Begin your response to **QUESTION 3** on this page.

3. A student is given the task of determining the molar concentration of a $CuSO_4$ solution using two different procedures, precipitation and spectrophotometry.

For the precipitation experiment, the student adds 20.0 mL of 0.200 *M* $Ba(NO_3)_2$ to 50.0 mL of the $CuSO_4(aq)$. The reaction goes to completion, and a white precipitate forms. The student filters the precipitate and dries it overnight. The data are given in the following table.

Mass of dry filter paper	0.764 g
Volume of $CuSO_4(aq)$	50.0 mL
Volume of 0.200 *M* $Ba(NO_3)_2$	20.0 mL
Mass of filter paper and dried precipitate	1.136 g

(a) Write a balanced net ionic equation for the precipitation reaction.

(b) Calculate the number of moles of precipitate formed.

(c) Calculate the molarity of the original $CuSO_4$ solution.

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For the spectrophotometry experiment, the student first makes a standard curve. The student uses a 0.1000 M solution of $CuSO_4(aq)$ to make three more solutions of known concentration (0.0500 M, 0.0300 M, and 0.0100 M) in 50.00 mL volumetric flasks.

(d) Calculate the volume of 0.1000 M $CuSO_4(aq)$ needed to make 50.00 mL of 0.0500 M $CuSO_4(aq)$.

(e) Briefly describe the procedure the student should follow to make 50.00 mL of 0.0500 M $CuSO_4(aq)$ using 0.1000 M $CuSO_4(aq)$, a 50.00 mL volumetric flask, and other standard laboratory equipment. Assume that all appropriate safety precautions will be taken.

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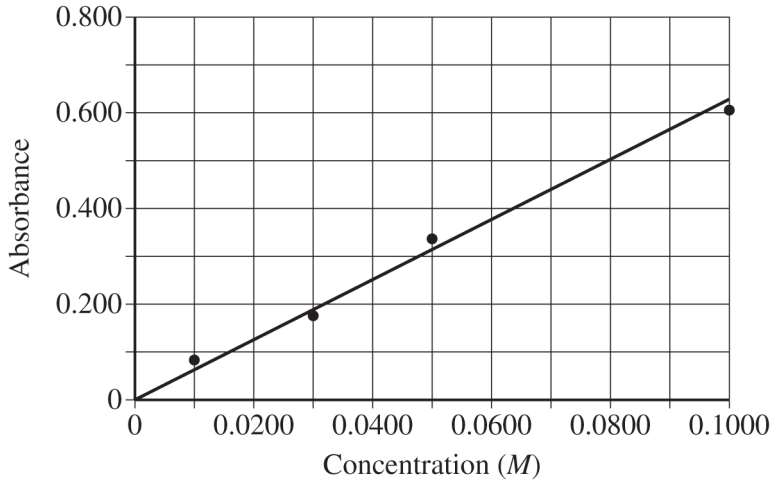
The standard curve is given below.



(f) The absorbance of the $CuSO_4$ solution of unknown concentration is 0.219. Determine the molarity of the solution.

(g) A second student performs the same experiment. There are a few drops of water in the cuvette before the second student adds the $CuSO_4(aq)$ solution of unknown concentration. Will this result in a $CuSO_4(aq)$ concentration for the unknown that is greater than, less than, or equal to the concentration determined in part (f) ? Justify your answer.

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Question 3: Long Answer — 10 points

(a) For the correct balanced equation (state symbols not required): **1 point**

$$Ba^{2+}(aq) + SO_4{}^{2-}(aq) \rightarrow BaSO_4(s)$$

(b) For the correct calculated value of the mass of precipitate (may be implicit): **1 point**

$$1.136\ \text{g} - 0.764\ \text{g} = 0.372\ \text{g}\ BaSO_4$$

For the correct calculated value of the number of moles, consistent with mass of precipitate: **1 point**

$$0.372\ \text{g} \times \frac{1\ \text{mol}}{233.39\ \text{g}} = 0.00159\ \text{mol}$$

Total for part (b) 2 points

(c) For the correct calculated value, consistent with part (b): **1 point**

$$0.00159\ \text{mol}\ BaSO_4 \times \frac{1\ \text{mol}\ CuSO_4}{1\ \text{mol}\ BaSO_4} = 0.00159\ \text{mol}\ CuSO_4$$

$$\frac{0.00159\ \text{mol}\ CuSO_4}{0.0500\ \text{L}} = 0.0318\ M\ CuSO_4$$ *(0.0319 M if decimals are carried)*

(d) For the correct calculated value: **1 point**

$$M_1V_1 = M_2V_2$$

$$V_1 = \frac{(0.0500\ M)(50.00\ \text{mL})}{(0.1000\ M)} = 25.0\ \text{mL}$$

(e) For a correct technique to measure the volume of solution: **1 point**

First, measure out the correct volume of 0.1000 M $CuSO_4$ solution with a 25.0 mL volumetric pipet (graduated cylinder or buret is acceptable).

For a correct technique to dilute the solution to the final volume: **1 point**

Transfer the 25.0 mL of solution to a 50.00 mL volumetric flask and dilute the solution with water up to the 50.00 mL mark.

Total for part (e) 2 points

(f) For the correct value (between 0.032 *M* and 0.038 *M*): **1 point**

Accept one of the following:

- $y = mx = \frac{0.63}{0.1000}x = 6.3x$

  $x = \frac{y}{6.3} = \frac{0.219\ M}{6.3} = 0.035\ M$
- *Estimated value from the graph within the specified range.*

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(g)	For the correct answer: *The concentration will be <u>less than</u> that determined in part (f).*	**1 point**
	For a valid justification: *The additional water will decrease the concentration of $CuSO_4$ in the cuvette. Therefore, there will be a decrease in absorbance (according to the Beer-Lambert law). This dilution results in a lower estimated concentration of $CuSO_4$.*	**1 point**
	Total for part (g)	**2 points**
	Total for question 3	**10 points**

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