UNIVERSITY OF SAN FRANCISCO | College of Arts and Sciences

ASSESSMENT REPORT (REGULAR TEMPLATE)

BS CHEMISTRY_AGGREGATE

ACADEMIC YEAR 2019 - 2020

REPORT DUE DATE: December 4, 2020

This is our regular assessment template.
Given the unusual circumstances of the 2019-2020 academic year, each program/department/major/minor/certificate has two options of assessment:
(a) Usual assessment report based on this template OR
(b) Alternative assessment reflections on distance learning pivot based on the alternative attached template
Every program/department/major/minor/certificate can choose ONE of the two alternative reports to submit

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- **Who should submit the report? – All majors, minors (including interdisciplinary minors), graduate and non-degree granting certificate programs of the College of Arts and Sciences.**
- **Programs can combine assessment reports for a major and a minor program into one aggregate report as long as the mission statements, program learning outcome(s) evaluated, methodology applied to each, and the results are clearly delineated in separate sections**
- **Undergraduate, Graduate and Certificate Programs must submit separate reports**
- **It is recommended that assessment report not exceed 10 pages. Additional materials (optional) can be added as appendices**
- **Curriculum Map should be submitted along with Assessment Report**

Some useful contacts:

1. Prof. Alexandra Amati, FDCD, Arts – adamati@usfca.edu
2. Prof. John Lendvay, FDCD, Sciences – lendvay@usfca.edu
3. Prof. Mark Meritt, FDCD, Humanities – meritt@usfca.edu
4. Prof. Michael Jonas, FDCD, Social Sciences – mrjonas@usfca.edu
5. Prof. Suparna Chakraborty, AD Academic Effectiveness – schakraborty2@usfca.edu

Academic Effectiveness Annual Assessment Resource Page:

https://myusf.usfca.edu/arts-sciences/faculty-resources/academic-effectiveness/assessment

Email to submit the report: assessment_cas@usfca.edu

Important: Please write the name of your program or department in the subject line.

For example: FineArts_Major (if you decide to submit a separate report for major and minor); FineArts_Aggregate (when submitting an aggregate report)

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).**

Osasere Evbuomwan
oevbuomwan@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?

AY 18-19 was the final year in our previous 3-year assessment plan. A new 3-year assessment plan was developed (see attached).

II. MISSION STATEMENT & PROGRAM LEARNING OUTCOMES

1. **Were any changes made to the program mission statement since the last assessment cycle in October 2019? Kindly state "Yes" or "No." Please provide the current mission statement below. If you are submitting <u>an aggregate report, please provide the current mission statements of both the major and the minor program</u>**
   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 October 2019? 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.**

Yes, a minor change was made to the PLOs. LO#5 was removed as the department agreed that it wasn't exactly a program learning objective but rather, a goal or an aspiration.

"*LO#5: Students will be encouraged and recognized when they go beyond the minimum requirements in the major via semester or summer-long activities that apply the knowledge gained in the discipline, such as research at USF, NSF-REU programs, science internships, discipline-related volunteer or paid science positions, ongoing outreach/teaching in science or PLTL leadership experience.*"

Note: Major revisions in the program learning outcomes need to go through the College Curriculum Committee (contact: Professor Joshua Gamson, gamson@usfca.edu). Minor editorial changes are not required to go through the College Curriculum Committee.

PLOs (Major/Graduate/Certificate):

LO #1: Students will demonstrate their mastery of the four (or five for BS biochemistry emphasis) principle 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) principle 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.

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

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.

PLO(s) being assessed (Minor):

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.

III. METHODOLOGY

Methodology used (Major/Graduate/Certificate):

LO#2 was assessed in Organic Chemistry I (CHEM 230, sections 1 - 4), Analytical Chemistry (CHEM 260), Inorganic Chemistry (CHEM 320), and Biochemistry II (CHEM 351). Please note that the data presented for CHEM 230 in this report was collected in Fall 2020 instead of Fall 2019 due to some mixed communication. Attempts at assessing this learning objective in General Chemistry II (CHEM 113) and Physical Chemistry II (CHEM 341) were unsuccessful due to the sudden shift online brough about by the pandemic in Spring 2020. The methodologies used in each course are listed below:

CHEM 230: The instructors in each of the four sections of Organic Chemistry I (CHEM 230) gave a Lewis structure quiz the Friday of the first week of class. The ability to draw accurate chemical structures with proper formal charges on specific atoms presumably correlates with student success in organic chemistry. Students are taught how to draw Lewis structures in General Chemistry and a few weeks before the semester started students were emailed a list of topics, including Lewis structures, that they should review to prepare themselves for success in Organic Chemistry. They were also told via email and Canvas announcement that there will a be a quiz the first week of class that is primarily focused on Lewis structures. Each professor also reviewed this skill in the context of organic chemistry on the first day of class. In addition to providing an assessment of Chemistry Program Learning Outcome #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" – the quiz also encouraged Organic Chemistry I students to start the semester strong by studying Lewis structures and a few other topics prior to the first day of class. We assessed students' abilities to: generate structures from molecular formulas and condensed molecular structures, properly employ single and multiple covalent bonds, ionic bonds, apply the octet rule, and assign formal charges to atoms within the structures.

CHEM 260: Students earned a digital badge by successfully completing and recording a lab technique learned in general chemistry lab. The badge was earned after practice with a partner from a written 7-step "must have in a video" procedure: "Properly fill a buret, run out liquid to a starting volume and <u>deliver about 10 mL of liquid</u> showing proper delivery to a flask. Read the exact initial and final volumes". Three lab TAs graded the videos using a rubric, and the instructor spot-checked the video grading and found no disagreements.

CHEM 320: Students were assigned a lab practical in which they were required to determine the concentration of an unknown solution. The goal of this practical was to evaluate student retention of lab skills from Analytical Chemistry (CHEM 260), which is a prerequisite for CHEM 320. Students were required to design and execute the experiment entirely on their own working in pairs or groups of three. The quality of experimental design, accuracy of final results, and lab report writing skills were evaluated.

CHEM 351: To assess the ability of students to recognize and understand the concepts and skills learned in prerequisite course, the instructor administered a quiz on the first day of class on material from CHEM 350 Biochemistry I. Students were not informed of the quiz beforehand. All 26 students who took the quiz had taken the prerequisite course the previous semester (Fall 2019). Students worked individually on the assignment, which consisted of 5 multiple-choice questions. The quiz is 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):

Results obtained for each course are listed below the corresponding course number.

CHEM 230:

We broke down our assessment based on student mastery of a) assigning formal charges, and b) drawing Lewis structures on the quiz. The benchmarks were: Good = > 80%, Adequate = 70%-80%, Poor = < 70%. We averaged the percentage of students who achieved each of these benchmarks over the four sections, which allowed for variability in the difficulty of the quiz from section to section.

Mastery	*Lewis Structure Drawing*	*Formal Charge Assignment*
Good (> 80%)	*57%*	*58%*
Adequate (70-80%)	*21%*	*11%*
Poor (< 70%)	*22%*	*31%*

The data indicates that 70-80% of the students in the first week of Organic Chemistry have an adequate to good ability to draw Lewis structures with formal charges. With this assessment we are assuming that skill of drawing such structures indicates a potential for success in Organic Chemistry and indeed this data accords with our experience teaching this class. Specifically, it indicates that 1/4th – 1/3rd of our students are unprepared for organic chemistry, which correlates with our data on how many students drop the class or receive a C- or lower and are unable to go on to Organic Chemistry II over many years.

CHEM 260:

The passing grade in this activity was 7 out of 10 points. Students who scored below the passing grade were asked to re-shoot videos after feedback was provided.

Level for delivering volume using a buret (Total attempts))	***Percentage of Students (n=41)***
Complete Mastery of the outcome (10/10 points)	44%
Mastered the outcome in most parts (9/10)	41%
Mastered some parts of the outcome (7 or 8/10)	15%
TOTAL	**100%**
Did not master the outcome at the level intended on first attempt (6 or fewer points): all 2nd tries gave passing grade	25%

As this was a first-time assessment using cell phone video, we were quite encouraged by the outcome of 85% mastering most or all of the technique (some had a second try). However, the fact that 25% of the students did not come close to mastering a technique they had done several times in general chemistry lab on their first try, despite being supplied with a written procedure and practice with feedback from a partner before shooting the video, was somewhat concerning. It is possible that some students may have not been comfortable or nervous with video and just forgot steps or did not review the video before submitting. In an experiment, later in the course, utilizing this technique, lab TAs received almost no questions on "how do I do this" and the recorded data did not need correction (i.e. significant figures from the device).

CHEM 320:

This activity was designed to evaluate three things:

1) Experimental Design: Students needed to recognize that they were supposed to prepare standard solutions to generate a calibration curve and then use the calibration curve to determine the concentration of the unknown. They also needed to remember to run a blank.
2) Accuracy of Results: Result accuracy was heavily dependent on good lab technique. Students needed to accurately measure volumes, generate a good quality standard curve (R-squared value close to 1.000), and recognize that the unknown solution had to be diluted in order for its measured absorbance to fall within the standard curve.
3) Writing lab reports: Students are introduced to writing full lab reports in CHEM 260 and were expected to demonstrate mastery of this skill in this activity. The reports were expected to consist of an introduction, experimental methods and instrumentation section, a results and discussion section, and a conclusion.

Students in general seemed to do well in the parts of this activity that involved group work (experimental design, result accuracy) but some struggled with the parts that involved individual work (lab report). Although most student groups were able to figure out the experimental design and execution components of this activity for some groups, success in this area was mainly due to one student knowing what to do and taking the lead on this project. Result accuracy for most groups was also above average for the most part, with the exception of a few instances where inaccurate preparation of standard solutions or failure to dilute the unknown solution either resulted in poor calibration curves or absorbance readings that fell outside of the standard curve. Several students struggled with calculating the concentration of the unknown solution using the line equation from the calibration curve and most students were unable to produce the quality of lab reports expected of them at this point in the curriculum. We have consistently found that our majors and minors struggle with scientific writing, particularly when it comes to analyzing and discussing results. In anticipation of this, the lab period preceding this activity was dedicated to a workshop focused on how to write a report. This workshop appeared to help with the quality of figures presented and most of the sections in the lab report however, students still appeared to struggle with the results and discussion section and more fundamentally, with general sentence structure and grammar. It is worth noting that by the end of the semester, there was a significant improvement in the quality of reports turned in for this course.

Level of Mastery	**Number of Students**	**Percentage of Students**
Complete Mastery of the outcome (>87%)	5	23%
Mastered the outcome in most parts (80 - 87%)	4	18%
Mastered some parts of the outcome (74 - 79%)	5	23%
Did not master the outcome at the level intended (< 74%)	8	36%
TOTAL	**22**	**100%**
Met the Benchmark (>=74%)	14	64%

The benchmark for this activity was set at a score of 74 %, which is reflective of the prerequisite C letter grade required for CHEM 260 in order to enroll in CHEM 320. A little under two-thirds of the class met the benchmark of a 74% (C letter grade) while a third of the class (8 students) did not achieve this standard. Of the eight students who failed to meet this standard, two of them had not taken CHEM 260, while four of them had earned a C/C+ grade in CHEM 260. These results are consistent with the fact that students who do not do as well in CHEM 260 have a harder time bringing working knowledge of the necessary prerequisite skills into CHEM 320. It also highlights the importance of enforcing CHEM 260 as a prerequisite for CHEM 320.

CHEM 351:

The preparation level of the students varied widely, as seen below. Approximately 50% of the students met the benchmark of 60% on the quiz. This is an improvement from the previous assessment of this learning outcome (Spring 2018), in which 20% students met the benchmark.

Level	Percentage of Students
Complete Mastery of the outcome	15.4%
Mastered the outcome in most parts	30.8%
Mastered some parts of the outcome	26.9%
Did not master the outcome at the level intended	26.9%

Results (Minor):

Please see above.

V. CLOSING THE LOOP

Closing the Loop (Major/Graduate/Certificate):

CHEM 230: A clearer analysis of whether student achievement on this quiz and their ability to achieve a C or higher in Organic Chemistry should be evaluated. To do so we need determine if there is a correlation between a student's grade in the class and their performance on the quiz. This, along with our data on which students dropped the class during this semester, will give us a relatively complete understanding of how/if weaknesses in the ability to draw chemical structures correlates with student achievement. We also need to determine if there is a correlation between student grades in General Chemistry II (CHEM 113), their grades on the quiz, and their overall achievement in Organic Chemistry. Assuming such correlations above are found, we will work with faculty in Chemistry and other departments (primarily Biology) to advise students who are less prepared for Organic Chemistry I to take Fundamentals of Organic Chemistry instead.

In the short term, we intend to record and post a video on Lewis structures for organic chemistry students to watch prior to entering Chemistry 230 and/or provide a one day summer workshop (live or synchronous on Zoom) on Lewis structure solving and other key aspects of General Chemistry to prepare students for Organic Chemistry I.

CHEM 260:

This assignment was very popular and easy to complete for students using the Canvas Cell Phone app for direct recording of video. To further improve student mastery, we will explore adding the requirement that students re-shoot the video after they see themselves on the first try and introduce video digital badges in the pre-requisite course which would help the comfort level. We would still need to determine the best approaches to enforce these new requirements. Nonetheless, the results of this activity were in-line with Purdue University [J.Chem.Ed. article] on success of digital badges as a mastery assignment.

CHEM 320:

The results of this activity reinforced a few things that we have noticed in the Chemistry program; particularly in lab courses: 1) Students often do well with group work but have a harder time demonstrating mastery of various skills on an individual level, and 2) There is significant room for improvement in student data analysis and scientific writing skills. To facilitate this improvement, we plan to permanently adopt a modified version of this activity over the first two lab periods in CHEM 320. The first lab period would involve experimental design and execution, and the second lab period would involve a writing workshop with peer reviews based on the results of the experiment. We would also like to explore a collaboration with CHEM 260 and other Chemistry faculty to develop a plan for students to "write across the curriculum". Such a plan would provide the opportunity for students to focus on learning how to write specific sections in each lab course in a scaffolded way. This approach could potentially allow for the introduction of more consistent writing standards across courses in the department. Finally, the results of this assessment highlight the need to strictly enforce CHEM 260 as a prerequisite as there is a clear correlation between failure to meet this prerequisite and poor student performance in this activity.

CHEM 351:

In previous assessment years, different adjunct instructors have taught one section of the prerequisite course, CHEM 350. The material covered may have varied, as well as the emphasis placed on different topics. With the addition of a new full-time faculty member to teach biochemistry, we anticipate that the curriculum in CHEM 350 Biochemistry I will be more consistent from year to year and this should result in an overall improvement in student performance on this quiz.

OVERALL:

Overall, the majority of students (>50%) appeared to bring reasonable working knowledge of prerequisite material and skills to the various courses assessed. In some courses, students were informed of these quizzes and had some time to prepare, while in others, they were not. These differences in notification approaches probably contributed to the varied performance levels in the different courses and led to more questions about how to accurately assess student retention of prerequisite knowledge. Specifically, does "retention" mean students should be able to remember information on the spot without notice? Or does it mean that they should be able to demonstrate proficiency after being given an opportunity to review the material?

In terms of lab skills, most of our students demonstrated adequate mastery in activities that were completed in groups, while students seemed to struggle with data analysis and writing scientifically. While the proposal to explore an approach to "writing across the curriculum" could present some potential benefits, significant improvement in the student writing skills would require more targeted feedback from faculty; however, we have found that this is only feasible with smaller lab sections (8 students or less). Another potential approach to addressing this issue to some extent would be to have our students take scientific writing courses that fulfill the written communication core requirement as this would provide a more tailored approach to meeting the writing needs of our program. We recognize that these approaches warrant more substantive discussions about the course enrollment policy and potential staffing of core courses and we will be more than happy to engage if there is room for such discussions.

Closing the Loop (Minor):

Please see above.

Suggestions (Major/Graduate/Certificate):

We agreed as a department that the fifth PLO was not necessarily a learning outcome and unanimously voted to remove it. We appreciate the other suggestions about revising the PLOs however, since we have already begun a new 3-year assessment cycle, we have opted to stick with the current PLOs as they are. We will engage in a departmental discussion on how to proceed with revisions and will incorporate any revisions we decide to make in future assessment reports.

Since some of the other suggestions made were about PLOs that were not assessed in this cycle, we have taken them to heart and will attempt to address them in future assessment reports that focus on those PLOs.

Suggestions (Minor):

Please see above

ADDITIONAL MATERIALS

(Any rubrics used for assessment, relevant tables, charts and figures could be included here)

BS CHEM Curriculum Map: 3-Year Assessment Plan

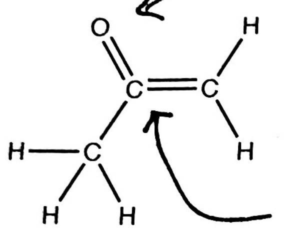
Chemistry Program Learning Outcomes **A=Assessed**	**113**	**114L**	**230**	**232L**	**231**	**234L**	**260**	**340/341**	**333**	**332**	**350/351**	**352**	**410**	**320**	**397**	**334**
Year 1: AY 19-20 **Year 2: AY 20-21** **Year 3: AY 21-22**	**General II**	**General Lab II**	**Organic I**	**Organic 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	
year of assessment (written or oral)									**2**	2		**2**	**2**	**2**	2	

CHEM 230 – Nikolayevskiy
Fall 2020 - Quiz 1

Name: key

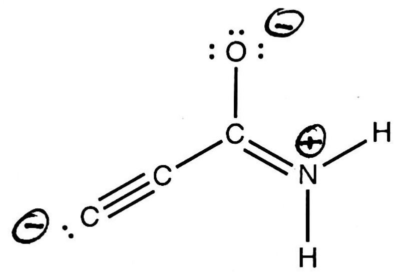
1. (1 pt) A student draws the following Lewis structure. In one sentence, describe what is wrong with this Lewis structure.

missing lone pairs



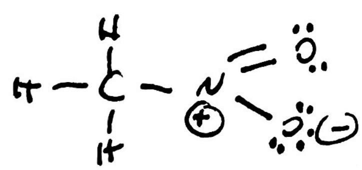
5 bonds, breaks octet rule

2. (3 pts) Indicate all the ***non-zero*** formal charges on the following Lewis structure.

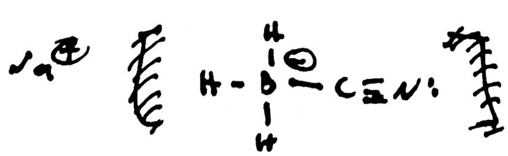


3. (6 pts, 3 pts each) Provide Lewis structures for the following molecular formulas. Include all non-zero formal charges where appropriate.

a) CH_3NO_2 (***Hint*** – all three H's are bonded to C)



b) $NaBH_3CN$ (***Hint*** – all three H's are bonded to B)



CHEM 351 Review Quiz

1. **The most important contribution to the stability of a protein's conformation appears to be the:**

    a. entropy increase from the decrease in ordered water molecules forming a solvent shell around it.
    b. maximum entropy increases from ionic interactions between the ionized amino acids in a protein.
    c. sum of free energies of formation of many weak interactions among the hundreds of amino acids in a protein.
    d. sum of free energies of formation of many weak interactions between its polar amino acids and surrounding water.
    e. stabilizing effect of hydrogen bonding between the carbonyl group of one peptide bond and the amino group of another.

2. **The relative mobility of different proteins during SDS-polyacrylamide gel electrophoresis is primarily determined by which property of the proteins**

    a. Antigenicity
    b. Hydrophobicity
    c. Isoelectric point
    d. Mass
    e. Native structure

3. **Which of the following would not alter the equilibrium of a biochemical reaction?**

    a. Increasing the substrate concentration
    b. Changing the pH of the reaction mixture
    c. Changing the temperature of the reaction mixture
    d. Adding a non-competitive inhibitor to the reaction mixture
    e. Adding an enzyme to the reaction mixture

4. **The fluidity of a lipid bilayer will be increased by:**

    a. decreasing the number of unsaturated fatty acids.
    b. decreasing the temperature.
    c. increasing the length of the alkyl chains.
    d. increasing the temperature.
    e. substituting 18:0 (stearic acid) in place of 18:2 (linoleic acid).

5. The chemical forces that contribute to the stability of the DNA due to the base stacking present in the DNA helix are

a. hydrogen bonds.
b. van der Waals.
c. disulfide bonds.
d. van der Waals and disulfide bonds.
e. None of the answers are correct.

CHEM 260 RUBRIC for video grading (audio required: 3-minute time limit)

Chem 260 Buret Digital Badge (narrated by the student) Must get 70% or higher (7/10 to Pass)

1. With buret clamp holding the buret on a stand: Place a funnel into the burette, add liquid via small beaker.
2. **Go past the zero mark, remove funnel and show how to check/remove air bubbles below the stopcock by running out some liquid below the zero mark.**
3. **State/read the initial volume of liquid to two decimal places & record in notebook.**
4. Adding liquid quickly at first, then drop-wise towards end point of about 10 mL delivered
5. Show how to touch the buret tip to the inside of the flask to remove the final hanging drop and wash down the inside of the flask with water bottle
6. **State/read the final volume of liquid to two decimal places and record.**
7. **Show how to do the math for volume delivered to two decimal places [should not be exactly 10.00 mL delivered]**

Bold items #2,3,6,7 are required for minimum mastery (7/10)

- If #1-7 all completed correctly (10/10)
- If only #1 or #4 or #5 is missing = 9/10
- If two of #1, 4 or 5 is missing = 8/10
- If any of #2,3,6,7 are not done correctly, mark this as 6/10 and Canvas will deny the Badge until Re-submit/re-grade.

Lab Project 1. Beer's Law Review: Determine the Concentration of an Unknown Sample

PROJECT GOAL:

The goal of this project is to determine the concentration of an unknown sample of $NiSO_4$. You will be provided with 20 mL of a 0.4 M $NiSO_4$ stock solution, a plastic cuvette, some DI H_2O, and an unknown sample, also containing $NiSO_4$. You will need to design an experiment that would allow you determine the concentration (average ± std. dev) of $NiSO_4$ in your unknown sample.

LEARNING OUTCOMES:

By the end of this project, students should be able to:

- Design and implement an experiment based on Beer's Law, with minimal guidance.
- Successfully operate a UV-Vis spectrophotometer.
- Determine the concentration of an unknown sample with the aid of a calibration curve.

PRELAB:

Follow the prelab instructions provided in the lab syllabus. In addition to these instructions, complete the following tasks:

- Outline the procedure that your group intends to follow to achieve your experimental goal.
- Create a table that contains pertinent information about the solutions you intend to prepare and analyze.

If you do this right, another group in the lab should be able to achieve the project goal by following your detailed instructions. We will test this by exchanging your procedure with another group for them to follow.

REPORT:

Write a full report based on the report guidelines posted on the canvas site. Save your report as a pdf file and upload to canvas by the due date.