Dougherty Valley HS Chemistry - AP
Kinetics – Beers Law Activity

Worksheet #10

Name: **Period:** **Seat#:**

Required Sections: (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.)

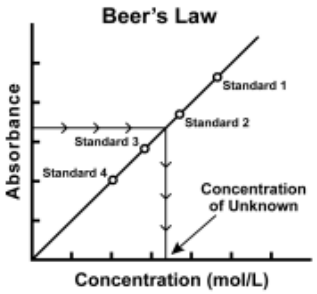
Prelab: Materials, Reagent Table, Procedures, and set up Data Tables before you get to class.

During Lab: Data section – Fill out your data table that is already set up from the prelab.

Post-lab: Calculation section, Discussion Questions Section

Introduction

Figure 1



The primary objective of this experiment is to determine the concentration of an unknown copper (II) sulfate solution. The $CuSO_4$ solution used in this experiment has a blue color, so Colorimeter users will be instructed to use the red LED. Spectrometer users will determine an appropriate wavelength based on the absorbance spectrum of the solution. A higher concentration of the colored solution absorbs more light (and transmits less) than a solution of lower concentration.

You will prepare five $CuSO_4$ solutions of known concentration (standard solutions). Each solution is transferred to a small, rectangular cuvette that is placed into Spectrometer. The amount of light that penetrates the solution is used to compute the absorbance of each solution. When you graph absorbance *vs*. concentration for the standard solutions, a direct relationship should result. The direct relationship between absorbance and concentration for a solution is known as *Beer's law (look it up!)*.

You will determine the concentration of an unknown $CuSO_4$ solution by measuring its absorbance. By locating the absorbance of the unknown on the vertical axis of the graph, the corresponding concentration can be found on the horizontal axis. The concentration of the unknown can also be found using the slope of the Beer's law curve.

Objectives

- Prepare and test the absorbance of five standard copper (II) sulfate solutions.
- Calculate a standard curve from the test results of the standard solutions.
- Test the absorbance of a copper (II) sulfate solution of unknown molar concentration.
- Calculate the molar concentration of the unknown $CuSO_4$ solution.

Materials

Chemicals

- 0.40 M Copper (II) Sulfate solution
- Copper (II) sulfate solution, unknown concentration

Equipment

- Computer with USB port or a USB adaptor
- Vernier Spectrometer
- 1cm Cuvette
- 20x150mm test tubes x 5
- 600 mL waste beaker
- 100 mL beaker x 2
- Pipettes x3 and pipette wheel
- Test tube rack
- Stir rod
- Kimwipes
- Distilled H_2O

SAFETY PRECAUTIONS

Copper (II) sulfate solution.

Do not eat or drink when using this product – harmful if swallowed. Causes skin and eye irritation.

Procedure

1) Obtain and wear goggles.

2) Obtain small volumes of 0.40 M $CuSO_4$ solution and distilled water in separate 100 mL beakers.

3) Label four clean, dry, test tubes 1-5. Use pipettes to prepare the standard solutions according to the chart below. Thoroughly mix each solution with a stirring rod. Clean and dry the stirring rod between uses.

Test Tube	0.40 M $CuSO_4$ (mL)	Distilled H_2O (mL)	Concentration (M)
1	2	8	0.080
2	4	6	0.16
3	6	4	0.24
4	8	2	0.32
5	10	0	0.40

4) Prepare a *blank* by filling a cuvette 3/4 full with distilled water. To correctly use cuvettes, remember:
- Wipe the outside of each cuvette with a lint-free tissue.
- Handle cuvettes only by the top edge of the ribbed sides.
- Dislodge any bubbles by gently tapping the cuvette on a hard surface.
- Always position the cuvette so the light passes through the clear sides.

Using the Spectrometer – YOU WILL BE USING THE SPECTRAL ANALYSIS PROGRAM, NOT GRAPHICAL ANALYSIS

5) Connect the Spectrometer to the computer. Select ***Absorbance****, then* ***Absorbance vs. Concentration (Beer's Law).***

6) A calibration will automatically begin when you select this experiment type. It can take 90 seconds or more for the lamp to fully illuminate. It is recommended that you wait for the warmup countdown to complete before proceeding with the calibration.

7) When the lamp warmup is complete place a blank cuvette (prepared in step 4) in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap FINISH CALIBRATION to complete the calibration.

8) Once the calibration is complete, you will need to select the wavelength you will use for your experiment. Follow the onscreen instructions for selecting a wavelength to use.

9) Click or tap DONE to use the wavelength you have selected. *Tip – if your independent variable is not Concentration (mol/L) click or tap ••• next to the table column heading and select Column Options to change the column name and units to match your experiment.*

10) Using the solution in Test Tube 1, rinse the cuvette twice with ~1 mL amounts and then fill it 3/4 full. Wipe the outside with a KimWipe to remove fingerprints. Place it in the cuvette holder, and making sure the clear sides align with the white arrow on the spectrometer.

11) In this data-collection mode, you will be prompted to enter the solution concentration each time you KEEP a data point. Click or tap KEEP the spectrometer reading has stabilized.

12) Enter the corresponding concentration value for this data point, then click or tap KEEP POINT to record the entry in the data table. The point is automatically plotted on the graph. *Tip – it may be necessary to move the graph inset to see the collected point. You can drag the graph to a new location or click or tap x to dismiss it. You can click or tap*  *and choose Graph Inset to redisplay the graph inset if needed.*

13) Discard the solution as instructed. Continue collecting data for Test tubes 2-5. Click or tap STOP to end data collection and continue with data analysis. *Tip – the graph rescales as you* KEEP *each point to ensure all data points are shown on the graph. After data collection is complete, the graph will autoscale to fit the data. Tip – If you inadvertently stop data collection before all of the your data points have been collected, click or tap* COLLECT *and select* APPEND *to continue collecting points in the current data set.*

14) Click or tap  to access the graph tools. Choose Apply Curve Fit. The default model is linear. Click or tap APPLY to display the curve fit equation and coefficients. Curve fits for all plotted columns are calculated. The curve fit details dialog includes the RMSE (root mean square error), a measure of how well the fit matches the data. *Tip – you can reposition the curve fit details dialog by dragging it up and down the right boundary of the associated region.*

15) Write down the absorbance values, for each of the five trials, in your data table.

16) Determine the absorbance value of the unknown $CuSO_4$ solution.
a. Come up front to obtain the *unknown* $CuSO_4$.
b. Rinse the cuvette twice with the unknown solution and fill it about 3/4 full. Wipe the outside of the cuvette, place it into the device. ***Important***: The reading in the meter is live, so it is not necessary to click KEEP to read the absorbance value.
c. Read the absorbance value displayed in the meter. When the displayed absorbance value stabilizes, record its value as Trial 6 in your data table.

17) Click or tap  to access the graph tools. Select Interpolate. Find the absorbance value that is closest to the absorbance reading you obtained in Step c above. Determine the concentration of your unknown $CuSO_4$ solution and record the concentration in your data table.

Disposal and Cleanup

Your teacher will provide disposal and cleanup instructions.

Data Table

	Trial	Concentration (mol/L)	Absorbance
	1	0.080	
	2	0.16	
	3	0.24	
	4	0.32	
	5	0.40	
Unknown # _____	6	Unknown number _____	

Calculations

Record all values into your Data Table

1. Print a copy of your Vernier graph and glue/tape it into your notebook. Make sure your graph includes a line of best fit with the equation for the line displayed, a descriptive title, and that both axis have labels/units where appropriate.

Post Lab Discussion Questions

Answer as part of your post lab. Do not recopy the questions, just paraphrase them into your answer so the reader can infer what the question was.

1. What is the equation for Beer's Law? Name each of the variables in the equation.
2. What is the molar concentration of your unknown sample of copper (II) sulfate solution based on the reading you got on your Vernier graph (not doing any calculations, just using the cursor on the graph software to find your A value and then seeing what C is)?
3. Calculate algebraically what the Concentration for the unknown is by using Beer's Law, your Absorbance reading for your unknown, the known path length of the cuvette, and the accepted molar absorptivity value of $CuSO_4$ at 635nm of 2.81 $M^{-1}cm^{-1}$. Show your work.
4. Does the answer you got from the graph in Question 2, match what you got from the algebra in Question 3? (Within reason, obviously there may be slight differences from lab errors).
5. What do you notice about the slope of your best fit line on your graph – meaning, does that number represent something from the equation you used in Question 3?
6. What factors are included in the Beer's law expression for determining how much light passes through a liquid solution?
7. How would your test results be affected if you left fingerprints on the sides of the cuvette in line with the light path of the Spectrometer?
8. Could this method of testing be used to determine the concentration of a NaCl solution? Why or why not?