

CHE 139. General Chemistry II Lab

Kahveci Group

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General Chemistry II Lab

Note: CHEM 139 General Chemistry II Lab (undergraduate level) was taught by [Murat Kahveci](#) at [DePaul University](#) in Summer 2020. [CHEM 139 Course URL](#)

Course Description

CHE 139 is a co-requisite for CHE 138, General Chemistry II. This course, in conjunction with CHE 138, can be used by non-science majors to fulfill a Scientific Inquiry-Lab (SI-Lab) learning domain requirement in the Liberal Studies Program. The virtual laboratory experiments will reinforce material presented in lecture and allow you to explore lecture topics in more detail. Specific learning objectives for each experiment can be found in the laboratory manual. You will be assessed based on your level of preparedness, observations made during the virtual experiments, data analysis, and overall understanding of the experiments. Your results, analysis, and understanding will be presented in laboratory reports. The laboratory is a critical component of your education as a scientist. Because of the importance of the laboratory, if you have two or more laboratory absences for invalid reasons, you will fail this course.

Schedule

Week	Experiment	Lab Experiment	Relevant Textbook Sections	Date
1		No Lab		7/20/20
	Experiment 1	Gas Chromatography: Raoult's Law	13.6	7/22/20
2	Experiment 2	Iodine Clock	14.2 – 14.5	7/27/20
	Experiment 3	Qualitative Analysis of Anions		7/27/20
	Experiment 4	KHP Titration	15.9	7/29/20
	Experiment 5	Acids and Bases	8.7, 16.2 – 16.8	7/29/20
3	Experiment 6	Buffer Solutions	17.2 – 17.3	8/3/20
	Experiment 7	Le Châtelier's Principle	17.5 – 17.7	8/3/20

Week	Experiment	Lab Experiment	Relevant Textbook Sections	Date
	Experiment 8	Amino Acid Titration	16.10, 17.4	8/5/20
	Experiment 9	Thermodynamics of a Cobalt Complex	8.9, 19.2	8/5/20
4	Experiment 10	Spectrophotometric Analysis of Manganese in Steel	18.6 – 18.9	8/10/20
	Experiment 11	Electrochemistry	19.3 – 19.6	8/12/20
5	Experiment 12	Coordination Chemistry	22.3 – 22.5	8/17/20
		No lab		8/19/20

Gas Chromatography: Raoult's Law

Summary: Goals, assignments, and Q&A highlights about the Raoult's Law Experiment.

Note: SSQ20: Experiment 1

1 Goals

- Determine the moles of each pure liquid per unit area (Equation 1).

$$n_A = A_{i,l} \frac{V_l \rho_i}{M_i A_{i,l}^0} \quad (1)$$

- Determine the mole fraction of component A in the liquid phase (Equation 2).

$$\chi_A^l = \frac{n_A}{n_{\text{total}}} \quad (2)$$

- Determine the partial pressure of each component (Equation 3).

$$P_{i,v} = A_{i,v} \frac{P_i^0}{A_{i,v}^0} \quad (3)$$

- Generate the Raoult's law plot (see Figure 1 in the manual).

2 Assignment

- Watch the Excel workshop video for calculations and plotting expectations.
- Download the students spreadsheet for the workshop and do step by step calculations in the workshop.
- Download the data set and do the same analysis.
- Upload the Worksheet in PDF format (download the template as MS Word file and fill it out by following the instructions).
- Upload all calculations and data tables in an MS Excel file.

3 Q&A Highlights

3.1 The area values for the pure substances

I noticed that we did not have the area (pA.s) values for the pure substances. This value is necessary in order to begin calculations on the rest of the data. I have watched the lab introduction videos as well as your excel tutorial but I could not find this information and am hoping for some guidance to point me in the right direction.

These values can be extracted from the Liquid data (the first table) and Gas data (the second table) separately. So, we will read this information as follows:

- When Part A equals to 1.0, it is **pure pentane** . Pure pentane has both liquid and gas phases.
 - Liquid area: 5.10×10^4 pA.s
 - Gas area: 6.19×10^4 pA.s
- When Part A equals to 0.0, it is **pure hexane** . Pure hexane has both liquid and gas phases.
 - Liquid area: 6.57×10^4 pA.s
 - Gas area: 2.82×10^4 pA.s

[illegible]

Figure 1. Data analysis view in Excel.

3.2 Pre/postlab quizzes

I just completed the post lab quiz for lab 1 but it doesn't let me see which questions I answered incorrectly. Is there any way you can turn this setting on?

I was just wondering how I can check what 2 answers I got wrong?

These quizzes are set for unlimited attempts because 70% or higher is needed to continue the next steps. Therefore, the feedback functionality is limited on them. You would not see which questions were answered incorrectly in a previous attempt.

3.3 Access to the datasets

I have completed to pre-lab, post-lab, and lab videos for Lab 1. Can I have access to the data now?

After the completion of postlab quiz with 70% or higher grade, you are allowed to download the data sets assigned to you. You may need to refresh your browser to enable the hyperlink for [Experiment 1 Raoult's Law Data](#).

3.4 The data for the worksheet

What data do I use?

The worksheet should be completed by using the Experiment 1 Raoult's Law Data dataset. This data set belongs to the [hexane](#) and [heptane](#) mixture.

3.5 The data for the Excel file

What data do I use?

According to the rubric, your Excel file should include the analyses of both data sets:

- [DCM](#) and [acetone](#)

- pentane and hexane

You will need to choose and report one of the data sets in the worksheet. Please make sure that you indicate which data set you chose by marking the appropriate checkbox in the worksheet.

Raoult's Law Students dataset is for only practice. This data set is used for instructional video. Students should download the DCM and acetone data and do the analysis while watching the video for the Excel workshop: Raoult's Law Excel Workshop.

3.6 The worksheet

Is the assignment only a worksheet, no lab report?

Yes. This experiment has only worksheet. You do not write a lab report.

3.7 Using the online version of MS Office and a Chromebook

I was wondering if you could assist me with making the graphs for Experiment 1... This is a very short video the issue I am running into.

Watching the video, I see that you are using the online version of MS Office and a Chromebook. I have not tested Chromebook specifically but I am quite positive that you need a regular computer to complete this course assignments. Even an old laptop/desktop maybe more powerful than a Chromebook. You should download and install a copy of MS Office on your computer in order to fully follow my instructions to make graphs and calculations in Excel. Here is the [link](#) for students to obtain a free MS Office copy.

4 Assessment

4.1 Misconceptions

Pentane and hexane can be considered dipole-dipole due to the both being dipolar molecules.

Please do your research more carefully. How do you determine the polarity of a compound?

Raoult's Law Plot is made with trendlines (linear fit function).

Not correct. This plot has hypothetical diagonal lines in order to observe deviations from the ideal behavior.

4.2 Formatting issues

- Figures have gridlines.
 - We require no gridlines on the figures. Please review the **Lab Report Guidelines** and **Sample General Chemistry Lab Report**.
- Figure titles are missing.
- Ranges for the chart axis values are not properly constrained.
 - e.g. Raoult's Law Plot should be constrained as follows:
 - Pressure (torr) ranges from 0.0 to 514.0
 - Mole fraction ranges from 0.0 to 1.0
 - This way your data will be easily interpreted by looking at the graph.
 - Remember we use plots to summarize our data in visual manner, not to confuse us even more.

4.3 Issues with calculations

- Formulae are missing.
- Values are not properly plugged in with units.
- Calculations are not shown step by step until the final result.
 - i.e. Writing a formula and a value as its final result do not suffice the requirement: **Include all of the steps necessary to obtain the correct value**.

4.4 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.5 Grades

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	83.02%	7.16%	83.50%	92.50%	66.25%
^a All zero values are excluded.					

4.6 Team grading

Table 1. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Proofreading and General Formatting	Figure Formatting
Prelab Assignment	Graph 1
Lab Conduct	Graph 2
Example Calculations	Excel Calculations: Acetone and DCM
Discussion Questions	Excel Calculations: Pentane and Hexane

Iodine Clock

Summary: Goals, assignments, and Q&A highlights about the Iodine Clock Experiment.

Note: SSQ20: Experiment 2

1 Goals

- Determine the general rate law for a chemical reaction by calculating the reaction rate for various concentrations of reactants.
- Using the concentrations listed on the reagent bottles and the volumes in Table 2, calculate the diluted concentrations for each species using

$$M_2 = \frac{M_1 V_1}{V_2} \quad (1)$$

- Calculate the reaction rate for each trial using the diluted concentration of thiosulfate and the time (in seconds) it took for the blue complex to appear, using

$$\text{rate} = \frac{1}{2} \frac{[S_2O_3^{2-}]_i}{\Delta t} \quad (2)$$

- The partial order of each reactant will be found by comparing different rates and sets of concentrations to one another, yielding the experimental rate law for this specific reaction.
- Use the method of initial rates and logarithms to calculate the partial order of each reactant for the **a** and **b** set of runs separately. e.g. The ratio of **run 2** over **run 1** gives:

$$\frac{\text{rate}_2}{\text{rate}_1} = \frac{k[H^+]_2^x [H_2O_2]_2^y [I^-]_2^z}{k[H^+]_1^x [H_2O_2]_1^y [I^-]_1^z} = \left(\frac{[I^-]_2}{[I^-]_1} \right)^z \quad (3)$$

where z can be found by

$$z = \frac{\log \frac{\text{rate}_2}{\text{rate}_1}}{\log \frac{[I^-]_2}{[I^-]_1}} \quad (4)$$

- This process is then repeated until all of the partial orders in the rate law are determined. The average partial orders should be listed to the same number of significant figures as the individual trial partial orders.
- Calculate the rate constant at that temperature using the rate and concentration data from any run

$$k = \frac{\text{rate}}{[H^+]^x [H_2O_2]^y [I^-]^z} \quad (5)$$

- k value should be calculated for each run, which means (4 runs) \times (2 trials) = 8 different k values are calculated.
- Report average k constant \pm standard deviation, following the rules for significant figures.

2 Assignment

- Watch the demo video for the experiment
- Download the data set and do the data analysis
- Upload the **partial lab report** in the PDF format:
 - This is a deviation for the summer session only.
 - Include the following sections: **Abstract**, **Procedures**, **Results**, **Data Table**, **Experimental Rate Law**, and **Discussion** (not a full discussion section; just itemize and answer the questions.)
 - You don't need to include sample calculations in the **partial report** (it is in Excel only), don't need to write narrative explaining data tables and calculations.
- Upload all calculations and data tables in an MS Excel file
- You should review the **Lab Report Guidelines**, **Sample General Chemistry Lab Report**, and **Appendix E** on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Concentrations of the stock solutions

I was only given the concentration for $[H^+]$. However I believe that I need the stock concentrations of the other reactants as well in order to be able to calculate the diluted concentration of thiosulfite. Is there something that I am missing about this?

Assume that the stock solutions are exactly prepared in the suggested values in Table 1.

Table 1. The concentrations of stock solutions.

Compounds	Concentration (M)
Hydrochloric acid	0.0500
Hydrogen peroxide	0.0500
Potassium iodide	0.0500

Compounds	Concentration (M)
Sodium thiosulfate	0.0100

3.2 Calculating the initial concentrations

We're supposed to calculate M_2 using data from Table 2. I'm not sure which volume to use with regards to runs since they change for different runs. Do I need to find M_2 of all reactants for all 4 runs? Or do I just need to find M_2 for a specific run?

Using the stock concentrations listed in Table 1 and the volumes in Table 2, calculate the diluted concentrations for each species by plugging in the values to Equation 1. These calculated concentrations are known as initial concentrations.

Table 2. First row of from the lab manual.

	Hydrogen peroxide	Hydrochloric acid	Potassium iodide	Sodium thiosulfate	Water
Run 1 volume (mL)	10.00	10.00	10.00	10.00	10.00

For example, the initial concentration of hydrogen peroxide Run 1:

$$M_{H_2O_2} = \frac{(0.5000 \text{ M})(10.00 \text{ mL})}{50.00 \text{ mL}} = 0.1000 \text{ M (4 sig. figs.)}$$

For Run 1, you will do this calculation for all species across the line. These values are the initial concentrations for Run 1. Repeat this calculation for all 4 runs and plug into Equation 3 to find the partial orders of x , y , and z .

Please note that you are expected to make an Excel table and do all of these individual calculations by using Excel functions.

4 Assessment

4.1 Misconceptions

4.1.1 Determining partial orders

The partial order of each reactant is the same value of the stoichiometric number or the exponent linked to a particular reactant.

Incorrect. Partial orders are experimentally determined using the initial concentrations. See Equations 3 and 4 for more details.

If the concentration of HCl were doubled, the reaction time would not change because thiosulfate is the limiting reactant and therefore the reaction time is dependent upon the consumption of thiosulfate. The concentration of H_2O_2 and KI do not effect the reaction time since the reaction time depends on the consumption of thiosulfate, the limiting reactant.

This explanation is based on the following rate law: $\text{rate} = k [\text{H}_2\text{O}_2]^1 [\text{HCl}]^1 [\text{KI}]^1$. If all partial orders are determined as 1, which is incorrect for this experiment, then every species would affect the reaction rate in the same proportion. e.g. If the concentration of HCl or H_2O_2 or KI were doubled, the reaction time would be half.

4.1.2 If the concentration of HCl were doubled, how would the reaction time change?

If the concentration of HCl were doubled, the reaction time would increase. The concentration of H_2O_2 would slow down the reaction time. The concentration of KI would speed up the reaction time.

This would increase the reaction time because there is more concentration so the reaction would take longer than it would have originally.

You would need to base your discussion on the experimental rate law that you discovered. If the species of interest has nonzero partial order, then you would be able to relate its concentration to the overall reaction rate.

Please remember that scientific argument is only valid (i.e. viable) if it is based on evidence. Therefore, you must use all the evidences you gathered in this experiment to answer these questions.

Another hint is that the question itself guides you to talk about some species, like H_2O_2 and KI.

Increasing any of the concentrations would allow for a faster rate to be observed. The reason behind this is that there are more particles in an increased concentration which allows for more collisions to happen. This would entail a faster reaction rate.

The rate law should be experimentally determined to answer this question.

4.1.3 Would you expect the rate constant to change if you heated up the reactants before mixing?

Yes, the rate constant would change if it were heated up. This would make the heat constant smaller because the time of the reaction would decrease.

I see two issues here.

1. You say that **if the rate constant were heated up**. Well, the rate constant is a concept; you cannot heat it up. Perhaps you meant the reaction vessel was heated up but it was not clear. Again, in a scientific argument we read what you say, as you say it. You have the observations and you have the power to make claims.
2. You said **the heat constant**. What do you mean? We did not define **heat constant** as a term in this context.

The rate constant would change if the reactants were to be heated up before mixing, the heat would increase the concentration which then would also increase the rate constant.

Again, there are two issues here:

1. You have no evidence to claim that **the heat would increase the concentration**.
2. Even if so, increasing concentration does not necessarily increase the rate constant. Hint: consider 0th order reaction.

4.1.4 How would a wet pipette affect the experimental results?

A wet pipette would change the experimental results in that it would increase the concentrations of the mixtures.

A wet pipette means that the solution is diluted.

A wet pipette could affect the experimental results significantly by increasing the delivered volume value, therefore making the experimental results inaccurate and inconsistent.

Disagree. Volume is measured correctly all the time by the use of pipette.

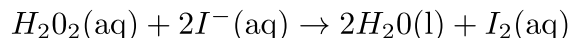
4.2 Formatting issues

If the concentration of HCl, H₂O₂, and KI were doubled the reaction time would also double (increase).

You should use an equation editor to write equations and chemical formulas properly. i.e. I expect to see H₂O₂ rather than H2O2.



You must use the equation editor for all equations and chemical formulas. So, I expect:



4.3 Issues with calculations

The overall reaction for Reaction 3 is determined by the sum of x, y and z. The sum is equal to 2.212.

Although the sum of partial orders can be a fractional number in rare cases, normally at this level you should use general case as whole numbers only. Remember that you learnt only 0th, 1st, and 2nd order reactions. We do not always explicitly say all details but you can use common sense when you do experiments and data analysis.

...the rate constant being $1.39 \times 10^{-6} \text{M}^{-1}.\text{s} \pm 2.64 \times 10^{-6}$.

There are a few issues:

1. Value and standard deviation do not share a common multiplier, when a multiplier is present.
2. Standard deviation does not have a unit.
3. Rules for significant figures are not followed.

The expected format is: $(1 \pm 3) \times 10^{-6} \text{M}^{-1}.\text{s}$.

- Standard deviation has 1 sig. fig. (requirement)
- The value has zero decimal place —same as the standard deviation (requirement)

4.4 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.5 Grades

Table 3. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	76.06%	8.51%	73.50%	95.50%	61.50%
^a All zero values are excluded.					

4.6 Team grading

Table 4. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Abstract	Table Formatting
Results	Prelab Assignment
Discussion	Postlab Quiz
Proofreading and General Formatting	Data Table
Experimental Rate Law	Average Rate Constant
Discussion Questions	Excel Calculations

Qualitative Analysis of Anions

Summary: Goals, assignments, and Q&A highlights about the Qualitative Analysis of Anions.

Note: SSQ20: Experiment 3

1 Goals

- Analysis of known solutions
 - For this experiment, you will first test a series of known samples, each containing a particular anion, according to the prescribed test for it and record your observations.
 - Download the lab notebook from the course web page, and take notes while watching the lab video recording. So, you will rely on your careful observations and own notes. This page will not be uploaded, it is for self-study only.
 - Lab manual has enough details for preparing the sample test solutions.
- Analysis of unknown solutions
 - You will then carry out the same analysis for two unknown samples, one from each batch of unknowns (i.e., NA #, NB #).
 - Using the figure below, determine the unknown sample.
 - Do not forget to note the unknown number in your lab report.

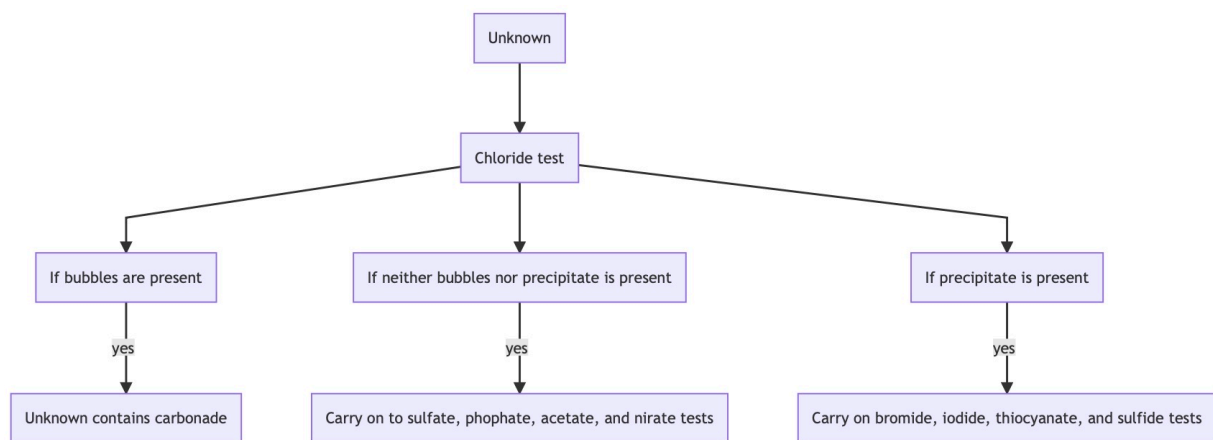


Figure 1. Suggested analysis flowchart.

2 Assignment

- Download the lab notebook from the course web page and fill it up while watching the demo video for the experiment.
- Download the data set and do the data analysis.
- You must upload a PDF file of **partial lab report**.
- You should review the [Lab Report Guidelines](#), [Sample General Chemistry Lab Report](#), and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

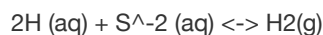
3.1 Lab notebook pages

I see in the Lab 3 instructions on your website that the lab notebook pages are used to collect the observations necessary to transfer them to the main data table in the partial lab report, would you like us to submit that file with the notebook page as well or will just the PDF of the lab report suffice?

Just the PDF of the lab report, with the required observations tables, is sufficient. The file for lab notebook pages is posted for your own use.

4 Assessment

4.1 Formatting issues



Should be $2\text{H}(\text{aq}) + \text{S}^{2-}(\text{aq}) \rightleftharpoons \text{H}_2(\text{g})$.

4.2 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.3 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	92.64%	6.94%	95.00%	100.00%	76.39%
^a All zero values are excluded.					

4.4 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Abstract	Table Formatting
Results	Prelab Assignment
Results Table for Known Samples	Postlab Quiz
Unknown Identification	
Discussion Questions	

KHP Titration

Summary: Goals, assignments, and Q&Q&A highlights about the KHP Titration Experiment.

Note: SSQ20: Experiment 4

1 Goals

1.1 Calculate the molarity of standardized NaOH

- Find the moles of KHP.

$$n_{\text{KHP}} = \frac{m_{\text{pure KHP}}}{204.2212 \text{ g/mol}} \quad (1)$$

- Determine the moles of NaOH using the stoichiometric ratio for the reaction.

$$n_{\text{NaOH}} = n_{\text{KHP}} \times \frac{1 \text{ mol NaOH}}{1 \text{ mol KHP}} \quad (2)$$

- Determine the molarity of NaOH

$$M_{\text{NaOH}} = \frac{n_{\text{NaOH}}}{V_{\text{NaOH}}} \quad (3)$$

where V_{NaOH} is the volume of NaOH in liters (L) to reach the endpoint.

- Calculate the average molarity of NaOH and its standard deviation. Use the average concentration value for the subsequent calculations.

1.2 Calculate the mass of KHP in impure KHP

- Calculate the moles of base delivered when analyzing the impure KHP sample.

$$n_{\text{NaOH}} = V_{\text{NaOH}} \times M_{\text{NaOH}} \quad (4)$$

where V_{NaOH} is the volume of NaOH in liters (L) to reach the endpoint for impure KHP titration.

- Calculate the moles of KHP using the stoichiometric ratio for the reaction.

$$n_{\text{KHP}} = n_{\text{NaOH}} \times \frac{1 \text{ mol KHP}}{1 \text{ mol NaOH}} \quad (5)$$

- Calculate the mass of KHP in impure sample.

$$m_{\text{KHP}} = n_{\text{KHP}} \times (204.2212 \text{ g/mol}) \quad (6)$$

- Calculate the mass percent of KHP in impure sample.

$$\text{mass \% KHP} = \frac{m_{\text{KHP}}}{m_{\text{impure sample}}} \times 100\% \quad (7)$$

- Calculate the average mass percent KHP and its standard deviation. Report the unknown number of the sample as well.

2 Assignment

- Print out pages 7-11 of the lab manual and respond to all prompts in a clearly written and well-organized manner.
- Presentation matters; sloppy and illegible work will not score well.
- Your goal is to use the space provided to communicate your understanding of this experiment.
- Scan and upload your work as a single PDF file by its deadline. You do not need to upload an Excel file for this experiment.
- You should review the [Lab Report Guidelines](#), [Sample General Chemistry Lab Report](#), and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Having double burette readings for a trial

I was wondering why each trial had two initial burette volumes and two final burette volumes instead of just one.

If the burette is to be refilled before the titration ends, you would have two readings of initial and final values. Another reason could be if you are delivering more than 50 mL volume. You would just sum the amount delivered from each reading.

4 Assessment

4.1 Misconceptions

If the sample did not completely dry, the mass reading would have overestimated the true value because there would be weight in water attributing to the reading.

Should consider mathematically. *Hint:* Does moisture affect the mol amount of KHP in the sample?

... If the volume increases then the concentration of the sample would increase as well.

How? Again, please consider mathematically. e.g. Consider the formula, where the mol amount, n , is constant in Equation 3. What would you expect about the trend when V gets larger?

4.2 Formatting issues

0.08692 M \pm 0.000212

Two issues:

- Incorrect sig.figs.
- Standard deviation has no unit

Should be reported as 0.0869 \pm 0.0002 M or preferably using the scientific notation: $(8.69 \pm 0.02) \times 10^{-2}$ M

- Rules applied:
 - Standard deviation is rounded to 1 sig. fig. (requirement)
 - Average value is matched to the decimal place in the standard deviation (requirement) (also see [this example](#))

4.2 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.3 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	78.19%	13.02%	81.75%	96.50%	58.00%
^a All zero values are excluded.					

4.4 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Proofreading and General Formatting	Prelab Assignment
Average NaOH concentration and Standard Deviation	Postlab Quiz
Average %KHP and Standard Deviation	Tables 1 and 2
Discussion Questions	Sample Calculations

Acids and Bases

Summary: Goals, assignments, and Q&A highlights about the Acids and Bases Experiment.

Note: SSQ20: Experiment 5

1 Goals

1.1 Examine the effect of dilution on the pH of strong and weak acids and bases

- Calculate, using $M_1V_1 = M_2V_2$, the concentration of HCl, NaOH, CH_3COOH , and NH_4OH for the 1:10 and 1:100 diluted solutions and the mixtures.
- Calculate $[\text{H}_3\text{O}^+]$ for each solution using the measured pH values and Equation 2.

$$\text{pH} = -\log[\text{H}_3\text{O}^+] \quad (1)$$

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} \quad (2)$$

- Make a plot of pH vs. concentration for HCl and CH_3COOH , and another for NaOH and NH_4OH .
- The strong and weak species should show a different dependence of pH on concentration.

1.2 Calculating the values of K_a and K_b

$$K_a = \frac{[\text{A}^-][\text{H}_3\text{O}^+]}{[\text{HA}]} \quad (3)$$

where, $[\text{H}_2\text{O}]$ is omitted because it is pure liquid.

$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} \quad (4)$$

where, $[\text{H}_2\text{O}]$ is omitted because it is pure liquid.

$$\% \text{ ionization} = \frac{[\text{H}_3\text{O}^+]}{[\text{HA}]_0} \times 100\% = \frac{[\text{A}^-]}{[\text{HA}]_0} \times 100\% \quad (5)$$

$$\% \text{ ionization} = \frac{[\text{BH}^+]}{[\text{B}]_0} \times 100\% = \frac{[\text{OH}^-]}{[\text{B}]_0} \times 100\% \quad (6)$$

- Calculate K_a using Equation 3,
- Calculate K_b using Equation 4,
- Calculate the percent dissociation of the weak acid using Equation 5, and
- Calculate the percent dissociation of the weak base using Equation 6.

1.3 Examine the pH of mixtures of strong and weak acids and bases

- Examine the pH of mixtures of strong and weak acids and bases to see how the presence of a strong acid or base impacts the percent dissociation of the weak acid or base.
- Calculate the percent dissociation of the weak acid using Equation 5, and
- Calculate the percent dissociation of the weak base using Equation 6.

2 Assignment

- Watch pH meter calibration video
- Watch solution preparation and pH determination video
 - Only shown for HCl; same process used for other solutions
- Take the post-lab quiz with a 70% or higher
- Download the data set and do the data analysis
- You must upload a PDF file of **partial lab report**:
 - This is a deviation for the summer session only
 - Include the following sections: **Procedures**, **Results**, **pH Data Tables**, **pH vs. Concentration Plots**, and **Discussion** (not a full discussion section; just itemize and answer the questions.)
 - You don't need to include sample calculations in the partial report (it is in Excel only), don't need to write narrative explaining data tables and calculations.
- You must upload all calculations and data tables in an MS Excel file
- You should review the **Lab Report Guidelines**, **Sample General Chemistry Lab Report**, and **Appendix E** on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Calculating the concentration of 1:10 and 1:100 solutions

I think V_1 for stock solutions is 50 mL, but can't figure out what V_1 is for 1:10 (10 mL ?) and 1:100 dilutions. I want to confirm that M_1 is 1.0 M for all calculations and V_2 is 100 mL. I've looked at the lab procedure and lab video, but get confused about the process of dilutions regarding volumes of V_1 .

As an example, I will walk through the concentration calculations for the hydrochloric acid dilutions.

The concentration of the stock solution, (let's use 3 sig. figs.)

where 1 means initial state. Likewise, we would use 2 to indicate the final state.

3.2 10-fold or 1:10 dilution

Dilute the solution 10-fold by using a clean, primed, 10 mL volumetric pipette to add 10.00 mL of the stock acid solution to a 100 mL volumetric flask and filling it to the line with deionized water.

This means:

- $V_1 = 10.00$ mL, which is the amount taken from the stock solution.
- $V_2 = 100.00$ mL, final volume after the dilution.

Calculate the concentration of 10-fold dilution as follows.

$$M_1 V_1 = M_2 V_2$$

Isolate M_2 :

$$M_2 = \frac{(1.00 \text{ M})(10.00 \text{ mL})}{100.00 \text{ mL}} = 0.100 \text{ M HCl solution}$$

3.3 Second 10-fold or 1:100 dilution

Dilute this solution [i.e. 10-fold diluted solution] another 10-fold by using a 10 mL volumetric pipette to add 10 mL of the 1:10 acid solution to a 100 mL volumetric flask and filling it to the line with deionized water.

So, we are using the concentration of 10-fold dilution as the initial concentration for the second 10-fold dilution.

$$M_2 = \frac{(0.100 \text{ M})(10.00 \text{ mL})}{100.00 \text{ mL}} = 0.0100 \text{ M HCl solution}$$

3.4 Volumes in L or mL for dilution calculations

I noticed in your sample calculations for the 10 and 100 fold dilutions you used the volumes in mL where molarity is calculated using the units liters. I was wondering if we were to use the volumes in mL as you did in the sample calculations under the Q&A's or convert these to the units of liters.

The unit of analysis for volume could be mL or L in dilution calculations because the volume units cancel.

4 Assessment

4.1 Misconceptions

The ratio of the hydronium ion concentration that was calculated came out to be 0.645% for the weak

base and 0.912% for the weak acid. Based on the data gathered for the combination of a strong acid and weak acid, the percent dissociation of a weak acid affected the presence of a strong yield by caused the weak acid to dissociate. The calculated pK_a is less than the pK_b which would mean there was an error that occurred

Chemical species are not clearly defined. Arguments are not supported by the experimental findings.

When the strong acid and the weak acid are combined, the concentration of the hydroniumions increases for the weak acid. This increase of hydronium ions would increase the percent ionization for the weak acid. This is shown in the calculated percent ionization of the combined strong and weak acid.

...Therefore, the percent dissociation of the weak acid increases in the presence of a stronger acid because...

The percent dissociation of a weak acid in the presence of a strong acid causes the weak acid to dissociate more than usual.

What is the evidence for supporting these arguments? *Hint:* Perhaps pH is only affected by the strong acid.

Based on the data for CH_3COOH , as the concentrations of the weak acid decreases, the percent dissociation of the acid increases.[more explanation continues based on experimental values.]

Nice that you are using experimental values to justify your argument. However, it would be nicer to explain this phenomenon by considering the Le Châtelier's Principle. *Hint:* What happens to the equilibrium condition when you dilute the solution?

4.2 Formatting issues

$3.31 * 10^{-14}$

Should be reported as: 3.31×10^{-14}

2.82E-14

Should be reported as: 2.82×10^{-14}

NH4OH

Should be reported as: NH₄OH

Figures with missing legends.

All legends should be present when there are more than one data series.

Figures with gridlines.

All gridlines should be removed. Formatting requirement.

4.3 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.4 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	79.26%	14.96%	77.42%	95.83%	43.83%
^a All zero values are excluded.					

4.5 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Results	Table Formatting
Proofreading and General Formatting	Figure Formatting
pH Data Tables	Prelab Quiz
pH vs. Concentration Plots	Postlab Quiz
Discussion Questions	Excel Calculations

Buffer Solutions

Summary: Goals, assignments, and Q&A highlights about the Buffer Solutions Experiment.

Note: SSQ20: Experiment 6

1 Goals

1.1 Prepare the buffers A1-E1

- Calculate the concentration of each component present in buffers A1-E1 using the concentration of each stock solution, the volume of each solution delivered, and the total volume of buffer created.

Table 1. Preparing buffer solutions.

Solution	Volume (mL) of CH_3COOH or NH_4Cl	Volume (mL) of CH_3COONa or NH_3
A1	15.00	15.00
B1	20.00	10.00
C1	25.00	5.00
D1	5.00	25.00
E1	10.00	20.00

1.2 Generate the plot of pH vs. $\log([\text{base}]/[\text{acid}])$

- Fit the data to a line (i.e. trendline).
- Calculate the slope (3 sig. figs required) using `=SLOPE()` function in Excel.
- Calculate the intercept (3 sig. figs required) using `=INTERCEPT()` function in Excel.

1.3 Generate the plot pH vs. the logarithm of the dilution factor

- Generate a single scatter plot of pH vs. the logarithm of the dilution factor (1, 10, 100) for each buffer component using Excel.
- Both data sets should be presented on the same plot.
- Do not fit the data to a trendline.

2 Assignment

- Watch pH meter calibration video
- Watch the videos, pass the postlab quiz, and download your data set for Experiment 6
- Analyze the data in Excel
- Submit your partial lab report in a PDF file and all calculations in an Excel file.
- You should review the [Lab Report Guidelines](#), [Sample General Chemistry Lab Report](#), and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Total volumes of buffer solutions

I'm not confident which volumes I should use as my volume delivered and total volume. Should I add the volumes of NH_4Cl and NH_3 together as my volume delivered? In my Excel calculations, I then added 75mL from HCl for my total volume for A1, C1, and D1. The procedure mentions adding HCl to A1, C1, and D1, but I'm not sure what I need to incorporate into my total volume for B1 and E1 since the procedure doesn't say much else about them, or what to do with A2.

First of all, please try to make your questions more concise. It is a little hard to follow what is being asked here. Perhaps, sending your existing work might help clarify your confusion easier.

According to Table 2, solution A1 has the following total volume:

$$V_{tot,A1} = V_{\text{CH}_3\text{COOH or NH}_4\text{Cl}} + V_{\text{CH}_3\text{COONa or NH}_3}$$

$$V_{tot,A1} = (15.00 \text{ mL}) + (15.00 \text{ mL}) = 30.00 \text{ mL}$$

Likewise, sum the volume values of each species for B1, C1, D1, and E1 to calculate their respective V_{tot} values.

Next step is about addition of HCl solution. [Obtain 75 mL of 0.10 M hydrochloric acid and 75 mL of 0.10 M sodium hydroxide. Add 10 mL of hydrochloric acid to solutions A1, C1, D1, and Water 1.](#)

I will show the volume calculation for A1 only. 10.00 mL HCl solution is added to A1. Thus:

$$V_{tot,A1 \text{ with HCl}} = V_{tot,A1} + V_{\text{HCl}}$$

$$V_{tot,A1 \text{ with HCl}} = (30.00 \text{ mL}) + (10.00 \text{ mL}) = 40.00 \text{ mL}$$

4 Assessment

4.1 Misconceptions

4.1.1 Henderson-Hasselbalch plot

- The plot should have one data series
- Variables are confused:
 - x- axis should be $\log \frac{[base]}{[acid]}$.
 - One refers to this variable as **Henderson-Hasselbalch constant**.
 - How can a constant be a variable at the same time, plotted in the axis?
 - So, common sense can easily avoid some confusions¹ (page 34).
 - See the relevant instructions [above](#).

Log[base/acid]

It should be $\log \frac{[base]}{[acid]}$. Bracket represents molarity. Bracket of base/acid does not represent molarity.

4.1.2 Dilution plot

- Variables are confused:
 - x- axis should be $\log(\text{dilution factor})$.
 - See the relevant instructions [above](#).

4.3 Formatting Issues

NH3 and NH4

Should be written as: NH_3 and NH_4^+

4.3.1 Data table

- Sig. fig. errors. For example:

- Presented:
 - 0 mL
 - 5 mL
- Expected:
 - 0.00 mL
 - 5.00 mL
- Title is missing

4.4 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.5 Grades

Table 2. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	88.55%	8.19%	91.80%	100.00%	73.00%
^a All zero values are excluded.					

4.6 Team grading

Table 3. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Abstract	Table Formatting
Results	Figure Formatting
Proofreading and General Formatting	Prelab
Strong Acid-Strong Base Data Table	Postlab
Henderson-Hasselbalch Plot	Excel Calculations
Dilution Plot	

Instructor	Teaching Assistant
Discussion	

1. Being confused is good because it means you are learning. *Can you learn without thinking? Can you think without any confusion? Can you get confused without any desire to learn?...* → [\(page 32\)](#)

Le Châtelier's Principle

Summary: Goals, assignments, and Q&A highlights about the Le Châtelier's Principle Experiment.

Note: SSQ20: Experiment 7

1 Goals

- Observe the effect of adding mixing various solutions or changing the temperature of a solution.
- Explain the observations using the relevant chemical reactions and Le Châtelier's principle.
- Be thorough!
 - Do not simply state "Sodium hydroxide was added and the reaction shifted left."
 - See the lecture notes posted for more elaborate examples.

2 Assignment

- Watch the videos, pass the postlab quiz, and download the Word document worksheet posted.
- Make careful observations.
- Type your responses on the Word document.
- Still photos are shown in addition to the video content to allow you to see the results more clearly.
 - For precipitates, describe the color, apparent consistency.
 - For translucent solutions, state the color and the depth of color (dark, light, etc.).
 - Note the formation of gas bubbles and any comments regarding temperature changes.
- Upload your final worksheet as a PDF document.
- You should review the [Lab Report Guidelines](#) , [Sample General Chemistry Lab Report](#) , and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

No incoming questions for this experiment.

4 Assessment

4.1 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.2 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	82.72%	8.84%	83.00%	96.50%	70.00%
^a All zero values are excluded.					

4.3 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Proofreading and General Formatting	Prelab
Magnesium Chloride Solution	Postlab
Cobalt II Chloride Solution	Saturated Sodium Chloride Solution
Silver Ion Solution	Potassium Chromate Solution

Amino Acid Titration

Summary: Goals, assignments, and Q&A highlights about the Amino Acid Titration Experiment.

Note: SSQ20: Experiment 8

1 Goals

1.1 Identification of the unknown amino acid

- Plot a graph of pH vs. V(mL) of NaOH added.
- If a break (or breaks, in the case of polyprotic acids) is clearly visible, estimate the pKa (or multiple pKa values in the case of polyprotic acids).
- Use the example titration curve in the previous slide as a guidance:
 - The vertical dashed line shows equivalence point and corresponding NaOH volume.
 - The horizontal dashed line shows pH value, which is equal to pKa value. So, you determined the pKa value.
 - Repeat this process for each break if you have multiple breaks and determine all values.
- Estimate the molar mass of the acid.
- Use these data to find a match in Table 2, Table 3, or Table 4.

1.2 Calculate the molar mass of the acid

- At the equivalence point:

$$\text{mol } OH^- = \text{mol amino acid} \quad (1)$$

which means:

$$\text{volume of } OH^- \times \frac{\text{mol } OH^-}{L} \times \frac{1 \text{ mol amino acid}}{1 \text{ mol } OH^-} = \text{mol amino acid} \quad (2)$$

- Calculate molar mass using the moles of amino acid and the mass of sample.

$$\text{molar mass of amino acid} = \frac{\text{g amino acid}}{\text{mol amino acid}} \quad (3)$$

1.3 Determine the identity of amino acid

- Using the pKa and molar mass values determine the identity of amino acid.
- Find a match in Table 2, Table 3, or Table 4.

2 Assignment

- Watch the videos, pass the postlab quiz, and download your data set.
- Analyze the data in Excel
- Submit your partial lab report in PDF and all calculations in Excel file.
- You should review the [Lab Report Guidelines](#) , [Sample General Chemistry Lab Report](#) , and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 The unknown amino acid I found doesn't match

The molar mass of the unknown amino acid I found doesn't match any of the options in Tables 2-4. My unknown number is XYZ [hidden for general post]. I'm unable to figure out which calculation I am not doing correctly and have attached my Excel file. Based on my graph, I think I have a monoprotic acid and that I did do the calculation correctly since the break is approximately XYZ [hidden for general post] and my calculated molar mass is XYZ [hidden for general post].

Reviewing your calculations in Excel reveals that you are pretty much okay with the methodology. I would double-check the values such as the mass of sample, etc. If they are okay, then you can leave this analysis as is. Hint: Your calculated molar mass is much smaller than its actual value. So, I would not rely on molar mass if everything is correct, and it stays as is. Finding the correct half-way(s) might be much more helpful.

With respect to finding the half-way points, I would make the plot much larger. Only then, you would see that there are more than one half-way points.

4 Assessment

4.1 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.2 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	89.47%	8.74%	92.00%	99.00%	72.50%
^a All zero values are excluded.					

4.3 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Abstract	Table Formatting
Results	Prelab
Discussion	Postlab
Proofreading and General Formatting	Results Table
Equivalence Points	Titration Curve
Discussion Prompts	Excel Calculations

Thermodynamics of a Cobalt Complex

Summary: Goals, assignments, and Q&A highlights about the Thermodynamics of a Cobalt Complex Experiment.

Note: SSQ20: Experiment 9

1 Goals

1.1 Calculate the equilibrium concentration

- Calculate the equilibrium concentration of tetrachlorocobaltate(II) in solution at each temperature using Beer's law with the measured absorbance value at the temperature of interest.

$$A = abc \quad (1)$$

- Assume that the molar absorptivity, b , of CoCl_2^{2+} in water at 690 nm is constant ($6.00 \times 10^2 \text{ M}^{-1} \cdot \text{cm}^{-1}$) for all 4 temperature values.
- The path length, a , is equal to 1.00 cm.
- The equilibrium concentration of uncomplexed cobalt(II), Co^{2+} , ions in solution at any given temperature is found using conservation of mass, the initial concentration of cobalt(II) ions in the stock solution, and the equilibrium concentration of tetrachlorocobaltate(II) at that temperature.

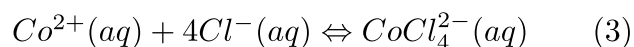
1.2 Calculate the equilibrium constant

- Calculate the equilibrium constant for the reaction of interest at each temperature using Equation 2.

$$K = \frac{[\text{CoCl}_4^{2-}]}{[\text{Co}^{2+}][\text{Cl}^-]^4} \quad (2)$$

In doing this calculation, assume that the $[\text{Cl}^-]$ is constant due to the presence of strong 6.00 M HCl acid. For the sake of significant figures in this calculation, assume the concentration of HCl is exactly 6.00 M.

1.3 Calculate the equilibrium concentration of uncomplexed cobalt(II)



The equilibrium concentration of uncomplexed cobalt(II), Co^{2+} , ions in solution at any given temperature is found using conservation of mass (i.e. the stoichiometric calculation based on Equation 3), the initial concentration of cobalt(II) ions in the stock solution, and the equilibrium concentration of tetrachlorocobaltate(II) at that temperature.

1.4 Calculate ΔG° using K

- Calculate ΔG° at each temperature studied for each trial using Equation 4.

$$\Delta G^\circ = -RT \ln K \quad (4)$$

where $R = 8.3145 \text{ J/mol.K}$ (use all figures to ensure proper significant figures), and all temperature values are in Kelvin.

1.5 Make $\ln K$ vs. $1/T$ plots

- Make $\ln K$ vs. $1/T$ plots for each trial separately.
- Temperature values are in Kelvin.
- Using the Excel formulas, calculate slope, `=SLOPE()`, and intercept `=INTERCEPT()` for the line of best fit.
- Calculate ΔH° and ΔS° for each trial using Equation 5.

$$\ln K = -\left(\frac{\Delta H^\circ}{R}\right)\left(\frac{1}{T}\right) + \left(\frac{\Delta S^\circ}{R}\right) \quad (5)$$

where slope = $-(\Delta H^\circ / R)$, y- intercept = $(\Delta S^\circ / R)$, R is in energy unit like in Equation 4, and temperature is in Kelvin.

1.6 Calculate ΔG° using ΔH° and ΔS°

- Calculate ΔG° at each temperature studied for each trial using Equation 6.

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \quad (6)$$

where T is in Kelvin.

- Assume that ΔH° and ΔS° are constant with temperature.

1.7 Generate a combined plot of $\ln K$ vs. $1/T$

- Generate a combined plot of $\ln K$ vs. $1/T$. In this plot, you should include the results from all trials.

2 Assignment

- Watch the videos, pass the postlab quiz, and download your data set
- Analyze the data in Excel
- Submit your **full lab report** in a PDF file and **calculations** in an Excel file.
 - Be sure to fully discuss your results.
 - Compare the values from the two trials and discuss how similar or different they are, as well as potential reasons for differences observed.

- Discuss the values of ΔG° : are the values obtained similar for each type of calculation? Why might they be different?
- There are two discussion prompts that should be incorporated into your overall discussion
 - One relates to the signs of ΔG° and K , and why the signs you obtained do or do not follow your expectations.
 - The other relates to the conditions for spontaneity. Remember that ΔG° and K relate to standard state conditions when you calculate the temperature range over which the reaction will occur spontaneously.
- You should review the [Lab Report Guidelines](#), [Sample General Chemistry Lab Report](#), and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Calculating the equilibrium concentration of Co^{2+}

I had a question on how to calculate the equilibrium concentration of Co^{2+} . In the lab, it gives a brief description but no equation.

To answer this question, a new subsection was added to this document. Please [see](#) : Calculate the equilibrium concentration of uncomplexed cobalt(II)

4 Assessment

4.1 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.2 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	79.30%	13.65%	76.17%	97.00%	52.83%
^a All zero values are excluded.					

4.3 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Abstract	Table Formatting
Proofreading and General Formatting	Figure Formatting
Results	Prelab
Discussion	Postlab
ln K vs. 1/T Figures	Temperature Study Table
Discussion Prompts	Free Energy Comparison Table
	Excel Calculations

Spectrophotometric Analysis of Manganese in Steel

Summary: Goals, assignments, and Q&A highlights about the Spectrophotometric Analysis of Manganese in Steel Experiment.

Note: SSQ20: Experiment 10

1 Goals

1.1 Generate the standard curve

- Mass by difference calculate the mass of the known steel sample.
- The percent by mass of the known steel sample is known as 0.94% Mn.
 - Using the mass of the known steel sample and the weight to weight percent of Mn in this sample, calculate the mass and moles of Mn in the sample. Use Equation 1 and 2.

$$m_{Mn} \text{ (g)} = m_{\text{known sample}} \text{ (g)} \times \frac{0.94 \text{ g } Mn}{100 \text{ g steel sample}} \quad (1)$$

$$n_{Mn} \text{ (mol)} = m_{Mn} \text{ (g)} \times \frac{1 \text{ mol } Mn}{54.938049 \text{ g } Mn} \quad (2)$$

- Calculate the molarity of known steel sample solution using Equations 3 and 4.

$$n_{MnO_4^-} \text{ (mol)} = n_{Mn} \text{ (mol)} \quad (3)$$

$$[MnO_4^-] = \frac{n_{MnO_4^-} \text{ (mol)}}{0.25000 \text{ L solution}} \quad (4)$$

- Using Equation 5, calculate the concentrations of each diluted solutions of MnO_4^- . Remember that the dilutions were 3:1, 2:2, and 1:3 volume to volume ratio.

$$M_1 V_1 = M_2 V_2 \quad (5)$$

- Generate a standard curve (absorbance at 525 nm vs. concentration of MnO_4^- in M) for the solutions of known MnO_4^- concentration.
 - In doing so, add 0 absorbance, 0 molar values as well.
 - Thus, in total there are five data points in this plot.

1.2 Determine the molar absorptivity

- Apply trendline analysis over the standard curve.

- Following Beer's Law, Equation 6, the slope of the plot determines the molar absorptivity a of MnO_4^- .

$$A = abc \quad (6)$$

where the path length, $b = 1.00$ cm.

$$a = \frac{\text{slope}}{1 \text{ cm}} \quad (7)$$

1.3 Calculate the concentration of unknown steel solution

- Use Equation 6 to calculate the concentration, c of MnO_4^- .
- Probably your data has three trials of absorbance value.
- Repeat this calculation over all trials.
- Calculate the average concentration of MnO_4^- , and also report the standard deviation.

1.4 Calculate %Mn in the unknown steel sample

- This is a straightforward calculation as you will be plugging in the average concentration of MnO_4^- in Equation 8.

$$\text{percent Mn} = \frac{(V_{\text{MnO}_4^-})([\text{MnO}_4^-])}{m_{\text{sample}}} \left(\frac{1 \text{ mol Mn}}{1 \text{ mol MnO}_4^-} \times \frac{54.938049 \text{ mol Mn}}{1 \text{ mol Mn}} \right) \times 100 \quad (8)$$

where m_{sample} is the mass of unknown sample; $V_{\text{MnO}_4^-}$ is the total volume of unknown sample solution, which is 250.00 mL; $[\text{MnO}_4^-]$ is the average concentration of MnO_4^- in the unknown solution (calculated in subsection 1.3 (page 0)).

2 Assignment

- Compare the molar absorptivity from your plot to the literature value given in the lab instructions.
- Read the lab instructions carefully so you can explain why you do or do not have to worry about Cu^{2+} and Ni^{2+} ions interfering with your results.
- Think through how a molar absorptivity that is too low would affect your results. To answer this correctly, follow the computational steps to make sure you can clearly state if an a value that is too small will lead to a higher or lower percent Mn than the correct value.
- Incorporate the responses to the above prompts in your overall discussion. Be sure to discuss the quality of your fit, the spread in the absorbance readings for the unknown, etc. to ensure your discussion is complete.
- Watch the videos, pass the postlab quiz, and download your data set.
- Submit your **full lab report** in a PDF file and **calculations** in an Excel file.
- You should review the [Lab Report Guidelines](#), [Sample General Chemistry Lab Report](#), and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Taking the prelab quiz

Is there anyway you can give me an example of how to enter the answers for the calculations? I just can't seem to figure that out.

Please pay attention to the values of calculations. The values should be entered with correct significant figures and units. Units are case sensitive. Use the SI unit conventions.

For example:

- 1250 is not equal to 1250.
- L is not equal to l

3.2 Calculations

I would like to attend your office hours at 4pm tomorrow to ask a couple questions about the calculations for Experiment 10.

After this meeting, the Goals section was revised. Although the lecture notes were elaborate enough, now this page has more details with relevant formulae, for those of whom are confused ¹ (page 48).

3.3 The unit of absorbance

I was wondering if there are units that are necessary for the absorbance values on the figure needed for this lab.

Absorbance does not have a unit. The absorbance, A , is defined by the incident intensity, I_0 , and transmitted intensity, I .

$$A = \log_{10} \left(\frac{I_0}{I} \right) \quad (9)$$

Overall, the equation shows no unit.

3.4 The concentration of undiluted solution

I am confused on where the fifth point on the standard curve graph comes from. I know that there is supposed to be a point where it is at the origin so I added that in the curve but since the volume of the diluted water is 0 isn't the concentration of MnO_4^- also 0? If it is then it is way off the trend line and I don't know what I did wrong. Please let me know if you can help me figure out what I did wrong that made the point for 1.610 absorbance have 0 concentration.

I suspect a **potential misunderstanding** here. When there is an aqueous solution, it is mostly water. Water is the **solvent**, so by definition solvent is in abundance. When the solution is diluted, more water added. This is an important point to understand about aqueous solutions.

Undiluted solution has the highest concentration. Follow Equations 1, 2, 3, and 4 to calculate the molarity of permanganate. This value is the undiluted concentration, in which the highest absorbance (A) value is observed.

3.5 Dilution formula

I just wanted to follow up on my last email. I read the questions page and I am still confused on how the concentration is less than the concentration multiplied by three. Because of the dilution formula where $M_2 = M_1 V_1 / V_2$ wouldn't the one with the highest volume standard with the lowest volume DI water had the highest value. I am sorry if I am getting confused on something simple here.

You are applying the dilution formula incorrectly. You should follow the following steps to find and plug in the correct V values. I am using the second row of your data table.

- $V_1 = 30.00$ mL of the stock MnO_4^- solution.
- Add 10.00 mL of DI water.
- Final volume becomes $V_2 = 40.00$ mL of diluted MnO_4^- solution.
- In sum, you should plug in the following values:
 - $V_1 = 30.00$ mL
 - $V_2 = 40.00$ mL
 - $M_1 = 0.0005126$ M based on your first row. (Please check this calculation, the concentration value looks too low.)

4 Assessment

4.1 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.2 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	84.06%	10.24%	86.67%	95.83%	57.33%
^a All zero values are excluded.					

4.3 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Overall Clarity and Flow	Procedure
Abstract	Table Formatting
Proofreading and General Formatting	Figure Formatting
Results	Prelab
Discussion	Postlab
Mass Percent of Mn in Unknown Sample	Results Table
Discussion Prompts	Calibration Curve
	Excel Calculations

1. Being confused is good because it means you are learning. *Can you learn without thinking? Can you think without any confusion? Can you get confused without any desire to learn?...* → [\(page 46\)](#)

Electrochemistry

Summary: Goals, assignments, and Q&A highlights about the Electrochemistry Experiment.

Note: SSQ20: Experiment 11

1 Goals

- It is important that you identify the cathode and anode half-reactions for each galvanic cell before beginning the following calculations.

1.1 Experimental E for Cu

- From the standard reduction potential, E° , of the copper half-reaction of 0.340 V and the concentration of Cu^{2+} , calculate the actual value of E for the experimental copper half-reaction using the Nernst equation (Equation 1).

$$E_{\text{red}} = E_{\text{red}}^\circ - \left(\frac{RT}{nF} \right) \ln \left(\frac{1}{[M^{n+}]} \right) \quad (1)$$

1.2 Experimental E for Al

From the actual value of E for the experimental copper half-reaction and the measured value of E_{cell} for the copper-aluminum cell, determine the value of E for the experimental half-reaction for aluminum (Equation 2).

$$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}} \quad (2)$$

1.3 Experimental E° for Al

From the calculated value of E for the experimental aluminum half-reaction and the actual concentration of Al^{3+} , calculate E° for the aluminum half-reaction using the Nernst equation (Equation 1).

1.4 Experimental E for Zn

From the actual value of E for the experimental copper half-reaction and the measured value of E_{cell} for the copper-zinc cell, determine the value of E for the experimental half-reaction for zinc (Equation 2).

1.5 Experimental E° for Zn

From the calculated value of E for the experimental zinc half-reaction and the actual concentration of Zn^{2+} , calculate E° for the zinc half-reaction using the Nernst equation (Equation 1).

1.6 Experimental E for Pb

From the actual value of E for the experimental copper half-reaction and the measured value of E_{cell} for the copper-lead cell, determine the value of E for the experimental half-reaction for lead (Equation 2).

1.7 Experimental E° for Pb

From the calculated value of E for the experimental lead half-reaction and the actual concentration of , calculate E° for the lead half-reaction using the Nernst equation (Equation 1).

1.8 Internal Consistency Check

Using the experimental E values for zinc and lead calculated above, calculate . Compare this result to the value you measured.

2 Assignment

- Watch the videos, pass the postlab quiz, and download your data set.
- Analyze the data in Excel.
- Submit your worksheet in a PDF file.
- You should review the [Lab Report Guidelines](#) , [Sample General Chemistry Lab Report](#) , and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Printing off the worksheets

I was wondering if I may print off the worksheets for Experiments 11 and 12, hand write them and then upload them as a pdf file as I did for a previous experiment. In the lab guide, it says you may either write or type your responses, but other places it says that they must be typed. Thank you for the clarification!

Yes, you may print and fill out them. However, if any part of the worksheet requires you to copy and paste a graph, you should print and attach the graphs physically. One drawback for this approach is that you may not have enough space to attach a graph. In that case, you could add your graph as a separate page and make sure that you refer to the page in the given space, where you are expected to provide the graph.

4 Assessment

4.1 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.2 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	82.71%	9.01%	85.40%	96.08%	62.07%
^a All zero values are excluded.					

4.3 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Proofreading and General Formatting	Prelab
Questions 6-9	Postlab
Questions 10-11	Table 1
Questions 12-13	Question 2
	Question 3-5

Coordination Chemistry

Summary: Goals, assignments, and Q&A highlights about the Coordination Chemistry Experiment.

Note: SSQ20: Experiment 12

1 Goals

1.1 Mass of Copper(II) Sulfate Pentahydrate

Calculate the mass of copper(II) sulfate pentahydrate used in the reaction from the initial and final mass of the reagent vial.

1.2 Moles of Copper(II) Sulfate Pentahydrate

Calculate the moles of copper(II) sulfate pentahydrate used in the reaction using the mass and the molar mass of the compound.

1.3 Moles of Ammonia Added

Calculate the moles of ammonia added using the volume added and the molarity of the solution.

1.4 Theoretical Yield of Tetraamminecopper(II) Sulfate Monohydrate

Calculate the theoretical yield (in moles) of tetraamminecopper(II) sulfate monohydrate produced from the limiting reagent and the relevant balanced chemical equation.

1.5 Mass of Product Collected

Calculate the mass of the collected product from the initial and final mass of the beaker.

1.6 Actual Yield of Tetraamminecopper(II) Sulfate Monohydrate

Assuming that all of the collected solid was the product of interest, calculate the actual yield (in moles) of the reaction from the mass of the product and the molar mass of tetraamminecopper(II) sulfate monohydrate.

1.7 Percent Yield

Calculate the percent yield of the reaction using the theoretical and actual yields.

2 Assignment

- Watch the videos, pass the postlab quiz, and download your data set.
- Analyze the data in Excel.
- Submit your worksheet in a PDF file.
- You should review the [Lab Report Guidelines](#) , [Sample General Chemistry Lab Report](#) , and [Appendix E](#) on D2L while writing to ensure that your drafts are correctly formatted.

3 Q&A Highlights

3.1 Printing off the worksheets

I was wondering if I may print off the worksheets for Experiments 11 and 12, hand write them and then upload them as a pdf file as I did for a previous experiment. In the lab guide, it says you may either write or type your responses, but other places it says that they must be typed. Thank you for the clarification!

My response is posted [here](#) .

4 Assessment

4.1 Feedback

- The PDF file you uploaded: annotations are highlighted with gray background and pink font.
- E-Rubric: D2L will show the rubric with scores and any feedback provided.

4.2 Grades

Table 1. Grade stats for this experiment.

Term Statistics ^a	Average	Stdev	Median	Maximum	Minimum
SSQ 2020	88.03%	3.11%	87.50%	93.00%	83.00%
^a All zero values are excluded.					

4.3 Team grading

Table 2. Task sharing for team grading based on the sections of the rubric.

Instructor	Teaching Assistant
Proofreading and General Formatting	Prelab
Mass and Moles of the Species	Postlab
Theoretical Yield	Chemical Equation
Mass of Product, Actual Yield, Percent Yield	Data and Results Table