UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

Chemistry Majors and Minors Aggregate Report

Academic Year 2021-2022
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 2021?**

   This is the third year of our 3-year assessment plan which had no planned changes. However, we were unable to provide assessment of two courses (Analytical Chemistry Lab, CHEM 260L and Experimental Biochemistry, CHEM 352) due to either the instructor leaving or being on sabbatical.

II. Mission Statement & Program Learning Outcomes

1. **Were any changes made to the program mission statement since the last assessment cycle in December 2021? 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 2021? 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 2021-2022.**

The Department of Chemistry underwent an APR on October 28-29, 2021. Prior to the APR, we had assessed all PLOs for that cycle. Now, we will assess all PLOs again before the next APR.

PLO(s) being assessed (Major/Graduate/Certificate):
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.

PLO(s) being assessed (Minor):
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.

III. Methodology

Methodology used (Major/Graduate/Certificate):
LO#3 was assessed in General Chemistry Lab II (CHEM 114), Organic Chemistry Lab II (CHEM 334), Inorganic Chemistry (CHEM 320), Advanced Organic Lab (CHEM 333), and Integrated Lab (CHEM 410). Due to two faculty either leaving the department or on sabbatical, we are unable to provide assessment for two courses that were on the curriculum map which are Analytical Chemistry (CHEM 260) and Experimental Biochemistry (CHEM 352). The methodologies used in each course assessment are listed below:

CHEM 114: In the second semester of General Chemistry Lab, students were assessed on a lab practical (PLO 3) in the third week of a three-week experiment. The overall experiment was to see if fruit peels could be used to clean drinking water. In the first two weeks of this experiment, students made (saponified) fruit peel samples and tested them to see if the peels could adsorb dyes under a given set of conditions. In the third week, when the lab practical took place, students made a group hypothesis to test dye adsorption under different independent variables to maximize binding. Students were not allowed to use lab manuals, but could use their lab notebooks, probing at their ability to keep an updated, meticulous lab notebook. First, they needed to form a group hypothesis to test one independent variable such as temperature, time, ionic strength, etc. on dye adsorption. Then, groups worked together to carry out the experiment to accept/reject their hypothesis. Students were assessed on the quality of their hypothesis, testing the hypothesis, recording the data, and writing a claim based on the evidence collected.

CHEM 234: A lab practical was administered to all students taking CHEM 234 during the last day of lab as a way to assess their expertise in fundamental laboratory skills first gained in CHEM 232, and regularly utilized throughout CHEM 234. The lab practical required students to ***independently*** set up a reflux apparatus, perform an extraction of a 2-component mixture, and analyze the results of their extraction using thin-layer chromatography, all within the span of 2 hours. Lab instructors were provided with a rubric that evaluated students on the basis of technique, laboratory problem-solving, and proper data analysis. Each step of the procedure was graded on a scale of 0–3, with a maximum of 51 possible points. Students were able to utilize their lab notebooks but no other support materials, and had the previous week to practice lab techniques.

CHEM 320: Students were asked to quantify the concentration of an unknown sample of $NiSO_4$ for assessment of the lab practical (PLO 3). They were given a known concentration of $NiSO_4$, one cuvette, deionized water, and an unknown concentration of $NiSO_4$. Students were required to develop a protocol with minimal guidance before lab started using concepts learned from General Chemistry (CHEM 111, 112, 113, 114) and Analytical Chemistry (CHEM 260). Once in the lab, the students swapped protocols with each other to test how thoroughly and concisely the protocol was written. After peer feedback, students rewrote their protocol addressing the points of concern, and performed the experiment. Students were assessed on their revised protocols, a reflection of challenges encountered when switching protocols, and a properly formatted calibration curve with calculations for determining the concentration of the unknown.

CHEM 333: After a semester of learning a wide variety of advanced organic lab techniques and complex data analysis, including performing air-sensitive reactions, purification by flash chromatography and interpreting 2-D NMR and chiral GC data, the students in this class were assessed on the lab practical “A Short, One-Pot Synthesis of Wellbutrin/Bupropion [the Hydrochloride salt of (+/-)-2-(t-butylamino)-3’-chloropropionone].” This practicum occurred over two lab sessions: During the first, they synthesized and isolated Wellbutrin, and in the second they collected and interpreted spectral data[1] (IR, 1H, and 13C NMR) on their synthesized Wellbutrin. Over both sessions, they worked with their semester-long lab partners. In addition, they were only allowed to speak with their lab partner during the experiment and while interpreting their data.[2] They were, however, allowed to ask me questions about safety or waste disposal. During the first week of the practicum, the student’s laboratory techniques were carefully assessed (see the attached rubric). In addition, over the two days of the practicum their step-wise and overall yields, the quantity and quality of their product, and their data interpretation were assessed (see the attached experimental and post-lab document).

1) During the semester the departmental NMR was not working, therefore, the students did not learn to accumulate their own spectra. They were, however, provide with the raw data (FIDs) to work-up using MNova.

2) There were 16 students and 8 hoods, therefore the students worked in pairs with the same lab partner throughout the semester. Normally, there are 8-9 students in this class, and students work alone.

CHEM 410: Integrated Lab is an advanced laboratory for students in their junior and senior years. They do a series of experiments involving the use of various departmental instrumentation and complete an independent research project that is presented at our annual campus poster session. The emphasis is on instrumental analysis, keeping good laboratory records, and communicating their results. The assessment exercise involved students acting as archaeological chemists and using gas chromatography mass spectrometry (GCMS) to analyze lipids adsorbed on "archaeological" potsherds. Students needed to:

- Keep an organized and detailed laboratory notebook record of their procedures and results
- Demonstrate an understanding of the theory behind GC and MS
- Operate the instrument safely and in a way that provided usable data
- Understand the difference between blank and control samples.
- Identify the fatty acids present on particular potsherds, calculate their ratios, and identify the oil that likely produced them.
- Write an abstract detailing their findings and the archaeological interpretations they could draw from them.

Student notebooks were assessed on how well they kept a record of what they did in the lab. Their understanding of GC-MS, blank/control samples, and identification of the fatty acids was mainly assessed in the pre-lab and post-lab questions. The abstract was assessed based on the detailed instructions given (see attached).

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 114: There were 131 students across 12 lab sections who participated in this practical. In the lab practical, students needed to rely on what they had written in their lab notebooks and their experience in the previous week to test a new, independent variable on dye adsorption. This practical emphasized the use of their lab notebooks and meticulous record keeping along with determining an independent variable, writing a hypothesis, and testing it. The class did well where about ~85% of the students completely or mostly mastered the lab practical. The remaining students either partially mastered the lab practical or did not master it at any level. There were two main points where students struggled the most. The first was creating a calibration curve and making a proper figure. Often, the graphs were incomplete from either not collecting enough points to make a good calibration curve or missing axes titles or labels. The second point of struggle was writing a claim based on the evidence they collected. This is often one of the most challenging aspects of the lab practical because it requires in-depth analysis of the data and/or pointing to the data to support or reject the hypothesis.

	Percentage of Students
Complete mastery of the outcomes (>90%)	49.6%
Mastered the outcome in most parts (80-90%)	35.9%
Mastered some parts of the outcome (70-80%)	12.2%
Did not master the outcome at any level intended (<70%)	2.3%

CHEM 234: 78 students (across 6 sections) participated in this lab practical. Of 51 total points, the average score on this assessment was 48.4, or 95%, indicating that the large majority of students demonstrated good mastery of LO#3 as assessed by the attached rubric.

	Percentage of Students
Complete mastery of the outcome (>90%)	89.7%
Mastered the outcome in most parts (80-90%)	9.0%
Mastered some parts of the outcome (70-80%)	1.3%
Did not master the outcome at any level intended (<70%)	0%

CHEM 320: Overall, the class of 16 students did well on this exercise as they wrote, revised, and carried out a lab protocol quantify the concentration of an unknown solution. This exercise was important for students to see that what, and how, they write for a protocol is extremely important. If only the first drafts were used, students would not have been able to effectively and quantitatively determine the concentration of the unknown. Two big things that the students addressed from their first draft to their final draft was being explicit in every step and not making assumptions that the reader would know what they mean and identify the most useful piece of information for analysis. In the latter, students often said something like 'measure the absorption spectrum for each sample'. However, no one made the statement to identify the maximum absorption wavelength and record it; an essential part of this experiment. This was a very challenging activity for all the students because they all had taken Analytical Chemistry and some General or Organic Chemistry remotely. However, the class seemed to rise to the occasion and overcome the lack of experience in the laboratory.

	Percentage of Students
Complete mastery of the outcome (>90%)	81.3%
Mastered the outcome in most parts (80-90%)	6.3%
Mastered some parts of the outcome (70-80%)	12.5%
Did not master the outcome at any level intended (<70%)	0%

CHEM 333: 1) COVID led to significant variations in student preparation for this class. The seniors in this class took Organic Laboratory I in person. However, in the Spring of 2020 their Organic Chemistry II lab course was disrupted by COVID, as were their Analytical and Inorganic Chemistry lab courses, all of which they took, at least in part, via Zoom. The juniors in the class had no in-person Organic I and II lab experience although some of the students had research experience. Throughout the semester, and during this practicum, the student's abilities to perform

independently (i.e., without my assistance) clearly correlated with their previous laboratory experience or lack thereof. 2) Due to COVID there were twice as many students in this class then there normally are. As a result, the students had to work in pairs throughout the semester, and the relatively experimentally inexperienced students had less opportunity to develop individual laboratory skills. 3) In general, the students with a greater amount of previous lab experience performed at a higher level on the practicum than those with less experience.

	Percentage of Students Lab Practicum / Technique
Complete mastery of the outcome (90-95%)	37% / 0%
Mastered the outcome in most parts (85-89%)	38% / 69%
Mastered some parts of the outcome (80-84%)	25% / 31%
Did not master the outcome at any level intended	0% / 0%

CHEM 410: Students came into the course with already well-developed skills at keeping a good laboratory notebook, and by the time this exercise occurred (about halfway through the semester) they were doing a great job and a formal point-by-point assessment was no longer needed. A series of pre-lab and post-lab questions led them through the theory and applications of GC-MS, and they all answered those correctly by using their textbook and external internet resources. This was the first time I had asked them to write an abstract for an experiment and they were assessed on whether all necessary parts (purpose, methods, results, conclusions) were present. The most difficult part was the archaeological interpretations, but as that is somewhat outside the scope of their major and the program objectives, that doesn't affect my assessment of their chemistry skills. All five of the students enrolled in the class mastered the objectives at a high level based on the assessments. This is the first time I taught the course so I don't have any data for year-on-year trends.

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 114: This lab practical was performed in pairs or groups of three due to the limited number of spectrophotometers, so it difficult to assess the individual students. However, working with a partner did foster the collaborative environment seen in science. A potential workaround for this challenge is to have students work independently but share the spectrophotometers between two or three students. For the two points of concern noted in the Results and Major Findings, students could get more practice making calibration curves and stating their claims. It is worth noting that this lab practical was done in the third lab of the second-semester General Chemistry Lab sequence. We are implementing more claim-based experience and assessments in all the lab experiments, which will give the students more practice.

CHEM 234: Although the vast majority of students demonstrated a proficient mastery of the lab techniques assessed during this practical, the small number who performed below 90% likely struggled due to the individual nature of the lab practical as compared to the team nature of most labs throughout CHEM 234. Due to the large number of students per lab section, most of the labs performed in CHEM 234 are conducted by student teams of 2–3. Many student groups fall into a rhythm of assigning particular tasks to the same individual in order to finish the experiment faster. For instance, student A may always perform the extraction regardless of the experiment, while student B may always perform the TLC. During the lab practical practice week, many students found themselves performing techniques with their own hands for the first time. To improve on the mastery of this learning outcome, I intend to introduce one or more individualized skill-checks earlier in the semester.

CHEM 320: This assessment focused on developing and carrying out a useful protocol for the quantification of an unknown. It was challenging given that many students took Analytical Chemistry, Organic Chemistry, and even some General Chemistry over Zoom, which gave them very little lab experience. In fact, most of the lab coursework over the pandemic was through online systems like Labster or watching videos of the experiment and answer questions about it. I believe that the students did a great job given that this was the first semester back in about 1.5 years. I want to try this assessment again in future years to see what, if any, effect the pandemic had on this lab practical. Moving forward, one way to increase the number of students mastering this assessment would be to give them some pre-lab homework on what goes into an effective lab protocol.

CHEM 333: Due to COVID, a significant number of the students were relatively under-prepared for the rigors of this course. Nevertheless, the majority of students completely, or in most parts, mastered the assessed practicum outcomes (~72%). In addition, the number of students in the course and the lack of a lab coordinator was not optimal. These issues have now been resolved and will, presumably, remain so the next time the class is taught which should increase student learning.

CHEM 410: I don't propose any changes to the department/program for mastery of these outcomes.

Closing the Loop (Minor):
Please see above.

VI. Suggestions from AY 2019-2020 Feedback

Suggestions (Major/Graduate/Certificate):
In last year's assessment, the department was asked if the mission statements and PLOs for the major and minor are in fact identical. They have been identical for the last few years. However, we will discuss these mission statements and PLOs as a department.

Suggestions (Minor):
Please see above.

Additional Materials

BS CHEM Curriculum Map: 3-Year Assessment Plan (2019-2022)

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 <u>may</u> 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

BS CHEM Curriculum Map: 3-Year Assessment Plan (2022-2025)

Chemistry Program Learning Outcomes A=Assessed	**113**	**114L**	**230**	**232L**	**231**	**234L**	**260**	**320**	**332**	**333**	**334**	**340/341**	**350/351**	**352**	**397**	**410**
Year 1: AY 22-23 Year 2: AY 23-24 Year 3: AY 24-25	**General II**	**General Lab II**	**Organic I**	**Organic Lab I**	**Organic II**	**Organic Lab II**	**Analytical + Lab**	**Inorganic**	**Medicinal**	**Advanced Organic Lab**	**Advanced Synth**	**Physical I/II**	**Biochemistry I/II**	**Biochemistry Lab**	**Research**	**Integrated Lab**
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

CHEM 114 Rubric
Lab 5: Fruit Peels Week 3

- Overall (7 pts)
  - (4 pts) Carbon copy is legible and easy to read
  - (3 pts) Name, name of experiment, and date

- Group hypothesis (10 pts)
  - Something like "Increasing the temperature of the incubation will result in less dye adsorbed to the saponified peels because there is more energy overriding the electrostatic attraction."

- Data table of tested hypothesis (8 pts)
  - They need at least four data points of their independent variable
  - Calculated apparent binding capacity (only need to show once)

- Table for calibration curve (similar to page 31) is made and filled in (10 pts)
  - Dye name, stock solution concentration, peak wavelength
  - Concentration and absorption of each diluted standard

- Linear plot fit (y=mx+b) and goodness of fit (R) (5 pts)

- Writing a claim based on evidence (10 pts)
  - What is the new claim based on the experiment
  - What is your interpretation of the data (graphs, class data, trends, or other analysis) to support the claim(s)?
  - What did your observations mean in terms of your dye structure, charge, or the IMFs involved?
  - New hypothesis: "When we varied..., then….(that trend happens) which is different/ same as our initial group hypothesis"

Lab Practical Grading Rubric
(3 – nearly flawless, 2 – minor errors, 1 – major errors, 0 – skipped)

Reflux Setup	**Hood ___**	**Hood ___**	**Hood ___**	**Hood ___**
Proper positioning of stir plate and lab jack				
Proper setup of heating mantle, mantle cord, and rheostat				
Proper clamping technique (pinch)				
Proper glassware setup (RBF, Claisen adapter + stopper, reflux condenser)				
Proper water hose placement (inlet down, outlet up)				
Properly fitted drying tube (glass + rubber)				
Extraction				
Proper separatory funnel positioning (iron ring)				
Proper beaker and flask labeling				
Technique – addition to sep. funnel				
Technique – shaking/venting				
Sequential washing of organic layer (bicarbonate, water, brine)				
Proper drying technique ($MgSO_4$)				
Proper gravity filtration technique				
TLC				
Proper TLC plate and chamber setup				
Proper TLC development (labeled solvent front, not too high or low)				
TLC spots of a reasonable size/intensity				
Biphenyl Rf calculation (~0.8)				

CHEM 320 Rubric
Lab 2: Beer's Law Review
Post-lab Assignment (50 pts)

- Uploaded a PDF (3 points)
- Question 1 (10 points):
  - There should be a thoughtful responses discussing some or all of the following questions:
    - Describe what happened when you switched protocols
    - What challenges did you or the other group encounter
    - How could these challenges be avoided
    - What did you like about the protocol of the other group
    - How could you make your protocol better
- Question 2 (20 points):
  - This protocol should be very detailed. Look for:
    - (5 pts) Thoroughness
    - (7 pts) Explicit step(s) that describe how to make the samples for the standard curve such as
      - How should the samples be made
      - What should be used to accurately measure volumes
    - (3 pts) State the wavelength to monitor on the UVVis
    - (5 pts) Describe how to calculate the concentration of the unknown sample (could be as simple as "use the trendline determined from the known samples to calculate the concentration of the unknown sample"
- Question 3 (10 points):
  - The calibration curve should follow the guidelines from Lab 1 and posted on Canvas
  - Look for:
    - (2 pts) Scatter plot used (no lines connecting points)
    - (2 pts) Labels for x-axis (concentration in molarity) and y-axis (absorbance)
    - (1 pts) No graph title!
    - (2 pts) Trendline is present with equation
    - (3 pts) Caption is present. Should include the following information:
      - It's a calibration curve
      - Absorbance monitored at a specific wavelength
      - Equation should be either on graph or in caption
- Question 4 (7 points):
  - (2 pts) A representative calculation, or description of how to find it, should be included.
  - (3 pts) Average and standard deviation explicitly stated
  - (2 pts) Correct units and significant figures used

Chem. 333 Practical Assessment – Synthesis of Wellbutrin

α-Bromination

RXN SETUP/RXN – use of balance; reaction setup; stir plate, use of lab jack; rate of bromine addition
1=low, 3=high score

Students	1 – multiple problems with setup; bromine addition too fast	2- small problems with setup/bromine addition	3-No problems with setup/bromine addition

ROTOVAP – proper size flask to avoid bumping; proper use of rotavap
1=low, 3=high score

Students	1-Wrong flask size /bumping and unclear on use of rotavap	2- Wrong flask size /bumping/ **or** unclear on use of rotavap	3-right flask size, confident use of rotovap

Reaction with t-butylamine

EXTRACTION – purpose; identifies ether layer = top layer; shaking/venting technique; isolation of proper layer
1=low, 3=high score

students	1-poor technique and/or no understanding of which layer is which	2-mostly good technique, some uncertainty re which layer is which	3-good technique, awareness of which layer is which at all times

CRUDE ISOLATION – drying; gravity filtration setup (proper funnel, fluted filter paper, clamp)
1=low, 3=high score

students	1-flawed technique, no crude product obtained	2-some technique flaws, obtained crude product	3-good technique, obtained crude product

TLC – spotting (SM, co-spot, rxn mixture) & marking/staining; prediction/explanation of relative Rf of SM and product.
1=low, 3=high score

students	1-poor technique and poor understanding of Rf	2-good technique but poor understanding of Rf, or vice versa	3-good technique and good understanding of relationship of Rf to compound structure/polarity

ISOLATION OF HCL SALT – crystals obtained; vacuum filtration set-up (clamped, proper type/size of flask, neoprene collar)
1=low, 3=high score

students	1-No crystals obtained	2- obtained crystals, average technique	3- good technique, obtained crystals

CHEM 410 Rubric

Submit a typed abstract describing your experiment. Abstracts usually appear at the beginning of journal articles or in conference proceedings, and provide a succinct summary. An abstract consists of four parts, between 1-3 sentences each.

Purpose – What were the goals of the experiment?
Methods – What experimental techniques were used?
Results – What are the key findings of the experiment?
Conclusions – What do the results mean in light of the purpose of the experiment?

Write an abstract about your results of Experiment 5, as though you were analyzing real potsherds from Knossos. What purpose would an archaeological chemist have for analyzing these sherds? How did you do the analysis? What oils did you find on the sherds? What archaeological interpretations can you draw?