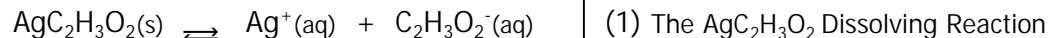


# EXPERIMENT 18: Determination of K<sub>sp</sub> of Silver Acetate

## INTRODUCTION

In this experiment, you will determine the solubility product constant of silver acetate. The equilibrium between the very slightly soluble salt, AgC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(s), and its saturated solution is represented by equation (1).



The solubility product constant expression for the above reaction is given by equation (2) in which [Ag<sup>+</sup>] and [C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup>] are the molarities of Ag<sup>+</sup> and C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> ions in the saturated solution.

$$K_{\text{sp}} = [\text{Ag}^+][\text{C}_2\text{H}_3\text{O}_2^-] \quad (2)$$

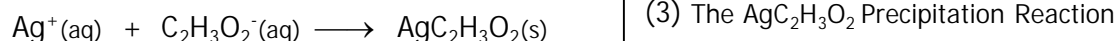
Equation (2) implies that in any system containing solid AgC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(s) in equilibrium with its ions, the product of [Ag<sup>+</sup>] times [C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup>] will, at a given temperature, have a fixed value, independent of how the equilibrium system was initially made up.

### A. Preparation of Saturated Silver Acetate Solution by Dissolving Solid Silver Acetate in Water.

The above equilibrium system can be established in several different ways. One is by dissolving enough solid AgC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> in water to give a saturated solution. Reaction (1) will proceed to the right until the system reaches equilibrium.

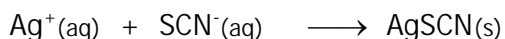
### B. Preparation of Saturated Silver Acetate Solution by Precipitation from Solutions of Salts

Another way to prepare a saturated silver acetate solution is by mixing solutions of two salts, one that has Ag<sup>+</sup> as the cation and another that has C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> as the anion, for example, aqueous solutions of AgNO<sub>3</sub> and NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>. Upon mixing these solutions, the Ag<sup>+</sup> and C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> ions in the solutions react to form solid silver acetate:

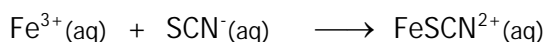


### 3. Determination of [Ag<sup>+</sup>] by titration with Standard KSCN Solution

The concentration of Ag<sup>+</sup> at equilibrium in the saturated AgC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> solutions will be determined by titration with a standard solution of potassium thiocyanate, KSCN. Addition of potassium thiocyanate to a saturated solution of silver acetate will cause the formation of solid silver thiocyanate, AgSCN. The net ionic equation for the titration reaction is:



The indicator used in the titration is a solution of ferric alum, FeAl(SO<sub>4</sub>)<sub>3</sub>. When the precipitation of AgSCN is complete, Fe<sup>3+</sup> ions from the ferric alum indicator will react with excess thiocyanate ions to form the red FeSCN<sup>2+</sup> complex ion:



For the end point of the titration you will be looking for a color change of the solution from colorless to a very pale salmon orange.

## EXPERIMENT

### A. DAY 1: Preparation of Saturated Silver Acetate Solutions by Precipitation

CAUTION: Silver solutions cause stains. Handle carefully !

NOTE : These solutions must be prepared at least one lab period before the titration is to be performed.

1. Prepare the two mixtures listed below, measuring as accurately as possible, using the graduated cylinder set next to each reagent bottle. Place each mixture in a clean, dry, labeled 5-inch test tube.

	Volume of 0.200 M $\text{AgNO}_3$	Volume of 0.200 M $\text{NaC}_2\text{H}_3\text{O}_2$	Mixture Volume
Mixture 1	6.00 mL	4.00 mL	10.00 mL
Mixture 2	3.00 mL	7.00 mL	10.00 mL

Stopper the test tubes using #3 corks, and then mix well by swirling, but carefully! Also, mix them just before you leave lab today. Let the test tubes sit overnight or longer.

2. Clean three 25 mL Erlenmeyer flasks. Do a final rinse with deionized water and let them air dry for next lab period.

### B. DAY 2: Determination of $[\text{Ag}^+]$ by Titration with KSCN

1. From the stockroom check out the following items:

25 mL buret  
two plastic funnels

2. Get a 4-funnel support from the reagent bench and attach it to a ring stand. Put the funnels (sure hope they're clean because you can't clean them now) into the funnel support and put filter paper into each one, but do not wet the filter paper with deionized water. Filter the two mixtures prepared in Part A above into separate clean, dry, labeled 5-inch test tubes. Put the used filter paper/precipitate into the special waste container labeled "Filter Paper and  $\text{AgC}_2\text{H}_3\text{O}_2(\text{s})$ "
3. At the reagent bench dispense about 20 mL of standard KSCN into a clean, dry 50 mL beaker. Record the molar concentration of the KSCN solution on the report sheet.
4. Clean the 25 mL buret with distilled water. For the final rinse add about 3 mL of the standard KSCN solution, roll it around the inside walls of the buret and then let it drain through the stopcock. Discard the rinse solution.
5. Add standard KSCN solution to the buret until it reads about 15 mL. Record the initial buret reading on the report sheet.

6. Use your clean, dry 10 mL graduated cylinder to measure exactly 5.00 mL of filtrate #1 into a dry 25 mL Erlenmeyer flask for titration. Add about 6 drops of ferric alum indicator and about 6 drops of DIL nitric acid solution to it. (The  $\text{HNO}_3$  prevents hydrolysis by ferric ion.)
7. Titrate the mixture with standard KSCN. A white precipitate of AgSCN will form but it will not interfere with the endpoint. Titrate carefully because you do not have enough filtrate to repeat the titration. At the endpoint the aqueous solution above the AgSCN(s) will change from colorless to a very pale salmon color.

Dispose of the flask contents in the waste container labeled "Waste AgSCN".

8. Repeat steps 6 and 7 for sample # 2. (Before using the 10 mL graduated cylinder to measure 5.00 mL of the solution, rinse it with two small portions of the solution.) Don't forget to refill the buret and take the initial buret reading before titrating.
9. Get about 10 mL of saturated silver acetate solution from the bottle on the reagent bench and filter it. Repeat steps 6 and 7 on this third sample. (Before using the 10 mL graduated cylinder to measure 5.00 mL of the solution, rinse it with two small portions of the solution.) Don't forget to refill the buret and take the initial buret reading before titrating.

Dispose of all remaining solutions in the waste container labeled "Waste AgSCN".

10. Calculate the  $K_{sp}$  for each sample, and calculate the average  $K_{sp}$ . Also determine the precision and accuracy of your  $K_{sp}$



## REPORT SHEET

Experiment 18: K<sub>sp</sub>Name \_\_\_\_\_  
last first

Instructor's Initials \_\_\_\_\_

## DATA

Molarity of Standard KSCN Solution \_\_\_\_\_

	Preparation of Mixtures			Titration DATA			
	Volume of 0.200 M AgNO <sub>3</sub>	Volume of 0.200 M NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	Total Mixture Volume	Titration Sample Volume	Initial Buret Reading	Final Buret Reading	Volume KSCN solution
Mixture 1	6.00 mL	4.00 mL	10.00 mL	5.00 mL			
Mixture 2	3.00 mL	7.00 mL	10.00 mL	5.00 mL			
Saturated AgC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>				5.00 mL			

## CALCULATIONS

## A. Mixture #1

1. Total moles Ag<sup>+</sup> in mixture:
2. Total moles of C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> in mixture:
3. [Ag<sup>+</sup>] from titration data:
4. Mole Ag<sup>+</sup> dissolved in the 10.00 mL of solution:
5. Mole Ag<sup>+</sup> in precipitate:
6. Moles C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> in precipitate.
7. Moles C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> dissolved in the 10.00 mL of solution:
8. [C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup>]
9. K<sub>sp</sub>

B. Mixture #2

1. Total moles  $\text{Ag}^+$  in mixture:
2. Total moles of  $\text{C}_2\text{H}_3\text{O}_2^-$  in mixture:
3.  $[\text{Ag}^+]$  from titration data:
4. Mole  $\text{Ag}^+$  dissolved in the 10.00 mL of solution:
5. Mole  $\text{Ag}^+$  in precipitate:
6. Moles  $\text{C}_2\text{H}_3\text{O}_2^-$  in precipitate.
7. Moles  $\text{C}_2\text{H}_3\text{O}_2^-$  dissolved in the 10.00 mL of solution:
8.  $[\text{C}_2\text{H}_3\text{O}_2^-]$
9.  $K_{\text{sp}}$

C. Saturated  $\text{AgC}_2\text{H}_3\text{O}_2$  solution:

1.  $[\text{Ag}^+]$  from titration data.
2.  $[\text{C}_2\text{H}_3\text{O}_2^-]$
3.  $K_{\text{sp}}$

D. SUMMARY

1. Experimental  $K_{sp}$  Values for  $\text{AgC}_2\text{H}_3\text{O}_2$ :

Mixture #1: \_\_\_\_\_

Mixture #1: \_\_\_\_\_

Saturated  $\text{AgC}_2\text{H}_3\text{O}_2$ : \_\_\_\_\_

2. Average experimental  $K_{sp}$  \_\_\_\_\_

3. Precision of Experimental  $K_{sp}$

4. Accuracy of Experimental  $K_{sp}$  (theoretical  $K_{sp}$  of  $\text{AgC}_2\text{H}_3\text{O}_2$  is  $2.0 \times 10^{-3}$ )

## EXERCISES

1. HCl is slowly added to a solution that is 0.250 M in  $\text{Pb}^{2+}$  and 0.00150 M in  $\text{Ag}^{+}$ .  
( $K_{\text{sp}}$  for  $\text{PbCl}_2$  is  $1.6 \times 10^{-5}$ ;  $K_{\text{sp}}$  for  $\text{AgCl}$  is  $1.7 \times 10^{-10}$ )
- Which precipitate forms first,  $\text{PbCl}_2$  or  $\text{AgCl}$ ?
  - What will the  $\text{Cl}^{-}$  ion concentration be when the precipitate first appears?

2. How many grams of silver sulfate can be dissolved in 450.0 mL of 0.200 M sodium sulfate solution?  
 $K_{\text{sp}}$  for  $\text{Ag}_2\text{SO}_4$  is  $1.2 \times 10^{-5}$