ALLEGHENY COLLEGE DEPARTMENT OF CHEMISTRY

**SENIOR PROJECT GUIDELINES**

## I. INTRODUCTION

A. General philosophy. As stated in the Academic Bulletin, the Senior Project "is not a mere report or semester paper, but a significant piece of independent study, research, or creative work." Indeed, a mandatory comprehensive senior research project is unusual among liberal arts colleges, and this experience distinguishes Allegheny graduates as they embark on professional careers. More importantly, the successful completion of an independent research project is a milestone in personal development, with merit transcending the context of vocational utility.

Students are fully responsibility for the successful completion of the project, including literature research; documentation and interpretation of results; procurement, proper maintenance, and (in some cases) construction of equipment; troubleshooting; and the deft redirection of approaches not yielding desired results. This is a never-ending cycle requiring constant initiative.

Of course, the research advisor is an integral part of this cycle, but the student should not expect to wait upon the advisor to issue directives. Rather, the advisor should be viewed as an expert resource from whom guidance about specific research issues may be obtained. The advising relationship is a complex dynamic, however, and chemistry faculty have differing styles, which reflect the diversity of approaches in the discipline. Students are therefore encouraged to be mindful of this when choosing their Senior Project advisor.

B. Goals and Behaviors. The Chemistry Department has defined specific goals for the Senior Project, which include:

- exposing the student to cutting-edge laboratory research in chemistry
- beginning the development of the student's ability to ask interesting and well-defined scientific questions
- furthering the development of the student's ability to work independently
- engaging the student intellectually in a multi-dimensional chemical investigation

Students completing a Senior Project should therefore exhibit a variety of observable behaviors, which are detailed in the attached rubric.

## II. LOGISTICS

A. Academic Credit. Chemistry has a two-semester Senior Project. Students sign up for 2 hours in the fall (CHEM 600), followed by 4 hours in the spring (CHEM 610). Students receive grades for both the fall and spring semester courses.

B. Scope of Project. The Senior Project must: a) exhibit scientific merit, b) contain a body of work appropriate for a senior-level research experience, and c) fall within the realm of at least one faculty member's area of expertise. The exact scope of the project is defined collaboratively through discussion between the student and the research advisor.

C. Choice of Research Advisor. During the Junior Seminar, faculty members present research overviews of current projects, after which students submit three possible choices for a Senior Project advisor. Assignments are then decided by the department as a whole. Once assignments are made, students are encouraged to be in contact with their advisors as soon as possible.

D. The Senior Project Committee. Each Senior Project is evaluated by a three-member committee. The first reader is the student's research advisor; two additional readers are assigned to the student by the department. The written and oral presentations of the project should conform to the format and expectations of the first reader's subdiscipline; however, care must be taken so that the project is presented to an audience of non-specialists. All committee members have significant input in evaluating the project.

E. Biochemistry Majors & Joint Senior Projects. The goals, behaviors, appropriate topics, and meeting schedules of biochemistry majors, self-designed majors, and joint senior projects must conform to the department in which the primary research advisor is a member. Furthermore, the student is expected to abide by the guidelines of the specific group in which they are working.

Biochemistry majors wishing to complete a Senior Project in the Chemistry department must have completed the Chemistry Junior Seminar. The

research advisor is assigned through the Junior Seminar, as described above. The second reader, who must be a Biochemistry faculty member outside the Chemistry department, is assigned by the Biochemistry program director. The third reader is assigned by the Chemistry department.

**III. SPECIFIC GUIDELINES**

A. Scope. Anything presented as "Results" must be from research carried out by the student during the senior academic year. Work from summer research or previous independent study—or work by other students—may be included in the thesis, but must be presented as "Background" or "Previous Work" and must be cited accordingly. These results will not be considered for the purposes of evaluating the progress of the project.

B. Audience. Students are reminded that their Senior Project board is composed of chemists, but not specialists. Information should be communicated in a way that is understandable to a general scientific audience and not heavily laden with discipline-specific jargon.

C. First Written Document (Progress Report). This document has many functions, and it should address three main topics. An 'Introduction and Background' section should provide a selective but thorough review of previous work in the field and should hint at the student's comprehensive knowledge. In addition, it should show how the student's research fits into this global picture. More importantly, it should naturally substantiate the motivation behind the proposed research (*i.e.*, why is it interesting?).

An 'Experimental Plan' section should outline in detail how the project is to be carried out, and it should include any references that validate the proposed work. This portion should also include any contingency plans—in other words, how might the project be modified if Plan A doesn't provide the desired outcome?

Finally, the student is expected to produce results in the first semester, and these should be included in a 'Preliminary Results' section. All supporting information (data, spectra, etc.) should be included and clearly labeled. The report should also include a thorough 'Works Cited' section.

D. First Oral Presentation. The student should prepare a ca. 20-minute PowerPoint presentation giving a condensed background of the topic and focusing primarily on preliminary results. The talk should start from the premise that the committee has read the Progress Report (*i.e.*, not simply rehash the written work), but it should still be cohesive and understandable on its own merit.

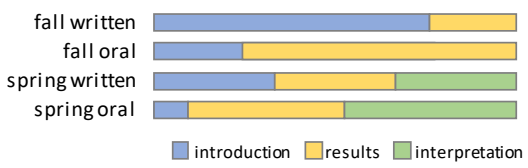
Students may be interrupted during their presentations for points of clarification. Authors of hastily prepared or poorly organized presentations and/or theses may expect more interruptions. At the conclusion of the formal presentation, students should be prepared for in-depth questions about any and all aspects of the project, which may include experimental design issues, interpretation of data, literature background, or basic chemistry concepts related to the project.

E. Final Written Document (Thesis). The final written work should address three areas with roughly equal attention: a) an introduction which should be relevant to the results presented and may look very different from the Progress Report of the fall semester, depending upon the course of the research, b) results of the project and explicit experimental details about how they were obtained along with any supporting data, and c) interpretation of the results and discussion of their significance. These are not meant to suggest particular headings in the thesis, but rather areas to be addressed.

As authors of a scientific thesis, students are expected to interpret their data within the context of their field of study and fully document their results according to the accepted criteria of proof for their subdiscipline. Specific format will depend upon the particular subdiscipline.

F. Final Oral Presentation. The same guidelines apply as for the first oral presentation, except the focus is almost entirely on results and discussion. If addressed at all, only enough introductory material should be included to contextualize the rest of the talk. Where appropriate, results should be supported with spectra or other instrumental data. The talk should conclude with an indication of what future work might be carried out.

**Figure 1**. Relative proportions of content



## IV. EXECUTION OF THE PROJECT

A. Meetings. Research advisors' styles vary from more directive to more "hands-off", reflecting the diversity of environments within the discipline. Students are encouraged to consider this aspect in their choice of advisor. In all cases, however, responsibility for successful completion of the Senior Project lies with the student.

Some advisors have required weekly group meetings. The format of these meetings varies, but can include opportunities for students to engage the rest of the group in their project and/or to review literature that is relevant to the entire group. These meetings might also provide an opportunity for students to speak both formally and informally and to show adequate intellectual engagement with their chosen field of study. In contrast, some advisors have no formal meetings with students. Some advisors schedule weekly meetings with students one-on-one and some schedule one-on-one meetings only as the need arises. There are no formal meetings with second and third readers.

### B. Calendar & Deadlines

1. First Oral Presentation. Students present progress to date and summarize their plan for the spring semester. They also defend their written Progress Report (see below). Presentations are scheduled beginning the Monday after Thanksgiving.

2. Written Progress Report. Students submit a well-written report providing motivation for the project and placing the project in the context of other work in the field. Students must submit an electronic copy of the Progress Report (in PDF format) to their "Chemistry Senior Project" Sakai drop box by 4:00 pm on Tuesday of Thanksgiving week. It is the student's responsibility to verify that the file has been properly transferred to the Drop Box folder. *Not submitting the Progress Report on time will result in a failing grade for the first semester of the Senior Project*.

3. Final Oral Presentation. Students present and interpret the results of their research project and explain the significance of their work. They also defend their final thesis (see below). Presentations are scheduled for the last two full weeks of classes.

4. Final Thesis. Students must submit an electronic copy of the final thesis (in PDF format) to their "Chemistry Senior Project" Sakai drop box by 4:00 pm on the Friday three weeks before finals begin. The file must contain all necessary experimental documentation (e.g., spectra, crystallographic data, etc.) to support the conclusions drawn. Please consult with your research advisor for guidance. It is the student's responsibility to verify that the file has been properly transferred to the Drop Box folder. *Not submitting the thesis on time will result in a failing grade for the Senior Project.*

The file must also be uploaded to DSpace before grades are released. Advisors may request revisions to the thesis (e.g., for accuracy or clarity) before uploading to DSpace; however, the revised document will not be regraded.

5. Rescheduling an oral exam. Times for an oral exam may be changed only under extenuating circumstances. Any change of time must be approved by the entire committee. It is the student's responsibility to arrange the new meeting time and reserve the room.

### C. Assessment

The Senior Project grade is dependent upon three broad categories (investment, expertise, and communication), and an acceptable threshold must be achieved in all categories for a passing grade. Please consult the rubric for further guidance.

Immediately after each oral exam, the committee meets in private to determine a recommended grade. The research advisor then meets with the student, at which point the student is told if the project has received a passing or failing grade. At this point, however, a letter grade has not been assigned. Committee recommendations are reviewed by the entire department after all oral exams have been completed. At this time final grades are assigned to each Senior Project.

Grades may be withheld until the student properly attends to his/her laboratory space, including properly storing all samples, disposing of waste, and cleaning equipment. The release of Senior Project grade is also contingent upon uploading the thesis document to DSpace.

Department of Chemistry
**Senior Project Evaluation**

Date: _____

Student: _____

1st Reader: _____

2nd Reader: _____

3rd Reader: _____

*assigned after departmental meeting*

Senior Project Grade: _____

**NOTE: ALL THREE AREAS MUST ACHIEVE THE "DEVELOPING" THRESHOLD FOR A PASSING GRADE**

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A. INVESTMENT

unsatisfactory | developing | proficient | exemplary

| never | seldom | sometimes | often | almost always | Contributing factors to INVESTMENT |
|---|---|---|---|---|---|
| ❑ | ❑ | ❑ | ❑ | ❑ | **time commitment**<br>the student spends an appropriate amount of time each week conducting experiments (at least 6 hr/week for CHEM 600; 12 hr/week for CHEM 610) in regularly scheduled time slots (agreed upon with the research advisor), with additional time outside of lab for preparation (literature research, etc.) |
| ❑ | ❑ | ❑ | ❑ | ❑ | **efficiency and productivity**<br>the student uses the time in the lab wisely, having adequately prepared beforehand, multitasking as much as possible; a suitable quantity of results is generated each week |
| ❑ | ❑ | ❑ | ❑ | ❑ | **initiative**<br>the student takes active steps to move the project forward without prompting; reasonable efforts are made to solve problems as they are encountered |
| ❑ | ❑ | ❑ | ❑ | ❑ | **project management** ■ SPA 2 Independent Project Planning & Development<br>the student is cognizant of the overarching goals of the project and is able to move priorities dynamically to achieve the goals; specific benchmarks are set and used to monitor progress |
| ❑ | ❑ | ❑ | ❑ | ❑ | **engagement in the scientific process** ■ SPA 4 Evaluation and Use of Information<br>the student critically evaluates experimental results as they are generated and leverages these results along with knowledge of the literature to inform appropriate next steps in the project |
| ❑ | ❑ | ❑ | ❑ | ❑ | **self-efficacy** ■ SPA 5 Integrative Thinking<br>the student is able to integrate all the necessary components of literature research, preparation, execution, and analysis to successfully complete discrete laboratory tasks in a timely fashion |
| ❑ | ❑ | ❑ | ❑ | ❑ | **self-reflection** ■ SPA 6 Reasoning<br>the student creates coherent meaning from individual components of the project, and is able to articulate the reasoning behind actions taken or planned; inconsistencies and confusion in thought processes are self-identified |

B. EXPERTISE

unsatisfactory | developing | proficient | exemplary

| never | seldom | sometimes | often | almost always | Contributing factors to EXPERTISE |
|---|---|---|---|---|---|
| ❑ | ❑ | ❑ | ❑ | ❑ | **foundational knowledge** ■ SPA 1 Disciplinary Proficiency<br>the student demonstrates an understanding of the basic chemical principles underlying all aspects of the project, as well as an appreciation for how the project fits into the larger context of what has been done before |
| ❑ | ❑ | ❑ | ❑ | ❑ | **technical sophistication**<br>the student exhibits the practical competency required for the reliable and reproducible execution of experimental tasks, according to accepted best practices; experimental results are not clouded with doubt about proper experimental technique |
| ❑ | ❑ | ❑ | ❑ | ❑ | **literature research** ■ SPA 3 Locating Information<br>the student takes initiative in locating appropriate information (journal articles, monographs, etc.) throughout the project; literature research is carried out using proper databases and effective search strategies; the project is conducted as a living conversation between project outcomes and the available literature |
| ❑ | ❑ | ❑ | ❑ | ❑ | **creativity**<br>the student demonstrates flexibility and adaptability in the execution of the project, and recognizes the true implications of experimental outcomes (whether positive or negative); the student takes the lead in providing new ideas for the project, and demonstrates insight into new approaches for achieving project goals |
| ❑ | ❑ | ❑ | ❑ | ❑ | **ethical conduct**<br>the student adheres to the highest standards of ethics in the execution of the project, including (but not limited to) data integrity and honesty in communication; rules regarding plagiarism and proper attribution are strictly observed in all products of the project |
| ❑ | ❑ | ❑ | ❑ | ❑ | **safe practice**<br>the student demonstrates a thorough knowledge of departmental safety policies, as well as the specific guidelines governing the lab(s) in which the research is conducted; material safety data sheets (MSDSs) are consulted before working with reagents; proper protective equipment (PPE) is used; proactive mitigation of potential safety risks is observed |
| ❑ | ❑ | ❑ | ❑ | ❑ | **lab citizenship**<br>the student maintains an orderly work space and ensures equipment is cleaned and put away in a timely fashion; proper care for, and operation of, all equipment and instruments is demonstrated; the student takes initiative to replenish common reagents and supplies; the student is respectful of lab mates and fosters an environment conducive to research |
| ❑ | ❑ | ❑ | ❑ | ❑ | **documentation**<br>the laboratory notebook is clear and organized, conforming to the standards of the lab and containing all necessary information to reproduce the experiment and publish the results; data files are named according to the standards of the lab and promptly & properly archived; a system of tracking data and samples is rigidly observed; rules for instrument sign-up are observed |
| ❑ | ❑ | ❑ | ❑ | ❑ | **growth** ■ SPA 9 Intellectual Development<br>substantial intellectual development is observed during the Senior Project |

C. COMMUNICATION

unsatisfactory | developing | proficient | exemplary

| never | seldom | sometimes | often | almost always | Contributing factors to COMMUNICATION |
|---|---|---|---|---|---|
| | | | | | *informal communication* |
| ❑ | ❑ | ❑ | ❑ | ❑ | **results and priorities**<br>the student takes initiative to communicate with the advisor about current results and project strategy |
| ❑ | ❑ | ❑ | ❑ | ❑ | **group communication**<br>the student effectively communicates with other group members about logistical and scientific matters |
| | | | | | *formal written communication* ■ SPA 7 Written Communication |
| ❑ | ❑ | ❑ | ❑ | ❑ | **attention to audience**<br>the document describes the project parameters and key findings in a manner that a non-specialist chemist can immediately comprehend; the background, results, and interpretation are presented in a way that would be useful to future senior project students working on the project |
| ❑ | ❑ | ❑ | ❑ | ❑ | **clarity, conciseness, and level of language**<br>ideas are clearly expressed in appropriate terms avoiding unnecessary verbiage; the document is free from grammatical and other mechanical issues; the document conforms to all formatting standards of the relevant sub-discipline |
| ❑ | ❑ | ❑ | ❑ | ❑ | **figures**<br>figures, charts, schemes, tables, etc., are well-constructed, informative, and persuasive |
| ❑ | ❑ | ❑ | ❑ | ❑ | **coherence of document**<br>ideas follow in a logical progression with strong paragraph structure |
| ❑ | ❑ | ❑ | ❑ | ❑ | **appropriate evidence**<br>literature evidence is drawn from reliable scholarly sources; findings are supported by appropriate experimental evidence |
| ❑ | ❑ | ❑ | ❑ | ❑ | **scientific arguments**<br>arguments are coherent and connect evidence to scientific claims |
| ❑ | ❑ | ❑ | ❑ | ❑ | **synthesis of ideas**<br>literature sources and scientific findings are presented as an interconnected whole rather than a collection of individual facts |
| | | | | | *formal oral communication* ■ SPA 8 Oral Communication |
| ❑ | ❑ | ❑ | ❑ | ❑ | **content**<br>the experimental data and literature background are relevant and described clearly and accurately |
| ❑ | ❑ | ❑ | ❑ | ❑ | **visual aids**<br>slides are visually attractive, organized, accurate and legible; visual elements effectively and efficiently convey key information |
| ❑ | ❑ | ❑ | ❑ | ❑ | **technical delivery**<br>the presenter speaks clearly and confidently, making eye contact with the audience; adequate rehearsal is evident by smooth transitions and minimal use of notes |
| ❑ | ❑ | ❑ | ❑ | ❑ | **response to questions**<br>the presenter addresses questions from the Committee in a manner that reveals intimate knowledge of the project and of general chemical principles |

SPA Instrument

**1. Disciplinary Proficiency**
Students with excellent disciplinary proficiency demonstrate the depth and breadth of knowledge and skills necessary to complete independent, creative work in the discipline(s) in which the senior project is situated while adhering to the highest standards of quality and professional ethics.

**2. Independent Project Planning and Development**
Students who excel in planning and working independently require little guidance in identifying a specific, significant problem; proposing alternative methods for resolving the problem; designing an appropriate project to address the problem; working effectively within the context of the plan; and adjusting the plan as needed as more information becomes available.

**3. Locating Information**
Students who excel in locating information conduct a thorough yet not excessive search, locate a sufficient amount and appropriate range of source material for their project, and consult primary sources as needed.

**4. Evaluation and Use of Information**
Students who excel in the evaluation and use of information critically evaluate both the information and its sources, incorporate appropriate information into their work and interpret information to draw reasonable and defensible conclusions.

**5. Integrative Thinking**
Students with excellent integrative thinking skills carefully consider multiple perspectives, models and/or theories; synthesize and reconcile opposing arguments (when appropriate); and clearly present and justify their own perspective, model and/or theory.

**6. Reasoning**
Students who have excellent reasoning abilities activate prior knowledge in completing new tasks, express their reasoning and strategies for problem-solving, apprehend the implications of results or outcomes of their activities, seek to create coherent meaning from individual components, identify inconsistencies and confusion in their own thought processes, and are persistent in their quest for comprehension.

**7. Written Communication**
Excellent writing is clear, interesting, logically organized (both as a unified whole and within its constituent parts), concise and articulate. Assertions are specific, precisely stated, and persuasively supported. Arguments are carefully crafted and cohesive. The author employs the conventions and citation protocols of the discipline correctly. The document is free of the sorts of errors that careful proofreading catches.

**8. Oral Communication**
Excellent oral communication is clear, organized, interesting, and focused on a specific claim that is appropriate to the context. Assertions are specific, precisely stated, and persuasively supported. Arguments are carefully crafted and cohesive. Excellent oral communication is also characterized by consistent professionalism, sincerity, enthusiasm, and confidence.

**9. Intellectual Development**
During the period of time they spend completing the senior project, students develop to various degrees. In thinking about this student's senior project from start (e.g., pre-comp oral and/or initial proposal) to finish (e.g., final written version and/or oral defense/presentation), how would you rate this student's degree of intellectual development over the course of the senior project?