UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

Chemistry Majors and Minors Aggregate Report

Academic Year 2020-2021
Assessment Report (regular template)

I. Logistics

1. **Please indicate the name and email of the program contact person to whom feedback should be sent (usually Chair, Program Director, or Faculty Assessment Coordinator).**

   Michael Stevenson (mstevenson3@usfca.edu)

2. **Please indicate if you are submitting report for (a) a Major, (b) a Minor, (c) an aggregate report for a Major & Minor (in which case, each should be explained in a separate paragraph as in this template), (d) a Graduate or (e) a Certificate Program.**

   This is an aggregate report for Major and Minor.

3. **Please note that a Curricular Map should accompany every assessment report. Has there been any revisions to the Curricular Map since October 2019?**

   This is the second year of our 3-year assessment plan. There were no planned changes to the plan. However, due to COVID and the low enrollment policy, several classes were cancelled which include Medicinal Chemistry (CHEM 332), Advanced Organic Lab (CHEM 333), Experimental Biochemistry (CHEM 352), and Integrated Lab (CHEM 410). To assess as many courses and students as possible, Biochemistry II (CHEM 351) and the elective course Kitchen Science (CHEM 310) were added. These temporary changes are reflected in the 3-year assessment plan attached to this report.

II. Mission Statement & Program Learning Outcomes

1. **Were any changes made to the program mission statement since the last assessment cycle in December 2020? Kindly state "Yes" or "No." Please provide the current mission statement below. If you are submitting an aggregate report, please provide the current mission statements of both the major and the minor program.**

   No

   Mission Statement (Major/Graduate/Certificate):
   To deliver a broad-based and challenging chemistry experience that will train students for graduate school in science or as professionals in a variety of health, government or private industry positions. The program will foster a culture that values our students, faculty and staff; strives to help students become self-learners; creates opportunities for students to discover the excitement and creativity of research, and promotes an understanding that social consciousness and ethical behavior are essential features of a principled chemistry community.

   Mission Statement (Minor):
   To deliver a broad-based and challenging chemistry experience that will train students for graduate school in science or as professionals in a variety of health, government or private industry positions. The program will foster a culture that values our students, faculty and staff; strives to help students become self-learners; creates opportunities for students to discover the excitement and creativity of research, and promotes an understanding that social consciousness and ethical behavior are essential features of a principled chemistry community.

2. **Were any changes made to the program learning outcomes (PLOs) since the last assessment cycle in December 2020? Kindly state "Yes" or "No." Please provide the current PLOs below. If you are submitting an aggregate report, please provide the current PLOs for both the major and the minor programs.**

   No

   PLOs (Major/Graduate/Certificate):
   LO #1: Students will demonstrate their mastery of the four (or five for BS biochemistry emphasis) principal disciplines: analytical, organic, physical, (biochemistry) and inorganic chemistry.
   LO#2: Students will recognize and understand the concepts and skills learned in prerequisite courses at or before the start of the new course or laboratory.
   LO#3: Students or student teams will demonstrate mastery in problem solving by performing a broad variety of analytical, computational and synthetic procedures using proper safety protocols, and will critically evaluate the results.
   LO#4: Students will demonstrate effective scientific communications skills in both written and oral form. Students will be able to write reports and present results while following professional policies regarding intellectual property, plagiarism, and group work.

PLOs (Minor):
LO #1: Students will demonstrate their mastery of the four (or five for BS biochemistry emphasis) principal disciplines: analytical, organic, physical, (biochemistry) and inorganic chemistry.
LO#2: Students will recognize and understand the concepts and skills learned in prerequisite courses at or before the start of the new course or laboratory.
LO#3: Students or student teams will demonstrate mastery in problem solving by performing a broad variety of analytical, computational and synthetic procedures using proper safety protocols, and will critically evaluate the results.
LO#4: Students will demonstrate effective scientific communications skills in both written and oral form. Students will be able to write reports and present results while following professional policies regarding intellectual property, plagiarism, and group work.

3. State the particular Program Learning Outcome(s) you assessed for the academic year 2019-2020.

All PLOs have been assessed since the previous Academic Program Review (APR). The Department of Chemistry underwent an APR on October 28-29, 2021. We will assess all PLOs before the next APR.

PLO(s) being assessed (Major/Graduate/Certificate):
LO#4: Students will demonstrate effective scientific communications skills in both written and oral form. Students will be able to write reports and present results while following professional policies regarding intellectual property, plagiarism, and group work.

PLO(s) being assessed (Minor):
LO#4: Students will demonstrate effective scientific communications skills in both written and oral form. Students will be able to write reports and present results while following professional policies regarding intellectual property, plagiarism, and group work.

III. Methodology

Methodology used (Major/Graduate/Certificate):
LO#4 was assessed in Organic Chemistry Lab II (CHEM 234, sections 1-6), Kitchen Science (CHEM 310), Inorganic Chemistry (CHEM 320), and Biochemistry II (CHEM 351). Due to COVID and the low enrollment policy, several classes that we planned to assess were cancelled which include Medicinal Chemistry (CHEM 332), Advanced Organic Lab (CHEM 333), Experimental Biochemistry (CHEM 352), and Integrated Lab (CHEM 410). The methodologies used in each course are listed below:

CHEM 234: Students gave partnered presentations to their (Zoom) lab section (6 lab sections, 84 students). The presentation was worth 15% of their course grade and included the following components: 1) each pair of students was assigned and worked on a multistep synthesis problem by their lab instructor (see the document Chem 234 Synthesis Problems for the list of problems), and 2) based on their proposed synthesis they: filled in the synthesis project worksheet (see the document Synthesis Project Worksheet) (30%), searched the American Chemical Society

Journals database to find an article from one of four journals (Organic Letters (OL), The Journal of Organic Chemistry (JOC), The Journal of Medicinal Chemistry, or the Journal of the American Chemical Society (JACS) that employed one of the carbon-carbon bond forming reactions used in their proposed synthesis (10%), interpreted ^{1}H and ^{13}C NMR data from the article (10%), created a presentation PowerPoint based on part a-c above (20%), and gave an oral presentation to their lab section based on parts a-d above (30%).

CHEM 310: Students gave partnered presentations (15% of course grade) from a chosen list of topics related to the course material provided on the syllabus (e.g. The Chemistry of Alliums, the Chemistry of Wine Making, etc). Prior to their presentations students were required to hand in the following (these research and presentation materials accounted for 20% of their course grade): two research papers from the current literature related to their presentation topic (10%), a rough draft of presentation (60%), and a final draft of presentation (30%).

CHEM 320: Students were placed in groups of 3 - 4 and assigned various topics reflective of inorganic chemistry applications. The topics assigned included: Quantum Dots, Fuel Cells, Solar and Photovoltaic Cells, Gold-based therapy for Arthritis, Metal-based biomedical imaging agents, heavy metal poisoning and chelation therapy, gold nanoparticles, the role of heme is gas transport, disease, and gas poisoning, and platinum-based anticancer therapies. Students were required to research these topics as a team, write a paper, and after receiving and incorporating feedback on the paper, create a google website on the topic. The website was evaluated based on the following criteria: visual appearance (20 pts), organization (20 pts), quality of content (25 pts), sources (10 pts), and quality of writing (25 pts). All the members of each group received the same final score for the website regardless of their individual contribution.

CHEM 351: Presentations were used to assess effective scientific communication. Students worked in pairs and chose a metabolic process or disease. They researched the topic, constructed an outline of their presentation, and, after receiving feedback, made their presentation and presented it to the class. Additionally, the pairs of students were required to write two exam style questions that anyone who listened to their presentation should be able to answer. Finally, all students provided written feedback to their peers' presentations (before giving the feedback to the presenters it was made anonymous). The presentation was evaluated based on the following components: achievement of the stated learning goal(s) (10 points), knowledge of the chosen topic (5 points), presentation organization (5 points), engaging the audience and connecting to previously learned topics (10 points), writing two exam style questions (5 points), and providing written feedback to peers (5 points). With the exception of the written feedback, scores were identical between pairs of students. Scores were calculated out of 40 points and this grade comprised 10% of the overall course grade.

Methodology used (Minor):

The PLOs for the major and the minors in our department are exactly the same. Since assessment often happens at the course level, the data presented for each course is reflective of all students in our majors and minors. To minimize the unnecessary redundancy that would arise from copying and pasting the same information for the minor in this document, we have decided to leave those sections blank from this point on. The data presented under the "major" section should be treated as an aggregate of both the major and minor.

IV. Results & Major Findings

Results (Major/Graduate/Certificate):
The results and major findings for each course are listed below.

CHEM 234: The following data are based on the attached presentation rubric (Chem. 234 Presentation Rubric):

Level	Percentage of Students
Complete Mastery of the outcome (30-28%)	76%
Mastered the outcome in most parts (27-25%)	15%
Mastered some parts of the outcome (24-22%)	9%
Did not master the outcome at the level intended	0%

CHEM 310: The following data are based on the attached presentation rubric (Chem. 310 Presentation Rubric):

Level	Percentage of Students
Complete Mastery of the outcome	68%
Mastered the outcome in most parts	16%
Mastered some parts of the outcome	16%
Did not master the outcome at the level intended	0%

CHEM 320: All the student groups performed really well on this activity (average overall score = 91%), especially since the majority of the class indicated that this was their first time creating a website. The class scored highest in the visual appeal, organization and quality content categories, and lowest in the quality of writing and citation of sources categories.

Category	High Score	Low Score	Average Score
Visual Appearance	100%	90%	93.9%
Organization	100%	85%	93.3%
Quality of Content	100%	84%	93.3%
Quality of Writing	92%	82%	87.3%
Citation of Sources	100%	75%	87.2%
		Average Total Score	91.3%

The lower scores in the quality of writing and citation of sources categories are consistent with findings from previous years that showed that a decent number of our students still struggle with scientific writing even in their junior and senior years. However, their average writing scores in this project are much higher than averages in other writing activities assigned to previous cohorts. This overall improvement may be attributed to the fact that students worked in groups on this activity which allowed them combine and complement their skills, and significant feedback was

given to them at both the paper and initial website stages of this project. Overall, we can conclude that all of the student groups demonstrated mastery of this outcome; however, these data do not capture individual student performance and need to be interpreted with this is mind. Nonetheless, the results from this activity indicate that our students are highly capable of working collaboratively in groups and this group work results in improved outcomes relative to individual work.

CHEM 351: The class as a whole did well on this exercise and they conveyed the material in both a scientific way and in language accessible to a non-expert. Their slides were aesthetically pleasing and complimented what they were saying well. In general, the students who did not completely master the outcome struggled with either interpreting the literature or making connections to topics already studied in the course.

Level	**Percentage of students**
Complete mastery of the outcome (38-40 pts)	86%
Mastered the outcome in most parts (32-37 pts)	14%
Mastered some parts of the outcome (26-31 pts)	0%
Did not master the outcome at the level intended (<26 pts)	0%

Results (Minor):
Please see above.

V. Closing the Loop

Closing the Loop (Major/Graduate/Certificate):
The action plan based on the assessment result for each course is listed below.

CHEM 234: This is the first time we have included a presentation based multistep synthesis project into this class. I included it because it a lab course but due to COVID the course was remote. Normally students have a practicum at the end of second semester organic lab that encompasses the techniques and spectroscopic analysis they have learned throughout the year of organic lab. Therefore, this multistep synthesis project provided another way to create a comprehensive, cumulative experience for this course. This project was very successful and will be required in this class in the future.

CHEM 310: Most students participated relatively equally with their partners in giving their presentations and gave well prepared presentations but had difficulty handling the Q&A. Therefore, the department should formalize the training students to include methods for anticipating and cogently responding to questions when giving presentations.

CHEM 320: Although this was a group activity designed to help student develop their collaborative skills, it would be important to establish a method to assess individual student performance on these kinds of group activities to better ensure that all students are achieving the desired level of mastery. Previous attempts at doing this included asking group members to fill out a peer evaluation, and having individual students write a short reflection on their contribution to the

project and assigning themselves a grade. These approaches proved unsuccessful, as students tend to be uncomfortable evaluating each other, and often assign grades to themselves based on their perceived effort and not necessarily on the quality of their work. It is possible that this particular issue may be resolved through other individual activities that assess one or more of the same skills within the same course.

CHEM 351: This presentation was done in pairs, so it is difficult to assess the individual students. However, working with a partner did foster the collaborative environment found in science. Moving forward, this exercise could be changed to individual presentations which would make assessment of the student more direct. To help the students who did not completely master the outcome, increasing the number of check-ins during the semester may help keep the students on track and provide resources and one-on-one help to fully understand the material. Presentations will be maintained in the biochemistry courses because they are an integral part of the field.

Closing the Loop (Minor):
Please see above.

VI. Suggestions from AY 2019-2020 Feedback

Suggestions (Major/Graduate/Certificate):
In response to the feedback from the AY 2019-2020 assessment report: the mission statements are the same for both the Major and Minor.

Suggestions (Minor):
Please see above.

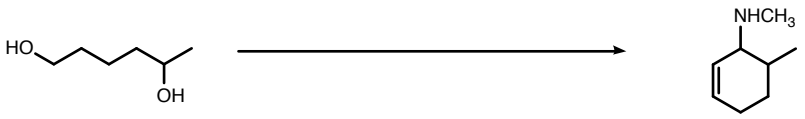
Additional Materials

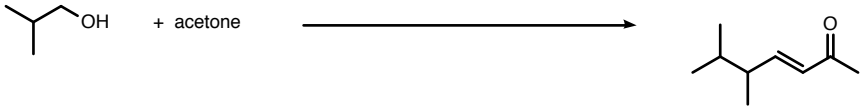
BS CHEM Curriculum Map: 3-Year Assessment Plan

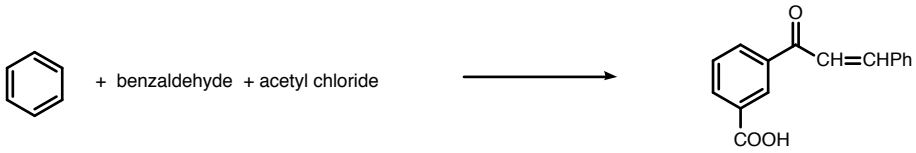
Chemistry Program Learning Outcomes **A=Assessed**	**113**	**114L**	**230**	**232L**	**231**	**234L**	**260**	**340/341**	**333**	**332**	**350/351**	**352**	**410**	**320**	**397**	**334**
Year 1: AY 19-20 **Year 2: AY 20-21** **Year 3: AY 21-22**	**General II**	**General Lab II**	**Organic I**	**Organic Lab I**	**Organic II**	**Organic Lab II**	**Analytical + Lab**	**Physical I/II**	**Advanced Organic Lab**	**Medicinal**	**Biochemistry I/II**	**Biochemistry Lab**	**Integrated Lab**	**Inorganic**	**Research**	**Advanced Synth**
LO #1: Students will demonstrate his/her mastery of the five principle disciplines: analytical, organic, physical, inorganic, and biochemistry	A				A		A	A						A		
year of assessment (1-3 means you may be collecting data every year anyway….ACS exam or common final exam question).	1-3				1-3?		1-3	1-3						1-3		
LO#2: Students will recognize and understand the concepts and skills learned in prerequisite courses at or before the start of the new course or laboratory	A		A			A		A			A			A		
year of assessment	1		1					1			1			1		
LO#3: Students or student teams will demonstrate excellent problem-solving skills in performing a broad variety of analytical, computational and synthetic procedures using proper safety protocols, and will critically evaluate the results (i.e. Lab Practical)		A				A	A		A			A	A	A		
year of assessment		3				3	3		3			3	3	3		
LO#4: Students will demonstrate effective scientific communications skills in both written and oral form. Students will be able to write reports and present results while following professional policies regarding intellectual property, plagiarism, and group work									A*	A*	A†	A*	A*	A	A	
year of assessment (written or oral)									2	2	2	2	2	2	2	

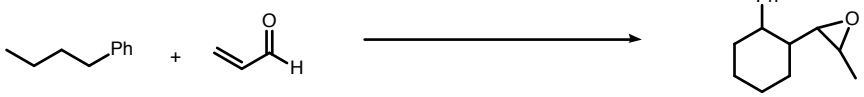
* Denotes course was cancelled due to COVID or the low enrollment policy
† Denotes course was added to assess as many students as possible
Not shown is the elective course Kitchen Science (CHEM 310) which is added to LO#4 during Year

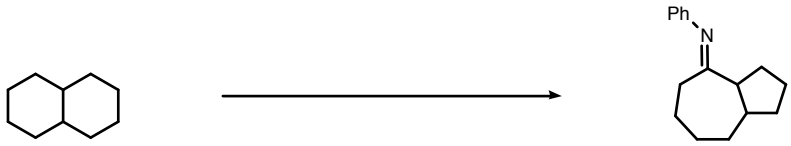
Chem 234 Synthesis Problems

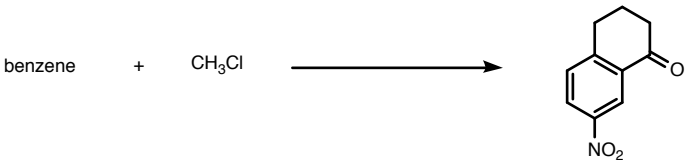
1. 

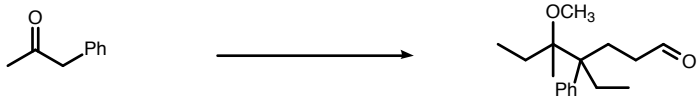
2. 

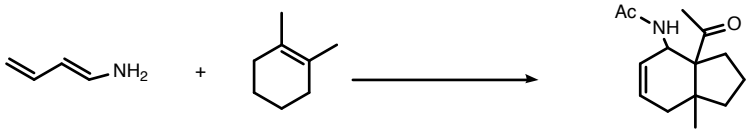
3. 

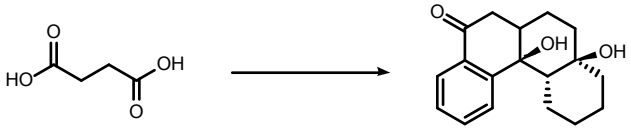
4. 

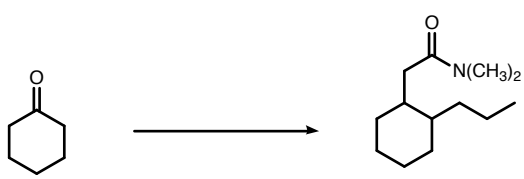
5. 

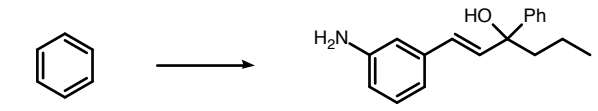
6. 

7. 

8. 

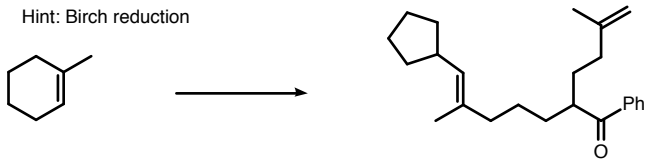
9. 

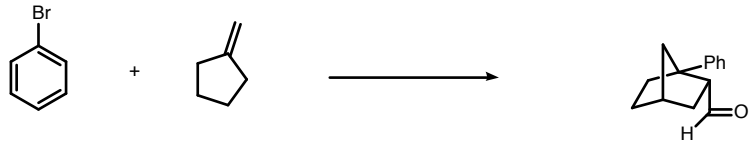
10. 

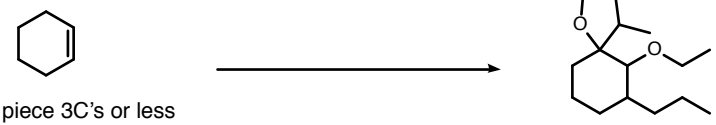
11. 

+ 1-propanol

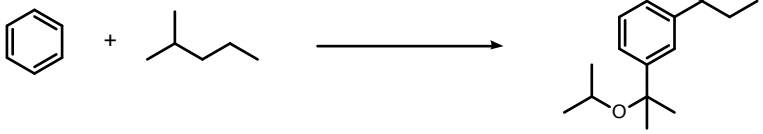
Hint: Birch reduction

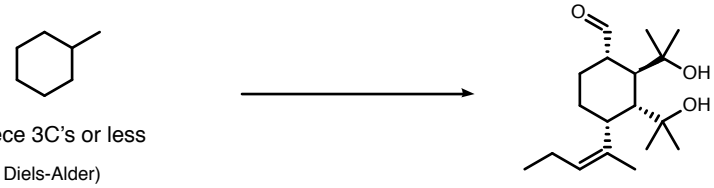
12. 

13. 

14. 

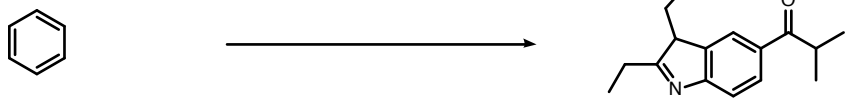
+any piece 3C's or less

15. 

16. 

+any piece 3C's or less

(hint: Diels-Alder)

17. 

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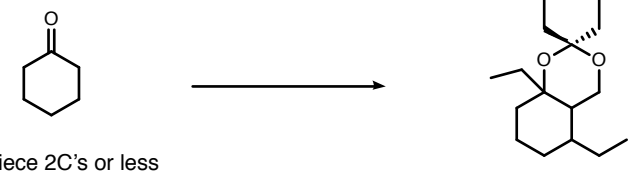
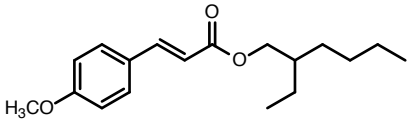
18. 

+ any piece 2C's or less

19. phenol

+ butanoil



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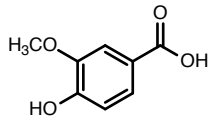

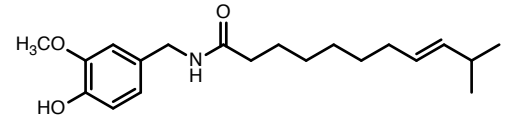

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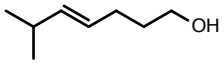

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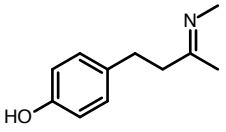

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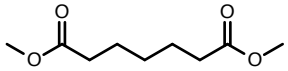

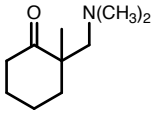

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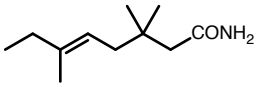
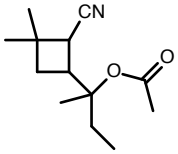
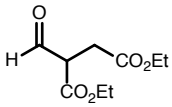
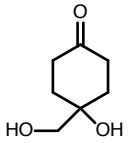




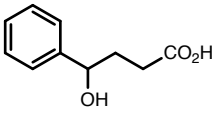
hint: epoxide

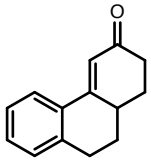
24.





25.





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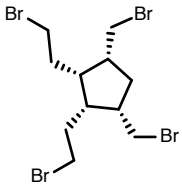

Your Name/Lab Section_____

Lab Partner's Name_____

Synthesis Project Worksheet

You will upload the following for this project:

i) This filled in Worksheet (30 Points)
ii) Your PowerPoint Presentation (20 Points)
iii) Your American Chemical Society (ACS) Journal Article (10 points)
iv) The relevant 1H and/or 13C NMR from the article or Supplemental Information (see question 7e below) (10 points)

What number is your synthesis:

Write your synthesis problem below:

1. (1) Which carbon-carbon bond forming reaction(s) are you using in your synthesis?

2. (3) Provide a retrosynthesis for the formation of the carbon-carbon bond forming reaction(s) in your synthesis.

3. (6) Provide the reagents for each step of your synthesis. Draw the product of each synthetic step.

4. (3) Provide the mechanism(s) for one of the carbon-carbon forming reaction(s) in your synthesis.

5. (3) Provide the mechanism for one of the other non-carbon bond forming reactions in your synthesis.

6. **Upload** an article published in the last 10 years that employs **one** of the carbon-carbon bond forming reactions you used in your synthesis from **one** of the following American Chemical Society (ACS) journals:
    a) *Organic Letters* (OL)
    b) *The Journal of Organic Chemistry* (JOC)
    c) *The Journal of Medicinal Chemistry*
    d) *the Journal of the American Chemical Society* (JACS)

    To do so go to https://www.usfca.edu/library and click on Search → databases, then type in "ACS publications" and click on ACS publications. In the drop down menu select Title and then search the name of the reaction. This will bring up a list of articles in all of the ACS journals. Sort: Relevance (Date) Newest first and find an article from one of the journals listed above that was published in the last 10 years.

7. All of the following questions refer to the article you uploaded. Some of the information might be found in the experimental details supplied in the Supplemental Information for the article.

    a) (3) Provide a specific example from the paper of your carbon-carbon bond forming reaction, including reaction conditions (i.e. solvent, temp., etc.)

b) (4) As you would in your notebook, list the step-by-step procedure for running and working up the reaction you provided in part 7a, NOT including the purification steps. This can be found in the **Experimental Section** or in the Supplemental Information provided for the article.

c) (2) How was the reaction in part 7a monitored? If this information is not included in the article or Supplemental Information also note that here and suggest a method that you have learned in lab that could have been used and why.

d) (2) How was the product in part 7a isolated and purified? If the product wasn't purified after isolation also note that here and suggest a method that you have learned in lab that could have been used and why.

e) (3) The NMR data is supplied in the article's Experimental Section or Supplemental Information. In addition the spectra for the article can usually found in the Supplemental Information. If available, provide the 1H NMR and/or 13C NMR of the product in part 7a and use specific aspects of these spectra to concisely explain how this data allowed the authors to determine with certainty that they isolated the product? (Were there any diagnostic peaks that either appeared or disappeared that were indicative of a successful reaction?)

Chem 234 Presentation Rubric

Names: _____ Section: _____

Synthesis #: _____

***Presentation partners will receive the same grade unless there is a clear distinction between their participation in the presentation.**

	Score	Comments
Presentation*		
Participation – Both students contributed (relatively) equally to the presentation.	**/4**	
Visual aids – Presentation materials were clear, complete and organized.	**/4**	
Questions – Both students contribute and try to give thoughtful answers.	**/4**	
Content (visual and oral)		
Must include – Synthesis problem, Synthetic Strategy and/or Retrosynthesis, Complete Synthesis.	**/6 (2 each)**	
Spectral data – Proposed IR, 1H and 13C NMR data that conclusively characterizes their synthetic product.	**/6 (2 each)**	
ACS Literature – Cited Scheme with C-C bond forming reaction	**/6**	

TOTAL: _____/30

Chem 310 Presentation Rubric

Group Members: Grade:

Topic:

(D range) 60-69	(C range) 70-79	(B range) 80-89	(A range) 90-100
Group as a whole does not demonstrate understanding of topic and its significance; Appears to have simply memorized presentation without any depth of knowledge.	Unable to clearly articulate topic although has some understanding of its significance; Significant variability in presentation by group members.	Clearly articulates topic and significance; errors in presentation indicating some lack of understanding. All group members have relatively equal and good understanding of topic.	Clearly articulates topic and significance; little to no errors in presentation; all group members demonstrate significant understanding of the topic.
Confusingly presented.	Somewhat disorganized presentation.	Adequate and relatively complete presentation.	Outstanding presentation with few ambiguities.
Dominated by organizational problems leading to difficulty in understanding the presentation.	Problems in organization leading to portions of the of the presentation that are difficult to understand.	Good presentation; clearly organized; mostly easy to understand and follow.	Excellent, well-expressed presentation; clearly organized; consistently easy to understand and follow.
Unable to answer/give a thoughtful response to most/all questions.	Able to answer/ give a thoughtful response to some but not the majority of questions.	Able to answer/give a thoughtful response to the majority of questions.	Able to answer/ give a thoughtful response to all questions.

When two ranges are highlighted in one category this means that the actual range in this category is someplace in between these two grade ranges (e.g., A-/B+)

Fall 2021

CHEM 320 Google Site Evaluation Rubric

Visual Appearance (20)
- Excellent use of font, color, graphics to enhance content
- Fonts are legible with consistent size
- Layout of website content enhances visual appeal and readability

Organization (20)
- Website organized into sections and subsections
- Good flow between different sections/topics
- Related information are presented together with minimal redundancy across different sections

Quality of Content (25)
- Topic is covered in-depth (thorough)
- Good quality figures, tables, and illustrations that help understand the project
- Figures have appropriate captions that are legible

Sources (10)
- Good quality primary sources
- Proper in-text citation of sources
- References formatted according to ACS style.

Quality of Writing (25)
- Easy to follow
- Good sentence structure
- No grammatical errors or typos
- Proper punctuation

CHEM 351 Faculty Feedback

Student presenters:

Topic of presentation:

Stated learning goal(s):

Grading criteria	Possible points	Earned points	Comments
Achievement of stated goal (is it possible for students to now do what you stated in your goal?)	10		
Knowledge of chosen topic (understanding everything that you present, critically evaluate what is being presented, etc.)	5		
Presentation organization (including keeping to time limits, referencing primary sources, appropriate use of terminology, correct spelling, etc.)	5		
Engaging the audience (making the lecture interesting, connecting your topic to other topics in the course, encouraging questions and answering them, etc.)	10		
Writing two exam style questions (a student who watches your presentation and takes the class should be able to answer)	5		
Providing written feedback to your peers' presentation (your feedback will be kept anonymous, compiled by me, and sent to each group)	5		
Final grade (out of 40 pts)			