraduate chemistry courses, suitable performance on the graduate record examination (GRE), or satisfactory completion of such specific additional requirements as may be stipulated in special cases. The Graduate Admissions Committee reviews and makes recommendations on each application for admission to the program. The Vice Chair for Graduate Studies has final approval on all offers of admission.

#### **ACADEMIC STANDARDS FOR GRADUATE PROGRAMS**

A graduate student doing acceptable work toward a graduate degree is expected to maintain a point-hour ratio of B (3.00) or better in all graduate-credit courses. If at any time a student's cumulative point hour ratio (CPHR) falls below the 3.00 requirement, the student is automatically placed on probation by the Dean of the Graduate School. Although the student is expected to raise the CPHR above 3.00 the next term, continued enrollment is permitted on a term-by-term basis, as determined by the Vice Chair for Graduate Studies and the Graduate School. For additional information, please visit <http://gradsch.osu.edu/handbook/all#5-3>.

#### **DURATION OF GRADUATE PROGRAMS**

Typically, an MS can be completed in two years and the PhD program is designed to be completed within 5 years. Students who enter having had strong undergraduate preparation generally complete the majority of the required courses during their first year. It is required that the candidacy exam be completed by the end of the second year, and efficient and productive researchers may complete their PhD sooner than the 5-year time limit.

#### **PROFICIENCY EXAMINATIONS**

At the time students enroll in the Graduate School, the department will administer written examinations that are used to gauge competence at the undergraduate level in analytical, biological, inorganic, organic, physical chemistry, and general chemistry. The purpose of these examinations is to aid the

student and faculty advisors in planning a suitable progression of course work leading to the advanced degree. Students who are considered "not proficient" in a given area will be provided with advice on how to strengthen competency in that area. Such advice may include suggested course work and/or a course of independent study.

### **SAFETY SEMINAR COURSE**

Every graduate student is required to complete the Safety Seminar (CHEM 6781) course during the second half of Autumn Semester and the Ethics in Scientific Research course (CHEM 6782) during the Spring Semester of the first year. The purpose of the series is to maintain high safety and ethics standards in the departmental teaching and research laboratories. Failure to attend any of the lectures associated with these two courses will result in a grade of "Unsatisfactory" for the course and will constitute an unsatisfactory performance as a Graduate Associate, which may result in loss of departmental support in future terms. In addition to these two classes, each student must become familiar with the department's Chemical Hygiene Plan and the Standard Operating Procedures associated with their work.

### **FINANCIAL SUPPORT FOR GRADUATE STUDENTS**

Most graduate students in the Ph.D. program receive financial support as Graduate Associates, either Teaching Associates (GTA) or Research Associates (GRA), or as Fellows during their tenure in the department. Graduate students supported by any of these appointments may not hold additional employment of any kind without express permission of the Vice Chair for Graduate Studies. Fellowship stipends may be supplemented up to the current GTA stipend; any stipends above that level must have prior approval by the Vice Chair for Graduate Studies.

The Graduate School sets minimum requirements of eligibility for GA appointments to students who are in a degree program. Until passing the candidacy exam (section II.B) students on GA appointments must register for at least eight (8) credit hours during fall and spring semester and four (4) during the summer session. After entering Ph.D. candidacy, the minimum number of credit hours per semester (including summer session) is three (3) to be considered a full-time student. Students who hold fellowships must register for twelve (12) credit hours during each fall and spring semester and six (6) during each summer session the appointment is held prior to entering Ph.D. candidacy. After candidacy, fellowship students must register for a minimum of three (3) credit hours each term. Each of these registration requirements qualifies the student to be considered a "full-time student" for purposes such as health insurance and visas for international students.

There are additional requirements imposed by the Graduate School. A student must be enrolled for at least three (3) credit hours during the term in which they graduate. A Master's degree requires at least 30 graduate credit hours, and the Ph.D. requires at least 80 graduate credit hours. Audited courses do not count toward these minima.

Departmental policies coincide with the guidelines set by the Graduate School for the most part:

- (1) Students with a GPA below 3.00 lose their right to a Department Graduate Research Associate appointment (dGRA), and may lose future support as a GTA.
- (2) Students who are not required to complete an M.S. degree are required to advance to candidacy by the end of spring semester of their second year. Students failing to advance to candidacy by this time must petition the Vice Chair for Graduate Studies for continuation of support in the form of a GRA, GTA, or Fellowship appointment.
- (3) Students required to obtain an M.S. degree prior to moving onto the Ph.D. track are still expected to advance to candidacy by the end of Autumn Semester of their third year. Students failing to advance to candidacy by this time must petition the Vice Chair for Graduate Studies for continuation of support in the form of a GRA, GTA, or Fellowship appointment.

- (4) Students required to take a terminal M.S. degree are expected to defend their thesis by the end of spring semester of their second year. Students failing to defend their M.S. thesis by this time must petition the Vice Chair for Graduate Studies for continuation of support in the form of a GRA, GTA, or Fellowship appointment.
- (5) The Ph.D. degree is a five-year program. Students who expect to enter their sixth year of graduate training must petition the Vice Chair for Graduate Studies to receive support during all or part of their sixth year, and must have the written approval of their advisor. This petition must be submitted before the end of the Spring Semester of the student's fifth year in the program. Approval of such petitions will require the demonstration of a reasonable prospect that the degree program can be completed within one year.
- (6) Department policies specify that students who have been enrolled for more than six years may not receive support as a GTA, GRA, or Fellow, from Research Foundation, departmental, or other funding sources. Only in exceptional instances, which require demonstration of extenuating circumstances, will the Vice Chair for Graduate Studies consider a petition for support beyond six years.
- (7) Every faculty member and lecturer is required to evaluate their Graduate Teaching Assistants each term with ratings of Excellent (E), Satisfactory (S+, S, or S-), or Unsatisfactory (U). Evaluations are based primarily on overall performance as a teaching associate, but also include punctuality, attendance of staff meetings, and attitude toward students and staff. Students receiving an unsatisfactory (U) teaching evaluation will be suspended from their teaching appointment for one semester (excluding summer) and must petition the Vice Chair for Graduate Studies for subsequent reinstatement. No GTA support will be available during such a suspension. Petitions to be supported as a GTA can be made at the end of the semester (excluding summer) following the term during which the U rating was received. Any subsequent U or S- evaluations following reinstatement will lead to dismissal from the teaching program and no further GTA support will be available. If a dGRA appointment is due at the end of the student's term in which he or she received the U, the department portion of the stipend will not be available. Two S- ratings are regarded as equivalent to one U rating.
- (8) Every faculty member is required to grade the performance of students taking research credits under his/her supervision each term with ratings of Satisfactory (S) or Unsatisfactory (U). Evaluations are based primarily on overall progress in research, but also include time spent in the lab, attendance at group meetings or other meetings set by the advisor, and handing in reports required by the advisor in a timely manner. Students receiving an unsatisfactory (U) grade will meet with the advisor and the Vice Chair for Graduate Studies to devise a plan to ensure future success. A U grade in research can lead to the student not being in good standing in the department and can result in dismissal from the program.

### **GRIEVANCE PROCEDURES**

Discussion with the Vice Chair for Graduate Studies usually leads to resolution of a grievance. If discussion with the Vice Chair proves unsatisfactory, the Graduate School has established grievance procedures for issues related to examinations and GA appointments (Appendix D of the Graduate School Handbook; <https://gradsch.osu.edu/handbook/d-student-grievances-related-to-graduate-examinations-and-ga-appointments>). Grievances not related to examinations or GA appointments that cannot be resolved through discussion with the Vice Chair may need to be referred to the Graduate School or Student Advocacy for further review.

## **ENGLISH REQUIREMENTS FOR INTERNATIONAL STUDENTS**

A student whose native language is not English must demonstrate proficiency in English at the beginning of the graduate program. Courses in written and oral English may be required for students who show a deficiency that might prove to be a handicap to graduate work. Students who hold a GTA appointment will be required to demonstrate proficiency in Spoken English, either by passing the Oral Proficiency Assessment (OPA) or an Oral Proficiency Certification Assessment (OPCA), both of which are administered by the English as a Second Language Program. Students must be certified to teach by the end of the Spring Semester of their first year. International students may also be required to take English composition courses (5901, 5901.5, 5902) as a result of composition assessments administered during check-in at the Office of International Affairs. Chemistry and Biochemistry students are required by the Department to complete all spoken English courses by the end of their second semester at OSU. The Graduate School requires all students to complete those courses by the end of the summer term of the first year at OSU

## **FACULTY RESEARCH PRESENTATIONS, ADVISOR SELECTION, AND INITIATION OF RESEARCH**

Dissertation research is initiated when a student has selected a research advisor and has been admitted into a research group. The selection of an advisor is a major step in a student's program. The process involves attendance of faculty research presentations the first half of the Fall Semester, followed by a formal system of interviews during the second half of the semester. In addition, an informal process for student to become acquainted with research groups is strongly encouraged; these activities can include attending group meetings, talking to students in the group, touring the lab, and gathering information on publication record, time-to-degree, and level and type of support typically available for group members. Students are required to enroll in a 7-week course designed to introduce them to the ongoing research in the department, CHEM 6780. During this class, each faculty member presents a short (~20 min) talk on their research. Students are required to attend at least five full sessions, two within their major area of study and three others, in order to obtain a satisfactory grade in the course. These presentations are expected to help students identify at least four faculty members that he or she wishes to interview. Attending presentations from other disciplines will provide students with broader knowledge of ongoing research in the department and has been shown to result in students becoming interested in the research of faculty members they had not previously considered as an option for an advisor. After the end of the course, students will interview individual faculty whose research is of interest to them.

To initiate the interview procedure, the student will obtain a "Selection of Research Advisor Form" (blue form) from the Graduate Office and designate a minimum of four (4) faculty members that he or she wishes to interview. Students are encouraged to interview as many faculty as they feel may provide research programs of interest. Students may also have engaged in rotations the summer prior to start of graduate school or during the semester. These rotations may be considered an interview of a faculty member. The Vice Chair for Graduate Studies may assign additional faculty members, and provide the student with an "Interview Record Sheet" (yellow form). All faculty members on the "Interview Record Sheet" must sign the sheet after they have been interviewed. Students then submit a rank-ordered list of their top three choices for advisor ("Choice of Preceptor" form found on the reverse side of the yellow form) to the Graduate Office by a date that is announced at the start of autumn semester, typically during the middle to the end of November. The Graduate Studies Office then provides the list of student advisor preferences to the division secretaries and all faculty. Following any formal faculty discussion that may be required by a division, the faculty member listed as the first choice must decide whether or not to serve as advisor to the student. The faculty member notifies the division secretary and Graduate Studies Office of his/her decision. If a faculty member decides not to serve as advisor, the faculty member who is the second choice makes a similar decision. This process is repeated until the student has an advisor. In the event a student is not accepted by one of their top three choices, the Vice Chair for Graduate Studies becomes active in helping the student find an advisor, in a manner left to the discretion of the Vice Chair. Once the list of advisor preferences has been distributed, it is a goal of the department to place students in research groups within a two-week period. The process of selecting an advisor must be completed by

the end of the second semester in order to remain in good standing in the program and to qualify for a summer dGRA appointment.

A student must complete their Ph.D. research under the supervision of a faculty member in the Department of Chemistry and Biochemistry. Collaborations with faculty outside the department are possible, however, the direct supervision or formal co-advising of the Ph.D. research of chemistry and biochemistry graduate students by faculty outside the department is not permitted. Only regular faculty members of the Department of Chemistry and Biochemistry may serve as advisors for Chemistry PhD and MS students. Auxiliary faculty, Adjunct faculty, Emeritus faculty, Regional faculty, and those whose tenure-initiating unit is not the Department of Chemistry and Biochemistry may not serve as advisors to students in the Chemistry graduate program. Any other advising arrangement is subject to approval by the Vice Chair for Graduate Studies, who will request a description of the proposed research and consider whether it is suitable for a Ph.D. thesis in Chemistry and Biochemistry.

After selection of an advisor and in consultation with the student and their advisor, the Vice Chair for Graduate Studies will appoint an advisory committee for each student. The purpose of the advisory committee is to provide each student with support and guidance during their graduate career. Students should meet with their advisory committee during the spring semester of each year following completion of the Candidacy Exam to discuss their progress in course work, examinations, and research. The student should provide the advisory committee and the Graduate Studies office with a short research progress summary prior to each annual meeting. The advisory committee will provide written comments on the student's progress. In addition, students are free to meet with any committee member at any time during the year. The department hopes that this process will provide a mechanism for forging closer ties between students and faculty, both before and after graduation, and to provide additional guidance and support to students as they complete their research toward the Ph.D. degree.

If a student leaves a group, or the faculty advisor resigns his/her position as preceptor, the student will have seven weeks to find a new advisor. After this time, support will be withdrawn (at the end of the term of enrollment) and the student will no longer be in good standing in the department.

# GRADUATE PROGRAMS

## I. DEGREES GRANTED, RESIDENCE AND CREDIT HOUR REQUIREMENTS

### A. MASTERS PROGRAM

The student must have a minimum residence of two semesters at The Ohio State University with completion of at least 30 hours of graduate work. The student's course program should be decided in conjunction with the advisor and follow divisional guidelines. Course work must be at the 6000-9000 level, and the courses in related fields outside of chemistry or biochemistry must be approved by the Vice Chair for Graduate Studies and the student's advisor. Divisional course requirements for the M.S. degree can be found under the section titled "Course and Examination Requirements for the Sub-disciplines" of this document.

Students will carry out a research program that will culminate with the writing of a thesis. The research program should be initiated upon joining a research group. See "Initiation of Research", under Ph.D. requirements and Graduate Examinations for various sub-disciplines, for more specific procedures.

A student must initiate an "Application to Graduate" form at [gradforms.osu.edu](http://gradforms.osu.edu) for the Graduate School no later than the third Friday of the semester or the third Friday of summer session for commencement) at the end of the term in which graduation is expected. The candidate must pass an oral examination before a committee composed of at least two faculty members from the Department of Chemistry and Biochemistry, including the student's research advisor. Should the graduate record of the candidate be wholly satisfactory to the examining committee, the scope of the examination will be confined to the candidate's field of specialization. The thesis Approval form to the Graduate School and the electronic submission of the approved thesis to OhioLink must be submitted by the deadline published by the Graduate School for the semester or summer session of graduation.

Students working toward an M.S. degree will not receive financial support from the department (GRA, GTA, GAA) after completion of two years in the program. The Department of Chemistry and Biochemistry does not award non-thesis M.S. degrees and does not award M.S. degrees on the basis of satisfactorily completing the doctoral candidacy examination.

### B. DOCTORAL PROGRAM

The Graduate School requirements for the Ph.D. degree are stated in Part VII of the Graduate School Handbook (<http://gradsch.osu.edu/7-14-doctoral-summary-ph-d-degree-graduation-requirements>). The Department of Chemistry and Biochemistry has several additional requirements and procedures as outlined below. The student may follow either of two paths. The first involves proceeding directly to the Ph.D. degree. The second involves completion of an M.S. degree followed by continuation toward a Ph.D. degree. In either program, the candidate must satisfy the course requirements of one of the divisions of the department, or a designed multidisciplinary course of study, in addition to all departmental requirements.

The purpose of coursework in the Ph.D. program is to prepare the student to take the Ph.D. Candidacy Examination and to undertake work on a significant original investigation in chemistry and/or biochemistry that culminates in the doctoral dissertation. With the approval of the advisor, a student may elect to meet specific degree requirements in any of the areas in the department, normally the one in which the student's major research effort is planned.

The Ph.D. degree is a research degree, thus, most course work is taken during the first year; usually only selected advanced subjects are taken in the second and subsequent years. Those courses indicated as electives may include those required in other areas by the Division and, in some cases, additional courses in the major field. Advanced subjects are usually in the major field. Students who want to register for a course offered by departments other than Chemistry and Biochemistry must obtain

permission from the advisor and the Vice Chair for Graduate Studies before registering the course. Students who register courses outside of the department without approval will be dis-enrolled from those courses and will be liable for any monetary penalties imposed by the University. Students are expected to enroll in research each term.

Students will enroll for either Research in Chemistry (CHEM 8999) or Research in Biochemistry (BIOCHEM 8999), depending on their program and division. Each student should enroll every term for one hour of a seminar course, unless doing so violates the credit hour limits. This course requires regular attendance at weekly seminars.

The broadly defined contents of the Ph.D. curriculum in Chemistry are illustrated in the "Suggested Ph.D. Curriculum" that follows. More specific sample curricula are presented on a divisional basis on following pages. Please keep in mind that many graduate courses will be offered as "half-semester" 7-week classes, such that each semester is divided into two sessions, Session 1 and Session 2. Each 7-week course is typically 1.5 credit hours, such that taking two of these modules in one term will result in 3 credit hours for the semester.

### C. SUGGESTED PH.D. CURRICULUM

#### **Year 1 - Autumn and Spring Semesters**

| Autumn Semester              |                         | Spring Semester         |                         |
|------------------------------|-------------------------|-------------------------|-------------------------|
| Session 1                    | Session 2               | Session 1               | Session 2               |
| Major Subject (1.5 hr)       | Major Subject (1.5 hr)  | Major Subject (1.5 hr)  | Major Subject (1.5 hr)  |
| Major/Elective (1.5 hr)      | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) |
| Elective (1.5 hr)            | Elective (1.5 hr)       | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) |
| Faculty Presentations (1 hr) | Safety Course (1 hr)    | Ethics Course (1 hr)    |                         |
| Seminar (1 hr)               |                         | Seminar (1 hr)          |                         |
| Research (variable)          |                         | Research (variable)     |                         |

**Year 1 - Summer Term:** Research (4 hr)

#### **Year 2 - Autumn and Spring Semesters**

| Autumn Semester         |                         | Spring Semester         |                         |
|-------------------------|-------------------------|-------------------------|-------------------------|
| Session 1               | Session 2               | Session 1               | Session 2               |
| Major/Elective (1.5 hr) | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) |
| Major/Elective (1.5 hr) | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) | Major/Elective (1.5 hr) |
| Seminar (1 hr)          |                         | Seminar (1 hr)          |                         |
| Research (variable)     |                         | Research (variable)     |                         |

**Year 2 - Summer Term:** Research (4 hr)

**Subsequent Terms:** Research or elective courses\*

\*Please consult the Graduate School Handbook to determine the number of credit hours required to retain the full-time student status, which varies pre- and post-candidacy and when a student is supported by a fellowship.

## **II. DEPARTMENTAL REQUIREMENTS FOR THE PH.D. DEGREE**

### **A. FIRST-YEAR ORAL EXAMINATION**

All students pursuing either an M.S. degree or Ph.D. degree must take an oral examination. These exams are typically conducted in May or June of the first year of study. The focal point of this examination is a paper selected jointly by the student and advisor that is related to the student's research topic. The purpose of this exam is to evaluate the student's progress within the context of an activity that is relevant to their research interests and to determine whether the student is ready to proceed with further requirements of the Ph.D. program. The administration of the first-year oral examination is outlined below.

1. By April 1, the Secretary of each division notifies the Graduate Studies Office and announces to students:
  - (a) The date(s) on which the oral exams will be administered;;
  - (b) The possible outcomes of the exam
  - (c) The members of the division's oral exam committee or, when applicable, each student's respective three-member committee

A single three-member committee of faculty members is typical because all students in a division will be evaluated by a common standard. However, it may not be practical for a single committee to examine all students in a given division.

2. By May 1<sup>st</sup>, a brief orientation for the examination committees will be scheduled such that the Vice Chair for Graduate Studies can ensure that the examinations are conducted consistently within the department.
3. The Graduate Studies Office, in consultation with committee members and students, will be responsible for scheduling the individual exams. All exams must take place within the specified period unless the student has a valid excuse. Significant life events (e.g., wedding), documented medical excuses, or important scientific activities (e.g., conference) constitute valid excuses.
4. The basis of the exam will be a journal article that is related to the student's research topic and has been jointly selected by the student and advisor. The article may or may not be one published with the advisor as a co-author. In some cases, prior approval of the article by the committee may be required (as defined in Section III of this document). It is a good strategy to choose an article that covers substantial scientific issues and that is not overly difficult. An article that is, for example, a brief communication of measurements will give the examination committee little inspiration for exam questions. In that case, the line of questioning will be less predictable, which will put the student at a disadvantage. The student and advisor are jointly responsible for delivering a copy of the article to the each examination committee member and to the Graduate Studies Office two weeks in advance of the exam period.
5. The format of the exam will include a short presentation by the student of no more than 5-10 minutes, followed by approximately 50 min of questions by the committee. The student may use the chalkboard or computer slides as part of this presentation (refer to divisional requirements in Section III of this document). The presentation and paper will serve as the starting point for the subject of the questions. Students will be expected to discuss the content of the paper and respond to questions about broader concepts underlying the research described in the paper and work in the references therein. The advisor, if not a member of the committee, can sit in on the exam. If not a committee member, the advisor may formulate questions with the permission of the committee, but may not assist the student with answers.

6. After the exam, the student is excused. The exam committee and the advisor will have a brief (5-10 minute) meeting to exchange impressions on the exam. This is very useful for getting a more accurate view of the student's performance and preventing later misunderstandings.
7. Within two business days of a division's last exam (excluding delayed exams), the examination committee(s) for the division will meet. Based on the student's overall performance on the oral exam and performance in first-year course work, the committee will determine whether each student should proceed directly to prepare for the candidacy exam, undergo further evaluation (as defined by each division in Section III of this document), or proceed to a terminal M.S. degree. These decisions are final and cannot be appealed.
8. Within three business days of a division's last exam, the results of the exams must be communicated to the division secretaries and to the Graduate Studies Office.
9. Within four business days of the last exam, the results of the exams will be reported to the students by the Graduate Studies Office.

Repeat exams or extra chances at cumulative exams (organic division) will only be given in exceptional cases. The student must clearly state the grievance and proposed redress in a petition to the Graduate Studies Committee, who will act on the petition in consultation with and based on the recommendation of the division administering the exam.

## B. CANDIDACY EXAMINATION

### 1. Timing, Content, and Procedure

The precise timing of the Candidacy Examination should be determined collectively by the advisor and the student using the following guidelines. Students who have passed the First-Year Oral Examination should initiate the Candidacy Examination no earlier than the fall of their second year and no later than spring of their second year. These students are required to complete their Ph.D. Candidacy by end of the spring term at the end of their second year. Students requiring further evaluation via cumulative exams should initiate their Candidacy Examination in a timeframe such that it may be completed by the end of summer term of the second year. Students requiring further evaluation via completion of an M.S. degree should initiate their Candidacy Examination during the semester immediately following the M.S. defense, but must be completed by the end of spring semester of their third year. With the exception of students who complete an M.S. degree first, students must complete their Candidacy Examination by the end of their second year in the program.

The Candidacy Examination offered by the different divisions in the Department of Chemistry vary somewhat in format, as described in sections that follow, but in each case this examination includes both written and oral portions. The examination is a comprehensive test administered by a committee of faculty, and is based on the fundamentals and depth of knowledge of the broad area of chemistry in which the student is specializing. The student's progress in research will be evaluated by the examination committee, as well as the student's ability to formulate a sound, innovative independent proposal within their area of research (consult Section III). Satisfactory performance in this examination or series of examinations admits the student to candidacy for the doctoral degree effective the subsequent semester.

The written portion of the Candidacy Examination for the Ph.D. takes the form of progress to date and proposed future work written by the candidate on the topic of their thesis research. In general, at least one portion of the proposed work (one element or aim) must be original from the student. The purpose of this written exam is to examine the progress to date, the creative potential of the candidate, and their knowledge of the field and relevant literature surrounding their ongoing research and proposed work. A copy of the approved proposal must be submitted to the Graduate Studies Office. Subsequently, the Candidacy Examination committee must acknowledge approval of the proposal by signing a form that will

be distributed electronically by the Graduate Studies Office. The details of this examination are indicated in Section III of this document.

The written portion of the Candidacy Exam must be approved by the examination committee two weeks prior to the oral exam. A final draft of the student's written examination must be available to all members of the oral examination committee, including a possible university representative appointed by the Graduate School (see next section), at least two weeks prior to the examination.

The oral portion of the Ph.D. Candidacy Examination consists of presentation of ongoing research, defense of proposed work, and general questions that may be related to the written portion of the Candidacy Examination or, if unrelated, on subjects in which the candidate is expected to be proficient. The candidate will be evaluated on the oral examination by his/her performance on the general questions, research progress, and the defense of his/her research proposal.

## 2. Selection of Candidacy Examination Committee and Initiation of Candidacy

The Vice Chair for Graduate Studies, with advice from the student's advisor, will assign faculty to the student's committee according to the following procedures.

1. The student's advisor recommends three faculty members to the Vice Chair, in addition to himself/herself, to serve on the oral committee. Two of the three faculty members in the examination committee will be from the student's division and one will be from outside the division. Prior to submitting the committee members' names to the Vice Chair, the student's advisor is expected to have asked the committee members if they were willing and available to serve on the committee.
2. The Vice Chair may suggest different faculty members or change the composition of the committee if inequities exist in the distribution of committee assignments among faculty.
3. When required by division rules, the Vice Chair will also assign a committee member from outside the division. A university representative will sometimes be assigned by the Dean of the Graduate School.
4. The Vice Chair will notify the advisor of those individuals who will serve on the committee, and the advisor (not the student) will arrange a time and location for the exam in consultation with his/her colleagues, and the Vice Chair's office.
5. The written portion of the candidacy exam must be approved by each committee member. Once the committee agrees to approve the written portion, the student must provide a copy of the approved exam to the Graduate Studies Office. Official approval of the written portion will be conducted electronically by the Graduate Studies Office.
6. After the written portion is approved, the student must initiate a Doctoral Notification of Candidacy Examination form electronically at [gradforms.osu.edu](http://gradforms.osu.edu), which must be signed electronically by all committee members and the Vice Chair. All signatures must be completed and available at the Graduate School at least two weeks prior to the examination date.

## C. DISSERTATION

The dissertation resulting from the student's graduate research must represent significant contribution to knowledge in chemistry. Its importance should be sufficient to warrant the acceptance for publication of a paper based upon it by one of the respected journals of chemistry or a related scientific area. A reading committee composed of the advisor and at least two graduate faculty members (often members of the student's Advisory Committee who must have P-status in the Chemistry PhD program) will consider the merit of the dissertation in detail. The student's advisor selects this committee. The student must initiate

an Application to Graduate form at gradforms.osu.edu for the Graduate School no later than the third Friday of the semester (or third Friday of May session for summer session commencement) in which graduation is expected.

#### D. FINAL ORAL EXAMINATION

On approval of the dissertation by the advisor and the reading committee, a final oral examination, based largely on the dissertation work, will be held in accord with the Graduate School guidelines. The examination committee will consist of the members of the dissertation reading committee, and a graduate faculty member nominated by the Dean of the Graduate School from a department other than Chemistry and Biochemistry. A unanimous vote of all committee members is required for a satisfactory decision.

### III. COURSE AND EXAMINATION REQUIREMENTS FOR THE SUBDISCIPLINES

With the approval of his/her advisor, a student may elect to satisfy the specific graduate degree requirements in any one of the areas of chemistry and biochemistry (i.e., division) in the department. Alternatively, the student and advisor may jointly propose a multidisciplinary program for the student by submitting a Multidisciplinary Track application for evaluation and approval by the Vice Chair for Graduate Studies.

The examination procedures employed by the different divisions are defined in the following sections. Each of the procedures allows an early delineation of the final study plan and the nature of the degree to which the student's effort will lead. Divisional requirements, such as satisfactory performance on a qualifying examination or presentation of seminars, are supplemental to the departmental requirements.

It should be noted that examinations should not take place during summer terms. Faculty support during the summer is typically from external research grants which require that faculty focus on research and not engage in committee work during this time.

## A. ANALYTICAL CHEMISTRY

The degree programs available to students in Analytical Chemistry are M.S. and Ph.D. Students may pursue and earn a Ph.D. degree without receiving an M.S. degree.

### **Ph.D. Degree**

#### **Course and credit hour requirements**

A Ph.D. candidate is required to take the courses listed below, in addition to graduate courses recommended by his/her advisor.

*Required Analytical courses:* Chem 6110, Chem 6120, and 9 credits of Chem 71xx

*Electives:* 6 credit hours outside the division (level >5000)

*Other required courses:* Chem 6780, Chem 6781, Chem 8899

#### **Typical Progress Timeline and Seminar Requirements**

Year one: Take required courses; attend faculty research presentations and choose an advisor; take safety course and attend seminars; begin thesis research; complete summer literature oral exam at the beginning of first summer; present research poster at end of first summer.

Year two: Literature seminar presentation; complete M.S. degree if assigned by first-year oral committee; continue thesis research. Complete Ph.D. Candidacy exam

Years three and four: Complete Ph.D. Candidacy exam if the student was required to complete M.S. degree first; thesis research, and seminar presentation (research-in-progress).

#### **Sample Curriculum for First and Second Year Students**

##### **Year 1**

| <b>Autumn 1 (7 weeks)</b>   | <b>Autumn 2 (7 weeks)</b>                 |
|---|---|
| Chem 6110 Survey Instrumental Methods (1.5)   | Chem 6120 Analytical Data Treatment (1.5) |
| Core Elective   | Elective                                  |
| Chem 7130 Separations or Chem 7160 NMR (3, taught every other year)                       |   |
| Chem 8896 Departmental Seminar (1)  |   |
| Chem 6780 Faculty research presentations (1)  | Chem 6781 Laboratory Safety (1)           |
|   |   |
| <b>Spring 1 (7 weeks)</b>   | <b>Spring 2 (7 weeks)</b>                 |
| Chem 7120 Electrochemistry or Surface Science (3, taught every other year)                |   |
| Chem 7140 Spectroscopy or Chem 7150 Mass Spectrometry (3, taught every other year)        |   |
| Elective and Ethics Course  | Elective                                  |
| Chem 8896 Departmental Seminar (1)  |   |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |   |

##### **Summer**

Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements)

##### **Year 2**

|   |
|---|
| Elective Courses within the division, Chem 71xx (see required credit hours)               |
| Elective Courses outside division (see required credit hours)                             |
| Chem 8896 Departmental Seminar (1) or Chem 8891 Analytical Division Seminar (1)           |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |

## **Analytical Chemistry Course Information**

### **Fall Semester (every year)**

Chem 6110 (Required) Survey of Instrumental Methods – *Introduction to instrumental analytical methods, including optical spectroscopy, mass spectrometry, surface spectrometry, microprobe methods, and separation science concepts relevant to chemical analysis. Not available for undergraduate credit.*

Chem 6120 Analytical Data Treatment – *Principles and practice of data acquisition, processing, and analysis in chemical research. Not open to students with credit for 720.*

### **Fall Semester (even academic year)**

Chem 7130 Separations – *Introductory course in analytical separation science: principles of chromatographic and electrophoretic processes. Not open to students with credit for 822.*

### **Spring Semester (even academic year)**

Chem 7120 Electrochemistry – *Electrochemical methods for trace analysis of species, including current/voltage relationships based on activation and diffusion control, electrode kinetics, and reaction mechanisms. Not open to students with credit for 821.*

Chem 7140 Spectroscopy – *Principles for measurement of interactions of electromagnetic radiation with matter, including classical & quantum mechanical principles, group theory, and principles and applications of atomic and molecular spectroscopy. Not open to students with credit for 823.*

### **Fall Semester (odd academic year)**

Chem 7160 NMR Spectroscopy – *Introduction to NMR spectroscopy for structural studies including nuclear magnetic resonance spectroscopy in the context of chemical and biochemical structural studies. Not open to students with credit for 824.*

### **Spring Semester (odd academic year)**

Chem 7150 Mass Spectrometry – *Advanced course on modern mass spectrometric methods and applications to chemical and biological sciences. Not open to students with credit for 825.*

Chem 7170 Surface Science – *Introduction to instrumentation and techniques for the chemical and physical analysis of surfaces.*

Chem 8199 Advanced Topics in Analytical Chemistry. *Topic varies by instructor and offering.*

### **Elective courses outside the division may include, but are not limited to:**

Biological Chemistry 7220; Inorganic Chemistry 6320, 6330, 7320, 7360; Organic Chemistry 6440, 7440; Physical Chemistry 6520, 6530, 7520, 7540, 7550

### **Other Requirements**

To proceed toward a Ph.D. degree without obtaining the M.S. degree students must make satisfactory progress as follows:

- The student must be enrolled in the Graduate School and maintain a 3.0 GPA at the end of the second semester of the first academic year and all terms thereafter.
- The student must have selected a research advisor by the end of the first semester of the first academic year and must remain in a research group thereafter.
- During the summer following the first academic year, the student must present a poster on his/her research carried out during the first academic year.
- The student must complete 14 hours of lecture courses (graded A thru E) during the autumn and spring semesters of the first academic year. A minimum of 9 of these credits must be at the 7000 level or above.
- The student must pass the First-Year Oral Examination (see below).

### ***First Year Research Project***

Each student seeking to earn the Ph.D. degree is expected to begin research upon joining a research group. The choice of such a project will be made in consultation with the student's advisor. A poster session will be held at the end of the summer term in which the first year students will have the opportunity to report on their progress and to discuss their research with other students and faculty. All first year students must present a poster. A brief written description of the poster presentation shall be provided, in advance, to the analytical division secretary.

### ***Student Seminars***

Students seeking to earn a Ph.D. degree are expected to present seminars to the analytical division during their second and final years in the program, as part of the requirement for Chemistry 8899. The second year seminar will generally be 30 minutes long on a topic determined by the student and his/her advisor, and will be evaluated by both faculty and students in attendance.

### ***First-Year Oral Examination***

The first-year oral examination will typically occur one week after finals week for spring semester, and will last approximately one hour. The structure of this examination will involve the student choosing (in consultation with their advisor) a published paper to present orally and evaluate critically. The chosen paper must receive prior approval by the examination committee. The examination committee will consist of three analytical faculty members with one alternate (the research advisor is not to be among the 3 person committee). The student may make a five-minute presentation and may use chalk and the chalkboard for the remainder of the exam.

Based on the exam performance, course grades, and early research progress, three exam outcomes are possible: (1) proceed directly to the Ph.D.; (2) completion of a M.S. degree before proceeding to the Ph.D.; or (3) stop graduate studies after completion of a terminal M.S. degree. The exam outcomes will not be decided until all students have taken the examination. All students who take the oral exam will be provided feedback on the results of their examination.

### ***Candidacy Examination***

The student will write a document consisting of their progress to date and proposed work based on the topic of their thesis research. At least one portion (element or aim) of the proposed work must be original from the student. This document represents the written portion of the Candidacy Exam. The student will present their progress and defend the research proposal during an oral examination that will be followed by a general question period by the examination committee. This exam represents the oral portion of the Candidacy Exam.

At least one month before the oral exam, the student will submit an abstract to the committee members in the Chemistry Department for approval of the research topic. At least three weeks prior to the examination the student is to submit to the committee a detailed description of the proposed research. This should include Objective (½ page), Background (1½ pages), Project Description and Data Analysis (14 pages) and References (1 page). This document must be approved by the committee prior to scheduling the oral defense of the proposal. The document describing the proposed research will constitute the written portion of the candidacy exam for analytical students. The defense of this proposal will constitute the oral portion of the candidacy exam.

### **M.S. Degree**

Students who intend to terminate graduate studies after the M.S. degree follow this degree program. It is also followed by students whose early graduate performance indicates that completion of a thesis problem and writing of a M.S. thesis would be of considerable help in advancing their academic program and students who cannot complete a given requirement of the Ph.D. program. For example, students who do not pass the Candidacy Examination portion of the Ph.D. program often complete the thesis M.S. degree program. The minimum requirements for the M.S. Degree are completion of 30 credit hours. Other courses may be required by the advisor as required for the student to gain expertise aligned with the thesis project. The student must also write an M.S. thesis and defend this thesis (oral examination)

## B. BIOCHEMISTRY

M.S. and Ph.D. degree programs are available to students in the Biochemistry division of the Chemistry graduate program. Students may pursue and earn a Ph.D. degree without receiving an M.S. degree.

### Ph.D. Degree

#### **Course and credit hour requirements**

The minimum course requirements consist of (1) Six credit hours of core biochemistry graduate courses. Biochem 6761, Biochem 6762 and Biochem 6763 are strongly recommended. (2) Three credit hours of core Chemistry electives outside the Biochemistry division, preferably including topics in physical organic chemistry and/or physical chemistry (especially thermodynamics and kinetics). (3) Three credit hours of lab rotation. (4) At least six additional credit hours in biochemistry or related disciplines. These additional courses should be selected with the advisor and come from those listed in the offerings of the department. Elective courses from outside of the department may count toward this requirement with approval of the Biochemistry division. (5) All Biochemistry division students should enroll in an appropriate seminar course each academic semester. All students enroll in Chem 8896 in the autumn. First and second year students enroll in Chem 8899 in the spring; third year and beyond enroll in Chem 8896 in spring.

#### **Typical Progress Timeline**

Year one: Take core and elective courses; complete three lab rotations in the autumn; attend faculty research presentations and choose an advisor by the end of autumn semester; complete safety course; attend seminars; attend the student seminar series; begin thesis research; complete summer literature oral exam.

Year two: Finish elective courses; complete Candidacy Exam (preferably by the end of the spring of the second year); perform thesis research; attend seminars; attend the student seminar series and give a literature presentation.

Year three: Complete general exam if required to complete an M.S. degree first; perform thesis research; attend seminar and give a research presentation (Research-In-Progress).

Year four and beyond: Perform thesis research; attend seminars. Students should expect to present their dissertation research to the department in an appropriate seminar series or with an open presentation at the beginning of the Final Oral Exam.

### Proposed Curriculum

#### **Year 1**

| <b>Autumn 1 (7 weeks)</b>   | <b>Autumn 2 (7 weeks)</b>                   |
|---|---|
| Out-of-division Chemistry Core Course (1.5 hr)  | Out-of-division Chemistry Course (1.5 hr)   |
| Biochem 6761 Macromolecular Structure-Function A (3 hrs)                                  |   |
| Chem 8999 Lab rotations (3 x 1 hr)  |   |
| Chem 8896 Departmental Seminar (CSMB/Biophysics) (1 hr)                                   |   |
| Chem 6780 Faculty research presentations  | Chem 6781 Laboratory Safety                 |
|   |   |
| <b>Spring 1 (7 weeks)</b>   | <b>Spring 2 (7 weeks)</b>                   |
| Biochem 6762 Biochemistry of Enzymes (1.5 hrs)  | Biochem 6763 Lipids and Membranes (1.5 hrs) |
| Elective Course (1.5 hrs) and Ethics Course (1 h)   | Elective Course (1.5 hrs)                   |
| Chem 8899 Biochemistry Division Student Seminar (1 hr)                                    |   |
| Chem 8999 Research or Biochem 8999 Research   |   |
| <b>Summer</b>   |   |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |   |

## Year 2

|  |
|--|
| Elective Courses (3 hrs)   |
| Chem 8896 Departmental Seminar (CSMB/Biophysics) (AU, 1 hr) or<br>Chem 8899 Biochemistry Division Student Seminar (SP, 1 hr) |
| Chem 8999 Research or Biochem 8999 Research  |

### Possible elective chemistry core courses outside the division

All the core courses in the Autumn 1 and Autumn 2 sessions offered by other divisions (Chem 6x10-6x40, 1.5 hrs). Preferable ones include:

- Chem 6410 Basic Organic Reaction Mechanisms (1.5 hrs)
- Chem 6440 Introduction to Physical Organic Chemistry (1.5 hrs)
- Chem 6520 Thermodynamics (1.5 hrs)
- Chem 6530 Kinetics (1.5 hrs)

### Other Available Elective Courses:

- Biochem 5701 DNA Transactions and Gene Regulation (4 hrs)
- Biochem 6701 Advanced Biochemistry: Molecular Biology (3 hrs)
- Biochem 6764 Advanced Biochemistry: Metabolism (1.5 or 3 hrs)
- Biochem 6765 Advanced Biochemistry: Physical Biochemistry (1.5 or 3 hrs)
- Biochem 7766 Advanced Biochemistry: Nucleic Acids (1.5 or 3 hrs)
- Biochem 7770 Advanced Biochemistry: Protein Engineering
- Biochem 7775 Special Topics in Biophysical Chemistry (1.5 or 3 hrs)
- Biochem 8821 Advanced Enzymology (1.5 or 3 hrs)
- Biochem 8900 Advanced Biochemistry: Biomolecular NMR (1.5 or 3 hrs)
- Biochem 8990 Advanced Topics in Biochemistry
- Chem 7220 Bioorganic Chemistry of Enzyme Catalysis (1.5 hrs)
- Chem 7230 Chemical Biology (1.5 hrs)
- Chem 7360 Bioinorganic Chemistry (1.5 hrs)
- Micro 8050 RNA World (1.5 hrs)
- Micro 7060 Advanced Topics in Molecular Microbiology

This is a sample program only. The particular program to be followed must be decided in consultation with the faculty advisor and must conform to the divisional guidelines given herein. Most students should take Biochem 6761 (Macromolecular Structure and Function), two 7-week elective core courses outside the division, and complete three lab rotations during the first semester.

### Lab Rotations

All biological division students will complete three lab rotations in autumn of their first year. These rotations will be 4 weeks each beginning in the second week of classes. Students should sign up for Chem 8999 for 1 credit hour under the advisor for each rotation. The main purpose of the lab rotations is to gain exposure to the scientific questions, methods and functioning of potential advisors' labs, as well as for you to get to know the advisor and the advisor to know you. Typically students will have some assigned reading, attend group meetings, and have some sort of shadowing or research experience. Students should plan to spend at least 10-15 hours per week in the lab. All rotations must be with a preceptor eligible to take Chemistry students. Students are not required to join a lab in which they have done a rotation.

### Seminar Requirements

Students in the Biochemistry division are expected to enroll in an appropriate seminar series in the department each academic semester. Students must give one literature presentation and one research-in-progress presentation to the division by the end of the third year. Students in their first and second

years will enroll in and attend the divisional student seminar series, usually in the spring semester. Typically, students will give a literature presentation in their second year in the student series, and a research presentation in their third year in a Research Focus Group series. All students are expected to present their dissertation research to the entire division, either in one of the biochemistry seminar series or in an open portion of the Final Oral Exam. All Biochemistry division students are expected to attend the appropriate weekly RFG seminar series (e.g., CSMB/Biophysics) as well as the weekly MLS (OSBP/MCDB) seminar series. Note that first and second year students who enroll in the student seminar series in spring are still expected to attend RFG and OSBP seminars.

### **Other Requirements**

To proceed toward a Ph.D. degree without obtaining the M.S. degree, students must make satisfactory progress as follows:

- The student must be enrolled in the Graduate School and maintain a 3.0 GPA at the end of the second semester of the first academic year and all terms thereafter.
- The student must have selected a research advisor by the end of the first semester of the first academic year and must remain in a research group thereafter.
- The student should complete the required and elective courses by the end of the second year, and certainly by the time of the candidacy exam.
- The student must pass the First-Year Oral Examination (see below).

### **First-Year Oral Examination**

This exam will take place after the end of the spring term, typically during the second half of the May term. The exam will last for approximately one hour. The student, in consultation with the advisor, will choose a published paper related to his/her research. It may be a paper from the student's own research group but must be a full original research article (i.e., not a communication or a review article). The chosen paper must be approved by the committee two weeks before the exam. The student will present the paper in 5-10 minutes using only chalk and the chalkboard; no overheads or computerized slides may be used. The student will be asked questions on the paper and background pertaining to the subject area of the paper. The committee members will evaluate the student's performance. The examination committee will consist of three faculty designated by the Biochemistry division. The advisor may attend the examination, and help the committee formulate the questions for the student, but cannot assist the student in any manner. After the examination, the committee and the student's advisor will have a brief meeting to exchange impressions on the examination. Based on a combination of the student's overall performance on the oral exam, course work during the first year and other factors, the committee will recommend one of the following options:

- (a) proceed directly to the Candidacy Exam;
- (b) complete an M.S. (see below), and upon successful completion continue to the Candidacy exam; or
- (c) terminate graduate studies with an M.S. (pending completion of all M.S. requirements; see below).

Written feedback from the committee will be provided to the students by the Graduate Studies office.

### **Candidacy Examination**

In the general examination, the student presents her or his research progress to date and defends a proposal for future work based on their thesis research before the members of an examination committee. At least one aim of the proposed future work must be original from the student (i.e., it must not be an area of active investigation in the advisor's laboratory, and it must not have been proposed by the advisor or anyone other than the student). The Vice Chair selects the members of the committee based on the recommendation of the advisor, according to the procedures specified in section II.B of the handbook. Two of the committee members must be from the Biochemistry division; the third member

must be a faculty member within the department but outside the Biochemistry division; and the fourth member may be from the department or another unit on campus. The student's advisor is the chair of the exam committee. Students are encouraged to take this part of the general examination by the end of Spring term of the second year and certainly by the end of the second year.

Before preparing the written proposal, the student is required to (1) submit to each member of the examination committee a proposal abstract (maximum of 300 words) that clearly outlines the problem, aims and overall research strategy, and (2) obtain approval from each committee member for the proposed study. The committee will evaluate the abstract within one week. It is advisable for the student to wait for comments from the entire committee before revising the abstract, if necessary. The written proposal should follow the NIH postdoctoral grant format, except that the proposal (including figures, schemes, charts, and other illustrations) is limited to 10 single-spaced pages. The font should be 11-point Arial. The margin should be at least 0.5" on each side and the pages should be numbered. The references, which should be in the *Biochemistry* journal style and include the full title of the article, are not counted toward the 10-page limit. The document describing the proposed research will constitute the written portion of the Candidacy Exam. The advisor will provide assurance that the outside aim is original and not under investigation in the advisor's laboratory. Members of the exam committee will provide a critique of the proposal to the advisor within two weeks of receiving the proposal. The advisor will share the committee's comments and communicate the decision of the committee to the student (typically, Pass, Revise, or Major Re-Write). The candidacy committee must unanimously approve this document prior to scheduling the oral portion of the Candidacy Examination, and a final draft of the document must be available to all members of the committee (including the university representative appointed by the Graduate School, if applicable) at least two weeks prior to the oral examination.

The advisor is solely responsible for arranging a time and location for the oral exam. In the oral portion of the candidacy exam, the committee will ask general questions to evaluate the research proposal and the student's knowledge of the entire area of biochemistry plus any areas related to the student's research. Students may bring up to five slides in any format (printed handouts, PowerPoint, etc.) to aid in the discussion of the proposal; however, the entire exam will consist of questions from the committee.

### **M.S. Degree in Chemistry (Thesis option)**

This program is followed by students who intend to terminate graduate studies after the M.S. degree, by students whose early graduate performance indicates that completion of a thesis problem and writing of a M.S. thesis would advance their academic program, and by students who cannot complete a given requirement of the Ph.D. program. For example, students who do not pass the Candidacy Examination portion of the Ph.D. program often complete the thesis M.S. degree program. The course requirements for the M.S. Degree in Chemistry with emphasis on Biochemistry are as follows.

#### *Core requirements*

- Biochem 6761 (3 hrs)
- Biochem 6762 (1.5 hrs)
- Biochem 6763 (1.5 hrs)

#### *Electives*

A total of at least 24 hours are required at the graduate level and must include two Chem 6x10-6x40 (1.5 hrs) core courses outside the division.

*Other electives may include the following:*

- Biochem 5701 (4 hrs)
- Biochem 6701 (3 hrs)
- Biochem 7770 (1.5 hrs)
- Biochem 6999 or Chem 8999 (at least 6.5 hrs)

These elective courses may consist of research courses or other graduate level courses required by the student's research advisor. The Graduate School requires the completion of a minimum of 30 graduate credit hours over a period of at least two semesters for the M.S. degree.

The student must also write an M.S. thesis describing original research and defend this thesis in front of a committee consisting of their advisor and one other faculty member from the department.

## C. INORGANIC CHEMISTRY

The degree programs available to students in Inorganic Chemistry are M.S. and Ph.D. Students may pursue and earn a Ph.D. degree without receiving an M.S. degree. The total hours for required Inorganic and Elective courses, excluding other required courses, should be 9 hours in Autumn and 9 hours in Spring.

### **Ph.D. Degree**

#### **Course and credit hour requirements**

A Ph.D. candidate is required to take the courses listed below, in addition to graduate courses recommended by his/her advisor.

*Required Inorganic courses:* Chem 6310, Chem 6320, Chem 6330, Chem 6340, and at least two Chem 73xx half-semester courses. At least four 7000 level courses, including at least two from the inorganic offerings and up to four other approved half-semester classes are required.

*Elective Courses:* Non-inorganic course electives can include 3 hrs of a core Chem 6xxx course in Autumn and up to 6 hrs outside the division (level  $\geq$  6xxx) in total.

*Other required courses:* Chem 6780, Chem 6781, Chem 8899

#### **Typical Progress Timeline and Seminar Requirements**

Year one: Take required courses; attend faculty research presentations and choose an advisor; take safety course and attend seminars; begin thesis research; complete summer literature oral exam.

Year two: Complete M.S. degree if assigned by first-year oral committee; continue thesis research; complete Ph.D. Candidacy exam

Years three and four: Thesis research, and seminar presentation (research-in-progress, year 3).

#### **Sample Curriculum for First and Second Year Students**

##### **Year 1**

| <b>Autumn 1</b>   | <b>Autumn 2</b>                              |
|---|--|
| 6310 Fundamentals of Coordination Chemistry   | 7320 Organometallic Chemistry                |
| 6330 Group Theory and Bonding   | 6340 Physical Methods in Inorganic Chemistry |
| Core elective   | Elective                                     |
| Chem 8896 Departmental Seminar  |  |
| Chem 6780 Faculty research presentations  | Chem 6781 Laboratory Safety                  |
|   |  |
| <b>Spring 1</b>   | <b>Spring 2</b>                              |
| Chem 7360 Bioinorganic Chemistry  | Elective                                     |
| Chem 7330 Solid State Chemistry   | Elective                                     |
| Elective and Ethics Course  | Elective                                     |
| Chem 8896 Departmental Seminar  |  |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |  |

##### **Summer**

Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements)

##### **Year 2**

|   |
|---|
| Elective Courses  |
| Chem 8896 Departmental Seminar or Chem 8893 Inorganic Seminar                             |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |

**Spring 2** - courses offered periodically; every two or three years depending on demand

**7350** Inorganic *Photochemistry*

**7340** *Diffraction Methods*

**7370** *Nano chemistry and Nanomaterials*

**8399** *Advanced Topics*

### ***Student Seminars***

Students seeking to earn a Ph.D. degree are expected to present a departmental seminar during their second year in the program which will generally be 30 minutes long, as part of the requirement for Chem 8893. A final 50 minutes long seminar is also required as the open portion of the Ph.D. defense. The subject of both seminars will be research progress on the student's project.

### ***First-Year Oral Examination***

The examination of all inorganic first-year students will occur early in the Summer Term. This will be an oral examination and will last approximately one hour. The structure of this examination requires a student to select a published paper that has been approved by the student's advisor. The student will give an oral presentation and critical evaluation of the content of the paper. The student will be asked questions by the committee on the contents of the paper as well as general background material pertaining to the subject matter of the paper. The examination committee will consist of three inorganic faculty members (the research advisor may be among the 3 person committee). The exam outcomes will not be decided until all students have taken the examination. All students who take the oral exam will be provided feedback on the results of their examination.

Based on the exam performance, course grades, and early research progress, three exam outcomes are possible: (1) proceed directly to the Ph.D.; (2) completion of a M.S. degree before proceeding to the Ph.D.; or (3) stop graduate studies after completion of a terminal M.S. degree. Students who are required to complete an M.S. degree first must defend their thesis by the end of summer term of their second year.

### ***Candidacy Examination***

Following a satisfactory evaluation in the first-year oral examination, or completion of an M.S. thesis (if required), a student may proceed to the Ph.D. Candidacy Examination. The decision on who may proceed to the Ph.D. will be predicated on the successful completion of the Ph.D. Candidacy Examination. The candidacy exam must be successfully completed by the end of the student's second year. For the candidacy examination, the student will write their progress to date and proposed future research. This document will represent the written portion of the Candidacy Exam. At least one portion (element or aim) of the proposed work must be original from the student. The student will present their research and defend the proposal, which will be followed by a general question period by the examination committee.

The Candidacy Examination consists of two parts. The first part is the completion the written portion that has been approved by the student's candidacy committee. The second part is an oral examination that will probe the student's grasp of concepts in the written portion as well as the student's understanding of general topics in chemistry.

At least one month before the oral exam, the student will submit an abstract to the committee members and the division secretary for approval of the research topic. The members of the committee and the division secretary must approve the topic within one week of submission.

At least three weeks prior to the examination the student is to submit to the committee a detailed description of the proposed research. The written proposal must clearly describe progress to date and define at least one original research problem to be pursued in future work and explain why its solution will be significant to the field of inorganic chemistry. The entire document should be limited to 12 pages. It is suggested that it contain an abstract stating the research problem, introduction of the problem (1

page), 3-6 pages of background, motivation, and progress to date, and 3-6 pages of proposed research and analysis. This document must be approved by the committee prior to scheduling the oral portion of the candidacy exam. Appropriate responses from faculty members on the committee will be made to the candidate within one week. The response may consist of evaluation, criticism, and/or suggestions. The candidate must obtain the approval of the committee, by signature of an approval form, at least two weeks prior to the exam and this will constitute passing the written part of the exam. The student is reminded that Graduate School rules require these exams to be scheduled at least two weeks in advance.

The document describing the proposed research will constitute the written portion of the candidacy exam. When the proposal is approved, the student has passed the written portion of the Candidacy Examination and their advisor may then set a date for the oral examination. The defense of this proposal will constitute the oral portion of the candidacy exam.

The oral examination session will run for no more than two hours and is mainly concerned with testing the fundamental knowledge and preparation of the student in his/her chosen discipline. The first half of the oral examination may involve questions relating to and discussion of the research proposal submitted by the candidate. Thereafter, questions will be of a more general nature, ranging over fundamental chemical subjects and detailed aspects of inorganic chemistry and the student's progress in research. Students should also be prepared to describe their research project briefly on the board.

Students should expect to be interrupted during their presentation by questions related to the proposal as well as general chemistry within their discipline and those that probe understanding of their own research project, including ideas for future directions and solutions to current problems in the lab. The student is free to consult with peers and with those members of the faculty who will not be serving on the student's examination committee in preparation for this exam.

The Ph.D. Candidacy Examination is evaluated based on academic and research ability. Defense of the proposal, performance with general questions, and demonstration of an understanding of the research project and research achievements will all be considered in the oral examination. Students may pass only part of the oral examination, and in certain situations, may be asked to repeat part of or the entire exam. For example, if the student has suitably defended the proposal but has not made sufficient research progress or does not possess sufficient general knowledge, he or she may be asked to repeat the research report and evaluation section of the oral portion of the Candidacy Examination after additional time spent in the lab. The timetable for reevaluation will be determined by the examination committee on a case-by-case basis, but should not extend beyond three months from the date of the original exam.

### ***Dissertation Defense and Seminars***

By the time a student reaches this stage, he or she will be the expert in some area within a subdiscipline of modern chemistry. After writing the dissertation in conjunction with the student's major professor, he or she will discuss the research before a dissertation committee that will be composed of the advisor and at least two graduate faculty members (often members of the student's Advisory Committee) who will consider the merit of the dissertation in detail. The student's advisor selects this committee.

In addition, students are required to present two seminars before the inorganic students, postdoctoral fellows, and faculty so that we can learn about your contributions to our knowledge of chemistry. The first seminar will be ~30 min long during the student's second year, and the final seminar will be a full 50 min seminar as part of the open portion of the Ph.D. defense.

### **M.S. Degree**

Students who intend to terminate graduate studies after the M.S. degree follow this degree program. The M.S. program is also followed by students whose early graduate performance indicates that completion of a thesis problem and writing of a M.S. thesis would be of considerable help in advancing their

academic program and students who cannot complete a given requirement of the Ph.D. program. For example, students who do not pass the Candidacy Examination portion of the Ph.D. program often complete the thesis M.S. degree program. In the M.S. program, the candidate must conduct independent research under the guidance of an advisor, prepare and present his/her thesis and demonstrate that it adds new knowledge to some area of chemistry.

The candidate is required to complete 15 hours of graduate course work in chemistry (5000-level and above) including the following required Inorganic courses. Inorganic elective courses are also listed below.

*Required*

- Chem 6310 Fundamentals of Coordination Chemistry (1.5 hr)
- Chem 6330 Group Theory and Bonding (1.5 hr)
- Chem 6340 Physical Methods in Inorganic Chemistry (1.5 hr)
- Chem 7320 Organometallic Chemistry (1.5 hr)

*Electives*

- Chem 7330 Solid State Chemistry (1.5 hr)
- Chem 7340 *Diffraction Methods* (1.5 hr)
- Chem 7350 *Inorganic Photochemistry* (1.5 hr)
- Chem 7360 *Bioinorganic Chemistry* (1.5 hr)
- Chem 7370 *Nanochemistry and Nanomaterials* (1.5 hr)

Part of the 15 hours of course work may be in related fields if they are acceptable to the Graduate Committee of the Department of Chemistry. Thesis work will require a minimum of 10 additional credit hours in Chemistry 8999. The total credit hours must be a minimum of 30 hours. Students not continuing on to the Ph.D. degree are expected to pursue this M.S. program. The student must write an M.S. thesis describing original research and defend this thesis as an oral examination in front of a committee consisting of their advisor and one other faculty member.

## D. ORGANIC CHEMISTRY

The degree programs available to students in Organic Chemistry are M.S. and Ph.D. Students may pursue and earn a Ph.D. degree without receiving an M.S. degree.

### **Ph.D. Degree**

#### **Course and credit hour requirements**

A Ph.D. candidate is required to take the courses listed below, in addition to graduate courses recommended by his/her advisor.

*Required Organic courses:* Chem 6410, 6420, 6430, 6440, 7430, 7440, 7450, 7460, and 5420.

*Electives:* At least 3 credit hours, which may include Chem 7470, 8499 or courses outside the division (level >6000).

*Other required courses:* Chem 6780, Chem 6781, Chem 8899

#### **Typical Progress Timeline and Seminar Requirements**

Year one: Take required courses; attend faculty research presentations and choose an advisor; take safety course and attend seminars; begin thesis research.

Year two: Complete written cumulative exams and/or M.S. degree if assigned by first-year oral committee; continue thesis research. Complete Ph.D. Candidacy exam.

Years three and four: Thesis research, and seminar presentation.

#### **Proposed Curriculum**

##### ***Year 1 - Required Courses***

| <b>Autumn 1</b>   | <b>Autumn 2</b>                                 |
|---|---|
| 6410 Basic Organic Reaction Mechanisms  | 6430 Introduction to Organic Synthesis          |
| 6420 Stereochemistry and Conform. Analysis  | 6440 Introduction to Physical Organic Chemistry |
| Core elective   | Elective  |
| Chem 8896 Departmental Seminar  |   |
| Chem 6780 Faculty research presentations  | Chem 6781 Laboratory Safety                     |
|   |   |
| <b>Spring 1</b>   | <b>Spring 2</b>                                 |
| Chem 7430 Advanced Organic Synthesis  | Chem 7460 Adv. Organic Reaction Mechanisms      |
| Chem 7440 Kin., Cat., and Trans. State Theory   | Chem 7450 Metals in Organic Synthesis           |
| Chem 5420 and Ethics Course   | Elective  |
| Chem 8896 Departmental Seminar  |   |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |   |

##### **Summer**

Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements)

##### ***Year 2***

|   |
|---|
| Electives   |
| Chem 8896 Departmental Seminar  |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |

##### ***Optional organic courses***

Chem 7470 Computational Chemistry

Chem 8499 Special Topics

**Course requirements:**

In addition to the required courses listed above, at least 3 credit hours of an elective course are required

**First-Year Oral Examination**

Students will take an oral examination during the first or second week of the summer term of their first year. The examination will last 60 minutes and the focal point of the examination will be a paper selected jointly by the student and his/her advisor. It is expected that the paper will be from organic chemistry literature that is related to the planned thesis research. The student will submit a copy of the paper to the committee (defined below) at least two weeks prior to the examination. The oral examination will start with a short presentation (5-10 minutes) by the student, highlighting the salient features of the paper. The rest of the examination will be devoted to the student answering questions from the committee members and discussing the broader issues underlying the research described in the paper. The questions will be directed principally toward the topic of the paper, but some general questions may also be asked if the answer to these questions help the student address specific issues related to the paper. The advisor may attend the examination, but may not participate in questioning or assist the student in any manner. After the examination, the committee and the student's advisor will have a brief meeting to exchange impressions on the examination.

Within two working days of the last examination in the division, the committee will meet and assign a point value (1-5) to each student based on his/her overall performance on the oral exam and first-year (graduate) course work. A total of five (5) points will be required to proceed to the Ph.D. Candidacy Examination. The score assigned by the examination committee will determine whether each student should:

- (a) proceed directly to the Ph.D. program;
- (b) take cumulative examinations to make up the deficient points. These examinations will be offered on an announced date during August, September, October, November, January, and February. Students will be awarded 0.0, 0.5, or 1.0 point on each exam. The student will have six (6) chances to collect a total of five (5) points including those awarded by the first-year oral examination committee. Students who fail to obtain the five points by the end of February of the second year will be asked to complete a terminal M.S. degree, except in rare cases when the division faculty, in consultation with the student's advisor, determines that further graduate work is warranted. In that case, the student may petition the division to proceed to Ph.D., but only after obtaining the M. S. degree;
- (c) proceed to a terminal M.S. degree.

Within three working days of the last of the first-year oral examinations, the results will be communicated to the organic division secretary and the graduate office. A single committee of current faculty will administer all the first-year examinations during a specific academic year. An alternate member will be appointed by the division secretary if the student's advisor is a member of the examination committee.

**Candidacy Examination Procedure**

Graduate school (<http://www.gradsch.osu.edu/handbook/all#7-4>) and departmental procedures are followed. Briefly, the student will be evaluated on their research progress to date and an original proposal. The original component may not be an area of active investigation but it may be an extension of existing research. This exercise is meant to encourage the student to consider the implications of their research; ideally, the original proposal grows from the thesis project. Prior to writing the full proposal, the student must provide to the committee 1 page, including abstract and specific aims. The abstract should make clear how the original

component is distinct from ongoing work in the research group. The original component must be approved by the committee as reasonable, sufficiently original and grounded in ideas relevant to the research aims. The committee will provide feedback within one week of receipt.

*Format:*

The proposal must be written in single-spaced 11pt Arial on numbered pages with a minimum of 0.5" margins on each side and include: 1 page of Specific Aims (see above) and a 10 page (including all figures) Research Strategy. The NIH grant format should be followed with the exception that Research Strategy is limited to 10 pages rather than 12. References must include full titles and are not counted toward the page limits. Students should consult with online documentation and grant writing guides for the NIH proposal format.

*Content:*

The document describing the research effort and proposal will constitute the written portion of the Candidacy Exam. The student must clearly indicate their contribution to the research aims, and whether the work was carried out on individually or on a team. The original components and research aims must be clearly marked as original proposal and research. Research efforts to date should be placed in a preliminary data section in each aim, as typical for an NIH-style proposal.

*Evaluation of Written Document:*

Evaluation will be on the basis of research efforts, proposal development and writing. Committee members will provide a critique to the committee and student within two weeks of receipt of the written document. The student will provide a summary of critiques and responses, as well as the revised proposal, to the committee. The committee must approve this final revised document prior to scheduling the oral portion of the Candidacy Examination. Graduate School rules require these exams to be scheduled at least two weeks in advance.

*Oral Exam and Evaluation:*

The committee will ask the student to describe their research and proposal, ask related questions, as well as questions within the general area of organic chemistry, according to graduate school rules. Though emphasis may be placed on areas related to the student's research, proposal and course material, any general question in organic chemistry may be used to evaluate the student's candidacy. Students may bring up to five slides (printed or electronic) and may refer to the written proposal to aid in discussion, but should be prepared to answer questions by drawing structures and diagrams as necessary.

*Outcomes:*

Defense of the proposal, performance with general questions, and demonstration of an understanding of the research project and research achievements will all be considered in the oral exam. Students may be asked to repeat part, or all of the exam. For example, if the student has suitably defended the proposal but has not made sufficient research progress or does not possess sufficient general knowledge, that student may be asked to repeat the research report (written) and oral defense after additional time spent in the lab. The timetable for reevaluation will be determined by the committee on a case-by-case basis, but should not extend beyond 2 terms from the date of the original exam according to graduate school rules.

**Seminar Presentation**

After passing the candidacy exam, each student will present a one-hour seminar, following the guidelines established by the division. The student must enroll in Chem 8894, Organic Chemistry Seminar, during the term in which the seminar will be presented. In planning the seminar and prior to the presentation,

the student should consult with the division faculty member in charge of student seminars during the term in which the seminar will be presented to obtain approval. This faculty member, in addition to helping the student with the technical aspects of the presentation, should make sure that the guidelines are followed. The responsible faculty member for Chem 8894, in consultation with other members of the division, will assign a grade (S or U) for the seminar. If the performance is judged unsatisfactory, the student will be asked to repeat the presentation to available organic faculty members.

The focus of the seminar will be the student's Ph.D. thesis research project. The talk should last 45-50 minutes and the student may choose any of the standard formats for presentation, including presentation software such as PowerPoint, blackboards, or overheads. The first part of the talk (20-30 minutes) should include a thorough review of the literature with the goal of providing a meaningful context and global perspective for current and future work. The material gathered for this review should be appropriate for and may eventually be used as introductory sections of the student's thesis. For the remaining portion of the talk, a progress report on the student's research accomplishments should be presented. The student should distribute a concise and carefully worded abstract (1-2 pages) before the beginning of the seminar.

### **M.S. Degree**

In the M.S. program, the candidate must conduct independent research under the guidance of an advisor, prepare and present his/her thesis and demonstrate that it adds new knowledge to some area of chemistry. The candidate must complete a minimum of 30 hours of course work in chemistry (6000-level and above) including the following organic courses: Chemistry 6410, 6420, 6430, 6440, and 9 credits of 7000-level courses. Thesis work requires a minimum of 15 credit hours in Chemistry 8999. Students completing this program must write and defend a thesis.

The Graduate School requires the completion of a minimum of 30 graduate credit hours over a period of at least two semesters for the M.S. degree.

## E. PHYSICAL CHEMISTRY

The degree programs available to students in Physical Chemistry are M.S. and Ph.D. Students may pursue and earn a Ph.D. degree without receiving an M.S. degree.

### **Ph.D. Degree**

#### **Course and credit hour requirements**

The Ph.D. student in physical chemistry will normally take at least 21 hours of graduate course work, including courses in the area of physical chemistry and electives.

A Ph.D. candidate typically takes the courses listed below, in addition to graduate courses recommended by his/her advisor.

*Typical Physical Chemistry courses:* Chem 6510, 6520, 6530, 6540, 6330, 7520, and 7550.

*Chemistry Electives:* Typical electives are listed below.

*Required courses:* Chem 6780, Chem 6781, Chem 8899

#### **Typical Progress Timeline and Seminar Requirements**

Year one: Take required courses; attend faculty research presentations and choose an advisor; take safety course and attend seminars; begin thesis research; take first-year oral during the May term.

Year two: Complete M.S. degree if assigned by first-year oral committee; continue thesis research; complete Ph.D. Candidacy exam.

Year three: Thesis research; students who completed M.S. degree complete Ph.D. Candidacy exam.

Year four: Thesis research.

#### **Sample Curriculum for First and Second Year Students**

##### **Year 1**

| <b>Autumn 1</b>   | <b>Autumn 2</b>                             |
|---|---|
| Chem 6510 Quantum Mech. Spectroscopy (1.5 hr)   | Chem 6540 Intro. Electr. Structure (1.5 hr) |
| Chem 6520 Thermodynamics (1.5 hr)   | Chem 6530 Kinetics (1.5 hr)                 |
| Elective (1.5 hr)   | Chem 6330 Group Theory (1.5 hr)             |
| Chem 8896 Departmental Seminar (1 hr)   |   |
| Chem 6780 Faculty research presentations (1 hr)   | Chem 6781 Laboratory Safety (1 hr)          |
|   |   |
| <b>Spring 1</b>   | <b>Spring 2</b>                             |
| Chem 7520 Adv. Molecular Quantum Mechanics and Spectra (3 hr)                             |   |
| Chem 7550 Statistical Thermodynamics (3 hr)   |   |
| Elective and Ethics Course  | Elective                                    |
| Chem 8896 Departmental Seminar (1 hr)   |   |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |   |

##### **Summer**

Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements)

##### **Year 2**

|   |
|---|
| Elective(s)   |
| Chem 8896 Departmental Seminar (1 hr)   |
| Chem 8999 Research (variable - please refer to Graduate School Handbook for requirements) |

**Usual alternatives for electives include:**

*Advanced physical chemistry classes:* 6550, 7530, 7540, 7570, 7580, 7590, 8599, 8699; Special topics courses in physical chemistry or fields related to physical chemistry may be taken as elective courses

*Other chemistry classes:* 6110, 6340, 6420, 6440, 7140, 7150, 7160, 7350, 7380, 7440, 7460, 7470

*Physics:* 5300, 5400

*Math:* 4512, 4551, 4552, 4568, 5101, 5102

***First-Year Oral Exam***

A student can qualify for admission to the Ph.D. Candidacy examination administered by the Physical Chemistry Division by satisfactory performance in their course work and on an oral exam offered during the summer term after the first academic year of graduate study.

An oral exam will be offered to Physical Chemistry students, normally during the May term. The topic of the exam is developed jointly by the student and his/her advisor and will be reflected by the choice of a research paper from the Physical Chemistry literature. It is expected that the paper will be related to the thesis research planned for the student. The student should submit a copy of the paper to the Physical division secretary at least two weeks in advance of the exam. The exam will be directed principally toward the topic, but some general physical chemistry questions may also be asked of the student if exploration of the topic touches upon broader issues. The student will receive feedback on his/her performance on the oral exam.

The oral examination committee will recommend one of the following options based on the student's performance in course work, the oral exam, and possible research activity to that point:

- (a) terminate graduate studies with an M.S. degree;
- (b) continue graduate studies by first completing an M.S. degree, followed by the Ph.D.;
- (c) proceed directly to the Ph.D. degree.

The terminal M.S. is invoked when the committee judges that doctoral work is not in the student's best interest. If progress toward the Ph.D. is recommended, the decision on whether to require an M.S. before the Ph.D. is based on all aspects of the student's activity to that point. The decision is made by considering that, for some students, it is helpful to have the smaller goal of an M.S. degree before the Ph.D. This decision is not exclusively linked to performance on the oral exam.

***Candidacy Examination***

The examination for admission to Ph.D. candidacy, consisting of written and oral portions, is given on an individual basis. The examination committee will be made up of 3 faculty members, at least 2 of which are from the Physical Chemistry Division. The written portion of the candidacy exam will consist of a summary of the student's research progress to date and a future thesis research proposal, where at least one part of the proposed work (one element or aim) must be original from the student. It is expected that the student will seek advice of their faculty mentor with regards to the direction of their thesis research and the faculty mentor may also be consulted for technical or bibliographic advice. However, the development of the entire written portion of the candidacy exam, including both the research progress and proposed future thesis research parts, should be performed independently by the student.

The written portion of the candidacy exam should provide the necessary background, significance and progress to date in the student's field of research supported by appropriate literature citations, summarize the student's own research progress to date and clearly define the proposed thesis research problems, including the aim that is original from the student. The written portion of the candidacy exam should consist of: (i) a title page, (ii) an up to 1-page abstract/summary that clearly outlines the student's

research accomplishments to date and lists the specific future research aims, (iii) the main section which is limited to 15 pages including figures (minimum 0.5 inch margins, single spacing, 12 point font), and (iv) a bibliography section. As a rough guideline, for a typical main section of 12-15 pages, approximately 2-3 pages would be devoted to introduction/background & significance, and approximately 5-6 pages each to research progress to date and proposed future thesis research.

Each member of the exam committee will submit a written critique of the research progress report and proposal to the student and the other members of the committee within 2 weeks of receiving the document. If the committee members judge that revisions are necessary, the student must submit a revised version to each committee member within 3 weeks of receiving their critiques. Presentation of a final version, which is judged satisfactory by each member of the committee, will constitute successful completion of the written portion of the Candidacy Exam. If a second revision of the document is not acceptable to all the committee members, then the committee can declare that the student has failed the written portion of the Candidacy Exam, and recommend that the oral portion not be scheduled.

The oral portion of the Candidacy Exam is scheduled by the advisor through the Graduate Studies office. The committee will normally consist of the faculty who evaluated the written proposal, but substitutions may be made if necessary. The content of the oral examination will be directed toward the contents of the written document and to some general issues in the field of physical chemistry. Satisfactory performance will result in admission to candidacy for the Ph.D. degree. Failure may result in a second attempt on recommendation of the Candidacy Examination Committee, no later than the second term following the first oral exam.

### **M.S. Degree**

While it is normally anticipated that the entering student will pursue the Ph.D. degree, in cases where the student performance has fallen below that necessary for continuing to the Ph.D., or so elects for personal reasons, the student may terminate his/her studies with the M.S. degree. The Graduate School of The Ohio State University automatically admits the student as a candidate in the M.S. degree program of the department to which the student applied. A student may be requested to obtain an M.S. before the Ph.D. degree, or may proceed directly to the Ph.D., depending on the best educational interests of the student.

In the M.S. program with thesis, the candidate must conduct independent research under the guidance of an advisor, prepare and present his/her thesis and demonstrate that it adds new knowledge to some area of chemistry. The candidate would complete at least 30 hours of graduate credits (6000-level and above) including the following physical chemistry courses: CHEM 6510, 6520, 6530, 6540, 7520, and 7550. Thesis work requires a minimum of 12 credit hours in CHEM 8999. Students completing this program must write and defend a thesis according to the guidelines presented within this document.

# M.S. IN BIOCHEMISTRY

## INTRODUCTION

The requirements for advanced degrees at The Ohio State University are summarized in the Graduate School Handbook, which can be found on the Graduate School website at <http://gradsch.osu.edu/graduate-school-handbook1.html> and downloaded as a pdf file (<http://gradsch.osu.edu/Depo/PDF/Handbook.pdf>). All incoming students should become familiar with the contents of the Handbook and should use it for reference during the tenure of his/her degree program at OSU.

This document summarizes specific requirements for the M.S. in Biochemistry, as well as additional comments and instructions for students in our program. A student who seeks an M.S. in Biochemistry is expected to expend a major effort on a research problem that culminates in a thesis. To reach this goal, the candidate will conduct independent research under the guidance of a faculty advisor, prepare and present a thesis on the study, and demonstrate that it adds significant new knowledge to some area of chemistry. The course requirements are designed to prepare the student for this major challenge of graduate education. The framework elaborated below is meant to facilitate a productive and rewarding experience.

## OPTIONS

There are two options within the M.S. program in Biochemistry.

The first track is the **M.S. with Emphasis in Biotechnology Option**. This program, in partnership with several biotechnology companies, will train students with a suitable bachelor's degree for a career in the rapidly growing biotechnology industry. Students will typically spend two years in this program. For the first three academic semesters and intervening summer term, the student is expected to complete course work that places a strong emphasis on laboratory research. The curriculum is designed to hone the student's skills in using biochemical and recombinant DNA techniques for biotechnology research. Subsequently, the student will spend at least six months as an intern with a participating biotechnology company, graduating in the summer of the second year. The six-month internship will provide practical experience and enhance placement opportunities for the student. Students in this program must write and defend a thesis based on the area of research in their OSU research, internship, or a combination.

The second track is the **M.S. with Thesis Option**. This program is designed to train students with a suitable bachelor's degree for a career in biochemistry. Students spend an average of two and one-half years in this program. Coursework includes a core curriculum with an emphasis on biochemistry (laboratory and lecture) courses, and electives for further specialization. Students typically select a thesis advisor and research project at the end of the first semester in the program.

In addition, the department also offers a **combined B.S./M.S. in Biochemistry**. The curriculum for this accelerated combined degree is designed to allow for the completion of both the B.S. and M.S. degrees in Biochemistry in five years. (Completion of the two separate degrees independently would typically take at least six years.) Students in the combined B.S./M.S. degree program will usually begin taking graduate level courses in the third year of the program. B.S./M.S. combined program students may participate in either the **Thesis Option** or **Emphasis in Biotechnology Option**. Students selecting the Thesis Option will conduct independent research under the supervision of a faculty member and use the findings for fulfilling the thesis requirement of a Master's degree. Students selecting the Emphasis in Biotechnology Option spend the last six months of the program in a participating biotechnology company and work as an intern. A stipend will be provided by the biotechnology company during the period of internship. Either option will offer career enhancement opportunities well beyond what is possible with the regular B.S. degree.

## **ADMISSION TO THE M.S. PROGRAM IN BIOCHEMISTRY**

Admission requires demonstration of an acceptable B.S. or B.A. degree typically in biochemistry, chemistry, biology or a related area, and a reasonable expectation of success in the graduate program. Considerable background in organic chemistry is desirable. The student should have a minimum overall undergraduate point-hour ratio of at least 3.2 (on a 4.0 basis), reasonable performance on the graduate record examination (GRE), or satisfactory completion of such specific additional requirements as may be stipulated in special cases. The Graduate Admissions Committee reviews and makes recommendations on each application for admission to the program. The Vice Chair for Graduate Studies has final approval on all offers of admission.

There are two options from the Graduate School for admission to the B.S./M.S. dual degree program. The first option is called the Combined Degree Program. This option has certain restrictions: (a) the undergraduate student must have completed 90 hours including all of the GEC requirements (i.e., senior status); (b) a minimum GPA of 3.5 is required. The student can be admitted to the M.S. program as soon as their 90-hr requirement is fulfilled; however, students are assessed graduate-level fees for this option. The second option is called the Senior Petition. The student must be a senior and have a minimum GPA of 3.3. Under this plan, a student can take a maximum of 9 credit hours during the senior year towards completion of the M.S. degree requirements. Courses cannot be double counted for both degrees. Students are not assessed graduate level fees for these 9 credit hours. Because the combined B.S./M.S. degree program demands considerable effort and commitment from the student, admission to this program is restrictive. Students interested in applying for the combined B.S./M.S. Degree Program are strongly encouraged to first consult with department advisors at [chemadvisors@chemistry.ohio-state.edu](mailto:chemadvisors@chemistry.ohio-state.edu) to obtain further information about the program eligibility requirements and the application process. The application includes a completed degree application form and three letters of recommendation from individuals who are familiar with your academic abilities.

## **TRANSFER STUDENTS**

Transfer students may petition to allow courses they took at a prior institution to stand in place of courses required at OSU. The student will submit previous course materials – syllabi, notes, homework, and exams – which will be evaluated by appropriate faculty in our department. Credits from other institutions cannot be transferred.

## **ACADEMIC STANDARDS FOR GRADUATE PROGRAMS**

A graduate student doing acceptable work toward a graduate degree is expected to maintain a point-hour ratio of B (3.00) or better in all graduate-credit courses. If at any time after 9 hours of graduate credit, a student's cumulative point hour ratio (CPHR) falls below the 3.00 requirement, the student is automatically placed on probation by the Dean of the Graduate School. Although the student is expected to raise the CPHR above 3.00 the next term, continued enrollment is permitted on a term-by-term basis, as determined by the Vice Chair for Graduate Studies and the Graduate School. For additional information, please visit <http://gradsch.osu.edu/5.3-probation.html>.

## **DURATION OF GRADUATE PROGRAMS**

Normally, a M.S. (Thesis Option) student will spend two years in residence; a M.S. (Biotechnology Emphasis Option) student will spend two years in the program including a 6-month internship. The B.S./M.S. program typically requires 5 total years.

## **SAFETY SEMINAR COURSE**

Every graduate student is required to attend a complete the Safety Seminar (CHEM 6781) course during the second half of Autumn Semester of the first year. The purpose of the series is to maintain high safety standards in the departmental teaching and research laboratories. The series of lectures, given by the departmental safety coordinator or a faculty member, covers topics ranging from the handling of corrosive and toxic chemicals to fire fighting. Failure to attend any of these lectures will result in a grade of "Unsatisfactory" for the course and may prevent any future support as a GA. In addition to the Safety Seminars, each student must become familiar with the department's Chemical Hygiene Plan and the Standard Operating Procedures associated with their work.

## **FINANCIAL SUPPORT FOR GRADUATE STUDENTS**

The M.S. program in Biochemistry is a self-supported program, and funding is not guaranteed for any period of the program.

However, at the discretion of the faculty advisor, M.S. students may receive financial support as Graduate Associates, either Teaching Associates (GTA) or Research Associates (GRA), or as Fellows during their tenure in the department. Graduate students supported by any of these appointments may not hold additional employment of any kind without express permission of the Vice Chair for Graduate Studies. Fellowship stipends may be supplemented up to the current GTA stipend; any stipends above that level must have prior approval by the Vice Chair for Graduate Studies.

The Graduate School sets minimum requirements of eligibility for GA appointments to students who are in a degree program. Students must register for at least eight (8) credit hours during fall and spring semester and four (4) during the summer session. Students who hold fellowships must register for twelve (12) credit hours during each fall and spring semester and six (6) during each summer session the appointment is held. International students who are not holding a GA appointment must register for eight (8) credit hours each fall and spring semester and four (4) each summer session. Each of these registration requirements qualifies the student to be considered "full-time" for purposes such as visas and health insurance.

There are additional requirements imposed by the Graduate School. A student must be enrolled for at least three (3) credit hours during the term in which they graduate. A Master's degree requires at least 30 graduate credit hours. Audited courses do not count toward these minima.

Departmental policies coincide with the guidelines set by the Graduate School for the most part:

- (1) Students with a GPA below 3.00 lose their right to a Department Graduate Research Associate appointment (dGRA), and may lose future support as a TA.
- (2) Students in the M.S. program are expected to defend their thesis by the end of their third year. Students failing to defend their M.S. thesis by the end of their third year must petition the Vice Chair for Graduate Studies to continue in the program.
- (3) Every faculty member and lecturer is required to evaluate their Graduate Teaching Assistants each term with ratings of Excellent (E), Satisfactory (S+, S, or S-), or Unsatisfactory (U). Evaluations are based primarily on overall performance as a teaching associate, but also include punctuality, attendance of staff meetings, and attitude toward students and staff. Students receiving an unsatisfactory (U) teaching evaluation will be suspended from their teaching appointment for two terms and must petition the Vice Chair for Graduate Studies for subsequent reinstatement. No GTA support will be available during such a suspension. Petitions to be supported as a GTA can be made at the end of the second term following the term during which the U rating was received. Two S- ratings are regarded as equivalent to one U rating. Any subsequent U will lead to dismissal from the teaching program and no further GTA support will be

available. A further S– rating will result either in complete dismissal from the teaching program or a two-term suspension, as decided by the Graduate Studies Committee.

- (4) Every faculty member is required to grade the performance of students taking research credits under his/her supervision each term with ratings of Satisfactory (S) or Unsatisfactory (U). Evaluations are based primarily on overall progress in research, but also include time spent in the lab, attendance of group meetings, and handing in reports required by the advisor in a timely manner. Students receiving an unsatisfactory (U) grade will meet with the advisor and the Vice Chair for Graduate Studies to devise a plan to ensure future success. Any subsequent U grades in research will lead to the student not being in good standing in the department and can result in dismissal from the program.

### **GRIEVANCE PROCEDURES**

Discussion with the Vice Chair for Graduate Studies usually leads to resolution of a grievance. If discussion with the Vice Chair proves unsatisfactory, the Graduate Council has established grievance procedures, copies of which are available in the Graduate School (for details, please see <http://gradsch.osu.edu/appendix-d.html>).

### **ENGLISH REQUIREMENTS FOR INTERNATIONAL STUDENTS**

A student whose native language is not English must demonstrate a satisfactory proficiency in English at the beginning of the graduate program. Courses in written and oral English may be required for students who show a deficiency that might prove to be a handicap to graduate work. Students who hold a GTA appointment will be required to demonstrate proficiency in Spoken English, either by passing the SPEAK test or a Mock Teaching Test, both of which are administered by the English as a Second Language Program. International students may also be required to take written English courses (5901, 5901.5, 5902) after taking English entrance examinations. Even though support is not guaranteed by the department, it is advisable for Biochemistry M.S. students to complete all English requirements by the end of the second semester at OSU in case opportunities for GTA support arise.

### **ADVISOR SELECTION**

Thesis research is initiated when a student has selected a research advisor, and has been admitted into a research group. The selection of an advisor is a major step in a student's program. Students must complete at least two 7-week lab "rotations" during which time they student and advisor will determine the suitability of the student for the research lab. Typically students should join a lab by the first day of the second semester in the program. Students who fail to do so may be granted additional time (not more than a semester) for finding a lab by the Vice Chair for Graduate Studies. After the end of the first year, students who have not joined a lab will not be in good standing and may be subject to dismissal.

Students formally join a lab by submitting a ranked list of the names of their top two choices of advisor to the Graduate Office by the end of the last day of final exams in the student's first semester in the program. The faculty members, in the order ranked, must decide whether or not to serve as advisor to the student. The faculty member notifies the Graduate Studies Office of his/her decision. If neither faculty member decides to serve as advisor, the Vice Chair for Graduate Studies will actively help the student find an advisor, in a manner left at the discretion of the Vice Chair.

Students must complete their M.S. research under the supervision of a faculty member in the Department of Chemistry and Biochemistry. In general, the advisor should be among those indicated to be part of the Biochemistry division on the departmental web page, but other advisors in the department are possible with approval of the Graduate Studies Committee. Research may be done in collaboration with faculty outside the department, including those affiliated with the department. The direct supervision of the M.S. research of Biochemistry graduate students by faculty outside the department is not permitted. Any other advising arrangement is subject to approval by the Vice Chair for Graduate Studies,

who will request a description of the proposed research and consider whether it is suitable for a M.S. thesis in Biochemistry.

After selection of an advisor and in consultation with the student and their advisor, the Vice Chair for Graduate Studies will appoint an advisory committee for each student typically composed the research advisor and one additional faculty member in the department. The purpose of the advisory committee is to provide each student with support and guidance during his or her graduate career. Students should meet with their advisory committee during the autumn semester of each year to discuss their progress in course work, examinations, and research. In addition, students are free to meet with any committee member at any time during the year. The department hopes that this process will provide a mechanism for forging closer ties between students and faculty, both before and after graduation.

If a student leaves a group, or the faculty advisor resigns his/her position as preceptor, the student will have until the end of that term to find a new advisor. If less than two weeks remain in the term including final examination week, then the student will have until the fifth week of the following term to find a new advisor. After this time, the student will no longer be in good standing in the department and support will be withdrawn (at the end of the term of enrollment) if the student was supported as a GA.

# M.S. PROGRAM IN BIOCHEMISTRY

## I. DEGREES GRANTED, RESIDENCE AND CREDIT HOUR REQUIREMENTS

### A. MASTERS PROGRAM

The student must have a minimum residence of two semesters at The Ohio State University with completion of at least 30 credit hours of graduate work. The student's course program should be decided in conjunction with the advisor. Course work must be at the 6000-9000 level, and the courses in related fields must be acceptable to the Vice Chair for Graduate Studies, the student's advisor, and the Biochemistry division.

Students must take (a) 11 hours of core classes including Biochem 6701, 6761, 6762, 6763 and 7770. (b) At least 2 hours of biochemistry electives from the department's listings (at the 6000 level or above). Related courses from other divisions (6000 level or above) or other departments (5000 level or above) may count as an elective with the permission of the Biochemistry division. Plant Pathology 7003 is recommended. (c) 2 hours of Biochem 6785 or Biochem 6999 for lab rotations in the fall. (d) 1 hour of seminar (Departmental Seminar, Chem 8896, or Biochemistry Division Student Seminar, Chem 8892) per academic semester.

Students will carry out a research program that will culminate with the writing of a thesis. The research program should be initiated upon joining a research group. Students must take at least 10 credit hours of research.

A student must submit an "Application to Graduate" form to the Graduate School no later than the third Friday of the semester (or third Friday of May session for summer session commencement) in which graduation is expected. The candidate must pass an oral examination before a committee composed of at least two faculty members from the Department of Chemistry and Biochemistry, including the student's research advisor. Should the graduate record of the candidate be wholly satisfactory to the examining committee, the scope of the examination will be confined to the candidate's field of specialization. The thesis Approval form to the Graduate School and the electronic submission of the approved thesis to OhioLink must be submitted by the deadline published by the Graduate School for the semester or summer session of graduation.

Students working toward an M.S. degree cannot receive financial support from the department (GRA, GTA, GAA) after completion of three years in the program.

### B. TYPICAL PROGRESS TIMELINE

Year one: Take core and elective courses; participate in two lab rotations and choose an advisor by the end of autumn semester; take safety course; attend seminars; begin thesis research.

Year two: Finish courses; thesis research; attend seminars.

Years three: Complete thesis research; attend seminar.

Note that students pursuing the option for Emphasis in Biotechnology will typically complete their courses by the end of fall semester of Year 2, and will participate in at least 6 months of internship beginning after the fall semester.

Note that students pursuing the B.S./M.S. option will typically complete 9 hours of graduate credit in their senior (fourth) year to complete the M.S. in one additional year.

## C. SUGGESTED BIOCHEMISTRY M.S. CURRICULUM

### **Year 1 - Autumn and Spring Semesters**

| Autumn Semester                |                                | Spring Semester                      |                       |
|--------------------------------|--------------------------------|--------------------------------------|-----------------------|
| Session 1                      | Session 2                      | Session 1                            | Session 2             |
| Biochem 6701 (3 hr)            |                                | Biochem 6762 (1.5 hr)                | Biochem 6763 (1.5 hr) |
| Biochem 6761 (3 hr)            |                                | Elective (2-3 hr)                    |                       |
| Rotation – Biochem 6999 (1 hr) | Rotation – Biochem 6999 (1 hr) | Research – Biochem 6999 (variable)*  |                       |
|                                | Safety Course (1 hr)           | Ethics Course                        |                       |
| Departmental Seminar (1 hr)    |                                | Departmental Seminar or BDSS* (1 hr) |                       |

\*BDSS, Biochemistry Division Student Seminar, Chem 8892

**Year 1 - Summer Term:** Research (4 hr)

### **Year 2 - Autumn and Spring Semesters**

| Autumn Semester                    |           | Spring Semester                     |           |
|------------------------------------|-----------|-------------------------------------|-----------|
| Session 1                          | Session 2 | Session 1                           | Session 2 |
| Biochem 7770 (2)                   |           |                                     |           |
| Departmental Seminar (1 hr)        |           | Departmental Seminar or BDSS (1 hr) |           |
| Research – Biochem 6999 (variable) |           | Research – Biochem 6999 (variable)  |           |

**Year 2 - Summer Term:** Research (4 hr)

**Subsequent Terms:** Research, seminar and/or elective courses\*

\*Please consult the Graduate School Handbook to determine the number of credit hours required to retain the full-time student status, when a student is supported by a fellowship or other appointment.

## **II. DEPARTMENTAL REQUIREMENTS FOR THE BIOCHEMISTRY M.S. DEGREE**

### **A. THESIS**

The thesis resulting from the student's graduate research must represent significant contribution to knowledge in biochemistry. Its importance should be sufficient to warrant the acceptance for publication of a paper based upon it by one of the respected journals of biochemistry or a related scientific area. A reading committee composed of the advisor and at least one graduate faculty member (often the student's Advisory Committee) will consider the merit of the thesis in detail. The student's advisor selects the other committee member from the department.

### **B. MASTER'S EXAMINATION**

On approval of the thesis by the committee, a final oral examination, based largely on the thesis work, will be held in accord with the Graduate School guidelines. The examination committee will consist of the members of the thesis reading committee. A unanimous vote of the committee members is required for a satisfactory decision.

