

# **PROGRAM PLANS**

*Updated: December 6, 2024*

## Overview of Ph.D. Program Plans

In consultation with their advisor(s), students select one of five area-based program plans described below or develop an individualized one that satisfies the three competencies summarized in the mission statement. Each program plan tailors their pre- and post-candidacy components to optimally prepare individual students for their future careers. Students following an area-based program plan must inform the GOC of the decision no later than the last day of spring semester of the first year. Individualized plans must be comparably rigorous to area-based plans and must include assessment criteria. Students must submit program plans to the GOC (Graduate Operations Committee) for approval with sufficient time for review and revision by the last day of spring semester of the first year through the Online GOC Request Form. Once approved, the student's program plan will be added to the file and available by request from the Graduate Program Coordinator. PhD students are responsible for understanding the PhD requirements in their respective program plan and completing required Department and Graduate School forms on time. The GOC and Graduate Program Coordinator will support students by monitoring their progress, but it is ultimately the student's responsibility to follow and successfully complete the activities described in the PhD timeline. Faculty advisors are responsible for monitoring progress for students with individualized program plans and must inform the coordinator of the graduate program as requirements are met.

*Grad Student Handbook:*

<https://col.st/JG0rR>

## Program: Analytical Chemistry

### Summary:

Competency	Pre-Candidacy	Post-Candidacy
1 - Original research	Prelim exam report	Dissertation, published manuscripts
2 – Ideas that generate enthusiasm	Prelim exam report	Independent proposal, published manuscripts
3 – Communication in an interdisciplinary world	Courses and literature seminar; prelim exam report	Research seminar and independent proposal

### Pre-Candidacy Details:

Coursework (Competency #3): At least ten credits of >500-level CHEM courses are required. Seven Analytical Chemistry course credits are required, including 1 credit of CHEM 530D (Statistical Analysis in Analytical Chemistry), 3 credits of CHEM 532 (Advanced Chemical Analysis II), and at least 3 credits selected from the list below. At least three credits are required from other Programs (e.g., Inorganic, Materials, Organic, or Physical). Aside from the 10-credit core program coursework, students must register for: (1) CHEM 751: Methods of Chemistry Laboratory Instruction in the Fall semester of their first year; (2) a responsible conduct course, CHEM 601 or GRAD 544, preferably in the second semester but before the end of the fourth semester in the program; (3) CHEM 702: Independent Research Proposal at least one semester prior to graduation.

At least three credits from the following list are required.

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 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

Required Courses: should be completed in the 1st year

CHEM 530D	Statistical Analysis in Analytical Chemistry	1	Fall
CHEM 532	Advanced Chemical Analysis II	3	Spring

In lieu of cumulative exams, the Analytical Program plans students to register for CHEM 532. This course covers fundamentals of quantitative analysis and analytical instrumental analysis and may include laboratory components. The course will include linkages between fundamental chemical concepts (equilibrium, kinetics, thermodynamics) to analytical chemistry and measurement approaches, professional development (e.g., proposal and paper writing approaches, peer review), and discussion of current scientific literature and the analytical seminar program. As part of the seminar discussions, students will be expected to accurately summarize seminars, critically evaluate methods and data interpretation, and describe the underlying chemical principles.

**Pre-Candidacy Seminar** (Competency #3): A critical evaluation of the literature surrounding students' current research project. To be completed during the 3rd semester in residence.

Expectations and Guidelines:

1. **Overview:** This seminar presents a critical and comprehensive evaluation of the literature in the area surrounding students' current research project and uses this literature to describe the "knowledge gap" that motivates their current research. The overall goal of this requirement is to provide an opportunity for students to practice and receive feedback on the skills required for the preliminary exam. These skills include clear and concise communication of the motivation for their research and their current/future plans to address this knowledge gap. This seminar bridges coursework and research efforts and so should introduce literature that motivates students' current research.
2. **Definition of "Critical Evaluation":** Critically evaluating the literature means finding the significance in the work, which includes understanding how the methods, results, and conclusions provide new or valuable information. Critical evaluation also requires integrating across multiple studies to find common themes, challenges, ideas, and open questions (i.e., "putting the literature in conversation"). Engaging with the literature in this way leads to a definition of the knowledge gap, which is a central component of this seminar requirement.
3. **Literature Selection:** The literature seminar should describe multiple papers (i.e., *this seminar is not a presentation of a single paper*). The literature background should be comprehensive, while presenting a tractable amount of information for a 15–20-minute presentation. Students should not use papers solely from their research group; as a starting point, no more than half of the literature evaluation should focus on your own group's work.
4. **Assessment & Feedback:** Students should apply their foundational chemistry knowledge when introducing the literature around their current project. While a Pass/Fail grade is not formally assigned, this seminar will assess students' progress toward preparation for their Candidacy Examination. Constructive criticism will be provided in discussion between the faculty and the student after their presentation, and in written feedback from faculty using the literature seminar rubric. Feedback will focus on evaluating students':
  - i. Knowledge of the topic based on their presentation and abstract logical structure and clarity, and ability to answer questions from the audience.
  - ii. Use of their knowledge to assemble a coherent and comprehensive narrative that describes the current state of knowledge on their research topic, articulating the overarching question(s) guiding research in their field and articulating the specific knowledge gap that motivates their current project.
  - iii. Ability to communicate foundational chemistry knowledge through their presentation of analytical techniques used, data and figures presented, and their answers to questions.
5. **Presentation Guidelines:**
  - The presentation will be 15-20 minutes, with ~10 minutes for questions and discussion.
  - Students will invite their committee to attend their presentation.
  - Most of the presentation should focus on the status of the students' research area, motivating open questions and the major knowledge gap.
  - The presentation should introduce the student's current project, namely, what the student is currently doing, or will do, to address the knowledge gap. Research results can be included in the presentation.
6. **Preparation:** The faculty seminar coordinator will host an open discussion to give students the opportunity to ask questions about the guidelines and review criteria, usually in mid-August. In addition:
  - Students are encouraged to talk with faculty, especially their advisors and in area committee members, regarding their seminar.
  - Students are strongly encouraged to schedule practice talks with their research group, and other students, >1 month before their seminar date to solicit feedback on their approach and presentation structure.
  - *1 week before the seminar:* Provide a title and seminar abstract to the seminar coordinator.

**Written cumulative exams and report(s):** Analytical chemistry students are not required to complete (1) Written Cumulative Exams; (2) a 1<sup>st</sup> year research report; and (3) seminar reports because (1) students gain fundamental analytical chemistry knowledge in CHEM 532; (2) the quality and quantity of original research contributions will be assessed by the student's degree committee throughout the program, but particularly at the second-year preliminary candidacy exam and the final thesis defense; and (3) CHEM 532 incorporates current scientific literature, and the analytical seminar program.

## Post-Candidacy Details

**Post-Candidacy Committee Meetings:** In the first semester of the student's fourth year, a formal meeting with the student's graduate committee should be held to evaluate the student's progress towards their degree and provide suggestions and feedback. Subsequent meetings should be held as deemed appropriate by the committee. It is recommended these meetings occur once per year beginning in the fourth year.

**Post-Candidacy Research Presentation** (Competency #3): After the preliminary exam, but no later than the 8<sup>th</sup> semester in residence, the student will give a presentation of their own graduate research. This presentation may be given as part of the Analytical Division seminar series or at a scheduled Analytical Division event (e.g., poster session). The student's committee members should be invited to attend the presentation and participate with other faculty present to evaluate the student's performance and provide feedback. With approval from the graduate committee, a student may fulfill this requirement by giving an oral presentation at a scientific conference. In that case the committee will be responsible to report on the completion of the assignment via an email to the Analytical Seminar Coordinator.

**Independent Proposal** (Competencies #2 & 3): In this activity, students will demonstrate their ability to propose an original research project in a written proposal. Students will register for CHEM 702 Independent Proposal and complete the proposal, usually in the 8<sup>th</sup> to 10<sup>th</sup> semester. 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).

Proposal submission process (a detailed description can be found at [chem.colostate.edu](http://chem.colostate.edu)):

1. The student must present the research idea to the reader and the advisor before embarking on writing the full proposal.
2. Once the reader and the advisor approve the idea, the student and reader will agree to a timeline that the student will follow to complete the proposal and the reader will follow to grade it, that is a deadline for the proposal to be completed and graded.
3. When the student completes the full proposal, the student will submit their report as a pdf file to the Graduate Coordinator, who will forward the report and proposal rating forms to the reader (in-area committee member).
4. Within the three weeks, the reader will review the proposal and ask for revisions if necessary. The reader will complete a proposal rating sheet and return it to the Graduate Coordinator 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.

## Program: Chemical Biology

### Summary:

Competency	Candidacy	Post-Candidacy
1 - Original research	Prelim exam and report	Dissertation
2 – Ideas that generate enthusiasm	Prelim exam and report	Independent proposal, dissertation, published manuscripts
3–Communication an interdisciplinary world	Courses and literature seminar	Independent proposal seminar, published manuscripts, dissertation

**Timeline:** In addition to sustained research, students pursuing the PhD with a focus on Biological Chemistry should meet the following milestones in their studies.

	Semester	Milestone
Year 1	Semester 1	Coursework, group joining, NSF GRF application (optional)
Year 1	Semester 2	Coursework
Year 2	Semester 3	coursework, NSF GRF application (optional)
Year 2	Semester 4	Preliminary exam (must be scheduled before October of semester 5)
Year 3/4	Semester 6-8	Independent research proposal
Year 4/5	Semester 6-10	Research seminar
Year 5	Semester 9	Degree completion plan, committee meeting
Year 5+	Semester 10+	Complete research, write dissertation, defense

### Pre-Candidacy Details:

Coursework (Competency #3): At least ten credits of >500-level CHEM courses are required. As part of the ten credits, CHEM 521 and 522 are required plus a one-credit seminar on the biological chemistry literature (the latter is required and not counting toward the 10 credits). Each student must also take at least three additional credits from a biologically-focused course (either in Chemistry or another department), and at least two out-of-area credits. Aside from the 10-credit core program coursework, students must register for: (1) CHEM 751: Methods of Chemistry Laboratory Instruction in the Fall semester of their first year; (2) a responsible conduct course, CHEM 601 or GRAD 544, preferably in the second semester but before the end of the fourth semester in the program; and (3) CHEM 702: Independent Research Proposal at least one semester prior to graduation.

*Required courses:*

Course #	Title	Credits	Semesters Offered
CHEM 521	Principles of Chemical Biology	3	Fall
CHEM 522	Methods in Chemical Biology	2	TBD
CHEM 793	Seminar: Pillars in Biological Chemistry	1	Spring

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

CHEM 530C (Bioanalytical), CHEM 530D (Statistical Analysis), CHEM 537 (Electrochemistry), CHEM 541 (Organic Structure and Spectroscopy), CHEM 543 (Organic Structure and Mechanism), CHEM 545 (Organic Synthesis), CHEM 549 (Organic Synthesis II), CHEM 550 A-C (Materials), CHEM 551 (Catalysis), CHEM 555 (Sustainability), CHEM 560 (Inorganic Syn I), CHEM 561 (Inorganic Syn II), CHEM 563 A-E (Methods in Inorganic), CHEM 566 (Bioinorganic), CHEM 567-569 (Crystallography), CHEM 571A (Quantum), CHEM 575 (Thermochemistry), CHEM 576 (Statistical Chemistry)

*Pillars in Biological Chemistry* (Competency #3): In lieu of seminar reports or a literature seminar, students will complete a one-credit course in the fall semester of the second year that focuses on the application of core biological chemistry concepts to the analysis of classic and modern literature in the field. Roughly two-thirds of the course will be devoted to in-depth analysis of several classic papers and will include written exams. The remainder will consist of brief student presentations on current papers that address problem description, experimental design, data analysis, and conclusions.

Chemical biology students are not required to complete (1) Written Cumulative Exams; (2) a 1st year research report; and (3) seminar reports because (1) students gain fundamental chemical biology knowledge in CHEM 521 and 522; (2) the quality and quantity of original research contributions will be assessed by the student's degree committee throughout the program, but particularly at the second-year preliminary candidacy exam and the final thesis defense; and (3) CHEM 793: Pillars in Biological Chemistry incorporates current scientific literature, and the chemical biology seminar program.

## **Post-Candidacy Details:**

*Post-Candidacy Committee Meetings*: In the first semester of the student's fourth year, the student should schedule a formal meeting with their graduate committee to evaluate the student's progress towards their degree. The committee should provide suggestions and feedback. Subsequent meetings should be held as deemed appropriate by the committee. It is recommended these meetings occur once per year beginning in the fourth year. After the meeting, students submit the signed Preliminary Degree Completion Plan.

*Post-Candidacy Research Presentation* (Competency #1, 2 & 3): After the preliminary exam and at least one year before the defense, the student will give a presentation of their own graduate research. The student's committee members should be invited to attend the presentation and participate with other faculty present to evaluate the student's performance and provide feedback. With prior approval from the graduate committee, a student may fulfill this requirement by giving one or more oral presentations at a scientific conference. In that case, the committee will be responsible to report on the completion of the assignment via an email to the Chemical Biological Seminar Coordinator.

*Independent Proposal* (Competencies #2 & 3): In this activity, students demonstrate their ability to propose an original research project in a written proposal. Students should plan to register for CHEM 702 Independent Proposal and complete the proposal, between the 6<sup>th</sup> and 8<sup>th</sup> semester. 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 reader (the "in-area" committee member). The written proposal will be assessed by the primary reader. (See next page for more details.)

*Purpose*: Before earning the PhD, students should be able to generate a research idea, articulate motivation for that idea, design a study to meet specific objectives, test hypotheses, and demonstrate proof of concept and viability of the proposed project. This activity demonstrates a capacity to not only generate new ideas, but also to provide lines of reasoning and critical evaluation of a project.

The project proposed should be more than a trivial extension of a current project comprising the student's graduate research but can be related. It is relatively straightforward to ensure a proposal is not a trivial extension of ongoing work by describing a research project that is not ongoing, would likely take several years of research, and is not, to the best of one's knowledge, currently planned or ongoing by any researchers at their institution or elsewhere." (*i.e.*, not something that another student in the group is planning to do or that one heard about at a conference). As a part of the proposal, students must explain how the proposed research is distinct from their existing research and different from work in the literature.

Because students have little or no experience with proposal writing, the exercise is often highly stressful, quite time consuming and can produce less than satisfactory results on the first draft. These factors can decrease student research

productivity while they are working on the proposal and also make the process more work for the reader. Therefore, the faculty recommend that students follow a well-defined structure for the proposal and how to interact with the reader.

*Independent proposal guidelines:*

1. Students must register for CHEM 702 Independent Proposal to
  - a. Help them to get ideas for proposals;
  - b. Demystify the proposal process both as a PhD requirement and as a means to fund research;
  - c. Receive coaching on purpose and language of proposals;
  - d. Give and receive peer feedback of proposals to improve documents before interacting with the reader.
2. Students will follow well-defined guidelines for the format of the independent research proposal. This can be either the form given in this document or an actual proposal format, such as NRC, NIH or other postdoctoral application, or NIH R21, etc. The alternative format must be approved by the advisor, the reader and the GOC.
3. The student must present the research idea to the reader and advisor before embarking on writing the full proposal. Once the reader and advisor approve the idea, the student and reader will agree to a timeline that the student will follow to complete the proposal and the reader will follow to grade it, that is, a deadline for the proposal to be completed and graded.
4. The project scope should allow it to be completed in about 2-3 years if it were actually funded research.

*Recommended proposal format:*

This proposal format is a modification of the ACS PRF DNI proposal format (spring 2021).

The complete independent proposal will include the following components:

1. Name and Contact Information for the Principal Investigator (aka student);
2. CV including the following components (2 pages limit):
  - a. Education and Experience:
    - i. All academic degrees, when and where received;
    - ii. Ph.D. supervisor and anticipated graduation date;
  - b. List current and previous positions, in reverse chronological order;
  - c. Significant honors and awards;
  - d. Publications and presentations: List all research publications and presentations. Include titles, co-authors, and literature references.
  - e. Additional relevant information, such as training, workshops attended, service, outreach, etc.
3. Proposal Title (succinct and descriptive);
4. At least 3-6 keywords/phrases that describe the broad area of the proposed research;
5. Abstract or Summary: up to 250 words;
6. Proposed Research
  - a. Identify the problem to be solved or research hypothesis;
  - b. List 2-3 specific aims, objectives, or detailed hypotheses that the proposed research will address;
  - c. The proposal should be at least 1,500 and not more than 3,000 words, double-spaced in 12-point font. Enter the word count at the end of the proposal narrative. Proposals that are shorter or longer will be returned for revision.
7. Include a statement (no longer than one page) of how the proposed research is significantly different from the PI's (aka student's) previous research and represents a new research direction for the PI. This is in addition to the 1500-3000 word proposal.
8. Cited references including all authors, title, journal, year, volume, pages/article number and DOI.
9. Safety: The proposal must describe any significant risks or hazards that may be encountered in the proposed work, and how these risks or hazards would be mitigated.
10. Budget Amount by Year and Justification, including:
  - a. Salaries for PI and any others needed to accomplish the proposed work;
  - b. Materials and supplies;
  - c. Equipment or access to equipment, *e.g.*, NMR time, access to multiuser facilities, etc.
  - d. Publication costs;
  - e. Miscellaneous other items, *e.g.*, travel to field sites, etc.



11. Suggested Reviewers: Names of at least two individuals who, if this were a real proposal, would be appropriate to review the proposal and why they would be appropriate reviewers.

*Proposal submission process:*

1. The student must present the research idea to the reader and the advisor before embarking on writing the full proposal.
2. Once the reader and the advisor approve the idea, the student and reader will agree to a timeline that the student will follow to complete the proposal and the reader will follow to grade it, that is a deadline for the proposal to be completed and graded.
3. When the student completes the full proposal, they, the student will submit their report as a pdf file to the Graduate Coordinator, who will forward the report and proposal rating forms to the reader (in-area committee member).
4. Within three weeks, the reader will review the proposal and ask for revisions if necessary. The reader will complete a proposal rating sheet and return it to the Graduate Coordinator 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.

# 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

## Pre-Candidacy Details:

Coursework (Competency #3): At least ten credits of >500-level CHEM courses are required. Of the ten credits, students must choose three credits from the four one-credit modules of CHEM 563 and three additional credits from Inorganic Chemistry courses. Of the ten credits, at least three credits should stem from an area outside inorganic chemistry. Aside from the 10-credit core program coursework, students must register for: (1) CHEM 751: Methods of Chemistry Laboratory Instruction in the Fall semester of their first year; (2) a responsible conduct course, CHEM 601 or GRAD 544, preferably in the second semester but before the end of the fourth semester in the program; and (3) CHEM 702: Independent Research Proposal at least one semester prior to graduation.

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

Research and 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.

Research Report 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 section; (5) a Discussion section ((4) and (5) maybe combined); and (6) 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; at least one other inorganic professor (not a student's advisor) will act as reviewers. The original submission will be read by a faculty reviewer, and the editor will pass through the reviewer's comments to the student. The editor (program head) will be available to help answer questions about the reviewer's comments so that expectations are clear. 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 November 1. Failure to submit a reasonably revised report by the communicated deadline will constitute a failed research report.

Finally, the Inorganic Division policy on the use of AI such as ChatGPT in the Research Report is recorded in a footnote [1].

Seminar report format and process. 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), who will share a grading rubric before the pre-seminar overviews are due.

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 student-written 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.
- Note that it is up to the student to plan each semester for themselves, so that they can ensure that at least one seminar report is passed per semester.

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

Literature Seminar Presentation: A literature seminar presentation is required before the candidacy exam. The seminar consists of a 20 min presentation on a topic of one's own research, followed by a 10 min Q&A. Two students will typically present during a single hour-long time slot. The seminar should be based heavily on research-related literature; preliminary results must be included 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 exam. The seminar will be assessed by faculty present at the seminar, and how the seminar is assessed by the faculty and student peers will be communicated to students at the beginning of each fall semester by the divisional seminar chair.

Details of preparing for the presentation include: (i) the proposed choice of topic and an outline, that includes key references, is due 4 weeks before the seminar (and should be sent to the full Inorganic Faculty), and (ii) a 1page Abstract of the talk with key references is due 1 week before the talk.

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.

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[1] (a) The use (or not) of AI such as ChatGPT in the 3<sup>rd</sup> semester Inorganic Research Report (as an editor for example) should be discussed with and OK'd (or not) with the student's research advisor. Recommended discussion issues between the student and Advisor should include: that release of any proprietary information by uploading material to ChatGPT could impact subsequent patenting or publishing as well as any ethical issues (for example, releasing materials that have co-authors, so that such release would need their approval as well). Also (b) any use of ChatGTP should be disclosed and described in the Research Report.

## Post-Candidacy Details

### *Post-Candidacy Committee Meetings:*

First, the Inorganic Division directs the student to contact their full Ph.D. Committee each year in January and concisely report to their Committee: (i) their progress towards their degree, (ii) any problems / issues they are experiencing, and (iii) ask if the Committee wishes to meet in person with the student to help problem solve / expedite the student's progress towards their degree. A meeting in person with the Committee is recommended, but not required.

Next, in the first semester of the student's fourth year, the student should schedule a formal meeting with their graduate committee to evaluate the student's progress towards their degree. The committee should provide suggestions and feedback. Subsequent meetings should be held as deemed appropriate by the committee. It is recommended these meetings occur once per year beginning in the fourth year. After the meeting, students submit the signed Preliminary Degree Completion Plan.

*Independent 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.

### *Proposal submission process:*

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 the Graduate Coordinator, 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 into the Graduate Coordinator, and provide a copy to the student. 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, publications
2 – Ideas that generate enthusiasm	Prelim exam report	Independent proposal
3 – Communication in an interdisciplinary world	Courses, written reports, and literature seminar	Independent proposal seminar, publications

## Pre-Candidacy Details:

*Coursework (Competency #3):* Students must take at least 10 credits of >500-level CHEM courses, with 6 credits from materials courses and at least 3 credits from an area outside materials chemistry. Aside from the 10-credit core program coursework, students must register for: (1) CHEM 751: Methods of Chemistry Laboratory Instruction in the Fall semester of their first year; (2) a responsible conduct course, CHEM 601 or GRAD 544, preferably in the second semester but before the end of the fourth semester in the program; and (3) CHEM 702: Independent Research Proposal at least one semester prior to graduation.

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 530F	Analysis of Materials	1	Varies
CHEM 550A	Materials Chemistry-Hard Materials	1	Spring, Even
CHEM 550B	Materials Chemistry-Soft Materials	1	Varies
CHEM 550C	Materials Chemistry-Nanomaterials	1	Varies
CHEM 555	Chemistry of Sustainability	3	Varies
CHEM 563C	Electronic Structure and Magnetism	1	Spring
CHEM 569	Chemical Crystallography	3	Varies

*Research and Seminar Reports (Competency #3):* As a substitute for traditional cumulative exams, students in the materials chemistry program are required to pass a total of three seminar-based reports and a research report before the end of the 4th semester in residence. These must be completed before the candidacy exam can be scheduled. Students are strongly encouraged to complete the seminar reports as soon as possible. The materials division seminar chair will host a meeting during the typical materials seminar slot (Friday) early in the fall semester to review the requirements and tasks. Tasks:

- **Seminar reports (3).** Students will actively participate in the Materials Chemistry seminar program and evidence this commitment in the form of seminar reports. CSU faculty members that host Materials Chemistry seminar speakers will provide detailed seminar discussion and report procedures one week before a given seminar. This may include a pre-seminar discussion, seminar participation, and a post-seminar report. Students must pass three reports (exams). At least two of these exams must be from materials or joint-materials seminars. Seminar attendance will be mandatory for all 1<sup>st</sup> and 2<sup>nd</sup> year graduate students; attendance is strongly recommended for advanced students.
- **Research report (1).** The report is designed to help prepare students for their advancement to PhD candidacy and stimulate students to perform graduate research as soon as they join a group. The report must be submitted to both the materials division head and the Graduate Coordinator by the 1<sup>st</sup> Friday of the 3<sup>rd</sup> semester. A review process similar to how manuscripts are vetted for publication is used. The division head serves as editor; other materials faculty (not a student's advisor) will act as reviewers. The division head reserves the

right to return reports to the student without review if they are deemed too preliminary in nature. The 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), together with a "Response to the Review" letter that explicitly addresses the issues raised by the reviewer and clearly points out the changes made in the revised report, 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 3<sup>rd</sup> 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.

*Literature Seminar Presentation (Competency #3):* A literature seminar presentation is required before the candidacy exam. The seminar consists of a 20 min presentation on a topic of one's own research, followed by a 10 min Q&A. It is possible for two students to present during a single hour-long time slot. Seminars are to be scheduled on Friday, Monday (for "soft" materials), or Tuesday (for "hard" materials). Students should discuss scheduling with their advisor and the seminar chair. The seminar should be based heavily on research-related literature; preliminary results must be briefly included to motivate the literature-based presentation. This seminar is typically given in the 3<sup>rd</sup> semester in residence and successful completion is required before the student can schedule the candidacy exam. The seminar will be assessed by faculty present at the seminar, and how the seminar is assessed by the faculty and student peers will be communicated to students at the beginning of each fall semester by the divisional seminar chair.

## **Post-Candidacy Details:**

*Post-Candidacy Committee Meetings:* In the first semester of the student's fourth year, the student must schedule a formal meeting with their graduate committee to evaluate the student's progress towards their degree. The student is expected to present a 20 minute progress update that outlines the major goals and aims of the thesis project and the progress thus far in accomplishing these tasks. It is recommended that the presentation follow a tentative outline of the PhD thesis. The committee should provide suggestions and feedback. After the meeting, students submit the signed Preliminary Degree Completion Plan. Subsequent meetings should be held as deemed appropriate by the committee to assess and update the Degree Completion Plan. It is recommended these meetings occur once per year beginning in the fourth year.

*Independent Proposal (Competencies #2 & 3):* *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. Seminars are to be scheduled on Friday, Monday (for "soft" materials), or Tuesday (for "hard" materials) during the 4 pm seminar slot. Students should discuss scheduling with their advisor and the seminar chair. 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 Materials seminar chair. The seminar chair will circulate the abstract and aims to materials chemistry faculty for approval of the topic.
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 once the materials 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 and at least two other Faculty members are able to be present. If the advisor turns out to be unavailable unexpectedly after the presentation is scheduled, the presentation will have to be re-scheduled. It then falls on the research advisor to reschedule the presentation when the advisor and the quorum of the materials faculty (>2) can be present.
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. 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):
  - a. Abstract and Specific Aims
  - b. Background and Significance
  - c. Research Design and Methods
  - d. Literature Cited (does not count towards the page limit)
7. Within one month, the student will submit their proposal as a pdf file to the graduate coordinator (who will forward the proposal and proposal rating forms to the reader (i.e., the in-area committee member).
8. Within three 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 into the graduate coordinator 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 2 weeks that addresses any identified issues. The revised proposal will be distributed to the materials faculty for a final pass/fail determination.



# 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

## Pre-Candidacy Details:

Coursework (Competency #3): At least ten credits of >500-level CHEM courses are required, with at least two credits from an area outside organic chemistry. Aside from the 10-credit core program coursework, students must register for: (1) CHEM 751: Methods of Chemistry Laboratory Instruction in the Fall semester of their first year; (2) a responsible conduct course, CHEM 601 or GRAD 544, preferably in the second semester but before the end of the fourth semester in the program; and (3) CHEM 702: Independent Research Proposal at least one semester prior to graduation.

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 at least two courses from the following:

CHEM 541	Organic Molecular Structure Determination	2	Spring
CHEM 548	Organometallics in Synthesis	2	Spring (even)
CHEM 549	Synthetic Organic Chemistry II	2	Spring (odd)
CHEM 651C	Computational Organic Chemistry	1	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 current literature to research problems. Students must pass five written exams to complete the program – of which three or more must be Organic exams. During the first semester in residence, students may take any exam (including Organic). After the first semester, students have up to twelve chances to finish the required total of five. After the first Semester passes must be obtained in Organic exams, with the exception of joint students, for whom up to two 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.

Organic chemistry students are not required to complete (1) a literature seminar/seminar reports; and (2) a 1st year research report; because (1) students gain critical thinking skills regarding current literature via the written cumulative exams; and (2) the quality and quantity of original research contributions will be assessed by the student's degree committee throughout the program, but particularly at the second-year preliminary candidacy exam and the final thesis defense.

## Post-Candidacy Details:

Post-Candidacy Committee Meetings: In the first semester of the student's fourth year, the student should schedule a formal meeting with their graduate committee to evaluate the student's progress towards their degree. The committee should provide suggestions and feedback. Subsequent meetings should be held as deemed appropriate by the committee. It is recommended these meetings occur once per year beginning in the fourth year. After the meeting, students submit the signed Preliminary Degree Completion Plan.

Independent Proposal (Competencies #2 & 3): 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 once 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 and at least two other Faculty members are able to be present. If the advisor turns out to be unavailable unexpectedly after the presentation is scheduled, the presentation will have to be re-scheduled. It then falls on the research advisor to reschedule the presentation when the advisor and a quorum of the organic faculty are able to be present.
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. 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):
  - a. Abstract and Specific Aims
  - b. Background and Significance
  - c. Research Design and Methods
  - d. Literature Cited (does not count towards the page limit)
7. Within one month, the student will submit their proposal as a pdf file to the Graduate Coordinator who will forward the proposal and proposal rating forms to the reader (in-area committee member).
8. Within three 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 into the Graduate Coordinator 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.

## 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

### Pre-Candidacy Details:

Coursework (Competency #3): At least ten credits of >500-level CHEM courses are required, with at least three credits from an area outside physical chemistry. Aside from the 10-credit core program coursework, students must register for: (1) CHEM 751: Methods of Chemistry Laboratory Instruction in the Fall semester of their first year; (2) a responsible conduct course, CHEM 601 or GRAD 544, preferably in the third semester but before the end of the fourth semester in the program; and (3) CHEM 702: Independent Research Proposal at least one semester prior to graduation.

The following five credits are required:

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

Students must complete one additional credit chosen from:

CHEM 571B	Quantum Chemistry: Electronic Structure	1	Fall
CHEM 573A	Chemical Spectroscopy: Interactions of Light and Matter	1	Fall/Spring
CHEM 578B	Computational Chemistry: Molecular Dynamics	1	Spring

Pillars of Physical Chemistry (Competency #3): In partial fulfillment of the written component of the preliminary exam, students must enroll in CHEM 775 Pillars of Physical Chemistry in the spring semester of the first year.

Literature Seminar Presentation (Competency #3): Students will register for a designated section of CHEM 793 in the fall semester of their 2nd year. This course aims to guide students to develop the ability to prepare and deliver an effective seminar based on a topic from the primary literature. The seminars are assessed by faculty present at the seminar.

Physical chemistry students are not required to complete (1) written cumulative exams; and (2) a 1st year research report; because (1) students gain fundamental physical chemistry knowledge in required coursework; and (2) the quality and quantity of original research contributions will be assessed by the student's degree committee throughout the program, but particularly at the second-year preliminary candidacy exam and the final thesis defense.

## **Post-Candidacy Details:**

Post-Candidacy Committee Meetings: In the first semester of the student's fourth year, the student should schedule a formal meeting with their graduate committee to evaluate the student's progress towards their degree. The committee should provide suggestions and feedback. Subsequent meetings should be held as deemed appropriate by the committee. It is recommended these meetings occur once per year beginning in the fourth year. After the meeting, students submit the signed Preliminary Degree Completion Plan.

Research Presentation (Competencies #1, 2, and 3): After passing the preliminary exam, students will present a 40-min seminar in the physical chemistry series based on the research they have accomplished. Usually, this seminar occurs in the 8<sup>th</sup> semester of graduate study but may occur earlier or later based on student progress. The seminar should be presented no later than the 10<sup>th</sup> semester.

Independent Proposal (Competencies #2 & 3): In this activity, students demonstrate their ability to propose an original research project in a written proposal. Students should complete the proposal when they register for CHEM 702 Independent Proposal, usually in the 8<sup>th</sup> to 10<sup>th</sup> semester. 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 primary reader assesses the written proposal.

Proposal submission process:

1. The student submits their report as a pdf file to the Graduate Coordinator, who forwards the proposal and its rating forms to the reader (in-area committee member).
2. Within three weeks, the reader reviews the proposal and asks for revisions if necessary. The reader completes a proposal rating sheet and returns it to Graduate Coordinator who provides a copy to the student. This evaluation, along with a copy of the proposal, becomes part of the student's permanent file.