The Senior Thesis Guide

The Department of Chemistry
Princeton University

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GUIDELINES FOR SENIOR THESIS WORK

GENERAL BACKGROUND

The promotion of independent thinking is one of the loftiest goals of higher education, and the senior thesis work represents Princeton's common mechanism for approaching this goal. To understand this role you may find it useful to look through the lens of the humanities, where the thesis is expected to demonstrate students' mastery of the art of scholarship, although in the sciences you may seldom hear the task put in these terms. You may also find it helpful to examine the general meaning of the term scholarship, as well as the underlying principles of knowledge that are used in mastering it: know, use, understand, analyze, synthesize, evaluate. These terms reflect a hierarchy of learning, and you are expected to apply all the steps in completing the work of the thesis.

The essence of scholarly research is the creation of new knowledge through careful, systematic study. Thus, your thesis work is expected to make a recognizable and novel contribution to the body of knowledge in your field. Note that this definition transcends all fields, and defines the common element in Princeton theses on topics as diverse as religion and chemistry. The common bond is analysis; you may want to consult a dictionary to get a clear understanding of this crucial term. Analysis is the single most important thing you will do in your thesis work as well as in the writing of the thesis, regardless of whether your novel contribution results from experimental or computational research in chemistry, or, as is more common in the humanities, analysis of existing works.

In chemistry, the thesis is not only the hallmark of your Princeton education and the culmination of untold hours of your effort. It is also a record that is written to document your accomplishments for a *scientific* audience. It is *not* expected to be understood by family and friends. Your efforts to make it so will not be appreciated by the reading committee, who must read all the theses in the department: it takes a lot of time to do a thorough and fair job even when theses are succinct. You should assume the members assigned to read your thesis have an appropriate background to understand your work without your explaining basic principles. Thus, more is definitely not better; extraneous information is neither warranted nor welcome. Although it is a laudable goal to make scientific work understood by a general audience, the thesis is not the place to hone this skill.

All theses must be organized into sections Introduction, Methods, Results, Discussion, and References. If you are unsure what the contents of each section should be, consult your thesis advisor, the senior class advisor, or published papers that you find clarifying. The placement and contents of the Methods section may vary by field; consult your advisor and/or prior theses from your group or in your field for guidance. Before you use a published paper or a thesis as a model for *any* purpose, consult one or more faculty members to be sure it is a *good* model!

ABSTRACT

The abstract should summarize as briefly as possible (never more than one page) the motivation, principal results, and conclusions of the thesis. Abstracts are typically easier to write after completion of the main text.

INTRODUCTION

The introduction to your thesis should be written to enable a professional chemist to understand why and how you carried out the thesis work. As you are writing for chemical professionals, the introduction need not *and should not* start from first principles. The following sub-sections may help you to frame the introduction appropriately.

BACKGROUND AND SIGNIFICANCE

This section should answer the question: **Why** is your work important? *Briefly* sketch the background to your thesis work; critically evaluate relevant existing knowledge; explain the problems and challenges in the field; and identify gaps in our present understanding that can be addressed by the thesis work. Conclude with a statement of what the thesis is about and why you believe it represents an advancement of the field. This exposition is intended to place your work into a broader scientific context, and to provide clear and logical motivation for both the general approach and the specific aims (below) of the thesis. This section may need to occupy as much as 5-6 pages, but not significantly more.

SPECIFIC AIMS

This section serves as a convenient abbreviation to help readers keep everything in order. It is intended to answer, in very specific terms, the question: **What** did you do/attempt to do? No background or other narrative material belongs in this section; it is not meant to stand alone, nor to provide details about the experiments or experimental system, but rather to provide a succinct and specific summary of the attempted and completed research. This section should occupy no more than one page. It could, for example, consist of little more than a well-organized, minimalistic outline describing questions to be answered, hypotheses tested, and experiments conducted. It may be easiest to write this section after writing the rest of the thesis.

EXPERIMENTAL APPROACH

This section of the Introduction should parallel Specific Aims to explain **how** you approached the thesis question, and why. Justify the approaches you chose. *Briefly* describe the experiments or calculations you conducted, and how you analyzed the data and interpreted the results. Indicate how each of your results addresses the gaps in present knowledge outlined in Background and Significance. For any gaps that are not addressed, discuss why. With some variation among fields, this section may be quite short or may need to occupy as much as 3-4 pages, but not more.

Note that most of the Introduction could have been written even before you began your work. Recall that the freshman writing seminars implement the idea of writing as an aid to thinking. Getting an early start on writing your Introduction is one of the best ways to leverage this idea for the work you will carry out.

Beyond the above sections, there are no page restrictions on the thesis. It must be complete, and no one grades theses on thickness.

METHODS

Methods for experiments, computations, and analysis must all be described here. The relevant rule for this section is that it should provide sufficient detail to enable a trained, competent chemist to replicate your work. The key phrase here is trained, competent chemist. Thus, you can simply name methods that are standard in your field, e.g., electrophoresis, and you should *not* describe them, but you must describe in full any novel features and any deviations from the standard. No details about the background of the methods belong here unless you have developed a new method (in which case it becomes a result itself, and must be also described in the Results section, with all the details required to replicate it in Methods). Thus, you need not explain how a method works unless you invented it. *Like the Introduction, much of the Methods might be written very early in your work.*

RESULTS

It can sometimes be difficult to draw a sharp line between results and discussion. A rough guideline is that results include things you observed; discussion includes what you think about them. Sometimes it is cumbersome to separate the two, requiring that you reiterate the results when you discuss them. For this reason some published papers combine the two sections, and you may do so. You may find it useful to read several papers of each type to see how each approach works in order to make the best choice for your case.

Each result *must* be explained in words even if it is shown in a figure. Although common knowledge says that a picture is worth a thousand words, scientific figures do not speak for themselves. You must describe what is shown on each figure almost as if the reader cannot see it, e.g., "Figure X shows that the free energy change for the reaction depends linearly on temperature over the range 298 to 325 K, with a slope of ~ -2 kcal/mol K." Again, find examples in the published literature that do this task well – not all do! Finally, *nothing* that is visible on a figure should be left unexplained in the text.

On the other hand, ironically, most experienced readers of scientific papers study the figures first, and sometimes do not even read the text. As a rule, each figure must be designed to be as self-explanatory and self-contained as possible. This requires clear labeling of all the features, and a clear and complete legend to explain *everything* that is shown. Although it goes without saying that all symbols, labels, etc. must be

distinguishable, legible, etc., you will need to make a final check to ensure that photoreduction or formatting requirements have not compromised clarity.

Control experiments are an essential part of scientific work that is as important as any others. As chemical professionals, graders will think of the controls *they* would have done, and will judge the quality of your conclusions in this context. Whenever control results are critical to your interpretation of an experiment, they must receive the same careful presentation, description, and interpretation as the rest.

Results that are not new need not be described in the same detail as novel ones. For example it may be adequate to simply say in words that certain results replicate those of published work, rather than showing a figure. You needn't characterize compounds that are not new; you can simply report that characteristics X, Y, or Z conform to those already reported. On the other hand, anything you did that is new must be documented completely.

Remember that your thesis is evaluated by graders who are professionals in your field. They will value a professional approach to your work. The thesis is no place to whine about why your experiments didn't succeed or why you did not complete the work.

DISCUSSION

The purpose of the Discussion is to interpret your results and to fit them into the context of previous knowledge. Furthermore, the reading committee will judge the quality of your thesis in part on the soundness of your conclusions and the logic of the arguments you marshal to reach them. Thus you must interpret your data, because results, like figures, do not speak for themselves. What do your data suggest? What are the ambiguities in your data? Are there alternative interpretations? These should be considered explicitly, and argued for or against using logically developed arguments. In other words, if you propose that the data support a given conclusion, you must lead readers through your logic so they can judge for themselves if your reasoning is sound.

The Discussion should also include your re-analysis of the current state of knowledge with respect to your thesis problem, given the results you have presented.

Finally, how would you continue the project if you were staying on beyond graduation? What would be the next steps? This part of the Discussion should reflect your re-analysis.

REFERENCES AND ATTRIBUTIONS

Complete citations, *including complete titles*, of all research articles, book chapters, etc. must be included in the list of references, and each one must be cited in the text at the appropriate place. Use a consistent formatting style for citations in the text; consistency is more important than the choice of style, and the same goes for the reference list.

It can sometimes be difficult for students to understand how to correctly reference statements in the thesis. It is not easy to give all-encompassing guidelines either, but the following may be useful. A statement that is common knowledge within your discipline, or that is self-evident from context, need not be referenced, but a specific fact generally requires a reference. For example, the fact that glucose oxidase oxidizes glucose need not be referenced, but its K_m and V_{max} values should be referenced, citing the original work in which the given values were determined. A useful dividing line might be whether the information is presented in the standard textbooks of the field. In other words, if a thesis grader would probably find the information on his or her bookshelf, it probably does not require a citation. However, graders will not appreciate having to do a search to confirm a fact that you don't reference. This is the one case where more is not necessarily worse; if in doubt it may be better to reference a statement unnecessarily than to omit a needed reference.

Referencing serves several purposes: to indicate information that is already established; to credit those who have established it; to demonstrate scholarship and thereby establish the authority of the cited facts. These points require that the cited source(s) be both authoritative and primary. Scientists have been called professional skeptics; your thesis readers will not accept claims at face value if the citations are substandard. When in doubt you should err toward using the most authoritative source available, generally published works rather than internet sources. Most published works have been vetted by the process of peer review, and experienced readers can often interpret the citation itself to infer the likelihood and quality of such review, and thus the authority of the claim. On the other hand, the provenance of internet sources is generally unknown and sometimes unknowable; exceptions are generally limited to sites maintained by scientific organizations, such as the Protein Data Bank. You should cite the original work that established the facts you cite, rather than a later review, summary, or textbook. High-quality scholarship demands that you have evaluated the quality of the evidence yourself directly in the published sources: you are responsible for knowing what is in the references you cite. Your grade will reflect the quality of your scholarship and not only the quality of your work.

Direct quotations of the words of others are essentially never used in scientific writing, regardless of whether or how they are attributed, placed in quotes, cited, etc. Just don't do it! And of course using the words of others without attribution is plagiarism. Graders easily recognize any deviation from your own characteristic writing voice, and routinely check such passages using efficient string searches. Students sometimes justify borrowing because someone else has said something much better than they could, or they may feel that there is only one way to say it. Neither is necessarily true. By recasting the information in your own words you demonstrate your mastery of it - besides the fact that plagiarism is an actionable offense.

Supporting evidence that comes from unpublished work other than your own must be clearly identified as such, and attributed to a specific person. For example, "The melting point of compound X is 165 °C (unpublished; personal communication from Dr. John Smith, postdoc in the research group of Prof. Jane Doe)."

It must be entirely clear what you did and what others did; anything and everything that was done by anyone other than yourself must be attributed specifically, with name and

details. For example, "The clone of protein X was provided by Dr. John Smith, a postdoc in the research group of Prof. Jane Doe." Ambiguities on this issue will not be regarded favorably by the reading committee. Related to this issue, *do not use the first person plural (*we*) anywhere*. This is *your* thesis; *there is no* we. Although the use of the first person singular is very restricted in the published literature in all fields of science, a thesis is one of the very few exceptions.

APPENDICES

All data and methods essential to replicate your work must be present in the thesis. Some large or unconventional items, or uninteresting but necessary details such as extensive data tables, standard characterization measures, etc. may be included as a supplement to the main text in the form of one or more appendices. Your advisor can suggest which items are appropriate for the appendix vs. the main text.

GENERAL GUIDELINES

It is essential that readers be able to follow the logic of your ideas or arguments. To this end, here are some general principles for scientific writing that you may find useful. These apply throughout the thesis (and for that matter in most everything you write!).

A paragraph should contain *only one* main idea (or claim or argument). The purpose of each paragraph is to present a stepwise development of its central idea. In general, six to eight sentences are the ideal length of a paragraph, the usual number required to develop one main idea and keep the reader's attention. A way to tell if you're on the right track is to write one word or phrase in the margin of each paragraph identifying its central idea. The transition between paragraphs must also be logical, leading the reader through your thought process.

Each of you has taken a freshman writing seminar. The thesis is the ultimate application of what you learned there, and in many ways the writing seminars aim to anticipate the thesis. Thus, you should certainly refer back to the critiques from the professional staff of the writing center for specific guidance about your own expository style. The writing program aims to provide guidance not only about writing but also about scholarship as well. Their course materials may therefore be useful at an early stage in the design of your thesis work, not just for the writing.

One of the hallmarks of high-quality scholarship is accurate and precise - even elegant - use of the language. However, unless you can use the language with absolute correctness, attempts at elegance will appear foolish. There is nothing wrong with a simple but correct style. Educate yourself about the many pitfalls in American usage (lead vs. led; imply vs. infer; the list is long but there are several websites devoted to clarifying common misusages). A well-written and well-argued thesis can command a higher grade than a poorly written one, and can redeem inconclusive results or unsuccessful experiments.

Finally, your thesis advisor has valuable experience with publishing papers, and should also be your most important source for critical input on scientific aspects of your work. Some of your Ph.D. student or postdoc mentors will also have experience with writing published papers, plus detailed knowledge of your work. You should encourage all readers of your drafts to make scientific as well as expository critiques. *Note that this implies you should seek scientific input while you still have time to act on it.* It is advisable to seek such advice outside your own research group as well, to provide perspective that is independent of the pre-existing narrative about your project.

GUIDANCE ABOUT SENIOR THESIS SCHOLARSHIP

Effort guidance is provided separately.

A-range scholarship is characterized by <u>all</u> of the following:

- the Abstract is both concise and thorough, and stands alone as a succinct summary;
- the Background and Significance section of the Introduction convincingly establishes scientific motivation, is thoroughly researched, and masterfully integrates the thesis problem into the context of prior knowledge;
- the Specific Aims section of the Introduction is succinct, specific, and complete;
- the Experimental Approach section of the Introduction convincingly justifies the approaches used;
- the Methods are succinct and complete;
- all Results are described clearly and effectively, depicted accurately with appropriate figures, presented in a logical format, and are journal-quality;
- in the Discussion section, all results are analyzed thoroughly, interpreted soundly and creatively in context of prior knowledge, and the discussion is journal-quality;
- Citations within the body of the text are appropriate, accurate, and *comprehensive*, are uniformly formatted throughout the text, and are all included in an uniform format in the References list;
- overall, the thesis is a masterpiece of impeccable scholarship throughout, and is written in clear, idiomatic, accurate and precise, sophisticated English.

A B-range thesis may in part resemble an A-range thesis, but may exhibit one or more of these minor deficiencies:

- the Abstract is less than concise or thorough, or would require revision to stand alone as a succinct summary;
- the Background and Significance section of the Introduction discusses scientific context and motivation, provides an accurate overview of the thesis problem, and integrates it into the context of prior knowledge;
- the Specific Aims section of the Introduction is complete;
- the Experimental Approach section of the Introduction provides some justification of the approaches used;
- the Methods are complete;
- most Results are described clearly and effectively, and depicted accurately with appropriate figures and presented in a somewhat logical manner;

- in the Discussion section, many of the results are analyzed thoroughly in the context of prior knowledge
- Citations within the body of the text are mostly appropriate and accurate, are uniformly formatted throughout the text, and are included in a uniform format in the References list;
- overall, the thesis displays very good scholarship, and is written in clear, idiomatic, accurate and precise English.

A C-range thesis may in part resemble a B-range thesis, but may exhibit one or more of these significant deficiencies:

- the Abstract includes the major points but does not communicate them effectively;
- the Introduction is sometimes confusing or disorganized;
- the Background and Significance section of the Introduction discusses scientific context and motivation, and provides an accurate overview of the thesis problem; the Specific Aims section of the Introduction is complete but unspecific or verbose;
- the Experimental Approach section of the Introduction provides little justification of the approaches used;
- the Methods are incomplete;
- some Results are not described clearly, nor depicted accurately with appropriate figures, and logical arguments are not developed fully;
- in the Discussion section, some of the results are not analyzed thoroughly or interpreted soundly within the context of prior knowledge
- some of the Citations used may be inappropriate or inaccurate, some sections may not be cited thoroughly, some of the citations may be missing from the References list, and the formatting may not be consistent throughout the document;
- overall, the thesis displays average scholarship, or is written in unclear or cumbersome English.

A D-range thesis may in part resemble a C-range thesis, but may exhibit one or more of these major deficiencies:

- the Abstract misses some major points or communicates the main points poorly;
- the Background and Significance section of the Introduction provides little or no scientific context or motivation nor a useful overview of the thesis problem;
- the Specific Aims section of the Introduction is incomplete, unspecific, or verbose;
- the Experimental Approach section of the Introduction provides inadequate justification of the approaches used;
- the Methods are incomplete;
- many Results are not described clearly, nor depicted accurately with appropriate figures, and logical arguments are difficult to comprehend;
- in the Discussion section, many of the results are not analyzed thoroughly or interpreted soundly in the context of prior knowledge;
- more than a few of the Citations used may be inappropriate or inaccurate, many sections may not be cited thoroughly, some of the citations may be missing from the References list, and the formatting may not be consistent throughout the document;
- overall, the thesis displays poor scholarship, or is written in unclear or cumbersome English;

An F-range thesis exhibits one or more of these fundamental deficiencies:

- the Abstract misses most major points and communicates the points poorly;
- the Introduction is confusing and disorganized;
- the Background and Significance section of the Introduction provides no scientific context or motivation and no overview of the thesis problem;
- the Specific Aims section of the Introduction is missing or incomplete;
- the Experimental Approach section of the Introduction provides no justification of the approaches used;
- the Methods are incomplete;
- most of the Results are not described, figures are missing, and key findings are missing
- in the Discussion section, most of the results are not analyzed at all or placed within the broader context of prior knowledge
- overall, the thesis displays little evidence of scholarship.

GUIDANCE ABOUT SENIOR THESIS EFFORT

Scholarship guidance is provided separately.

An A-range effort is characterized by <u>all</u> of the following:

- the student took both intellectual and practical responsibility for all aspects of his or her project from the beginning;
- the student developed context and approaches for his or her project by uncovering relevant materials well beyond those provided by the advisor or research mentor;
- the student persisted diligently in the face of failures, and suggested thoughtful alternatives once persistence appeared fruitless;
- the student was fully engaged in all the work of the research group, and was an active contributor to all group meetings;
- the student was an excellent group citizen, doing more than his or her share of common duties, and being highly respectful of lab rules and of the space and needs of coworkers.
- the student invested an amount of time, both under direction and under his/her own initiative, to move the project forward at a rate that exceeded expectations mutually agreed between student and advisor

A B-range effort may in part resemble an A-range effort, but may exhibit one or more of these minor deficiencies:

- the student took intellectual and practical responsibility after some delay, or for only some aspects of his or her project;
- the student developed some context or approaches for his or her project, but used mostly sources cited in material provided by the advisor or research mentor;
- the student persisted in the face of failures, but usually sought alternatives from others;
- the student was fully engaged in some of the work of the research group, or was an active contributor in some but not all group meetings;

- the student was a very good group citizen, doing his or her share of common duties, being respectful of lab rules, and being considerate of the space and needs of coworkers.
- the student invested an amount of time adequate to move the project forward at a rate that met expectations mutually agreed between student and advisor

A C-range effort may in part resemble a B-range effort, but may exhibit one or more of these significant deficiencies:

- the student took intellectual or practical responsibility but not both, or took responsibility only late, or for only limited aspects of his or her project;
- the student used only the material provided by the advisor or research mentor and did not go beyond it, or did not develop context or approaches;
- the student persisted in the face of failures, but did not seek alternatives;
- the student was engaged in little of the work of the research group, or was an irregular participant in group meetings;
- the student was an acceptable group citizen but did less than his or her share of common duties, or was sometimes inconsiderate of the space or needs of coworkers or neglectful of lab rules.
- the student invested an amount of time that moved the project forward at a rate that fell somewhat short of the expectations mutually agreed between student and advisor

A D-range effort may in part resemble a C-range effort, but may exhibit one or more of these major deficiencies:

- the student took little or no intellectual or practical responsibility for his or her project;
- the student made little or no use of the material provided by the advisor or research mentor;
- the student did not persist in the face of failures;
- the student was engaged in little or none of the work of the research group, or was an infrequent participant in group meetings;
- the student was a poor group citizen, doing far less than his or her share of common duties or being often inconsiderate of lab rules or of the space or needs of coworkers.
- the student invested an amount of time that moved the project forward at a rate that fell far short of the expectations mutually agreed between student and advisor

An F-range effort exhibits one or more of these fundamental deficiencies:

- the student took little or inconsistent interest in his or her project;
- the student was poorly acquainted with the material provided by the advisor or research mentor;
- the student completed little or no work;
- the student showed little or no evidence of being engaged with the research group;
- the student was an unacceptable group citizen.
- the student invested too little time to move the project forward

FORMAT AND BINDING GUIDELINES

Every senior thesis must meet the formatting and binding requirements indicated below. These guidelines a) permit the Seeley G. Mudd Manuscript Library to archive your document, b) help you produce a professionally formatted thesis, and c) assist our faculty in evaluating the thesis by giving them a clear, clean layout of your work.

COPIES:

You will submit **the following copies of your thesis by 4:30 p.m. on Monday, April 15, 2019.** Your material must be logged in by the Undergraduate Administrator to assure the department that you met the deadline and in order to avoid late penalties.

These copies will include:

1. **a) One electronic copy** – A PDF copy submitted to Thesis Central – Seeley G. Mudd Library, and made available to researchers in accordance with U.S. Copyright Law. Please see http://rbsc.princeton.edu/policies/senior-thesis-submission-information-students for instructions of thesis submission. It is the policy of the University that all researchers have access to senior theses on deposit in Mudd Library. In addition, "fair use," as defined by the federal copyright law, allows for limited copying of senior theses on deposit in Mudd. Under extraordinary circumstances, a student may petition the Dean of the College in writing to restrict access to a thesis for a specified period of time.

   If you have any difficulties converting your thesis to a PDF document, please consult the New Media Center for assistance in order to maintain your formatting, figures, graphs, etc

   b) One hardbound copy – The department's policy for submitting a hardbound copy is currently under review.

You may also want to order extra copies for yourself, your parents, etc.

BINDING - Timing:

Keep in mind that a stitched binding, which is the most durable type of binding, will take approximately three days to complete. Be sure to add enough time to your thesis production plan to account for this process. In general, allow at least forty-eight hours for binding services. It is not uncommon for companies to experience a backup of work.

All required copies of your thesis must be turned in by the due date. Difficulties in scheduling the binding process will NOT justify an extension of the thesis deadline.

Local resources for binding include, but are not limited to, Triangle Repro (150 Nassau Street, Princeton - (609) 924-4630) and Smith-Shattuck Bookbinding (759 State Road, Princeton (609) 497-1445).

FORMATTING[1]:

Cover: Covers must be constructed of a hard, firm material for durability. (Soft covered documents will not be accepted.)

Cover - Lettering:

1. The following information should be printed on the cover of your thesis:
   Thesis title
   Your full name
   Your thesis advisor's name
2. The following should be printed on the spine:
   Your last name
   Your class year

Software: The use of Microsoft Office Word is recommended but not required. Please work with your faculty advisor to determine the most appropriate software for the development of your thesis document.

Spacing: The thesis should be typed, double-spaced on standard size paper with the margins listed below.

Margins: In order to accommodate the binding process, set your margins as follows:

Left	1 ½"
Top	1"
Bottom	1"
Right	1"

Paper: It is recommended that your thesis be printed on acid-free, archival quality bond paper (20 to 24 pound substance), 8 ½ × 11 inches in size, for permanence and durability.

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1) Taken in part, with permission, from the Dissertation/Thesis requirements published by Seely G. Mudd library. (http://www.princeton.edu/~mudd/thesis/MuddDissertationRequirements.pdf)

Printing: Your thesis **must** be printed on only **one side** of the paper.

Font: Fonts must be clear and easy to read, and of 10 point or greater size or 10-12 characters per inch. To determine the characters per inch, put a rule under a line of text and count the average number of characters in an inch. The number may vary if you use right justification or a printer that produces proportional spacing. Serif fonts, such as Times New Roman or Garamond, are preferred, but Sans Serif fonts such as Arial are also acceptable.

The document should use only one style of font. Exceptions are made only for graphs, charts, pictures, or photographs that are imported from programs that do not allow captions and other attached material to be altered.

Widows and Orphans: Avoid "widow" lines (short lines ending a paragraph at the top of a page) and also "orphan" lines which are headings, subheadings or a single line of a paragraph at the bottom of a page as much as possible.

References: Follow the ACS Style Guidelines for listing references and formatting the bibliography. **A copy of the ACS Style Guide is available under E-reserves on the Senior Chemistry Blackboard site.** Your bibliography **must** include titles for all references.

Illustrations - Tables, figures, photos, and images: The term 'illustrations' covers all non-text elements of a thesis, such as line drawings, graphs, maps, photographs, facsimiles of manuscript pages, so forth. Each illustration must be numbered consecutively. Large illustrations are normally placed on separate pages with the identifying illustration number and page number. All illustrations must meet the margin requirements

All material in the thesis must be photo reproducible. Photographs may be included, but must be clear and high contrast. Color graphics may be included, but they must be clear when reproduced in gray scale.

Drawings, Equations and Formulas: Line drawings that are to be used directly in the bound copy of the thesis without photographic, offset, or electrostatic (i.e. Xerox) reproduction must be prepared directly on the same high-quality, long-lived and durable paper described previously and drafted and lettered in black India ink or other non-water-soluble ink. If copies of figures are to be used, they must be prepared and printed in such a way as to meet the same paper and reproduction standards required for the text of the thesis.

All subscripts and superscripts must be large enough to be read. To test for readability, photocopy such a page using a 25% reduction. If the sub- or superscripts are still readable, then the text is probably large enough. No letter or symbol should be less than 2 mm in size. Labels on figures can be lettered using a guide or template. Transfer letters are fragile, and figures or pages of text prepared with transfer lettering cannot themselves be part of the thesis, but must be presented in electrostatically reproduced (photocopied) form.

Printed Sources: Excerpts from other publications or sources, such as manuscript pages, maps, autographs, passages of script, formulas or mathematical symbols - whether text or illustration, letter- size or over-sized, high contrast or continuous tone - can be reproduced in black and white by the various methods developed for other illustrative materials. Items to be included in the thesis should be photographically reproduced or offset or electrostatically printed. Such copies should have high contrast. Copies should be made on the same long-lived and durable paper as required for the text of the thesis.

Pagination: The title page and copyright page should be unpaginated. All pages before the beginning of the body text of the thesis (abstract, table of contents, lists of tables, acknowledgements, etc.) should be paginated with lower case roman numerals, beginning with iii. All pages of the text, including drawings, illustrations, figures, bibliography, appendices, etc. should be numbered in Arabic numbers, beginning with 1 and running consecutively to the end of the manuscript, including Appendices. Numbers should be located in the bottom center or bottom right margin or top right margin, and should be no closer than ½ inch from an edge. Do not use letter suffixes (10a, 10b). ALL PAGES OF TEXT MUST BE NUMBERED.

PREFATORY PAGES:

Page 1 (unnumbered) - Title Page:

TITLE

Your name

Submitted in Partial Fulfillment
of the Requirements of the
Degree of
Bachelor of Arts

To the Department of Chemistry
of
Princeton University

(date)

Page 2 (unnumbered) - Copyright: If you wish to use a copyright statement, please use the following format on Page 2 of your document:

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Page 3 (numbered iii)– Honor Statement:

I hereby declare that I am the sole author of this thesis, and that this thesis represents my own work in accordance with University regulations.

_____
Signature

Note: The submitted electronic copy **MUST** contain a copy of your signature. You can not simply type your name.

Page 4 (numbered iv) - Acknowledgments: - This optional page is for giving credit to those who helped you with your thesis and/or gave you support to do so. The length and people acknowledged are left to your discretion.

Page 5 (numbered v) – Abstract: - No more than one page. Consult the thesis guidelines for content.

Page 6 (numbered beginning with vi) – Table of Contents: - Doubled spaced between entries. Entries longer then one line are singled spaced.

Page 7 (numbered sequentially after Table of Contents with lower case roman numerals) - List of Tables, List of Charts, and List of Figures: - Numbered sequentially after Table of Contents with lower case roman numerals

BODY OF THESIS: - Numbered sequentially in Arabic numerals starting with 1

Bibliography: - Numbered sequentially in Arabic numerals continuing from after the thesis body

Appendices - Each Appendix section is numbered sequentially starting with Appendix 1. Appendix pages are numbered consecutively in Arabic numerals continuing after the bibliography. Consult thesis guidelines for content.

RESPECTFUL AND PRODUCTIVE LEARNING ENVIROINMENT

The Department of Chemistry is committed to providing an open and supportive learning environment that is free from all forms of discrimination, harassment, exploitation, or intimidation. Academic rigor and intellectual exchange of scientific ideas is an integral part of your development as an independent scientist. However, exchanges with members of the department must be done in a respectful manner and an understanding of the diverse background of all members of the Chemistry Department. Dr. L'Esperance, Director of Undergraduate Studies, and Dr. VanderKam, Manager of Diversity Initiatives, are available to meet with any students to discuss any issues relating to interactions with any member of the departmental community.

SENIOR THESIS EVALUATION

The Senior Thesis is evaluated for both ***effort*** and ***scholarship.*** Each thesis is evaluated independently by the thesis advisor and by a thesis reading committee. The thesis advisor evaluates both ***effort*** and ***scholarship*** using separate guidelines attached here. The thesis advisor submits the completed evaluations and a brief note justifying the evaluation to the Director of Undergraduate Studies.

The thesis reading committee evaluates ***scholarship only*** using the same guidelines as the thesis advisor. The reading committee consists of two faculty members from each of the four sub-disciplines, Biological Chemistry, Inorganic and Materials Chemistry, Organic Chemistry, and Physical Chemistry. The two faculty members in each sub-discipline of the committee evaluate all theses in that sub-discipline. Theses that bridge disciplines are read by additional sub-discipline members as necessary. Members of the thesis reading committee submit their evaluations and a brief letter justifying the evaluation to the Director of Undergraduate Studies.

The Director of Undergraduate Studies and the thesis reading committee together review the evaluations and assign grades. The Director of Undergraduate Studies and the reading committee aim to maintain an overall balance of grades across sub-disciplines, as well as compliance with University grading expectations.

*EVALUATION OF SENIOR THESIS **SCHOLARSHIP***

Student: _____ **Advisor**: _____

This evaluation is to be used by ***both*** the research advisor ***and*** the reading committee. It evaluates only the thesis itself, i.e., the contents between the covers. Effort is graded separately, by the research advisor only, using the criteria presented in the document, "*EVALUATION OF SENIOR THESIS **EFFORT***."

Circle the point value corresponding to the appropriate statement that describes the scholarship of the thesis in each category. Evaluation is based on a scale of 5, high, to 1, low.

This thesis should be read by the following sub-disciplines of the reading committee:
(*check all that apply)*

_____ Biological _____ Inorganic _____ Materials _____ Organic _____Physical

Each assessment must be justified a brief note that evaluates merit based on the evaluation criteria rather than on comparison with other students. **Use the back of this form to provide the required justification, or attach a separate letter.**

Abstract

___ **5** Stands alone as a succinct summary; concise, thorough, and journal-quality
___ **4** Less than concise or thorough, or would require revision to be journal-quality or to stand alone as a succinct summary
___ **3** Includes the major points but does not communicate them effectively
___ **2** Misses some major points or communicates points poorly
___ **1** Misses many major points and communicates points poorly

Introduction: Background and Significance

___ **5** Convincingly establishes scientific motivation, is thoroughly researched, and masterfully integrates the thesis problem into the context of prior knowledge
___ **4** Discusses scientific context and motivation, provides an accurate overview of the thesis problem, and connects it to prior knowledge
___ **3** Discusses scientific context, prior knowledge, and motivation, and provides an accurate overview of the thesis problem
___ **2** Provides little or no scientific context or motivation or useful overview of the thesis problem
___ **1** Provides no scientific context or motivation or overview of the thesis problem

Introduction: Specific Aims section

___ **5** Succinct, specific, and complete
___ **4** Complete
___ **3** Complete but unspecific or verbose
___ **2** Complete but unspecific and verbose
___ **1** Incomplete

Introduction: Experimental Approach

___ **5** Convincingly justifies the approaches used
___ **4** Provides some justification of the approaches used
___ **3** Provides little justification of the approaches used
___ **2** Provides inadequate justification of the approaches used
___ **1** Provides no justification of the approaches used

Methods

___ **5** Succinct and complete
___ **4** Complete
___ **3** Partially incomplete
___ **2** Largely incomplete
___ **1** Incomplete

Results

___ **5** All results are described clearly and effectively, depicted accurately with appropriate figures, presented in a logical format, and are journal-quality
___ **4** Most results are described clearly and effectively, and depicted accurately with appropriate figures and presented in a somewhat logical manner
___ **3** Some results are not described clearly, nor depicted accurately with appropriate figures, and logical arguments are not developed fully.
___ **2** Many results are not described clearly, nor depicted accurately with appropriate figures, and logical arguments are difficult to comprehend
___ **1** Many of the results are not described, figures are missing, and key findings are missing

Discussion

___ **5** All results are analyzed thoroughly, interpreted soundly and creatively in context of prior knowledge, and the discussion is journal-quality
___ **4** Many of the results are analyzed thoroughly and interpreted soundly in the context of prior knowledge
___ **3** Some of the results are not analyzed thoroughly or interpreted soundly within the context of prior knowledge
___ **2** Many of the results are not analyzed thoroughly or interpreted soundly in the context of prior knowledge
___ **1** Most of the results are not analyzed at all or placed within the broader context of prior knowledge

Citations

___ **5** The citations within the body of the text are appropriate, accurate, and *comprehensive*, are uniformly formatted throughout the text, and are all included in an uniform format in the References list

___ **4** The citations within the body of the text are mostly appropriate and accurate, are uniformly formatted throughout the text, and are included in a uniform format in the References list

___ **3** Some of the citations used my be inappropriate or inaccurate, some sections may not be cited thoroughly, some of the citations may be missing from the References list, and the formatting may not be consistent throughout the document

___ **2** More than a few used may be inappropriate or inaccurate, many sections may not be cited thoroughly, some of the citations may be missing from the References list, and the formatting may not be consistent throughout the document

___ **1** The citations in the body of the text and recorded in the References list are incomplete and formatted poorly

Overall

___ **5** A masterpiece of impeccable scholarship throughout, written in clear, idiomatic, accurate and precise, sophisticated English

___ **4** Displays very good scholarship and is written in clear, idiomatic, accurate and precise English

___ **3** Displays average scholarship or is written in unclear or cumbersome English

___ **2** Displays poor scholarship or is written in poor English

___ **1** Displays little evidence of scholarship

Recommended *Scholarship* Numerical Grade: _____

Recommended *Scholarship* Letter Grade: _____

A⁺	**A**	**A⁻**	**B⁺**	**B**	**B⁻**	**C⁺**	**C**	**C⁻**	**D**	**F**
≥98	**≥93**	**≥88**	**≥84**	**≥81**	**≥78**	**≥73**	**≥68**	**≥63**	**≥55**	**<55**

Evaluation completed by _____

*EVALUATION OF SENIOR THESIS **EFFORT** – FACULTY ADVISOR*

Student: _____ **Advisor**: _____

This evaluation is to be used by the ***research advisor only***. Scholarship is evaluated separately, by the research advisor as well as (independently) by the reading committee, using the criteria presented in the document, "*EVALUATION OF SENIOR THESIS **SCHOLARSHIP***."

Circle the point value corresponding to appropriate statement that describes the student's thesis effort in each category. Evaluation is based on a scale of 5, high, to 1, low.

Each assessment must be justified in a brief note that evaluates merit based on the evaluation criteria rather than on comparison with other students. **Use the back of this form to provide the required justification, or attach a separate letter.**

Project ownership

___ **5** The student took both intellectual and practical responsibility for all aspects of his or her project from the beginning

___ **4** The student took intellectual and practical responsibility for most aspects of his or her project and/or with some delay

___ **3** The student took consistent intellectual or practical responsibility but not both, or took responsibility only late, or for only limited aspects of his or her project

___ **2** The student took limited and/or inconsistent intellectual or practical responsibility for his or her project

___ **1** The student took little or no responsibility for his or her project

Source materials

___ **5** The student developed context and approaches for his or her project by uncovering relevant materials well beyond those provided by the advisor or research mentor

___ **4** The student developed context or approaches for his or her project using mainly sources cited in material provided by the advisor or research mentor

___ **3** The student used the material provided by the advisor or research mentor without going beyond it, or did not develop context or approaches

___ **2** The student made little or no use of the material provided by the advisor or research mentor

___ **1** The student was poorly acquainted with the material provided by the advisor or research mentor

Persistence

___ **5** The student persisted diligently in the face of failures, and suggested thoughtful alternatives once persistence appeared fruitless

___ **4** The student persisted in the face of failures, mostly seeking alternatives from others

___ **3** The student persisted in the face of failures, but seldom sought alternatives

___ **2** The student did not persist in the face of failures

___ **1** The student did not persist irrespective of success or failure

Group engagement

___ **5** The student was fully engaged intellectually in all the work of the research group, and was an active contributor to all group meetings

___ **4** The student was engaged intellectually in much of the work of the research group and/or was an active contributor in many group meetings

___ **3** The student was engaged in little of the work of the research group, or was an irregular participant in group meetings

___ **2** The student was engaged in little or none of the work of the research group, or was an infrequent participant in group meetings

___ **1** The student showed little or no evidence of being engaged with the research group

Group citizenship

___ **5** The student was an excellent group citizen, doing more than his or her share of common duties, and being highly respectful of lab rules and of the space and needs of coworkers

___ **4** The student was a very good group citizen, doing his or her share of common duties, being generally respectful of lab rules and considerate of the space and needs of coworkers

___ **3** The student was an acceptable group citizen but did less than his or her share of common duties, or was sometimes inconsiderate of the space or needs of coworkers or neglectful of lab rules

___ **2** The student was a poor group citizen, doing far less than his or her share of common duties or being often inconsiderate of lab rules or of the space or needs of coworkers

___ **1** The student was an unacceptable group citizen

Commitment

___ **5** The student invested an amount of time, both under direction and under his/her own initiative, to move the project forward at a rate that exceeded expectations mutually agreed between student and advisor

___ **4** The student invested an amount of time adequate to move the project forward at a rate that met expectations mutually agreed between student and advisor

___ **3** The student invested an amount of time that moved the project forward at a rate that fell somewhat short of the expectations mutually agreed between student and advisor

___ **2** The student invested an amount of time that moved the project forward at a rate that fell far short of the expectations mutually agreed between student and advisor

___ **1** The student invested too little time to move the project forward

Recommended *Effort* Numerical Grade: _____

Recommended *Effort* Letter Grade: _____

A^+	A	A^-	B^+	B	B^-	C^+	C	C^-	D	F
≥98	≥93	≥88	≥84	≥81	≥78	≥73	≥68	≥63	≥55	<55

SENIOR THESIS MID-YEAR PROGRESS REPORT

Student: _____ **Advisor**: _____

To assist us in planning for evaluating this Senior Thesis, this thesis should be read by the following sub-disciplines of the reading committee: (*check all that apply)*

_____ Biological _____ Inorganic _____ Materials _____ Organic _____Physical

Evaluate your student's Senior Thesis progress based on the criteria listed in the "EVALUATION OF SENIOR THESIS EFFORT" document.

Circle the point value corresponding to appropriate statement that describes the student's thesis effort in each category.

Project ownership

5 The student shows both intellectual and practical responsibility for all aspects of his or her project
4 The student shows intellectual and practical responsibility for most aspects of his or her project and/or with some delay
3 The student shows consistent intellectual or practical responsibility but not both, or takes responsibility only late, or for only limited aspects of his or her project
2 The student shows limited and/or inconsistent intellectual or practical responsibility for his or her project
1 The student shows little or no responsibility for his or her project

Source materials

5 The student develops context and approaches for his or her project by uncovering relevant materials well beyond those provided by the advisor or research mentor
4 The student develops context or approaches for his or her project using mainly sources cited in material provided by the advisor or research mentor
3 The student uses the material provided by the advisor or research mentor without going beyond it, or does not develop context or approaches
2 The student makes little or no use of the material provided by the advisor or research mentor
1 The student is poorly acquainted with the material provided by the advisor or research mentor

Persistence

5 The student is diligent in the face of failures, and suggests thoughtful alternatives once persistence appeared fruitless
4 The student is persistent in the face of failures, mostly seeking alternatives from others
3 The student is persistent in the face of failures, but seldom sought alternatives
2 The student is not persist in the face of failures
1 The student is not persist irrespective of success or failure

Group engagement

5 The student is fully engaged intellectually in all the work of the research group, and is an active contributor to all group meetings
4 The student is engaged intellectually in much of the work of the research group and/or is an active contributor in many group meetings
3 The student is engaged in little of the work of the research group, or is an irregular participant in group meetings
2 The student is engaged in little or none of the work of the research group, or is an infrequent participant in group meetings
1 The student shows little or no evidence of being engaged with the research group

Group citizenship

5 The student is an excellent group citizen, does more than his or her share of common duties, and being highly respectful of lab rules and of the space and needs of coworkers
4 The student is a very good group citizen, does his or her share of common duties, being generally respectful of lab rules and considerate of the space and needs of coworkers
3 The student is an acceptable group citizen but does less than his or her share of common duties, or is sometimes inconsiderate of the space or needs of coworkers or neglectful of lab rules
2 The student is a poor group citizen, does far less than his or her share of common duties or being often inconsiderate of lab rules or of the space or needs of coworkers
1 The student is an unacceptable group citizen

Commitment

5 The student invests an amount of time, both under direction and under his/her own initiative, to move the project forward at a rate that exceeds expectations mutually agreed between student and advisor
4 The student invests an amount of time adequate to move the project forward at a rate that meets expectations mutually agreed between student and advisor
3 The student invests an amount of time that moves the project forward at a rate that falls somewhat short of the expectations mutually agreed between student and advisor
2 The student invests an amount of time that moves the project forward at a rate that falls far short of the expectations mutually agreed between student and advisor
1 The student invests too little time to move the project forward

I have met with my advisor and discussed the contents of this progress report. I understand his/her comments and recommendations, and the expectations required to move this project forward.

Student's Signature_____ **Date** _____

SENIOR THESIS MID-YEAR PROGRESS REPORT
ADVISOR COMMENTS

Student: _____

Please provide Dr. Robert L'Esperance, DUGS, with comments about this student thesis progress to date.

Advisor's Signature_____ **Date** _____

SENIOR THESIS MID-YEAR PROGRESS REPORT
STUDENTS COMMENTS

Advisor: _____

Please provide Dr. Robert L'Esperance, DUGS, with comments about your experiences with your thesis project and your lab work environment.

Student's Signature_____ **Date** _____