**Name: Period: Seat#:**

**Worksheet #7**

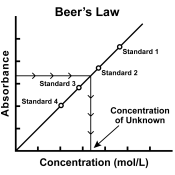
**Required Sections:** (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.)

**Prelab:** Prelab Questions, 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, Post-Lab Two Pager done on separate Worksheet.

Figure 1

**Introduction**

The primary objective of this experiment is to determine the concentration of an unknown copper (II) sulfate solution. The CuSO4 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 CuSO4 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.

You will determine the concentration of an unknown CuSO4 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**

In this experiment, you will

* 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 CuSO4 solution.

**Materials**

Chemicals

* 0.40 M copper (II) sulfate solution
* Copper (II) sulfate solution,   
  unknown concentration



**SAFETY PRECAUTIONS** *Copper (II) sulfate solution.*

Equipment

* Vernier computer interface
* Vernier Spectrometer
* Cuvette
* 20x150mm test tubes x 5
* 50 mL graduated cylinders x 2
* 100 mL beaker x 2
* Pipettes
* Test tube rack
* Stir rod
* Kimwipes
* Distilled H2O

*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 CuSO4 solution and distilled water in separate beakers.
3. Label five clean, dry, test tubes 1-5. Use pipettes to prepare five 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 CuSO4 (mL) | Distilled H2O (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 |

1. 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

1. Connect the Spectrometer to the computer. Choose New from the File menu.
2. To calibrate the Spectrometer, place the blank cuvette into the cuvette slot of the Spectrometer, choose Calibrate ►Spectrometer from the Experiment menu. Wait for the Spectrometer to warm up, and then click .
3. Determine the optimal wavelength for creating this standard curve.
   1. Remove the blank cuvette, and place the 0.40 M standard into the cuvette slot.
   2. Click . The absorbance vs. wavelength spectrum will be displayed. Click .
   3. To set up the data collection mode and select a wavelength for analysis, click Configure Spectrometer Data Collection, .
   4. Click Abs vs. Concentration (under the Set Collection Mode). Under the list of wavelengths, click Clear Selection. Choose the wavelength nearest to 635 nm from the list. Click OK to continue and proceed to Step 8.

Part II Conduct the Reaction Between Solutions of NaOH and NH4Cl

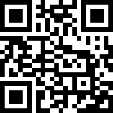
1. Measure out 50.0 mL of 2.0 M NaOH solution into a nested Styrofoam cup (see Figure 1). Lower the tip of the Temperature Probe into the cup of NaOH solution.
2. Measure out 50.0 mL of 2.0 M NH4Cl solution, but do not add it to the NaOH solution yet.
3. Conduct the reaction.
4. Click CollectNew to begin the data collection.
5. After three or four readings have been recorded at the same temperature, add the 50.0 mL of NH4Cl solution to the Styrofoam cup all at once. Stir the mixture throughout the reaction.
6. Data collection will end after three minutes. If the temperature readings are no longer changing, you may terminate the trial early by clicking StopNew2.
7. Rinse and dry the Temperature Probe, Styrofoam cup, and the stirring rod. Dispose of the solution as directed.
8. Between each trial Click “Experiment” 🡪 “Store Latest Run” 🡪 Make a note of which color data line is which trial.
9. Perform two more trials.

Part III Conduct the Reaction Between Solutions of HCl and NH4OH

1. Measure out 50.0 mL of 2.0 M HCl solution into a nested Styrofoam cup (see Figure 1). Lower the tip of the Temperature Probe into the cup of HCl solution.
2. Measure out 50.0 mL of 2.0 M NH4OH solution, but do not add it to the HCl solution yet.
3. Conduct this reaction in a fume hood or in a well-ventilated area. Repeat Step 10 to conduct the reaction and collect temperature data.

Part IV Data Analysis – done after all trials are completed

1. Save your data file from the experiment.
2. Either email the file to all group members, or make a shared Google Folder/Drive for your lab group and put the file there so all lab group members can access the file to complete their work.
3. At home – open the data file.
4. For each trial performed - Click the Statistics button, StatsNew. The minimum and maximum temperatures are listed in the statistics box on the graph. If the lowest temperature is not a suitable initial temperature, examine the graph and determine the initial temperature.
5. Record the initial and maximum temperatures in your data table.
6. Between each trial Click “Experiment” 🡪 “Store Latest Run” 🡪 Make a note of which color data line is which trial.
7. Perform two more trials.

**\*\*\*NOTE\*\*\*** You may not be doing all three reactions - the teacher may split it up so you perform multiple trials of one reaction and then share data with the groups. You may also be adding your data to a shared spreadsheet so that you can perform your calculations with AVERAGED data which is more accurate. Your teacher will inform you of these potential changes in class if they apply (depends on the year). ***Shared Data Spreadsheet:*** <https://tinyurl.com/4kw2nbfs>   
 *Must be logged in with SRVUSD email to open file*

**Disposal and Cleanup**

Your teacher will provide disposal and cleanup instructions.

**Data Table**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Reaction 1** | | | **Reaction 2** | | | **Reaction 3** | | |
|  | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 1** | **Trial 2** | **Trial 3** |
| Maximum temperature (°C) |  |  |  |  |  |  |  |  |  |
| Initial temperature (°C) |  |  |  |  |  |  |  |  |  |
| Temperature change (∆T) |  |  |  |  |  |  |  |  |  |
| Heat energy produced, q (J) |  |  |  |  |  |  |  |  |  |
| Enthalpy change, ∆H (kJ/mol) |  |  |  | Sample |  |  |  |  |  |

**Calculations**

Record all values into your Data Table

1. Calculate the amount of heat energy, q, produced in each reaction. Use 1.03 g/mL for the density of all solutions. Use the specific heat of water, 4.18 J/g°C, for all solutions.
2. Calculate the enthalpy change, ∆H, for each reaction in terms of kJ/mol of each reactant.

**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. Use your answers from 2 above, and Hess’s Law to determine the experimental molar enthalpy for Reaction 3
2. Use Hess’s law, and the accepted values of ∆H in the Pre-Lab Questions to calculate the ∆H for Reaction 3. How does the accepted value compare to your experimental value?
3. Does this experimental process support Hess’s Law? Suggest ways of improving your results.