

# REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN CHEMISTRY

**1 September, 2010**

*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.*

## A. PLACEMENT EXAMINATIONS

All entering students must take a set of three Placement Examinations, one each in Organic, Inorganic, and Physical Chemistry. These Placement Examinations cover undergraduate material at a level comparable to that of the corresponding courses offered by Northwestern. A student who does not achieve a suitable score on a Placement Examination will be required to take a specific graduate course in that area. The three courses are Principles of Organic, Inorganic, and Physical Chemistry (Chem. 401, 402, and 403, respectively). If a student is required to take two or fewer Principles Courses, those courses must be completed in the first year. If three Principles Courses are required, one course (not in the student's major field) may, with the agreement of the student's adviser, be deferred to the second year. However, deferral of a course could lead to deferral of admission to the Doctoral Program.

## B. COURSE REQUIREMENTS

Each student must take (for a letter grade and credit, not P/N) nine courses. These nine courses include the three Principles Courses discussed in Section A and six courses that are required to satisfy the specific requirements of a division or a program. These courses should be completed by the end of the spring quarter of the first year, except that, as indicated in Section A above, there is the potential for deferring one course if all three must be taken. A satisfactory score on a Placement Exam will result in a waiver of the associated Principles Course in that area, correspondingly reducing the total number of required courses. (See below for a further discussion of "Waived Courses"). If the number of required courses is reduced to fewer than nine as a result of the waiver of one or more courses, it is expected that the reduced number of courses will be completed by the end of the first year of study.

Each student should choose a major field of study and satisfy the requirements within that major field. The courses listed below for each major field **are in addition** to the three Principles Courses that are required for each of the divisional or program options. It should be noted that 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.

## Major Fields:

### *Divisional Options:*

- Inorganic: **433, 434, 435**, one course from 405, 406, 407, and two additional courses\*.
- Organic: **411**, at least two from **410, 412, 413, 414**, one course from 405, 406, 407, and one (if 410, 412, 413 and 414 are all taken) or two additional courses\*.
- Physical/Analytical: **442-1, 442-2, 443**, one course from 405, 406, 407, and two additional courses\*.

### *Program Options:*

- Environmental: **406** and one course from **411, 433, 442-1**, and two courses from: CivEnv 361-1, CivEnv 361-2, CivEnv 367, Earth 315, CivEnv 448, CivEnv 468 (in odd years), Earth 311, ChemEng 364 (not offered), and ChemEng 410 (not offered); and two additional courses\*.
- Life Processes: Option 1: Fulfill any one of the three divisional requirements (Inorganic, Organic, or Physical/Analytical), and take **405** as part of those requirements, and select two electives from among: Chem 414, Chem 435 (Advanced Inorganic), BioSci 301, BioSci 321, BioSci 361, BioSci 356, IBIS 402, BioSci 323, BioSci 390
- Option 2: **405**, and one from **411, 433, 442-1**; and either BioSci 301 or BioSci 401, and two from Chem 414 (Bioinorganic), BioSci 361 and one additional course\*.
- Solid State & Materials: **407** and one course from **411, 433**, and **442-1**, and two courses from: Chem 435 (X-ray Crystallography only), Chem 415 (Materials Chemistry only), MatSci 341, MatSci 351-1, MatSci 351-2, MatSci 355, MatSci 360, MatSci 361, MatSci 376, MatSci 395, MatSci 405, MatSci 445, MatSci 465, ChemEng 395, ChemEng 361, EECS 385, and Physics 422-3; two additional courses\*.

\* The additional courses are to be chosen in consultation with their adviser.

Bold type indicates courses that are eligible for being waived as described in the next paragraph.

*Waived Courses:* As indicated in Section A, any or all of the three Principles Courses can be waived as a result of performance on the Placement Exams. For each Principles Course that is waived, the number of required courses is reduced by one. In addition, students who are already proficient in the subject matter of a **specific** course (exclusive of the Principles Courses) required for their major field, whether by virtue of having completed a substantially equivalent course at another institution or by independent study, 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 they 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. For a waived course, a student should substitute a Research Seminar (Chem 570-78) taken for a letter grade. Research Seminars, may be taken for letter grade during the first and second year to complete the requirement of nine graded courses, but these grades **do not** count in the student's Departmental GPA.

In addition to any Principles Course(s) waived as a result of performance on the Placement Exams, students entering with a B.S./B.A. are allowed to waive one course as described in the paragraph above to reduce the total number of required courses by one. Note that courses that are eligible to be waived are in **bold** type in the list of courses set forth above. A waiver of an additional course(s) **does not** further reduce the total number of required courses. If more than one course, exclusive of the Principles Courses, is waived, additional eligible Northwestern courses, selected in consultation with the research adviser, must be substituted for any waived courses(s) beyond the first non-Principles Course that is waived.

In addition to any Principles Course(s) waived as a result of performance on the Placement Exams, students entering with a Masters degree from an accredited institution, as recognized by The Graduate School, are allowed to waive up to two required courses. Note that courses that are eligible to be waived are in **bold** type in the list of courses set forth above. A waiver of an additional course(s) does not further reduce the total number of required courses. If more than two courses, exclusive of the Principles Courses, are waived, additional eligible Northwestern courses, selected in consultation with the research adviser, must be substituted for any waived course(s) beyond the second non-Principles Course that is waived.

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 typically follow the Life Science option. The course work they have completed at FSM will be counted as satisfying the elective requirements. Given their advanced standing, MSTP students are allowed to waive up to two additional required courses as described above in the section entitled "Waived Courses."

### C. ADMISSION TO THE DOCTORAL PROGRAM

Although students are expected to enter into graduate work with the expressed intention of earning the doctorate, formal admission to the doctoral program is not granted until the student has adequately demonstrated his/her 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 year of graduate work (e.g., June for students entering in September).

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  $\geq 5.25$  and no more than one grade below B in the courses required by the Chemistry Department,

where A = 8, A- = 7, B<sup>+</sup> = 6, B = 5, B- = 4, C<sup>+</sup> = 3, C = 2, C- = 1, less than C- = 0.

The GPA is determined using this grading system.

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 have met these criteria and have demonstrated suitable competence in research and teaching by the end of their first year will be permitted to 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 probation or terminated from the program. The decision whether to place a student with a GPA  $< 5.25$  on probation or to terminate the student from the program is based on an evaluation presented to the faculty by the research adviser as to the student's competence in research and by an evaluation of teaching competence.

2) If the student has a GPA  $\geq 5.25$  but has more than one grade below B, and is judged to have shown suitable competence in research, he/she will be placed on probation.

3) If the GPA is  $\geq 5.25$  with no more than one grade below B but the research and/or teaching competency criteria have not been met, if the student shows sufficient promise in these areas, the student will be placed on probation to provide an additional opportunity to demonstrate competency. The final decision whether to place the student on probation or terminate him/her from the program is made by a majority vote of the faculty using a secret ballot.

For students placed on probation, the probationary period will continue for approximately two months, during which time the student is expected to spend full time on research and 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 written report of research results by the student and a letter from the research adviser. The report, written in the style of the Qualifying Exam Report (see section H below), 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 and the Graduate Affairs Committee, will be permitted to continue in the program. To remedy teaching incompetence, a student may be required to perform additional teaching duties to correct the deficiency, and consideration of admission to the Ph.D. program may be delayed until competency has been demonstrated.

#### D. 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; 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 to one official adviser, it is possible to do 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, you have no obligation to remain with that 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 seminars, 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 seminars 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 seminars.

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 some merit in scheduling the appointment after the faculty member has made his or her formal presentation, it is not necessary to wait until after the presentation to schedule a meeting with the faculty member. 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.

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 to tell you when group meetings are held and indicate you would like to attend.

4. 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 cannot get by talking with the faculty. If you wish, ask the adviser to introduce you to some of his/her group members.

5. 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. A listing of the most current publications by faculty in our Department is available in the main office. 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.

6. 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 preceptor 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. (Faculty Adviser Preference forms "Form II" are due at noon on Friday, November 12, 2010 at the Graduate Program Assistant's Office. Final decisions for adviser assignments are anticipated within approximately two weeks thereafter.)**

## E. CHANGING AN ADVISER

A student may leave a research group at any time. Likewise, an adviser may use his or her discretion to ask a student to leave the 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. 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 terminated from the program.

## F. 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 each of the following three requirements is met:

- 1) At least three quarters of full-time study are completed.
- 2) The student has been admitted to the Doctoral Program by the faculty (see section C).
- 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 form that would be acceptable for publication in the *Journal of the American Chemical Society* or in a form acceptable for a Ph.D. thesis at Northwestern. The decision as to which form is selected must be made in consultation with the research adviser.

## G. SEMINAR REQUIREMENT

All students must present one divisional seminar on their research in the Chemistry Department at Northwestern. Guidelines for the timing of the seminar may vary in each division. Students in one of the programs may choose the division in which they give their seminar and should notify the Graduate Assistant by the end of the second year of their choice. The Colloquium Series, Basolo Medal Lecture, Hurd Lectures, Industrial Associates Meeting, King Lecture, and Distinguished Summer Lectures are Departmental activities in which student participation is expected while in the doctoral program.

## H. QUALIFYING EXAMINATION AND ADMISSION TO CANDIDACY FOR THE PH.D. DEGREE

After completion of at least five quarters of graduate study and prior to the end of seven quarters of graduate study, each doctoral student must take a qualifying examination administered by a committee appointed by the Chair of Graduate Affairs in consultation with the research advisor. Students entering graduate work with a Master's Degree or with credit for three quarters of graduate study from another institution may take the examination after completing three quarters of study at Northwestern and must take the examination by the end of the seventh quarter of study at Northwestern.

The Qualifying (or Admission to Candidacy) Examination will be devoted primarily to an examination of the student's progress in research along with an examination of general knowledge, particularly in the major field. The exam has both written and oral components. Guidelines for writing the Qualifying Exam paper are included in this manual.

If the Qualifying Examination Committee is not convinced that the candidate has made satisfactory progress, the research adviser will be consulted, and the case will be reviewed by a Departmental Advisory Committee before a final decision is made regarding continuation in the doctoral program. The student may be given about two months to show dramatic improvement in research activities in order to continue in the program. A revised Qualifying Exam paper must be submitted at that time. The Qualification Examination Committee has discretion in each case

to set a second oral exam and/or to require a revised written document.

## I. RESEARCH PROPOSAL

One original Research Proposal, consisting of a written document and an oral defense, is required. This proposal may be in the candidate's general research area. But it must be original and not merely an extension of thesis research.

Every student must have an approved Research Proposal topic anytime AFTER the eighth quarter in residence (e.g., starting in the Fall quarter of the third year for students entering in September) and PRIOR TO the end of the thirteenth quarter in residence (e.g., end of the Fall quarter of the fourth year for students entering in September). The Research Proposal must be satisfactorily defended anytime after the ninth quarter in residence, but prior to the end of the fourteenth quarter in residence (e.g., the end of the Winter quarter of the fourth year). Failure to meet either of these established deadlines will be considered evidence of lack of satisfactory progress toward the Ph.D. degree (see Section O).

## J. REGISTRATION REGULATIONS

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.

### Grading System Regulations\*:

Letter grades are required under the following circumstances:

1. For the first nine courses with numbers below 460 taken as a graduate student at Northwestern and for all core courses.
2. For Research Seminars (570 – 578) 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).

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.

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\* 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 in that concurrent registration for any other course is not permitted.

The minimum period of study for the Doctor of Philosophy degree is eight full-time consecutive quarters including summer.

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.

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. 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.

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.

### K. 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, thesis research begins in the Winter quarter of the first year of graduate study and continues until a satisfactory thesis has been completed.

### L. FINAL ORAL EXAMINATION

The completed dissertation is submitted at least one week prior to the scheduled date of the oral examination to an examining committee appointed by the Dean of the Graduate School. Ordinarily the examination is concerned primarily with the contents of the dissertation, but it may include more general questions as well. The examination on the dissertation will be announced and open to the public, but the examining committee has discretion to exclude the public during part of the examination for additional questioning of the candidate.

### M. 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 support, or whether any support at all is provided, every full-time graduate student is assigned to teach. Inadequate performance of teaching responsibilities shows a lack of progress toward the Ph.D. degree (see Section O).

### N. 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 Affairs Committee.

## O. 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 Affairs Committee, and his/her 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 16 quarters (four 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 4<sup>th</sup> 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.

I, \_\_\_\_\_, have read and fully understand the document entitled "REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN CHEMISTRY" that became effective on 1 September 2010 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 Chair of Graduate Affairs.

Return signed and dated form to the Graduate Program Assistant by September 24, 2010.

## Guidelines for the Qualifying Examinations (QE)

The Qualifying Examination is the means by which students are advanced to candidacy for the Ph.D., and is typically conducted during your second year of study. You must prepare a written summary of your research progress and plans and take an oral examination that covers the summary and general chemistry topics. For students entering with a bachelor's degree, the Qualifying Exam may be taken after five quarters of graduate study and must be completed before the end of the seventh quarter of study. For students entering with a master's degree, the Qualifying Exam may be taken after three quarters of graduate study and must be completed before the end of the sixth quarter of study. Students who wish to take the exam prior to the last quarter in which it can be taken must obtain written approval from their adviser(s). The exam must be completed by the last day of classes of the quarter in which it is taken.

The Graduate Affairs Committee chair will assign committee members based on suggestions from the student's adviser. The forms should be returned by the research advisers to the Graduate Assistant within the first two weeks of the fall quarter for students with Masters degrees and the first two weeks of winter quarter for students with bachelor degrees. After the exam, the Qualifying Exam chair is replaced by the adviser on the student's RP and thesis committees; the other members remain. The Graduate Affairs Committee chair has discretion to have the assignments approved by the advisers before they become official.

Within two weeks after you receive notification of your committee assignment, you must schedule an exam date with your committee members and reserve a meeting room (notify the Graduate Assistant and Departmental Secretary of the date, room, time and title).

The Qualifying (or Admission to Candidacy) Examination will be devoted primarily to an examination of the student's progress in research along with an examination of general knowledge, particularly in the major field. The student must prepare a written summary of the research problem and of the progress on that problem and deliver this summary to the members of the examination committee one week or more prior to the scheduled date of the examination. The text of the summary should be double-spaced, using 12-point type and 1" margins and should not exceed 7 pages. Supplementary material including tables and figures should not exceed 5 pages. The tables, figures, schemes, etc. should be incorporated into the text. The student's research adviser will not be a member of the examining committee and will not be present during the examination, but will be consulted prior to the examination. The examining committee will want to determine whether the candidate is thoroughly acquainted with the relevant literature, is progressing as rapidly as can reasonably be expected on the research problem, is capable of exercising critical judgment, and is likely to produce an acceptable thesis within the next 2-3 years. 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. Students who do not demonstrate satisfactory research aptitude and research progress will be excluded from the doctoral program. Keep a copy of your Qualifying Exam paper.

## WRITTEN RESEARCH SUMMARY FOR QUALIFYING EXAMINATION

The written research summary should be clear, concise and coherent. An acceptable document must be no more than 7 double-spaced typewritten pages of text\*, using 12 pt type and 1" margins, plus no more than 5 pages of figures and tables. Two versions of the document are to be submitted: one in which all of the tables, figures, schemes, and structures are incorporated into the text and one in which the tables, figures, schemes, and structures are at the end, so that the page limitations can be determined. References are not counted in the page limitations. A research summary longer than the above limit will be returned for excessive length; adjust your graphic size to fit the page limitations. The format should be similar to that of a *Journal of the American Chemical Society* paper. The faculty is most interested in whether you understand the importance of the project and in what results you have obtained. Relate your project to the bigger picture of its relevance. The following outline is suggested:

A. Title

B. Abstract

The Title and Abstract should be together on one page or less.

C. Background

A concise summary with literature references of only information necessary for the reader to understand what has already been done in the field and why your project is significant—no more than 2 pages.

D. Objective

State your goals. Include a few sentences showing how the proposed research is related to the literature background. State what ideas are novel in your research.

E. Results

A concise summary of the work completed. The use of tables, figures, prepared schemes, etc., is encouraged. Unsuccessful approaches should be summarized briefly. Successful experiments should be summarized in more detail. Specific experimental details can be presented at the oral examination, unless they are essential to the understanding of the summary, in which case they should be included in the written document.

F. Discussion

The significance of the results should be explained, and plans for the future (i.e., completion of the project) should be outlined.

G. References and Notes

References should be in *JACS* format, except that titles of all references must be included as follows:

Authors, Title, *Journal*, **Year**, *Volume*, pp.(first)-pp.(last).

\*NOTE: Items C through F constitute the 7-page text limitation.

### CITATION ETIQUETTE

Strunk, W. and White, E. B., *The Elements of Style*, 3<sup>rd</sup> edition; Macmillan Publishing Co.: New York, 1979 would be a very helpful reference in writing this document. In addition, here are some examples of correct and incorrect

citations. Assume the following bibliography:

Jones, X. X.; Corey, E. J.

Corey, E. J.; Brown, K. K.

Jones, X. X.; Brown, K. K.; Corey, E. J.

The correct citations of these references in various combinations are as follows:

Jones and Corey<sup>1</sup> showed...

Corey and Brown<sup>2</sup> noted...

Jones et al.<sup>3</sup> found...

Corey and coworkers<sup>1,2</sup> showed...

Corey and coworkers<sup>1-3</sup> found...

Incorrect and impolite citations, favored by those who “pick out the great scientist,” are:

Corey<sup>1</sup> noticed...

Corey<sup>2</sup> found...

Corey<sup>3</sup> showed...

Of course, these problems are avoided by simple, direct statements such as:

Nitroglycerine melts at 355 °C.<sup>1-3</sup>

rather than

In one of the most classic series of scientific papers of the century it has been shown uniquely, beyond any doubt whatsoever and with 100% certainty by Corey<sup>1-3</sup> that nitroglycerine is found to melt at exactly and precisely 355 °C, which is of utmost importance in the history of chemistry.

Other obvious rules of citation etiquette are: 1) Give the correct reference with all of the authors' names included correctly spelled and the journal correctly abbreviated. To do this, you must check the reference yourself, rather than lifting it from some other source. 2) Give the **original** reference. Avoid talking about the “Smith method for the catalytic hydrogenation of alkenes” and then citing a textbook that mentions it or someone else's paper that uses it.

## Guidelines for the Research Proposal (RP)

The research proposal (RP) is another outstanding learning experience for a graduate student. The RP topic is due in the Graduate Program Assistant's office *before* the last day of classes of fall quarter of the fourth year, and the oral defense of the RP must be completed *before* the last day of classes of winter quarter of the fourth year. Deadlines are critical; if your NIH proposal is submitted after the deadline, it goes into the next funding cycle, and you lose 4 months of potential funding. The RP requirement is a great opportunity for you to learn how to write an original research proposal. It also is a *very* important requirement, because anyone in science, whether in academia or industry, must be able to write a concise and coherent research proposal. Furthermore, many students have used their RP for a postdoctoral fellowship application or in a job application.

Before starting to write your proposal, however, you are responsible for checking with your committee members to be sure that the topic you have selected is appropriate and sufficiently unrelated to your thesis research project. It is your responsibility to get each of your committee members to sign the approval form provided or to respond by email. The approval form is due in the Graduate Program Assistant's office by the last day of classes of fall quarter. It is advisable to submit your topic to the committee well in advance in case it is not approved.

Within two weeks after you receive notification for your Research Proposal, you must schedule an exam date with your committee members and reserve a meeting room (notify the Graduate Assistant and the Departmental Secretary of the date, room, time and title).

Prior to writing your RP, you should utilize your knowledge of chemistry to try to identify new areas, if possible. To broaden your knowledge base and arrive at a suitable RP topic, a serious examination of the current literature that is relevant to your field of interest is highly recommended.

As with all proposals, your RP should focus on **at least** one key idea.  
Your RP examination committee is looking for:

- Originality: the RP is your own idea;
- Feasibility: the RP includes testable hypotheses with literature support;
- Innovation based on sound fundamentals: the RP would significantly advance science; and
- Insight of scientific understanding: the RP demonstrates your knowledge of chemistry

Your RP should encompass a research program that is executable by no more than three students over a 3-year period. You should seek guidance from your research adviser as to the scope of the proposal and have it approved by the committee before writing it. **Your committee has the final word on what is an acceptable RP.**

Please consult with your adviser on how to best fit the time required for writing your RP into your regular research schedule.

The examining committee will expect the proposal to be of high quality. If the proposal is significantly deficient in any respect, the committee will require you either to do further work on the proposal originally submitted or, if the proposal is considered to be basically unsound, to develop a new, acceptable proposal. The written proposal must be submitted to the candidate's committee one week or more before the oral examination.

## General Format for the Research Proposal

A. TITLE

B. INTRODUCTION

1. Specific Aims - a paragraph outlining specifically what you hope to accomplish.
2. Background - a *concise* summary with literature references (provide enough background so that the reader is familiar with what is necessary to review the proposal; do not provide an exhaustive literature review of everything related to the topic).
3. Significance - state what ideas are novel in your proposal.

C. METHODS AND DISCUSSION

Discuss how your specific aims will be met. Describe the experimental aspects of the project in sufficient detail to convince the reader that you will be able to accomplish the project proposed. Discuss how your project will augment the studies referred to in the literature background and result in solving some problem proposed. Section headings should be used.

D. REFERENCES AND NOTES

Use the reference format for *J. Am. Chem. Soc.* except with the inclusion of the paper titles as follows: Author; Author; Author, Title. *Journal* **Year**, *Volume*, pp.(first)-pp.(last).

The writing must be clear, concise, and coherent. The text of the written proposal (items B and C above) should be double-spaced, using 12-point type and 1" margins. It should be no longer than 7 pages, excluding references. Supplementary material including tables, schemes, and figures should be no longer than 5 pages. Two versions of the document are to be submitted: one in which all of the tables, figures, schemes, and structures are incorporated into the text and one in which the tables, figures, schemes, and structures are at the end, so that the page limitations can be determined. A document that exceeds the limitations will be returned, so adjust your figure sizes to fit the page limitations.

At the oral exam of the RP, you will be expected to describe the significance and novelty of your proposal and how you will accomplish what you propose. Nothing *additional* beyond what is in the written document should be presented at the oral exam (i.e., no new graphs, data, interpretations, or rationalizations).