

PROGRAM PLANS

Updated: July 29, 2020

Program: Analytical Chemistry

Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Thesis
2 - Ideas that generate enthusiasm	Prelim exam report, fellowship submission (e.g. NSF GFRP) or a proposal from a course	Independent project
3 - Communication in an interdisciplinary world	Courses, seminar report and literature seminar	Research seminar and independent proposal

Details:

Coursework (Competency #3): At least ten credits of coursework is required with at least three credits from an area outside analytical chemistry. Eight credits of analytical coursework is required with at least three of the analytical credits from the 530 modules AND three credits from CHEM 532.

At least five credits from the following list are required; at least three credits must be from 530 modules.

Course #	Title	Credits	Semesters Offered
CHEM 530A	Environmental Chemical Analysis	1	Varying Fall
CHEM 530B	Absorption and Emission Spectroscopy	1	Varying Fall
CHEM 530C	Bioanalytical Chemistry	1	Varying Fall
CHEM 530D	Statistical Analysis in Analytical Chemistry	1	Varying Fall
CHEM 530E	Mass Spectrometry	1	Varying Fall
CHEM 530F	Analysis of Materials	1	Varying Fall
CHEM 533	Chemical Separations	3	Varies
CHEM 537	Electrochemical Methods	3	Spring

Three credits of Advanced Chemical Analysis II are required in the 1st year.

CHEM 532	Advanced Chemical Analysis II	3	Spring
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The course will cover fundamentals of quantitative analysis and analytical instrumental analysis, and may include laboratory components. Course topics include, but are not limited to:

- Equilibrium
- Chromatography
- Spectroscopy
- Mass Spectrometry

Students will be encouraged to link topics and projects to the scientific literature.

Seminar Report (Competency #3): Analytical students will be required to pass one seminar report in their first year to remain in good standing. The report should demonstrate mastery of foundational analytical knowledge relevant to the specific seminar topics. The "report" format may be an oral exam, take-home exam, paper, or alternative mechanism with form and rubric to be defined the seminar host. Two weeks prior to the seminar, students will be notified about the seminar report and have the opportunity to sign up. Participating students will be contacted with time/date for a pre-seminar meeting, the specific report format and deadlines, and any pre-seminar requirements (e.g. literature to be read prior to pre-seminar meeting). The reports will be assessed by the host faculty member(s).

Seminar Presentations (Competency #3): Two seminar presentations are required, one before and one after candidacy. Assessment will be provided by faculty present at each seminar.

1. Critical evaluation of the literature – 3rd semester in residence

Literature Seminar Objectives:

- Examine a student's foundational knowledge in one particular topic in analytical chemistry
- Build a student's critical thinking skills and skills in assessing the current literature
- Build a student's oral communication skills

Detailed Expectations:

Currently, three curricular components exist to prepare students for their preliminary oral exam: courses, cumulative exams, and the literature seminar. Of these, the literature seminar is the only component that requires all of the students to convey their knowledge and critical thinking skills in an oral format – a key requirement for success in the preliminary exam. As such, the literature seminar should provide a structured environment for students to practice these skills, receive thoughtful feedback, and reinforce the level of expectation (i.e., both skills and knowledge) that is required for success in the preliminary oral exam. In essence, **the literature seminar bridges the coursework to research efforts of the students. Because of this, the seminar should cover the background material related to the student's research activities (broadly defined).** To accomplish these goals, a set of expectations and guidelines for the literature seminar in analytical chemistry is described below.

A student will choose literature related to their research and present a seminar that covers this background information. The topic selection is the choice of the student and must be approved by student's faculty advisor at least 8 weeks prior to the seminar date. The literature background should be comprehensive. This means that primary and secondary literature from other groups must be included, and students should not use papers solely from their research group or the research group of their mentor's graduate advisor. Although review papers can/should be included, they cannot be the bulk of the information for the presentation. Students are also advised to review both past and current literature (at least one paper within the last 1.5 years) in their field. The student should have foundational knowledge in their chosen area, select appropriate papers, and be able to apply their foundational knowledge in their evaluation of the background literature of their research. As such, the assessment criteria are focused on 1) evaluating the student's knowledge of the topic based on the literature and 2) using this knowledge to assemble a coherent theme related to the topic.

The student will demonstrate their critical thinking skills through effective organization of the presentation that enhances the major points the student is trying to make, evaluations of the science, and assessment of the data and results. This assessment should include a discussion of the arguments presented in the literature, whether or not (or how) the data presented confirm/reinforce the arguments, and open questions that require further explanation. Further, the presentation should provide explanation of methods and place techniques/methods in the context of solving scientific problems related to the student's research project.

As with all seminars, the student should spend significant amounts of time and energy preparing for their literature seminar including the abstract, the presentation itself (slides and talking) and the Q&A session. Students should consult with their advisor on the balance of time spent on the literature seminar versus other research commitments, classes and teaching responsibilities.

1. The first form of public dissemination is usually an abstract. As such, students are required to submit an abstract at least one week prior to their seminar.
2. The presentation itself should reflect professionalism and demonstrate knowledge. Two ways of evaluating this is via assessment of the slides used (i.e., well-constructed and organized) and the student's verbal presentation. A successful presentation will only be realized, however, if the student can effectively communicate their knowledge orally.
3. The Q&A session allows students the opportunity to clarify mis-understandings from the audience and further demonstrate their knowledge of their research. Thus, it is important for students to understand the basic analytical principles as applied to their topic, the literature background to their own research, and the connections between their topic and broader research questions in analytical chemistry.

Taken together, the student should *prepare* their talk accordingly (evaluating the literature and assembling the information to convey their ideas appropriately) and in return, *be prepared* to *receive* constructive criticism regarding their literature seminar. This constructive criticism may come in three forms: discussion between the faculty and student after the presentation, a written composite evaluation of the student's performance based on the grading rubric agreed upon by the faculty, and peer feedback.

Taken together and with appropriate feedback, this activity will serve to continue to fully engage students in their research while at the same time teach them how to effectively evaluate the literature, give a professional presentation, and build the critical thinking skills needed in pursuit of an advanced degree in chemistry.

Logistics and Timelines:

- The seminar topic, approved by the advisor, and representative primary literature paper should be sent to Justin Sambur (justin.sambur@colostate.edu) **no less than eight weeks** ahead of time to receive additional feedback from the faculty.
- A title and abstract must be submitted to Elizabeth McCoy (elizabeth.mccoy@colostate.edu) **no less than one week** ahead of the assigned seminar date. Abstracts must be formatted according to the provided template.
- The presentation should be 20 minutes. A 10 minute Q&A session will follow.
- Switching computers between presentations can be a lengthy and distracting process. As a result, we require that the two students share a computer for their presentations. There are two ways that this can be accomplished: 1) Use a personal computer that belongs to one of the students or 2) Contact the seminar coordinator ahead of time (no less than two days before) to arrange a computer. Students can use a variety of file formats but should be aware that animations are difficult to transition between computers. If students elect to use a personal computer, they should work together ahead of time to make sure files are compatible.
- In person feedback from the collective faculty will occur immediately after the seminar. Written feedback will be provided after the seminar.
- To be transparent to all students, a faculty/student open discussion will be held in August to give students the opportunity to discuss aspects of last year seminars in order to aid in their understanding of how faculty are evaluating the seminars. Students are encouraged to talk with their faculty advisors and other faculty regarding their views of other student seminars. This will give students the opportunity to learn from the faculty themselves how they perceived the seminar.
- If the literature seminar is not at a passable level, the student will receive detailed feedback for their next seminar. The student will receive an incomplete grade for the literature seminar credit, and the seminar will subsequently be scheduled the following semester.

Suggestions from peers:

- Here is an example of a timeline. The times are approximate and will depend on your topic.
 - ~4 minute introduction about the topic which usually contains an attention grabbing device and clear identification of a prevailing problem in the field.
 - ~13 minutes giving the status of the field – what others have done to address the problem and the resulting successes and failures
 - ~3 minutes next steps/wrap-up/missing gaps
- Here is an example preparation timeline based on suggestions from your peers:
 - 3 months – begin looking for a topic and searching the literature
 - 2 months – narrow topic and focus, send representative paper; continue searching the literature and evaluating appropriate papers
 - 1 month – first practice talk
 - Seminar

We emphasize that this preparation time for the literature seminar does not substitute for time spent on research, classes or TA activities, and should be allocated on consultation with the research advisor.

Comments:

- **Critically evaluating the literature** does not mean “tearing apart someone’s work”. It means finding the significance in the work, which includes understanding the methods, the data, and how the methods and data together provide new or valuable information. It also means integrating across multiple studies to find common themes, challenges and ideas.
- **Comprehensive evaluation of the literature** means including primary and secondary literature as well as having a historical perspective of the field. What has been done in the past? How does this inform the present? What is still missing? What approaches can be used to solve these problems? This does not mean that you will be presenting every paper that you evaluate/find, or even summarizing every paper - but rather that you assemble the ideas into a coherent presentation that does not require the audience to read the papers to understand what you have presented. This may include reanalyzing data, creating new figures, and/or placing multiple studies in a broader context.
- **Foundational analytical knowledge** includes understanding all techniques, data or figures presented in the seminar at the Harris and Skoog level. This knowledge may be conveyed to the audience in either the formal presentation or the Q&A session.

Research Seminar (Competency #3): After the preliminary exam, but no later than the 8th semester in residence, the student will present a 30 minute presentation of their own graduate research, followed by up to 10 minutes of Q&A. This presentation should include background information for an analytical chemistry audience and a broader perspective of how the research contributes to the overall field. Some indication of work in progress and future work should also be included. The research seminar should coincide with a meeting of the students’ graduate committee to assess progress. All committee members should be invited to attend the research seminar and the meeting should take place immediately following the seminar or within 1 week afterwards. Private meetings may be held with committee members not able to attend the seminar prior to the committee meeting.

Original Concept: (Competency #2): Each student is required to develop some type of original concept based on the field of chemistry after the completion of their candidacy exam and no later than the eighth semester in residence. This concept should be developed in close cooperation with the students’ advisor, graduate committee, and reader. In most cases, this will result in a written document that will be presented to the committee and evaluated by the reader. There is considerable flexibility in the fulfillment of this requirement. For example, students may choose to fulfill this assignment based on their future career goals. Indeed, students may view this assignment as a way to assist them in the later stages of their graduate careers as they formulate their future plans. For example, students who plan to pursue postdoctoral research or academic positions will be required to develop an original research proposal as part of the job application process. Likewise, external funding agencies, such as NSF and NIH, offer postdoctoral fellowships, and students applying for these fellowships must prepare detailed research proposals. Developing such proposals along with the students’ committee would be an excellent way to fulfill this assignment. Students who plan to pursue careers in industry, as well as those contemplating entrepreneurial activity, may be better served by developing a business plan document or a patent application. Other concepts suitable for students contemplating careers in education, business, law, or health care may also be considered. The formatting of this assignment is flexible and depends on the specific purpose for which the assignment is being pursued. For example, an NIH postdoc proposal will have a specific format; whereas, a business plan or patent application will have very different formats. Students should use the appropriate format when submitting this assignment.

Submission and Evaluation:

Students must register for CHEM 702 (Independent Research Proposal) the semester they plan on completing the requirement. A 1-page preliminary outline describing the original idea must be submitted to the thesis advisor and reader for approval. The GOC assigns the proposal reader from the student’s thesis committee members. The student

will submit their report to Kathy Lucas (Kathy.Lucas@colostate.edu) in the main office, who will forward the report and proposal rating forms to the reader.

The reader will complete a proposal rating sheet, including a pass/fail grade, turn it in to the main office, and provide a copy to the student. The student must return the completed proposal rating sheet to Kathy Lucas. This evaluation, along with a copy of the proposal, will become part of the student's permanent file.

Program: Chemical Biology

Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Thesis
2 - Ideas that generate enthusiasm	Prelim exam report	Independent proposal, thesis
3 - Communication in an interdisciplinary world	Courses and literature exam	Independent proposal seminar

Details:

Coursework (Competency #3): Students must take at least ten credits. In addition, CHEM 521 and 522 are required plus at least two additional credits from a biologically-focused course (either in Chemistry or another department). Each student must also take at least two 'out-of-area' credits that are further afield.

Required courses:

Course #	Title	Credits	Semesters Offered
CHEM 521	Principles of Chemical Biology	3	Fall
CHEM 522	Methods in Chemical Biology	2	Spring

Possible options for additional Chem Bio credits include, but are not limited to:

BC 563	Molecular Genetics	4	Fall
BC 565	Cell Biology	4	Spring
CBE 570	Biomolecular Engineering/Synthetic Biology	3	Spring

Literature Exam (Competency #3): Students will take an oral examination based on two recent articles from the Chemical Biology literature (typified by papers in *ACS Chemical Biology* or *Nature Chemical Biology*) that are provided two weeks in advance. All students will be examined on the same day, at the end of the first year in residence (usually in May or June), by a committee of three Chemical Biology faculty members (the committee will also select the papers to be used).

Exam Details:

1. Each student will be examined for a period of 30 minutes. The committee will agree in advance on an ordered list of questions to be asked of all students (some students may get further through the list).
2. Exam questions will test understanding of the topics, experimental design, data analysis and conclusions from the work described in the papers, with the fundamental knowledge from CHEM 521/522 as a foundation.
3. After examining all students, the faculty committee will determine which students have passed and failed. It is expected that only students with significant and repeated deficiencies will fail.
4. Any student that not does pass will have one opportunity to retake the exam, which must be done before the beginning of the subsequent fall semester. Students failing the exam for the second time will be dismissed from the program.

Independent Proposal (Competency #2): After advancing to candidacy, and before the end of the eighth semester in residence, students must submit an original research proposal. The idea must be sufficiently distinct from a student's doctoral work to be considered original by both the research advisor and a designated reader (a member of the thesis committee). The written proposal should be at the level of postdoctoral fellowship proposals to Federal agencies. It should include the following sections (note page limitations):

- a) Abstract/Specific Aims (one page) – Concisely state the problem to be addressed and the specific major milestones your work seeks to achieve.
- b) Background and Significance (1-2 pages) – Briefly identify critical background information that establishes the general nature of the problem to be addressed, and identifies the specific objective of the proposed work. Describe why the problem is worthy of further study.
- c) Research Design and Methods (5-10 pages, including figures) – Describe the specific experiments and techniques that will be used to accomplish the Specific Aims. Descriptions of work to be performed should focus on experimental designs and objectives rather than technical detail. Potential pitfalls should be identified, and appropriate alternatives suggested.
- d) Literature Cited (no page limitation) – List all pertinent references, including complete titles. The bibliography need not be exhaustive, but should be sufficient to persuade an expert reader that you have consulted all relevant sources.

To begin, each student will submit the Abstract/Specific Aims page to his/her research advisor and proposal reader. Once this initial material is approved by both parties, the student should schedule an oral presentation on the proposal (see below). The final written proposal should be submitted after the oral presentation, and should incorporate any feedback gathered at that time. It is due before the end of the eighth semester in residence.

Seminar Presentation (Competency #3): After the abstract/specific aims page describing a student's original research proposal (see above) has been approved, the student will schedule a date to present a 30 minute seminar describing the idea. The seminar should briefly discuss the background in the field, and then proceed to clearly highlight both the existing problem to be solved, and the specific approach that will be used to solve it. Alternative competing methods should also be referenced, and context should be provided for how the proposed work will fit in to existing approaches. The seminar will be judged on a pass/fail basis by any faculty members in attendance.

Program: Inorganic Chemistry

Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Thesis
2 - Ideas that generate enthusiasm	Prelim exam report	Independent proposal
3 - Communication in an interdisciplinary world	Courses, seminar/research reports and literature/research seminar	Independent proposal and seminar

Details:

Coursework (Competency #3): At least ten credits are required with at least three credits from an area outside inorganic chemistry.

Three credits from the four one-credit modules of CHEM 563 Physical Methods in Inorganic Chemistry:

Course #	Title	Credits	Semesters Offered
CHEM 563A	Group Theory	1	Fall
CHEM 563B	Vibrational Spectroscopy	1	Spring
CHEM 563C	Electronic Structure and Magnetism	1	Spring
CHEM 563D	Magnetic Spectroscopies	1	Spring

Plus three credits from the following:

CHEM 511	Solid State Chemistry	3	Odd Fall
CHEM 551	Catalytic Chemistry	3	Odd Spring
CHEM 560	Fundamentals of Inorganic Synthesis	1	Fall
CHEM 561	Inorganic Synthesis	2	Fall
CHEM 565	Inorganic Mechanisms	3	Varies
CHEM 566	Bioinorganic Chemistry	3	Even Spring
CHEM 569	Chemical Crystallography	3	Odd Spring

Seminar Reports (Competency #3): Students will (1) complete a research paper due at the end of their first summer in residence, and (2) will participate in the inorganic seminar program.

1. Format. The research report must be submitted to the inorganic program head and the Graduate Coordinator by the 1st Friday of the 3rd semester. The report should focus on the graduate student's research, with the relevant background and progress presented in the general format of a journal article, with: (1) an abstract; (2) an introduction that provides journal-appropriate background literature material and concisely describes the rationale for the project; (3) a full experimental section; (4) a results and discussion section; and (5) conclusions and outlook, which should include plans for future research. A review process similar to how manuscripts are vetted for publication is used. The program head serves as editor; other inorganic professors (not a student's advisor) will act as reviewers. The original submission will be read by a faculty reviewer, and the editor will go through the reviewer's comments with the student. For the report with minor revisions requested, the revised report is due in two weeks, while the report with major revisions requested is due in one month. Subsequent revision(s) will be sent back to the reviewer, and the editor will use the reviewer's comments to decide if the final report passes or fails, no later than the end of the 3rd semester.

2. Discussions and reports. All inorganic students will register for inorganic seminar during the first four semesters in residence, and for any semester in which they will give a presentation. Starting in the spring, students must turn in at least one satisfactory seminar report per semester until four are passed. This requirement must be completed before the end of the 4th semester in residence. Students may pass more than one report per semester. The reports will be assessed by the host faculty member(s). The seminar report will include:
 - A pre-seminar overview that summarizes papers relevant to an outside speaker's topic (due one week before that particular seminar).
 - A pre-seminar discussion, led by the students writing reports and attended by the host as well as other graduate students and faculty. These discussions will cover papers suggested by the seminar speaker.
 - A post-seminar report that outlines the presentation and places the work in a more general context. The report must be submitted to the host within one week of the seminar.

Students who do not fulfill this requirement will get an incomplete grade for the semester, which will revert to an F after one year, according to University policy. Up to two of these reports may be substituted by passing an equivalent number of written exams offered by other divisions/programs.

Seminar Presentations (Competency #3): Two seminar presentations are required, one before and one after candidacy. Assessment will be provided by faculty present at the seminar.

Research Proposal (Competency #2): Each student is required to propose an original research idea in the field of chemistry after the completion of the candidacy exam and no later than the eighth semester in residence. The proposal should not be a trivial extension or modification of an existing research project. Proposals may be in the general area of a student's doctoral research, but must be sufficiently distinct to be considered original by the advisor and primary reader.

Students who have submitted a postdoctoral fellowship application (e.g. to NIH, NSF, etc.) may fulfill the proposal requirement by submitting a copy of that application. All other students should follow the format below.

General Guidelines:

1. Provide sufficient background information to permit review without extensive consultation of the literature.
2. Emphasize brevity and clarity of presentation.
3. Prepare publication-quality figures and schemes.
4. Take care to avoid spelling and other grammatical errors.

Specific Guidelines:

1. Length
 - a. The abstract (section a) is not to exceed 1 page single-spaced.
 - b. The body of the proposal (sections b and c) should be a minimum of 5 pages and a maximum of 10 pages, including figures.
 - c. There is no restriction on the length of the literature cited (section d) section. The text must all be in 10-12 point font.
2. Format
 - a. Abstract/Specific Aims. Concisely state the broad overall nature of your proposal. State the hypotheses to be tested and the aims of the research idea.

- b. Background and Significance. Provide a brief sketch of the background leading to your idea. Critically evaluate and summarize existing knowledge and specifically identify the problem that your proposed research will solve. State concisely the importance of your proposal.
- c. Research Design and Methods. Describe the research design and the procedures that will be used to accomplish the specific aims. Include how the data will be collected, analyzed, and interpreted. Describe any new methodology and its advantage over existing methodologies. Discuss the potential limitations of the proposed procedures and alternative approaches to achieve the aims.
- d. Literature Cited. List all pertinent references. Each reference must include the complete title of the paper or article, names of all authors, book or journal, volume number, page numbers, and year of publication. Do not include an excessive amount of text in your references. This section should be limited to relevant and current literature.

Submission and Evaluation:

Students must register for CHEM 702 (Independent Research Proposal) the semester they plan on completing the requirement. A 1-page preliminary outline describing the original idea must be submitted to the thesis advisor and reader for approval. The GOC assigns the proposal reader from the student's thesis committee members. The student will submit their report to Kathy Lucas (Kathy.Lucas@colostate.edu) in the main office, who will forward the report and proposal rating forms to the reader.

The reader will complete a proposal rating sheet, including a pass/fail grade, turn it in to the main office, and provide a copy to the student. The student must return the completed proposal rating sheet to Kathy Lucas. This evaluation, along with a copy of the proposal, will become part of the student's permanent file.

Program: Materials Chemistry

Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Thesis
2 - Ideas that generate enthusiasm	Prelim exam report	Independent proposal
3 - Communication in an interdisciplinary world	Courses, seminar/research reports and literature/research seminar	Independent proposal and seminar

Details:

Coursework (Competency #3): Students must take at least 10 credits with 6 credits from materials courses and at least 3 credits from an area outside materials chemistry.

Six credits from the following materials courses are required:

Course #	Title	Credits	Semesters Offered
CHEM 511	Solid State Chemistry	3	Fall
CHEM 515	Polymer Chemistry	3	Fall
CHEM 517	Chemistry of Electronic Materials	3	Varies
CHEM 530F	Analysis of Materials	1	Varies
CHEM 550A	Materials Chemistry-Hard Materials	1	Spring, Even
CHEM 550B	Materials Chemistry-Soft Materials	1	Spring, Even
CHEM 550C	Materials Chemistry-Nanomaterials	1	Spring, Even
CHEM 555	Chemistry of Sustainability	3	Spring, Odd
CHEM 563C	Electronic Structure and Magnetism	1	Spring
CHEM 569	Chemical Crystallography	3	Spring, Odd

Written Exams (Competency #3): Students in the materials chemistry program are required to pass a total of four seminar-based and one research-based written exams before the end of the 4th semester in residence. Students are strongly encouraged to complete the seminar-based exams as soon as possible. Tasks:

- The seminar-based exam may include a pre-seminar discussion, seminar participation, and post-seminar report. Details about the seminar report procedures will be communicated to students at the beginning of each fall semester. In essence, each faculty seminar host will provide detailed seminar discussion and report procedures one week before a given seminar.
- The research report must be submitted to the Graduate Coordinator by the 1st Friday of the 3rd semester. A review process similar to how manuscripts are vetted for publication is used. The program head serves as Editor, and other materials faculty (not a student's advisor) will act as reviewers. The original submission will be read by a faculty reviewer, and the Editor will go through the reviewer's comments make a decision on major or minor revisions. For the report with minor revisions requested, the revised report is due in two weeks, while the report with major revisions requested is due in one month. Subsequent revision(s), together with a "Response to the Review" letter that explicitly addresses the issues raised by the reviewer and clearly details the changes you made and your point-to-point responses, including explanations for disagreeing with any of the suggestions that you have chosen not to follow, will be sent back to the reviewer, and the Editor will use the reviewer's comments to decide if additional revisions are needed and if the final report passes or fails, no later than the end of the 3rd semester. The report should focus on the graduate student's research, with the relevant background and progress presented in the general format of a journal article, with:

1. Title;
2. Abstract;
3. Introduction (that provides journal-appropriate background literature material and concisely describes the rationale for the goals of your project);
4. Experimental Section;
5. Results and Discussion;
6. Conclusions and Outlook (which should include plans for future research); and
7. References (ACS style, including the article title).

Students who do not fulfill this requirement will receive an incomplete grade for the semester, which will revert to an F after one year, according to the University policy. Up to two of the seminar-based reports may be substituted by passing an equivalent number of written exams offered by other divisions.

Seminar Presentations (Competency #3): Two seminar presentations are required; the first one is required before candidacy and the second is required after candidacy. The first seminar consists of a 20-min presentation followed by a 10-min Q&A on topic of one's own research, based heavily on research-related literature; preliminary results may be included in order to motivate the literature-based presentation. This seminar is typically given in the 3rd semester in residence and successful completion is required before the student can schedule the candidacy examination. The second seminar consists of a 40-45 minute seminar on one's own research followed by an untimed Q&A session; this seminar is typically scheduled for the 4th year. The seminars will be assessed by faculty present at the seminar.

Materials Chemistry Literature Seminar Evaluation Criteria. The following rubric will be used to assess the literature seminar. A passing seminar typically results from a rating of $\geq 70\%$.

1. Motivation of topic (ability to define the research area and place in context of its merit and potential for impact on materials chemistry). [20%]
2. Scientific content (delineation of questions, hypotheses/goals, and approaches; accurate explanations of results). [20%]
3. Depth of knowledge and understanding (critical contextual analysis of the conclusions drawn in the literature and their broader implications in materials chemistry, not just a regurgitation of what was read and not just a critique). [20%]
4. Presentation style (logical outline, quality of slides, verbal clarity, eye contact, and use of pointer). [20%]
5. Ability to answer questions from the audience (correct interpretation of questions; accurate and concise responses). [20%]

Original Concept: (Competency #2): Each student is required to develop some type of original concept based on the field of chemistry after the completion of their candidacy exam and no later than the eighth semester in residence. This concept should be developed in consultation with the students' advisor, graduate committee, and reader. In most cases, this will result in a written document that will be presented to the committee and evaluated by the reader. There is considerable flexibility in the fulfillment of this requirement. For example, students may choose to fulfill this assignment based on their future career goals. Indeed, students may view this assignment as a way to assist them in the later stages of their graduate careers as they formulate their future plans. For example, students who plan to pursue postdoctoral research or academic positions will be required to develop an original research proposal as part of the job application process. Likewise, external funding agencies, such as NSF and NIH, offer postdoctoral fellowships, and students applying for these fellowships must prepare detailed research proposals. Developing such proposals along with the students' committee would be an excellent way to fulfill this assignment. Students who plan to pursue careers in industry, as well as those contemplating entrepreneurial activity, may be better served by developing a business plan document or a patent application. Other concepts suitable for students contemplating careers in education or business may also be considered. The formatting of this assignment is flexible and depends on the specific purpose for which the assignment is being pursued. For example, an NIH postdoc proposal will have a specific format; whereas, a business plan or patent application will have very different formats.

Students should use the appropriate format when submitting this assignment. Listed below are the guidelines for writing an original research proposal.

General Guidelines:

1. Provide sufficient background information to permit review without extensive consultation of the literature.
2. Emphasize brevity and clarity of presentation.
3. Prepare publication-quality figures and schemes.
4. Take care to avoid spelling and other grammatical errors.

Specific Guidelines:

1. Length
 - a. The abstract (section a) is not to exceed 1 page single-spaced.
 - b. The body of the proposal (sections b and c) should be a minimum of 5 pages and a maximum of 10 pages, including figures.
 - c. There is no restriction on the length of the literature cited (section 2d) section. The text must all be in 10-12 point font.
2. Format
 - a. Abstract/Specific Aims. Concisely state the broad overall nature of your proposal. State the hypotheses to be tested and the aims of the research idea.
 - b. Background and Significance. Provide a brief sketch of the background leading to your idea. Critically evaluate and summarize existing knowledge and specifically identify the problem that your proposed research will solve. State concisely the importance of your proposal.
 - c. Research Design and Methods. Describe the research design and the procedures that will be used to accomplish the specific aims. Include how the data will be collected, analyzed, and interpreted. Describe any new methodology and its advantage over existing methodologies. Discuss the potential limitations of the proposed procedures and alternative approaches to achieve the aims.
 - d. Literature Cited. List all pertinent references. Each reference must include the complete title of the paper or article, names of all authors, book or journal, volume number, page numbers, and year of publication. Do not include an excessive amount of text in your references. This section should be limited to relevant and current literature.

Submission and Evaluation:

Students must register for CHEM 702 (Independent Research Proposal) the semester they plan on completing the requirement. A 1-page preliminary outline describing the original idea must be submitted to the thesis advisor and reader for approval. The GOC assigns the proposal reader from the student's thesis committee members. The student will submit their report to Kathy Lucas (Kathy.Lucas@colostate.edu) in the main office, who will forward the report and proposal rating forms to the reader.

The reader will complete a proposal rating sheet, including a pass/fail grade, turn it in to the main office, and provide a copy to the student. The student must return the completed proposal rating sheet to Kathy Lucas. This evaluation, along with a copy of the proposal, will become part of the student's permanent file.

Program: Organic Chemistry

Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Thesis
2 - Ideas that generate enthusiasm	Prelim exam report	Independent proposal seminar
3 - Communication in an interdisciplinary world	Courses and written exams	Independent proposal seminar

Details:

Coursework (Competency #3): At least ten credits are required with at least three credits from an area outside organic chemistry.

The following five credits are required:

Course #	Title	Credits	Semesters Offered
CHEM 543	Structure/Mechanisms in Organic Chemistry	2	Fall
CHEM 545	Synthetic Organic Chemistry I	3	Fall

Plus four credits from the following two-credit courses:

CHEM 541	Organic Molecular Structure Determination	2	Varies
CHEM 548	Organometallics in Synthesis	2	Varies
CHEM 549	Synthetic Organic Chemistry II	2	Varies

Written Examinations (Competency #3): Written cumulative examinations in Organic Chemistry are given on the first Saturday of most months during the academic year. The questions are designed to emphasize the application of fundamental organic principles and knowledge of the current literature to research problems. Students must pass 5 written exams to complete the program. During the first semester in residence, students may take any exam (including Organic). After the first semester, students have up to 12 chances to finish the required total of 5, and all exams after the first semester must be Organic exams. For joint students one of these exams may be substituted by passing an equivalent number of written exams offered by other divisions/programs as directed from the individualized program accepted by the GOC.

Independent Proposal (Competencies #2 & 3): Students should demonstrate their ability to propose a new research idea by giving a 30 minute seminar on an original research project, followed by a written proposal. The seminar and proposal should be given after candidacy and will be assessed by faculty present at the seminar.

Details:

1. To start, each student will submit a 1 page Abstract and summary of Specific Aims to be achieved by the proposed work. This is due no later than one month prior to the start of the semester in which the presentation will be given.
2. Once the faculty have approved the topic and Specific Aims, the student may schedule a seminar slot, in consultation with the Organic seminar chair.
3. Each presentation should be 25 minutes with 5 minutes for questions. Two students will typically present during a single hour-long time slot.
4. The faculty will provide written feedback on the idea.
5. Based on the feedback, students will write a formal 5-10 page proposal on their original idea. This should be submitted to the student's thesis committee members within 1 month of the presentation.

Program: Physical Chemistry

Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Thesis
2 - Ideas that generate enthusiasm	Prelim exam report	Independent proposal
3 - Communication in an interdisciplinary world	Courses, written exams and seminar presentation	Independent proposal and seminar presentation

Details:

Coursework (Competency #3): At least ten credits are required with at least three credits from an area outside physical chemistry.

The following six credits of courses are required:

Course #	Title	Credits	Semesters Offered
CHEM 571A	Quantum Chemistry: Foundations	2	Fall
CHEM 571B	Quantum Chemistry: Electronic Structure	1	Fall
CHEM 575	Fundamentals of Chemical Thermodynamics	1	Fall
CHEM 576	Statistical Mechanics	2	Fall

Plus two credits of CHEM 793 are required based on the following learning objectives:

- Demonstrate competency in core physical chemistry concepts
- Read and comprehend the chemical literature
- Pursue topics of interest through independent literature based research

Students must receive a B grade or better to successfully complete this requirement. The first course will be taken in the spring semester of the first year of a student's graduate career and the second course will be taken in the fall semester of the second year of a student's graduate career.

Students will register for CHEM 793 in the spring semester of their 1st year:

- The first five weeks will cover select "classic" papers on the following core topics in physical chemistry. A written exam covering concepts from all of these topics will be given at the culmination of this five-week period.
 - Quantum Mechanics
 - Statistical Mechanics
 - Thermodynamics
 - Kinetics
- The subsequent 10 weeks will involve two five week periods in which the students are given a current topic of interest in the chemical research community. The students must then pursue the literature in this area and discuss it in groups. Each of the five-week periods will culminate in a written covering the provided topic.

Students will register for CHEM 793 in the fall semester of their 2nd year:

- The course will meet twice a week for 10 weeks in the fall semester.
- The first two weeks of the course will revolve around seminar presentation skills and students picking their own topics of interest to pursue in the literature and eventually give a literature seminar on.

- Subsequent weeks will involve in-class presentations by each student on his/her chosen topics.
- This course will culminate in a literature seminar given by each student as a part of the physical chemistry seminar series.
- Seminars will be assessed by faculty present at the seminar.

Seminar Presentations (Competency #3): Two seminar presentations are required – one pre-candidacy (as a part of a course) and one post-candidacy. The seminars will be assessed by faculty present at the seminar.

Independent Proposal (Competencies #2 & 3)/updated 2/2020: Students should demonstrate their ability to propose an original research project by giving a 30 minute seminar on an original research project, followed by a written proposal. The proposal should not be a trivial extension or modification of an existing research project. Proposals may be in the general area of a student's doctoral research, but must be sufficiently distinct to be considered original by the advisor and primary reader (the "in-area" committee member). The proposal seminar should be given after candidacy and will be assessed by faculty present at the seminar. The written proposal will be assessed by the primary reader.

Details:

1. To start, each student will submit a one-page Abstract and summary of Specific Aims to be achieved by the proposed work. This is due no later than one month prior to the start of the semester in which the presentation will be given. The student should email this to the Organic seminar chair (currently Jeff Bandar; Jeff.Bandar@colostate.edu).
2. Students should register for CHEM 702 (Independent Research Proposal) the semester they plan on completing the proposal seminar and written proposal.
3. The seminar chair will notify the student when the faculty have approved the topic and Specific Aims; the student may then schedule a seminar in consultation with the seminar chair on a date that the advisor is able to be present. If the advisor is unavailable to attend the seminar after the presentation is scheduled, the presentation will be re-scheduled. In such case, the research advisor is responsible for rescheduling the presentation in a timely manner when the advisor and a quorum of the organic faculty can attend.
4. Each presentation should be 20 minutes with 10 minutes for questions. Two students will typically present during a single hour-long time slot.
5. The faculty will provide feedback on the originality, significance and feasibility of the research idea and quality of the presentation to be incorporated into the written proposal.
6. Based on the feedback, students will write a formal 5 to 10-page proposal on their original idea. Literature citations, including all authors, title of publication, journal citation with inclusive page numbers, are not included in the page limit. Students should consider that the proposal will be evaluated on its originality, justification/literature precedent, experimental design, written presentation and the overall quality. A typical outline to follow may be (although the exact outline is up to the student):
 - Abstract and Specific Aims
 - Background and Significance
 - Research Design and Methods
 - Literature Cited (does not count towards the page limit)
7. Within one month, the student will submit their report as a pdf file to the graduate education assistant (Kathy Lucas Kathy.Lucas@colostate.edu) in the main office, who will forward the report and proposal rating forms to the reader (in-area committee member).
8. Within two weeks, the reader will complete a proposal rating sheet, including a pass/fail grade, and circulate that to the student's advisor and any faculty attending the presentation. After a one-week period for voluntary input from relevant faculty, the proposal evaluation sheet will be turned in to Kathy Lucas who will provide a copy to the student. This evaluation, along with a copy of the proposal, will become part of the student's permanent file.
9. If the final proposal is deemed unsatisfactory by the reader, the student must submit a revised version within two weeks that addresses any identified issues. The revised proposal will be distributed to the Organic faculty for a final pass/fail determination.