IMSA
Ad Chem

K_{sp} OF COPPER (II) TARTRATE

Purpose:
The purpose of this experiment is to determine the solubility product constant of copper (II) tartrate.

Introduction:

The solubility product constant, K_{sp}, of a slightly soluble salt provides a simple example of aqueous equilibrium. Spectrophotometric determination of this constant can be done quickly and simply. If an ion of a compound is colored or can be made to form a colored complex in solution, the solubility product constant may be determined by visible spectroscopy. The solubility product constant is defined as the product of the concentrations of the ions formed by the dissociation of the salt, each raised to the power of the coefficient of the balanced equation. Copper (II) tartrate dissociates according to the equation:

$CuC_4H_4O_6(s) \leftrightarrow Cu^{2+}_{(aq)} + C_4H_4O_6^{2-}{}_{(aq)}$

Thus the solubility product constant is represented by the expression: $K_{sp} = [Cu^{2+}] [C_4H_40_6^{2-}]$

The copper 2+ ion has a characteristic blue color. A saturated solution of copper (II) tartrate can be prepared by mixing solutions of copper (II) sulfate and sodium tartrate. The concentrations of the solutions to be mixed needs to be great enough to exceed the solubility of copper (II) tartrate. The copper (II) tartrate will then form a precipitate. The solution that remains is then saturated with respect to copper (II) tartrate. The concentration of copper 2+ ion is determined by comparing to a standard curve of copper 2+ ion using copper (II) sulfate; which is valid as it is the copper 2+ ion that imparts the blue color to the solution, not the anions.

Pre-lab Questions:

1. Write out the dissociation equation and Ksp expression (like shown above) for silver chloride; AgCl.

2. 10.0 mL of 0.05 M $AgNO_3$ and 10.0 mL 0.05 M NaCl are combined in a test tube and a precipitate of AgCl forms. After the precipitate is centrifuged down, the remaining solution (called the supernatant) is tested for the concentration of Ag+ ion. The concentration is found to be $1.3x10^{-5}$. Calculate the Ksp of AgCl from this information.

3. Perform the calculations necessary and fill in the table on the next page to make a standard curve from 0.10 M $CuSO_4$ stock. Make 5.0 or 10.0 mL of each dilution.

[$CuSO_4$] (M)	Volume of 0.10 M $CuSO_4$	Volume of dI H_2O
0.010 M		
0.020 M		
0.030 M		
0.040 M		
0.050 M		

Safety:
Always wear goggles in lab.

Procedure:

Part I: Preparation of standard curve

1. Prepare the dilutions for the standard curve according to your table above
2. Calibrate the spectrophotometer with dI water
3. Select the absorbance versus concentration setting and set wavelength to 675 nm
4. Determine the absorbance of each of the five standard copper solutions – 0.01 M, 0.02 M, 0.03 M, 0.04 M, and 0.05 M.
5. Record data on the following page
6. Use logger pro (or Excel) to determine the best-fit line, the equation of the line and the correlation

Part II: Determination of copper (II) ion concentration in the saturated copper (II) tartrate solution

The teachers have prepared a saturated solution of copper (II) tartrate ahead of time in order to give it time to reach equilibrium. The solution was prepared by combining equal volumes of 0.10 M copper (II) sulfate and 0.10 M sodium tartrate.

1. Obtain a few mL of the saturated copper (II) tartrate solution and pour it in a clean cuvette
2. Determine the absorbance of the saturated solution
3. Use the interpolator function or the equation of the line to determine the concentration of copper (II) ions in the saturated solution of copper (II) tartrate
4. Record the data on the following page

Experiment adapted from:

http://academic.ursinus.edu/scienceinmotion/Experiments/ExperimentWordDocs/VIS%20Spec/Ksp%20OF%20COPPER.doc

Data Analysis:

Concentration of Copper II ion (M)	Absorbance
0.01 M	_____
0.02 M	_____
0.03 M	_____
0.04 M	_____
0.05 M	_____
Saturated Copper (II) tartrate:	_____

1. What is the concentration of copper (II) ion in the saturated tube?

2. What is the concentration of tartrate ion in the saturated tube? Show work or explain how you obtained this value.

3. Calculate the Ksp of copper (II) tartrate.

4. Look up the accepted value for the Ksp of copper (II) tartrate. Calculate your percent error:

$$\% \text{ Error} = \frac{|\text{Experimental Value} - \text{Accepted Value}|}{\text{Accepted Value}} \times 100$$

Post-Lab Questions:

1. What is a K_{sp} value useful for (what does it tell you about a substance)?

2. Why was a wavelength of 675 nm used in this lab?

3. Assume a student performs Part II of the procedure (forming the precipitate). However, they do not allow adequate time for the precipitate to form before reading the absorbance of the solution. What would this do to the calculated K_{sp} value for copper (II) tartrate (increase, decrease, no change)? Explain your answer.

4. Write out the dissociation equation and K_{sp} expression for $PbCl_2$.

a. Look up the value of the K_{sp} for $PbCl_2$ on page 753 of the text. Use this value to calculate the concentrations of lead ion and chloride ion in a saturated solution of lead (II) chloride.

b. Which value gives you the solubility of lead (II) chloride in water, the concentration of lead ion or the concentration of chloride ion? Explain.

c. Would lead (II) chloride be more or less soluble in a .100 M solution of NaCl? **Calculate** the solubility of lead (II) chloride in .100 M NaCl to confirm your prediction.

5. The solubility of substance MX is 1.26×10^{-5} mol/L. Calculate the value of the K_{sp}. If X is a nonmetal with 7 valence electrons in principle energy level 3, what is the identity of MX?