

GRADUATE STUDENT HANDBOOK - DEPARTMENT OF CHEMISTRY
NORTHWESTERN UNIVERSITY

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REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN CHEMISTRY

This document lists Departmental requirements for the Ph.D. degree in Chemistry, along with a summary of the most significant general regulations of the Graduate School pertaining to this degree. Further details on the Graduate School regulations may be found in the Policy Guide of the Graduate School at the TGS website.

A. REGISTRATION REGULATIONS

1. Each course (except research and independent study) is one unit, and registration for either three or four units constitutes full-time registration. Normal registration is three or four units for the first quarter and four units thereafter, including 1-4 units of research. The minimum period of study for the Doctor of Philosophy degree is eight full-time consecutive quarters including summer.

2. Grading System Regulations:

The Chemistry Department uses an A, A-, B+, B, B-, C+, C, C-, F grading system for internal use. A student's GPA is determined using this grading system. Registration for 500 is an exclusive type of registration; concurrent registration for any other course is not permitted. Letter grades are required under the following circumstances:

1. For the first seven courses with numbers below 460 taken as a graduate student at Northwestern and for all core courses.
2. For Research Seminars (570) whenever necessary to fulfill full time registration status if required courses or appropriate electives are not available, as well as to replace waived courses (see Waived Courses in Section B above).
3. The P/N option is to be used as follows: For Research 590 - After the first quarter, each student is expected to register for their advisor(s) research each quarter until time for registration for Post-Candidacy Research.

3. All students who are receiving financial aid of any kind from any source must register as full-time students. For the purpose of this regulation, a full-time student is one who is registered for 3 or 4 courses or units, or one registered for TGS 500 (Advanced Doctoral Study). Deviations from this regulation are allowed only with the written permission of the Chair of the Department and the Dean of the Graduate School.

4. Students who have completed eight quarters of full-time registration consecutively over two years, including summer, are expected to register for TGS 500 (Advanced Doctoral Study) for every succeeding quarter in which they are in residence. After admission to candidacy for the Ph.D. degree, a student in residence must register in some appropriate way in every subsequent academic quarter until all degree requirements, including the final examination, are completed.

5. The Graduate School offers the TGS 512 (Continuous Registration) for students not being paid a stipend but who are in good standing and are continuing toward the Ph.D. degree. This requires that the student pay the quarterly tuition of \$100.00, which allows the student to maintain full-time student status with access to email and health insurance.

B. YEAR 1

1. SEMINAR & COLLOQUIA REQUIREMENTS

You are **required** to **attend two thirds of all departmental Colloquia and special seminars** during your 1st and 2nd years, and you are strongly encouraged to attend all of them. The aim of this requirement is to expose you to research in your particular area of interest but also to a broader

scientific set of topics.

This exposure to the latest science is a critical means you have at your disposal to prepare for your qualifying exam in year 2 and for your independent research proposal (years 3-5), so plan on attending colloquia and seminars in all your years in residency.

2. COURSE REQUIREMENTS

Each student must take **seven courses** for a letter grade and credit, not P/N. These courses satisfy the specific requirements of a division or a program and should be completed by the end of the spring quarter of the first year.

Each student, regardless of Major Field, must take the 515 (Theory and Practice of University Teaching, "TPUT"), which meets weekly at noon on Wednesdays in the Fall. The course is for a letter grade.

In addition, all students are required to take Chemistry 519 – “Responsible Conduct of Research Training” during the Spring Quarter and must complete 3 quarters of Chem 570 “Research Seminar”.

Each student should choose a major field of study and satisfy the requirements within that major field, as listed below. 300-level courses in Chemistry, research courses, and research seminar courses, such as 499 and all 500-level courses, **cannot** be used to satisfy the course requirements of any of the major fields of study, even as electives. PLEASE NOTE THAT NOT ALL COURSES LISTED BELOW WILL BE AVAILABLE EVERY YEAR.

Requirements of the Major Fields

1. Inorganic Chemistry: Must take **433**, and five additional courses chosen in consultation with prospective advisor(s).

In addition, all 1st-year inorganic concentrators must mandatorily attend BIP, and all inorganic concentrators must give at least 2 BIP presentations throughout their PhD careers.

2. Organic Chemistry: Must take six courses that the student chooses in consultation with prospective advisor(s).

In addition, organic concentrators must present one divisional seminar on their research in the Chemistry Department at Northwestern during their 3rd year in the program.

3. Biological Chemistry:

- a. Option 1: Fulfill any one of the three divisional requirements (Inorganic, Organic, or Physical/Analytical), take 405, and select electives from among: Chem 415-0-02 (Silverman) (), Chem 415-0-03 (Zhang), Chem 416 BioSci 301 BioSci 361 BioSci 390 IBIS 401 IBIS 402 IBIS 406 IBIS 410
- b. Option 2: 405 and one course from 411, 416, 433, 442-1, and either BioSci 301 or IS 401 and BioSci 361, and select two electives from among: Chem 415-0-02 (Silverman), Chem 415-0-03 (Zhang), IBIS 401 IBIS 402 IBIS 406 IBIS 410

4. Physical/Analytical Chemistry: Must take **442-1, 444**, and four additional courses chosen in consultation with prospective advisor(s).

PLEASE CONSULT OUR “COURSE RECOMMENDATIONS” DOCUMENT FOR SUGGESTED CLASSES FOR CERTAIN AREAS OF INTEREST

Waived Courses: **Bold type** indicates required courses for a given field of study that are eligible for being waived if a certain set of criteria are met as detailed here. If a student is already proficient in the subject matter, whether by virtue of having completed an equivalent course at another institution or by independent study, they may request **the instructor of the course** in question to waive that particular course requirement. (As an example, 442-1 is only required for the Physical/Analytical major field. Thus, students who plan to pursue this major field are eligible to request a waiver of this course. However, since this is not a specifically required course for students in other major fields, students who major in a field other than Physical/Analytical are **not** eligible to request a waiver of this course.) In requesting a waiver, the student will be expected to present evidence of superior knowledge of the course material to the instructor of the course.

A waiver of courses does not reduce the total number of required courses below seven. For each waived course, an additional eligible Northwestern course, selected in consultation with the prospective research adviser, must be substituted for any waived course(s).

Additional Information for Students with a Master's Degree: Students entering with a Master's degree from an accredited institution are allowed to reduce the number of courses taken from seven to a minimum of four. Permission for this class reduction requires evidence of having taken suitably relevant course work during the Master's degree and needs to be approved by the Director of Graduate Studies. Required classes for a given major field of study (i.e., **bolded** courses) must still be taken unless a waiver is obtained as described above. Please work with the Graduate Program office to make sure all requirements are met appropriately.

Additional Information for MSTP Students: Students entering from the Medical Scientist Training Program (MSTP) who have received a B.S. or B.A. in Chemistry and who have successfully completed two years of Medical School course work in the Northwestern University Feinberg School of Medicine (FSM) will be allowed to reduce the number of courses taken from seven to a minimum of four. Required classes for a given major field of study (i.e., **bolded** courses) must still be taken unless a waiver is obtained as described above. Please work with the Graduate Program office to make sure all requirements are met appropriately.

3. TEACHING RESPONSIBILITIES

Satisfactory performance of assigned teaching duties is a requirement for all advanced degrees in the Department of Chemistry. Regardless of the method of financial support, or whether any support at all is provided, every full-time graduate student must teach 5 full quarters in order to graduate with a Ph.D. All MSTP students must fulfill a teaching requirement of 3 full quarters in order to meet graduation requirements. Some students choose to teach additional quarters based on their interest. **Inadequate performance of teaching responsibilities shows a lack of progress toward the Ph.D. degree and may result in the student being placed on notice** (see Section K).

4. ADMISSION TO THE DOCTORAL PROGRAM

Although students are expected to enter into graduate work with the intention of earning the doctorate, formal admission to the doctoral program is not granted until the student has adequately demonstrated their qualifications for entering the program. Admission to the doctoral program is based on the scientific potential of the student as judged by performance in course work and effectiveness in research. A satisfactory teaching record is also required. Decisions are normally made at the end of the first academic year of graduate work (e.g., June for students entering in September of the prior year).

For admission to the chemistry doctoral program and for continuation in the Department of Chemistry after the first academic year, a graduate student must show competence in coursework,

research, and teaching. With regard to coursework, the student must have an overall grade point average ≥ 5.25 and no more than one grade below B in the courses required by the Chemistry Department. The GPA is determined using this grading system immediately below, where A = 8, A- = 7, B+ = 6, B = 5, B- = 4, C+ = 3, C = 2, C- = 1, less than C- = 0.

Note that 499 and 500-level courses (e.g., research courses and research seminar courses) taken to fulfill the total course requirements **do not** count in this evaluation. Students who meet these criteria and demonstrate suitable competence in research and teaching by the end of their first year continue working toward Ph.D. candidacy. **The following guidelines will be used by the faculty in making decisions about a student's status:**

- 1) If the student's GPA is < 5.25 , the faculty will decide, at a meeting that normally takes place in June of the student's first year, if the student should be placed on academic notice or terminated from the program. The decision whether to place a student with a GPA < 5.25 on notice or to terminate the student from the program is based on an evaluation, presented to the faculty by their research adviser, as to the student's competence in research and by an evaluation of teaching competence.
- 2) If the student has a GPA ≥ 5.25 but has more than one grade below B, and is judged to have shown suitable competence in research, they will be placed on academic notice.
- 3) If the GPA is ≥ 5.25 with no more than one grade below B but the research and/or teaching competency criteria have not been met, the faculty may choose to place the student on research or teaching notice, respectively, to provide an additional opportunity to demonstrate competency.
- 4) If a student's teaching competency criteria has not been met, the faculty may choose to place the student on teaching notice and elect to add teaching duties until the performance criteria are met. Persistent inadequate teaching may result in exclusion from the program.

The duration of a given period of notice will be approximately two months, during which time the student is expected to demonstrate competence in research. At the end of that period, the Graduate Affairs Committee and the student's adviser will assess progress in research on the basis of two criteria: a two-page written report of research results by the student and a letter from the research adviser. **The report is due by 5 pm on the next-to-the-last Friday of August of that summer.** Students who have demonstrated hard work and an ability to carry out research, as determined by their advisor(s) and the Graduate Affairs Committee at their academic discretion, will be permitted to continue in the program.

To remedy teaching deficiencies, a student may be required to perform additional teaching duties to correct the deficiencies, and consideration of admission to the Ph.D. program may be delayed until satisfactory performance has been demonstrated.

If a student has been terminated (excluded) from the program, their enrollment and financial support will end on the last day of the current academic quarter, and they are prohibited from doing any further work towards a Ph.D. degree in the department.

5. SELECTION OF A THESIS TOPIC AND RESEARCH ADVISER

One of your most important tasks during the fall quarter is to gather information that will enable you to choose a thesis topic and a research adviser. Because a large fraction of your time during the next four to five years will be devoted to research, it is important that you select a problem that you find interesting and exciting, and a research group in which you will be comfortable. There are

many faculty members and a wide variety of research topics; thus, you should have no difficulty in finding several interesting problems and compatible research groups. The number of new students to be accommodated in each research group is limited, so you should develop alternate choices in case you cannot be placed in the group of your first choice.

Although each student is most often assigned one official adviser, it is possible to complete a thesis under the joint supervision of two faculty members when the thesis problem involves two areas (e.g., theory and experiment; synthesis and structure). Joint advisers need not be in the same division. You may also investigate arrangements of this type. You are not restricted to problems in the branch of chemistry you indicated as your area of interest when you applied for admission, and you are encouraged to investigate problems in all areas. If you worked for a professor previously (i.e.- during the summer), you have no obligation to remain with that group, nor do they have an obligation to keep you in their group. You are free to investigate all possibilities.

There are many ways in which you can gather the information needed to make your choice; you should make use of all of them.

1. Faculty Presentations: These research presentations, beginning during Orientation, are intended to give you an overview of the type of work being done in each research group. They should help you identify potential areas in which you might like to work. These presentations will help you become generally familiar with all of the research that is underway in the Department. Even though you may not be interested in doing research in many of those areas yourself, you are expected to attend **all** of these presentations.
2. Discussion with Individual Faculty Members: Make appointments with every faculty member in all areas in which you think you might like to do your research to discuss in some depth the research problems that are available. Although there is merit in scheduling an appointment after the faculty member has made their formal presentation, you should not need to wait until after the presentation to schedule a meeting. You should try to make these appointments as early as possible so you will have time to weigh the merits of the various choices. **Do not postpone the appointment until just before the week for the selection of a research adviser.** If you would like to schedule a second or third meeting with any particular professor as you begin to narrow your selection, by all means do so. **It is required that you discuss possible research problems with at least four faculty members who are working in areas in which you would like to do your research, as evidenced by physically signed and dated faculty meeting forms (template online). Most faculty members expect to have a least one if not several meetings with students who eventually join their group.**
3. Group Seminars: Most faculty members schedule regular meetings of their research groups for informal discussion of research progress, recent pertinent literature, and other topics of special interest to that particular group. You are welcome to attend such group meetings. They provide an excellent way of getting acquainted with a research group. Ask the faculty member when group meetings are held and indicate you would like to attend. Depending on your class and teaching schedule, you may only be able to attend a portion of the group meetings (say, only the first 30 minutes). Please clarify with the faculty whether this is okay with them.
4. Some questions you may find interesting to ask faculty members and students in the groups in which you are interested relate to mentoring. Some faculty members have mentoring philosophy statements on their web pages or in their group handbooks, so it

will be important to ask for that information. You may also find it informative to ask faculty members and group members about a group's approaches to mental health.

5. Discussion with Graduate Students: Get acquainted with the graduate students in each of the research groups that you think you might like to join. They can provide insights that you might not get by talking with the faculty. If you wish, ask the adviser to introduce you to some of their group members.
6. Reading the Literature: You can learn much about the detailed nature of the research that is being pursued in each group by studying recent publications describing that research. It would be to your advantage to read some of the recent publications of each of the faculty members with whom you might be interested in working before you schedule an interview.
7. Departmental Seminars: Each week there are typically multiple seminars in which a faculty member, a graduate student, a post doc, or an outside speaker discusses some current research effort. You should attend at least one of these seminars each week, and you are welcome to attend as many as you like. If you have already reached a reasonably firm decision as to the general area of chemistry of most interest to you, then attend the seminars relevant to work in that division or program area.

Because the selection of a research advisor is such an important matter, we want to schedule enough time for you to examine all alternatives in a thorough and leisurely manner. For this reason, **neither students nor faculty are allowed to reach an agreement regarding thesis supervision prior to the faculty meeting dealing with adviser selection.** Yet, it is important to advocate for yourself and to clearly express to a faculty member your interest in joining their group once you have made that decision.

Faculty Adviser Selection forms are due to the Graduate Program Assistant's Office at noon on the first Friday of December of the first year in graduate school. Final decisions for adviser assignments are anticipated by the end of the first quarter of the first year in the program.

Acceptance into a research group is contingent upon having handed in the sheet at the end of this document with the student's signature and date to the Graduate Program Office.

6. CHANGING AN ADVISER

A student may leave a research group at any time. Likewise, an adviser may use their discretion to ask a student to leave their research group. In either case, a student in good standing with the Department and University may look for another adviser for a period of up to five weeks with pay. **The Department strongly recommends that students in these situations work directly with the Director of Graduate Studies to find a suitable solution.** A student who has not found a suitable adviser by the end of that time is no longer making satisfactory progress toward the degree and will be excluded from the program.

7. MASTER'S DEGREE IN CHEMISTRY

The Chemistry Department's graduate program is designed to lead to the Ph.D. degree, and it is expected that all students who enroll are pursuing the doctorate. However, a student leaving the Doctoral Program is eligible to receive a terminal Master's Degree if *all* of the following three requirements are met:

- 1) At least three quarters of full-time coursework are completed.
- 2) The student has been admitted to the Doctoral Program by the faculty (see section B).

3) The student has submitted a written research report that is approved by the research adviser(s) and the Graduate Affairs Committee and that demonstrates substantial progress on the student's research project. The report must be written in a format that would be acceptable for submission as an article in one of the journals of the American Chemical Society or in the form of one chapter of a Northwestern Ph.D. thesis. The decision as to which format is selected must be made in consultation with the research adviser.

C. YEAR 2

1. THE QUALIFYING EXAM

The qualifying examination (QE) is the means by which students advance to candidacy for the Ph.D. The exam can be taken after five quarters of residency, but must be taken before the end of your seventh quarter of graduate study (the first official quarter of graduate study being in September of the first year, even if the student works in a lab the summer before the first year). The vast majority of students take this exam in the Spring quarter of their second year.

Students who enter Northwestern with a Master's Degree, or with credit for at least three quarters of graduate study from another Institution that is accredited by The Graduate School, may take the examination after completing three quarters of study at Northwestern, but again must complete the requirement before the end of the seventh quarter of study.

You must prepare a written document, as detailed below, and take an oral examination that covers the material in your document as well as general chemistry topics. The purpose of the QE written document and oral exam is to assess: (i) whether the student is progressing as rapidly as can be expected on their research problem(s), (ii) the student's general knowledge of Chemistry, particularly in the field of Chemistry relevant to the student's research, (iii) the student's ability to put their research project in the context of their greater field within Chemistry, and their familiarity with the relevant literature, (iv) the student's ability to articulate plans for the near-term (next 1-2 years) for their project, and (v) whether the student is likely to produce an acceptable thesis within the next 2 – 3 years.

The student will write their QE document in *the format of a research proposal*, where the topic is their own thesis research, and where the Preliminary Results section is a summary of the work they have accomplished so far. The Preliminary Results Section will occupy a significantly higher fraction this document than it would in a typical original research proposal.

2. FORMAT OF THE WRITTEN QE DOCUMENT

The QE written document will have 7 sections (total maximum of 13 pages, double-spaced, one-inch margins, including abstract, figures and tables, but excluding references):

- (1) Title and abstract (1 page) The title and abstract should be descriptive of the total document.
 - a. In more detail: the portion of the work that has been accomplished, and the portion of the work that is proposed for the next 1 – 2 years of research.
- (2) Introduction, Background, and Significance of the Research
 - a. Should include the “intellectual merit” of the project: what it will do to move the field forward and further fundamental understanding. It should also demonstrate the student's mastery of the literature in their field
- (3) Scientific Objectives (“Specific Aims”)
- (4) Preliminary Results (no fewer than 5 full pages, including figures and tables). This section is a summary of progress on the research problem thus far.

- (5) Proposed Research (no fewer than 2 full pages, including figures and tables). This section should include:
 - a. A research plan for the next 1 – 2 years, including general objectives and specific experimental or theoretical plans.
 - b. A brief description of contingency plans
- (6) Summary and Conclusions
- (7) References (as many as are appropriate; not included in the page count) - references should be the following format:
 - a. Journal articles: Kramer, I.J.; Levina, L.; Debnath, R.; Zhitomirsky, D.; Sargent, E.H. Solar cells using quantum funnels *Nano Lett.* **2011**, *11*, 3701-3705.
 - b. Books: Odian, G. Principles of Polymerization; 4 ed.; John Wiley and Sons: Hoboken, NJ, 2004.

The student decides how to partition the document between text and figures, but should note that figures should not be seen as a replacement for text (i.e., the text must be a complete narrative). **All text must be 12-point, Times New Roman, double spaced, and type justified.** Pages must be numbered starting with the title/abstract page.

3. THE QUALIFYING EXAM (QE) COMMITTEE

In the beginning of January of the student's 2nd year, the chair of the department's Graduate Curriculum Committee will assign each student's committee members based on suggestions from the student's adviser. Students must turn in the printed and filled out online form "QE Committee Selection Form" listing these suggestions to the Graduate Assistant within the first two weeks of the fall quarter for students with Master's degrees, and within the first two weeks of winter quarter for students with a bachelor's degree. The student's research adviser will be a member of the QE committee and will be present during the examination. Upon completion of this examination, the QE committee becomes the student's PhD committee with the advisor as chair.

4. SCHEDULING THE QUALIFYING ORAL EXAM

(Deadline Before the end of your seventh quarter of graduate study)

In the Winter quarter of your second year, the department will arrange for you to meet with the administrative assistants of your committee members to schedule a QE exam date and reserve a conference room. This meeting room must have a projector screen and a chalkboard or whiteboard. Please contact gradasst@northwestern.edu with questions about QE scheduling.

****The QE document must be turned in to committee members at least one week before your examination date.**** If two or more committee members believe that the QE document is not satisfactory to move on with the oral exam portion, then the Chair of the committee must inform the student – *no later than 48 hours before the scheduled exam time* – that the exam will be postponed. The committee should give the student a general idea about why the written document was rejected but is not required to provide detailed feedback to the student. Typical causes for rejection at this stage include issues such as poor editorial formatting, lack of a testable hypothesis, and poorly eligible graphics. Alternatively, the committee may opt to not have the student submit a revised QE document, at which point they are not in good standing and will be excluded from the program but may qualify for a Terminal Master's.

If the committee opts to allow the student to submit a revised QE document, it is the student's responsibility to revise the document and reschedule the exam. The student is advised to consult

with the Graduate Program Assistant about a timeline for this process. It is desirable to reschedule within the same quarter, but the student can petition the Director of Graduate Studies for an extension. If the revised QE document is still judged unacceptable by two or more committee members, the student will be excluded from the program and may qualify for a Terminal Master's.

5. OTHER INFORMATION ABOUT THE QE

On the day of the scheduled QE, the student will make a 25-30 minute presentation and defense of the QE to their committee, in an exam that typically lasts ~1.5 to 2 hours.

Students are expected to present a slide deck outlining their QE document. It is advisable that additional backup slides be included so that they may be used to address likely science questions. The student should bring research notebooks and other similar research related materials to the examination so that any specific information or data that the committee may request can be provided.

The QE committee will first ask the student to leave the room and will discuss the student's record and hear a brief summary by the advisor of the student's progress and standing in the group. Then the student will be called in and the committee will decide whether the student should present the slide deck in full followed by the question and answer section, or if the committee reserves the right to interrupt and ask questions during the presentation.

When there are no more questions, the student is again asked to leave the room so that the committee may discuss the student's exam performance and make suggestions for improvements. The committee will also score the student's exam according to the QE evaluation form. The committee will also fill out the other parts of the evaluation form, which includes written feedback and forms the basis for the Lambert Award in Research Excellence that is administered by PLU.

Students who do not demonstrate satisfactory research aptitude and research progress will be excluded from the doctoral program. The committee may also opt to have a re-examination in the summer.

A Winter quarter Q&A lunch meeting with the Director of Graduate Studies in the form of a lunchtime question and answer session will further serve to clarify questions you may have about the process.

D. YEARS 3 - 4

1. THE ORIGINAL RESEARCH PROPOSAL (ORP) REQUIREMENT

Beyond being able to complete independent research commensurate with a PhD, all graduate students of the Department of Chemistry at Northwestern University are expected to be able to:

- research and refine relevant chemical literature
- independently generate novel scientific hypotheses and concepts
- formulate logical and rational arguments based on data and literature precedent
- write using concise and convincing scientific language
- deliver scientific information in a clear presentation or lecture

The Original Research Proposal requirement of the PhD program in chemistry at Northwestern University is designed to teach and refine these skills over a two-year period during the third and fourth years of graduate study. While the ability to craft scientific research proposals has direct relevance to a planned career path in academia, the general skills developed during this process are also highly transferable to all careers that utilize a chemistry Ph.D. Common career paths pursued by

chemistry graduate students, such as those within industry, at consulting firms, or within patent law all require the ability to research information, formulate arguments, and present ideas in both written and oral formats. Thus, the Original Research Proposal is a crucial cornerstone for all graduates in the program.

The process of writing an original research proposal (ORP) is broken down into two required parts. This two-step process is intended to develop the skills needed for proposal writing in stages rather than in one concerted activity. These stages are: **(i)** literature search and topic choice, accomplished through construction of *Quad Chart Proposals* to be discussed with the student's committee in a meeting held during the Winter quarter of year 3, and **(ii)** writing and defense of the *full original research proposal document*, to be discussed with the student's committee in a meeting held during the Fall quarter of year 4.

**The ORP meetings will occur in years 3 and 4 and
be accompanied by a brief research update, as outlined below.**

2. YEAR 3: LITERATURE SEARCH AND TOPIC CHOICE: QUAD CHARTS

(Deadline for completion: Last day of Winter quarter of the third year; committee meetings occur during the Winter quarter of the 3rd year)

By the end of Winter quarter of the third year, students must have obtained committee approval for a set of 3 approved "Quad-chart Proposals" (see "Quad Chart Examples" on the chemistry department webpage). *It is strongly recommended that the student bring at least 4 quad charts to this meeting, so that three can be chosen with which the student moves forward.* These quad charts contain the key elements of original research proposals. All four quadrants of the chart must be filled in for each ORP topic. The student can use text and/or schematic diagrams and figures to illustrate their points in one or more quadrants. They cannot use more space than provided by the quad chart on 8.5x11" paper (with no smaller than 11-pt Arial font), as oriented in the "Quad Chart Examples" on the chemistry department webpage. A list of at least five literature references must accompany each quad chart.

Students are required to get their quad charts approved before the Winter quarter ends.

The Quad Chart committee meeting should include the first 30 minutes to discuss the quad charts and the remainder of the meeting is reserved for the research update. For the latter, the student will prepare a brief summary (*2 pages max and/or 2 power point slides max*) of their **research progress** and plans for the next year, to be discussed at the Quad Chart committee meeting for what the committee considers an appropriate time.

a. Choice of Topics for the Quad-chart Proposals. Each proposal should be for a focused research project that could be carried out by 1 – 2 graduate students or postdocs over ~2 years. Each quad chart should represent a distinct topic, and not, for example, a larger topic split into three parts.

In choosing the topics for the quad charts, the students should imagine that they are choosing topics for proposals for postdoc fellowships, faculty applications, or a starter/entry project at a company. Each topic must be focused on fundamental chemical science and be an independently developed original idea of the student. The topics may be related to the student's area of expertise (more expertise usually leads to a more feasible and interesting proposal) **but should not be projects that their research advisor has addressed in the past, addresses currently, or would reasonably be expected to address in the near future as an extension of ongoing research.** Derivative proposals that are based on small to negligible extensions of the advisor's research projects ("methyl, ethyl, propyl") are not allowed, either.

A space is provided on the approval form for you advisor to certify that your proposals are independent ideas and satisfy the above criteria. The student can propose a topic in an area unrelated to their general expertise; however the student should realize that they must be considered a credible principal investigator for the project.

b. Approval of the Quad-chart Proposals. By the final day of the Winter academic quarter of the student's 3rd year, the student is required to have three quad-chart proposals approved by all of their thesis committee members (as indicated by their signatures on an approval form, available online). This approval will occur through the single, one-hour meeting (the Quad Chart/Research Update meeting) of the student with their committee members. Having all three quad charts approved and having demonstrated satisfactory research progress constitute passing of the Year 3 quad chart/research update meeting.

Importantly, *before the committee meeting*, the student should obtain their research advisors' signature indicating that the chosen topics are distinct enough from their own research to be appropriate for the ORP exercise.

The student's committee in the third year is the same as their QE committee, with the advisor acting as chair of the committee. During this committee meeting, the committee members will provide feedback on the quad chart proposals, and either approve three of them, or ask the student to revise them before approval, in which case approval must occur through email or individual meetings with committee members. *As stated above, it is strongly recommended that the student bring at least 4 quad charts to this meeting, so that three can be chosen with which the student moves forward. The same three quad-chart proposals must be approved by all thesis committee members.*

If the quad chart/research update meeting is not passed by the committee by the end of the Winter quarter, the student will be declared to be not in good standing in the graduate program. The student's committee may grant a modest extension of the deadline for revising and completing the quad charts if it is clear that progress is being made. If the committee opts not to grant an extension to complete the quad charts, or if no progress has been made in the revised quad charts, the student will be excluded from the program. They may qualify for a Terminal Master's.

c. Research Update. The Quad Chart committee meeting will also include a research update. To this end, the student will prepare a brief summary (*2 pages max and/or 2 power point slides max*) of their **research progress** and plans for the next year, to be discussed at the Quad Chart committee meeting for what the committee considers an appropriate time. This brief summary should ideally consist of copies of TOC graphics and abstracts of the student's manuscripts that are in preparation on under review, or papers already published.

d. Scheduling: In the Fall quarter of your third year, the department will arrange for you to meet with the administrative assistants of your committee members to schedule a quad chart/research update date and reserve a conference room. This meeting room must have a projector screen and a chalkboard or whiteboard. Please contact gradasst@northwestern.edu with questions about quad chart/research update scheduling.

e. What to Submit When: One week prior to the scheduled exam, the student needs to submit a single pdf of the quad charts (one quad chart per slide) and their research update. If two or more committee members believe that the quad charts/research update are not satisfactory to move on with the oral exam portion, then the Chair of the committee must inform the student – *no later than 48 hours before the scheduled exam time* – that the exam will be postponed. The committee should give the student a general idea about why the written document was rejected, but is not required to provide detailed feedback to the student. It is then the student's responsibility to revise the

document and reschedule the exam. The student is advised to consult with the Graduate Program Assistant about a timeline for this process. It is desirable to reschedule within the same quarter, but the student can petition the Director of Graduate Studies for an extension.

A Fall quarter meeting with the Director of Graduate Studies in the form of a lunchtime question and answer session will further serve to clarify questions you may have about the process.

3. YEAR 4: COMPLETION AND ORAL DEFENSE OF THE FULL ORIGINAL RESEARCH PROPOSAL

(Deadline: Last day of Fall quarter of the fourth year; students can schedule their oral PhD defense after that exam has been passed)

Between the 3rd year quad chart meeting and the end of Fall quarter of the fourth year, the student will develop their chosen quad chart project into a full proposal (format detailed below). In the Fall quarter of their 4th year, the student will then make a 30 minute presentation and defense of this ORP to their committee, followed by a 30 minute research update, in a ~1 hour format similar to that of the QE oral examination. For the research update, the student will prepare a brief summary (*2 pages max, 2 power point slides max*) of their **research progress** and plans for the final year, to be discussed at the Quad Chart committee meeting for what the committee considers an appropriate time. Just like for the Quad Chart committee meeting, this brief summary should ideally consist of copies of TOC graphics and abstracts of the student's manuscripts that are in preparation on under review, or papers already published.

a. Format of the Full Original Research Proposal. The full ORP written document will have 7 sections (total maximum of 13 pages, double-spaced, one-inch margins, including abstract and figures, but excluding references):

- (1) Title and abstract (1 page) - The title and abstract should be descriptive of the total document
- (2) Introduction, Background, and Significance of the Research. This section should include the “intellectual merit” of the project: what it will do to move the field forward and further fundamental understanding. It should also demonstrate the student’s mastery of the literature in their field
- (3) Scientific Objectives, if NSF- or DOE-style, or Specific Aims if NIH-style.
- (4) Previous Work (no fewer than 2 full pages, including figures and tables) - a summary of the relevant prior art and literature on the scientific topic
- (5) Proposed Research (no fewer than 6 full pages, including figures and tables).
 - a. A research plan for 2 years, including general objectives and specific experimental or theoretical plans.
 - b. A brief description of contingency plans
- (6) Summary and Conclusions
- (7) References (as many as appropriate, not included in the page count) should be the following format:

Journal articles: Kramer, I.J.; Levina, L.; Debnath, R.; Zhitomirsky, D.; Sargent, E.H. Solar cells using quantum funnels *Nano Lett.* **2011**, *11*, 3701-3705.

Books: Odian, G. Principles of Polymerization; 4 ed.; John Wiley and Sons: Hoboken, NJ, 2004.

The student decides how to partition the document between text and figures. Please note that figures should not be seen as a replacement for text (i.e., the text must be a complete narrative). All main text must be *12-point, Times New Roman, justified and double spaced, with 1-inch margins*. Figure captions may be 9-point, Arial, single spaced, justified. Pages must be numbered starting with the title/abstract page. Sample ORPs are posted online.

b. Scheduling the ORP Oral Exam (Deadline: Before the end of Fall quarter of the fourth year of graduate study)

In the summer prior to your ORP exam in the Fall quarter of your 4th year, the department will arrange for you to meet with the administrative assistants of your committee members to schedule the ORP exam date and reserve a conference room. This meeting room must have a projector screen and a chalkboard or whiteboard. Please contact gradasst@northwestern.edu with questions about ORP scheduling.

c. Other Information about the ORP

The student should reserve 1 hr for this exam. The format is similar to the QE oral exam, where the student prepares a 25-30 minute presentation that mirrors and elaborates on the ORP written document and the faculty have the opportunity to ask questions about this or related material. The second half of the exam should be reserved for the research update.

d. What to Submit When: The ORP document must be turned in to committee members at least one week before your examination date.** If two or more committee members believe that the ORP document is not satisfactory to move on with the oral exam portion, then the Chair of the committee (the student's advisor) must inform the student – *no later than 48 hours before the scheduled exam time* – that the exam will be postponed. The committee should give the student a general idea about why the written document was rejected, but is not required to provide detailed feedback. It is then the student's responsibility to revise the document and reschedule the exam. The student is advised to consult with the Graduate Program Assistant about a timeline for this process. It is desirable to reschedule within the same quarter, but the student can petition the Director of Graduate Studies for an extension.

If the committee does not approve the ORP document, or if the committee does not pass the student following the ORP/research update oral exam, the student is not in good standing and will be excluded from the program. They may qualify for a Terminal Master's.

A Spring quarter meeting in your 3rd year with the Director of Graduate Studies in the form of a lunchtime ORP question and answer session will further serve to clarify questions you may have about the process.

E. YEAR 5 AND BEYOND EXTENSION FORM REQUIREMENT

The Department requires that all students who will be extending their research past 5 years will need to complete a Research Extension Form. By no later than July 1st of the student's 5th year, the student and their advisor(s) must formulate a statement of what needs to be accomplished to obtain a Ph.D. along with a proposed time table. This timetable is to be submitted to the student's committee for approval, comments, and proposed modifications. This form and process will be repeated in six-month intervals until the student graduates.

F. DISSERTATION

Each student must complete an original research study and produce a dissertation acceptable to the faculty research supervisor and the Thesis Committee. For students entering in September of their first year, thesis research begins in the Winter quarter of the first year of graduate study and

continues until a satisfactory thesis has been completed.

G. FINAL ORAL EXAMINATION

The completed dissertation is submitted at least **two weeks** prior to the scheduled date of the oral examination to the student's dissertation committee. Ordinarily the examination is concerned primarily with the contents of the dissertation, but it may include more general questions and questions about the original research proposal as well. If two or more committee members believe that the dissertation document is not satisfactory to move on with the oral exam portion, then the Chair of the committee must inform the student – *no later than 48 hrs before the scheduled exam time* – that the dissertation must be revised and that the exam will be postponed. If two or more committee members believe that the revised dissertation is not satisfactory to move on with the oral exam portion, then the student is not in good standing and will be terminated from the program unless the committee opts for a second, final revision. A student who is terminated may qualify for a Terminal Master's,

The examination on the dissertation will be announced and open to the public, including questioning by the public, but the examining committee has discretion to exclude the public during part of the examination for additional questioning of the candidate.

If the dissertation committee decides not to pass the student, they will not be in good standing and terminated from the program. They may qualify for a terminal Master's.

A Winter quarter meeting with the Director of Graduate Studies in the form of a lunchtime question and answer session will further serve you to clarify questions you may have about the process.

H. GRADUATE AFFAIRS ISSUES

During your time in the Ph.D. program, your first point of contact for graduate program procedures or requirements (examples: course work, advisor choice) is the graduate program assistants in the chemistry graduate program office (Tech K145).

If a student has a conflict with their advisor that cannot be solved through a discussion with their advisor, the student may contact the chair of the Graduate Affair Committee (GAC) for assistance.

All conversations with the GAC Chair will be kept confidential to the fullest extent possible. Please familiarize yourself with NU's Mandatory Reporting policy, which is available online via a quick google search.

J. APPEALS AND PETITIONS

Although most doctoral candidates are normally expected to fulfill all of the foregoing requirements, the faculty recognizes that deviations are not only warranted but even desirable in certain individual cases. Students are encouraged to submit petitions requesting a variation in the requirements whenever they believe that they can adequately justify their request. All such petitions should be directed to the Chair of the Graduate Studies. The graduate program assistant should be copied on all communication with Graduate Affairs.

K. FINANCIAL CONSIDERATION

Continuation of financial support is conditional upon satisfactory progress toward the degree. Payment of excess tuition beyond the cost of registration for post-Candidacy Research will not continue past nine quarters of full-term registration.

A student receiving financial support through the Department may not undertake outside jobs or consulting without the prior approval of the Chair of the Department, the Graduate Studies Committee, and the Research Adviser. A student cannot enter into patent agreements without the

University's prior written approval.

It is Department policy to continue the support of all graduate students making satisfactory progress toward the Ph.D. degree for up to 20 quarters (five calendar years). In cases for which additional time for completion of the thesis research is necessitated by the nature of the research project, the student may petition by no later than August 31 of the 5th year to the Chair of the Graduate Affairs Committee for continued support for a period of time not exceeding one year. Such requests will normally be granted if endorsed by the thesis adviser. Additional requests for support beyond the period initially requested will be assessed on a case-by-case basis.

In all cases in which months, quarters, or years are used in stating above deadlines, a summer quarter preceding entry into the regular graduate program in September will not be counted. Thus, a new student who joins the Department in June will be considered to have entered in September.

L. LEAVES OF ABSENCE

The Graduate School defines a leave of absence as a temporary separation from the University for a minimum of one quarter and a maximum of one year. Students who need to interrupt their progress towards degree may petition for a leave of absence. Reasons for a leave are varied and may include medical, family, parental accommodation, and general leaves of absence. For further information on the processes involved in a leave of absence please see the guidelines listed on The Graduate School's website (<https://www.tgs.northwestern.edu/academic-policies-procedures/policies/leaves-of-absence.html>).

To the extent that you are comfortable, we recommend you communicate with your advisor and the Graduate Program Office to coordinate your leave and plan your return to the program.

Consideration of medical leave: If, at any point during your PhD you suffer from a medical illness (physical or mental) that is hindering your ability to maintain sufficient progress towards the degree, we recommend you consider taking a medical leave of absence (MLOA) to address your needs. The decision to apply for MLOA is completely the student's, and the granting of medical leave is determined by the dean of students. Your advisor has no say in the decision and does not need to sign off on any paperwork. Information regarding the application process can be found [here](#).

Prior to the granting of leave: While you are under no obligation to discuss the reasons for your leave with your advisor, we highly recommend that you inform your advisor that you are planning to apply for a medical leave.

Once granted leave: When you are granted a MLOA, your advisor will not be notified by TGS. TGS will not communicate the start date or the potential length of the leave to your advisor, either. To allow your advisor to plan for your absence, we recommend that you share the start date of your leave and potential date of return. We recommend informing your advisor that the return date is dependent upon obtaining clearance to return from the dean of students.

Preparing to return: While on a MLOA, you are under no obligation to conduct any work related to your PhD. In fact, you should not since your focus should be on addressing your medical needs. When the time comes for you to begin planning your return, we highly recommend you communicate with your advisor as early as possible to better enable planning; four weeks prior to planned date of return is a suggested reasonable timeframe.

Upon return: Once you have rejoined the program, you are expected to maintain sufficient research progress towards your PhD. You should work with your advisor to establish mutually agreed upon expectations. If for some reason your medical condition continues to make this challenging, you will need to address this situation appropriately. In such cases, we recommend working with the

chemistry graduate program office to discuss options.

M. CODE OF CONDUCT

Chemistry students, as members of the Northwestern community, are expected to conduct themselves maturely and exemplify behavior consistent with Northwestern's community standards (<https://www.northwestern.edu/student-conduct/index.html>). As a Northwestern student, you are expected to not only excel in the classroom and laboratory, but to engage in socially responsible behavior and to model exceptional conduct, character, and citizenship on campus, online, and beyond. All Chemistry students are subject to University-enacted policies and standards, which are found in the Northwestern University Student Handbook and Office of Student Conduct website. Any violation of these policies, or assisting or encouraging others to violate these community standards, may lead to student conduct action.

Prohibited and restricted conduct includes, but is not limited to:

- Discrimination or harassment by any member of the Northwestern community against any individual on the basis of race, color, religion, national origin, sex, pregnancy, sexual orientation, gender identity, gender expression, parental status, marital status, age, disability, citizenship, veteran status, genetic information or any other classification protected by law
- Endangering self or others, including but not limited to the physical, psychological/emotional well-being of any person
- Interfering with the learning of others, including but not limited to in-person behavior, online behavior or use of University resources or systems to interfere with the work of another student, a faculty member, or a University official, or other interference with the operation of University systems or processes
- Unauthorized entry or unauthorized use of University facilities, services, equipment, account numbers, or files, including using a NetID or account assigned to another user or providing another user with access to your NetID or account
- Misuse of University documents or knowingly furnishing false information to the University
- Theft of, or damage to, University property

See Northwestern University Student Handbook for full description of community standards, as well as prohibited and restricted conduct. A student who violates University community standards may be subject to sanctions, including, but not limited to a period of notice, suspension and dismissal.

N. ACADEMIC INTEGRITY AND USE OF GENERATIVE ARTIFICIAL INTELLIGENCE TECHNOLOGY

All graduate students are expected to adhere to Northwestern University's Academic Integrity guidelines, as well as individual school policies (e.g., WCAS and TGS etc.), as found here: <https://www.northwestern.edu/provost/policies-procedures/academic-integrity/>

Specifically regarding the use of generative artificial intelligence technology, the following sections of the [Academic Integrity: A Basic Guide](#) are reiterated below, and should be considered for all aspects of degree requirements (i.e., course work, qualifying exam and original research proposal documents, and final written thesis).

Cheating: using unauthorized notes, study aids, or information on an examination; altering a graded work after it has been returned, then submitting the work for regrading; allowing another person or resource (including, but not limited to, generative artificial intelligence) to do one's work and submitting that work under one's own name without proper attribution;

submitting identical or similar papers for credit in more than one course without prior permission from the course instructors.

Plagiarism: submitting material that in part or whole is not entirely one's own work without attributing those same portions to their correct source. Plagiarism includes, but is not limited to, the unauthorized use of generative artificial intelligence to create content that is submitted as one's own.

In addition, the Department of Chemistry expects all graduate students to follow additional guidance for the use of generative artificial technology as stipulated by [The American Chemical Society](#). As this relates to degree requirements, the use of generative artificial intelligence technology for writing or image creation is allowed, but the use of these tools should be disclosed to advisors and their use clearly attributed within any documents with appropriate citation.

For some helpful best practices on the use of artificial intelligence tools for scientific writing see, Buriak et al. *ACS Nano* **2023**, *17*, 4091–4093.

I, _____, have read and fully understand the document entitled "REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN CHEMISTRY" that became effective on 1 September 2026 for Northwestern University's Department of Chemistry. I agree to abide by all requirements and other terms set forth in the document.

Signature: _____

Date: _____

Students are responsible for a complete understanding of these guidelines. If you have any questions, please contact either the Graduate Program Assistant or the Director of Graduate Studies.

Please return signed and dated form to the Graduate Program Office