Part A. Solution Stoichiometry

1. Write the complete balanced chemical equation (including phases) for the reaction between copper (II) sulfate and sodium carbonate. This may be handwritten or typed.

$$CuSO_4(aq) + Na_2CO_3(aq) \rightarrow CuCO_3(s) + Na_2SO_3(aq)$$

2. Using the mass of your dried product, calculate the concentration of the unknown copper (II) sulfate solution. Show all work for full credit.

1 mole of $CuSO_4$ makes 1 mole of $CuCO_3$

Molar mass of $CuCO_3$ -> 123.56

Cu -> 63.55 g/mol

C -> 12.01 g/mol

O_3 -> 3 * 16.00 g/mol = 48.00 g/mol

Moles = Mass / Molar Mass -> 0.0416g / 123.56 g/mol = $3.37 * 10^{-4}$ mol

Therefore, $3.37 * 10^{-4}$ moles $CuSO_4$

Molarity = Moles / Volume

Moles = $3.37 * 10^{-4}$ mol

Volume – 0.01000 L

Molarity = .0337 M

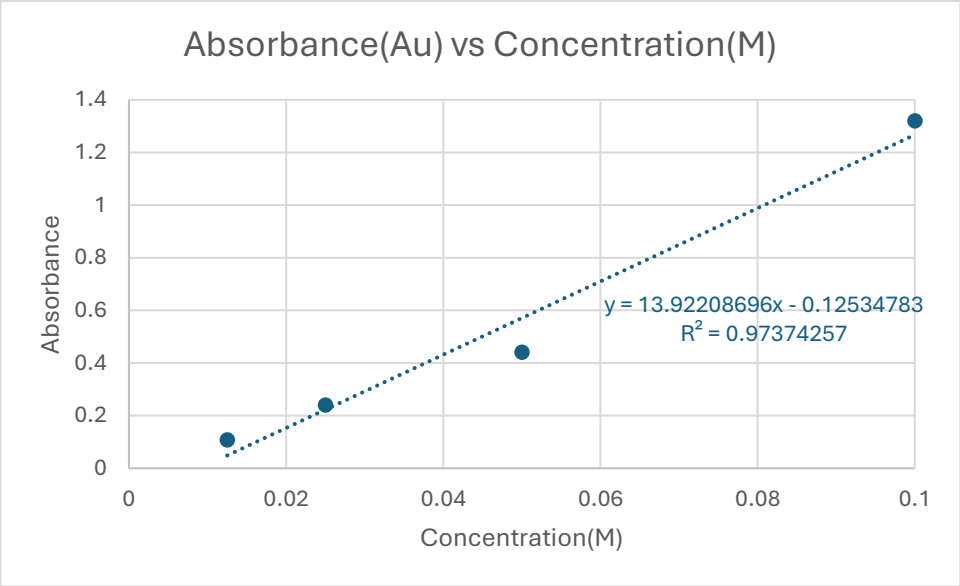
Part B. Calibration Curve and Beer's Law

3. Make a table of the absorbance vs. concentration data for your serial dilutions. Do not include the absorbance of the unknown solution in this table.

Table 1. Absorbance for different Concentrations of CuSO4(aq)

Absorbance (Au)	Concentration (M)
1.320	.1000
0.441	.0500
0.240	.0250
0.108	.0125

4. Now, plot the data from your table in Excel to make a calibration curve, and add that here.



Graph 1. Absorbance for different Concentrations of CuSO4(aq)

5. Calculate the concentration of the unknown copper sulfate solution using your calibration curve. Show all work for full credit.

y = 13.92208696x - 0.12534783

Absorbance = 13.92208696(Concentration) - 0.12534783

.566 = 13.92208696(Concentration) - 0.12534783

Concentration = 0.0497 M

Comparison and Analysis

6. You've now calculated the concentration of the unknown copper (II) sulfate solution using two methods. Compare the two values. Do they agree with each other? Which method is more accurate and why? Your explanation should include potential sources of error associated with both methods.

   My two values were .0337M numerically and .0497M graphically. They aren't the same and aren't the closest to each other. I would say the more accurate method is the numerical one, calculated using masses. I would say this because it involves direct usage of chemicals and substances to get values. However, there are potentials sources of error with this method, because when solid product is filtered out, mass is lost, and measurement isn't absolutely accurate, masses are left in containers, which can cause the final mass to be less than what its ideally supposed to be. There are also potential sources of error using the graphically calculated answer to. There could be issues with the machine's calibration, or the light beam, or the cuvettes, and all of these could lead to discrepancies in the readings. Another thing to realize that the line isn't a straight line, and so the line of the best fit, and using the best fit slope can throw off results.

Extrapolation

7. A student is performing a similar experiment and wants to have as many data points as possible for their calibration curve. After all, the more data the merrier, right? When the student is done plotting their data, they notice something strange when looking at high or low concentrations.

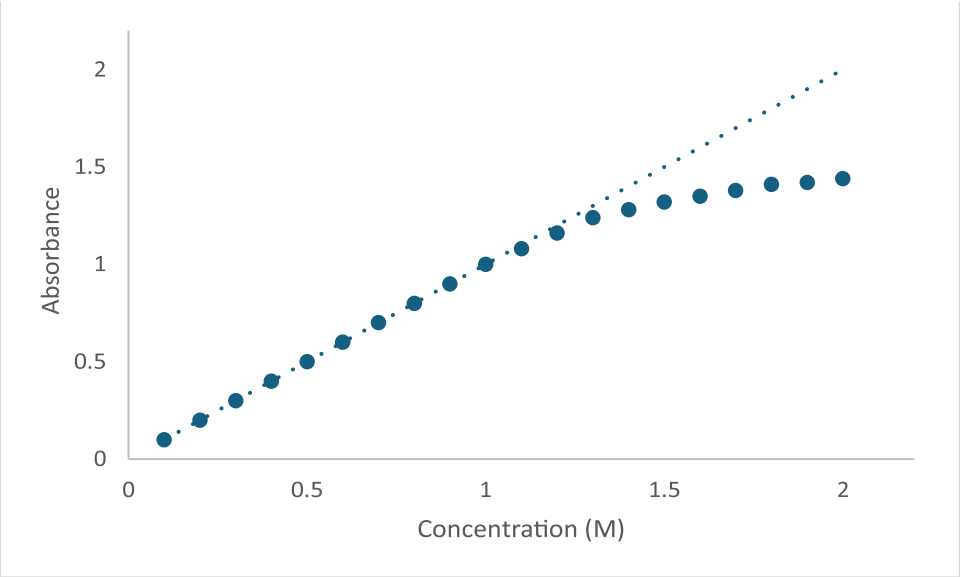


Figure 1. Calibration curve of analyte from 0.1 M to 2 M

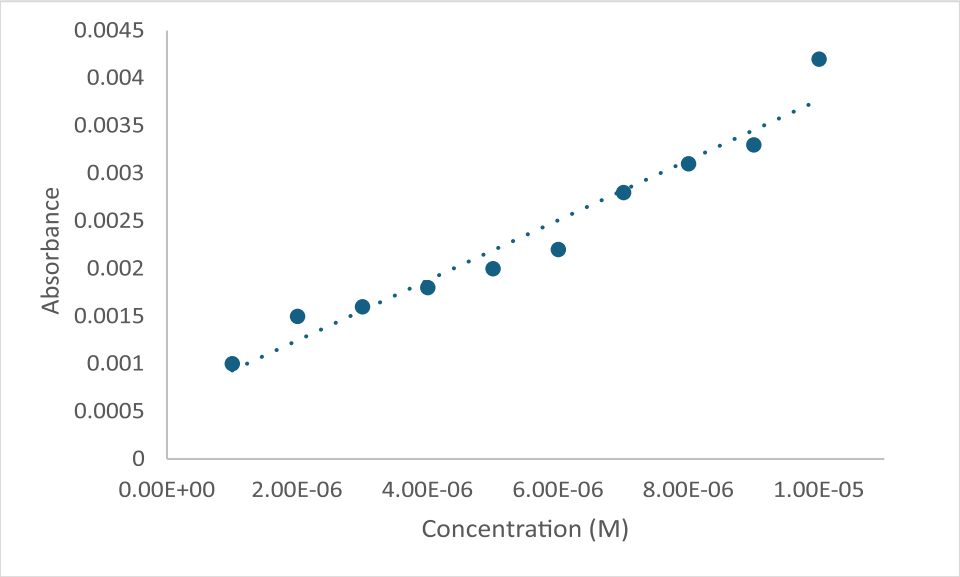


Figure 2. Calibration curve of analyte from 0.000001 M to 0.00001 M

After examining the student's data, what can you conclude about the validity of Beer's law at high or low concentrations? Explain what is occurring at low concentrations to result in the data shown.

As concentration increased, Beer' law doesn't work as the solution is saturated and absorbance flattens out and doesn't increase, as we see happening around 1.25, it plateaus, and absorbance's just doesn't increase anymore due to no more light being absorbed.

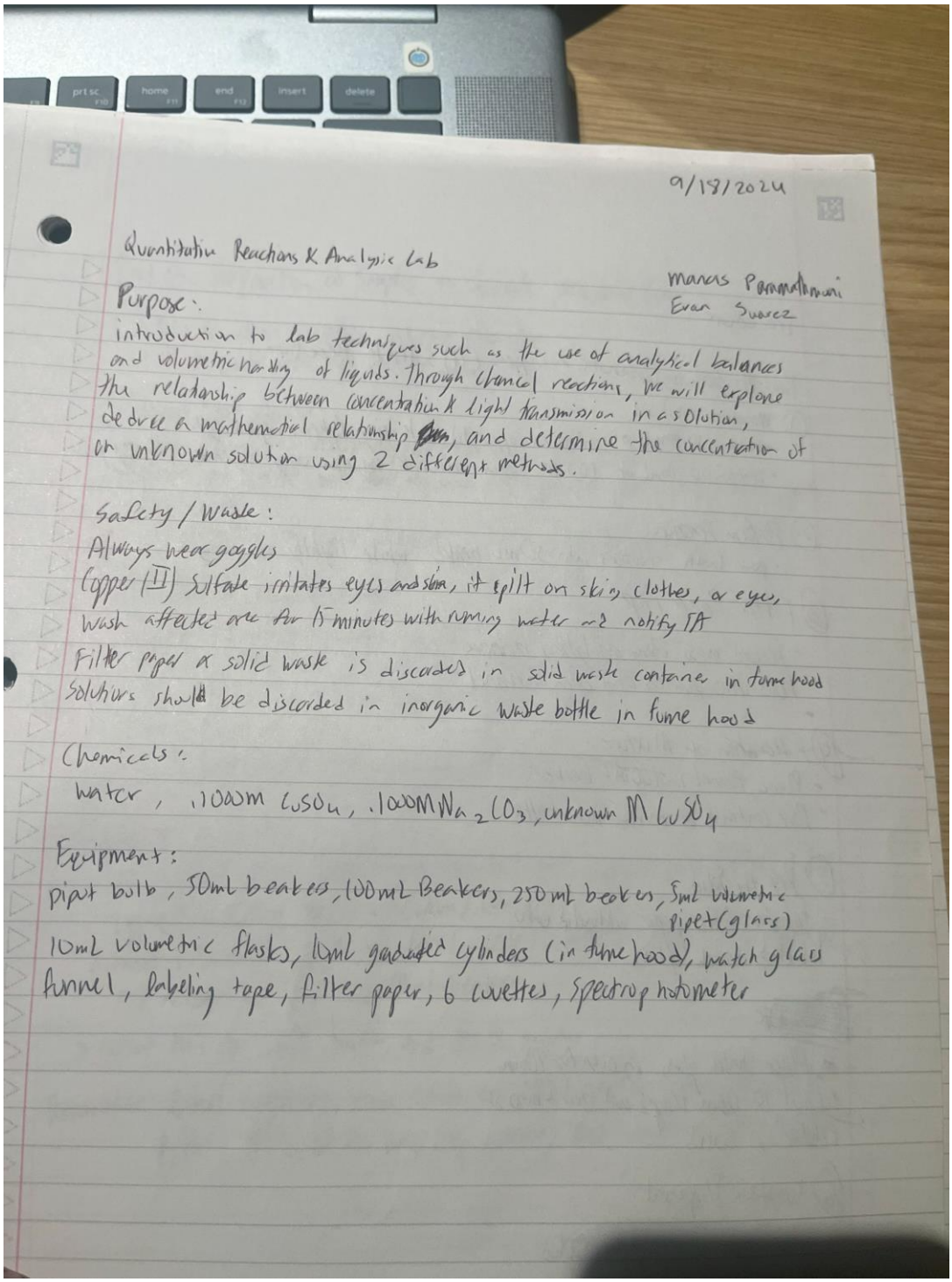
At these low concentrations, little fluctuations are most likely due to other influences of light or contaminants or cleaning that needs to be done. I would say this is due to concentration being so small, even the tiniest disturbances are going to affect data significantly more than higher concentrations. At higher concentrations, smaller disturbances aren't going to have such a big impact, and are going to yield a more constant line.

8. There are often many ways of gathering data that will allow you to draw similar conclusions. In your field of interest, find two analytical methods that can be used to show similar results, and give a general description of what the differences are between the methods. Be sure to cite your sources.

A good example I would say from electrical engineering. Using Ohm's law with resisters and using the equation with $I = V/R$, it will be a rough estimate due to resistances of batteries and wires and temperatures. Those things are mildly negligible but usually can lead to discrepancies. However, there exists a better solution such as using an ammeter to directly measure the current that is flowing through a wire at any given point and gives a much more accurate response.

Lab Notebook Pages

Attach ALL your lab notebook pages for this experiment. Don't forget to tag everything.



9/18/2024

Quantitative Reactions & Analysis Lab

Marcus Pennathomani
Evan Suarez

Purpose:
introduction to lab techniques such as the use of analytical balances and volumetric handling of liquids. Through chemical reactions, we will explore the relationship between concentration & light transmission in a solution, determine a mathematical relationship, and determine the concentration of an unknown solution using 2 different methods.

Safety / Waste:
Always wear goggles
Copper (II) Sulfate irritates eyes and skin, if spilt on skin, clothes, or eyes, wash affected area for 15 minutes with running water & notify TA
Filter paper & solid waste is discarded in solid waste container in fume hood
Solutions should be discarded in inorganic waste bottle in fume hood

Chemicals:
water, .1000M $CuSO_4$, .1000M Na_2CO_3, unknown M $CuSO_4$

Equipment:
pipet bulb, 50mL beakers, 100mL Beakers, 250mL beakers, 5mL volumetric pipet (glass)
10mL volumetric flasks, 10mL graduated cylinders (in fume hood), watch glass
funnel, labeling tape, filter paper, 6 cuvettes, spectrophotometer

Procedure:

Part A: Sodium Carbonate & Copper (II) Sulfate Reaction

(1) Measure Solutions
- obtain 10.00mL of unknown copper (II) sulfate using labeled grad. cyl.
- Obtain 10.00mL of .1000M sodium carbonate solution using seperate labeled grad. cyl.

(2) Perform Reaction:
- pour both solutions into 50mL beaker while lightly swirling

(3) Filter Paper Prep
- Record mass using analytical balance
- Fold into quarters and open in funnel

(4) Filteration of Mixture
- Place funnel in 100mL beaker
- Pour contents of mixture into filter

(5) Dry the Solid
- transfer filter paper with solid onto labeled watch glass

~~(6) Waste~~

- Place watch glass in oven for 90min.
- Cool to room temp. and record mass of filter & solid

(6) Waste Disposal
- Solid Waste = filter paper & solid
- Inorganic liquid waste

Part B: Preparation of Samples to Generate Standard Curve

(1). take 6 clean cuvettes and rinse thoroughly
- fill one cuvette with R.O. water (blank sample)

(2) Prepare Stock Solutions
- obtain 20mL of 1.000M copper(II) sulfate in clean 50mL beaker
- Rinse one cuvette with small aliquot of 1M copper(II) sulfate, using transfer pipette, then discard
- Fill with 80% of copper(II) sulfate - 100% stock solution

(3) Prepare Unknown Solution
- 10mL of unknown copper(II) sulfate solution in 50mL beaker
- rinse cuvettes with unknown copper solution, discard
- fill 80% with unknown copper solution
- cap & label all wipes
- wipe each cuvette with kimwipe before measurments

(4) Prepare dilutions
1. Using cleaned and conditioned 5mL Volumetric pipette, add 5.00mL of 1M copper(II) sulfate to 10mL (clean) volumetric flask
2. add R.O. water to 10mL level, cap it, invert 20 times = 50% copper(II) sulfate
(If necessary, put into clean 50mL beaker

3. repeat this for 25% solution, and 125% solution

Reminder: label everything, rinse each cuvette with respective solution before filling 80% of the way, cap everything, and kim-wipe clean everything

⑤ Using Spectrophotometer

- Open LoggerPro (connect device to USB)
- calibrate SpectroVis Plus
  - under experiment, select "calibrate" and "Spectrophotometer 1".
  - This turns on light source, wait 90 seconds for bulb to warm up
- Place blank cuvette (R.O. Water) in, clear side facing light source, following instructions to calibrate
- Place 100% sulfate solution into slot, click "collect", then stop data collection,
- Click "configure spectrometer data-collection", under collection mode, select absorption vs concentration
- Wavelength for λ_{max} will be selected by default, in range of 700-700nm
- record this value
- Click "collect" and then "keep"
- Enter concentration of the same (1M), and record absorbance in notebook
- replace stock with 50%, after reading stabilizes, click keep, and enter actual concentration (calculate from previous concentration), record data
- repeat for all dilutions
- When measuring unknown, do not click keep, only write in notebook
- After all solutions ran, click "stop", check recordings of all values,
- empty cuvettes and beakers/flasks into waste
- All waste into inorganic
- Wash all, rinse with R.O. water before returning
- NO cuvettes in trash

(1)

Filter mass : .3388 g Filter + solid mass : .3804 g

(2)

λ_{max} : 816.0 nm 5 absorbance values at λ_{max} (1 for each

concentration (mol/L)	absorption
.1000M	1.320
.0500M	0.441
.0250	0.240
.0125	0.108
unknown	0.566