Experiment : Determination of The Solubility Product Constant of Silver Acetate

In this experiment, you will determine the solubility product constant of silver acetate. The equilibrium between the sparingly soluble salt, $AgC_2H_3O_2(s)$ and its saturated solution is represented by equation (1).

$$AgC_2H_3O_2\,(s) \longrightarrow Ag^+(aq) + C_2H_3O_2^-\,(aq) \qquad (1)$$

The solubility product expression for the above reaction is given by equation (2) in which K_{sp} is the solubility product constant for silver acetate and $[Ag^+]$ and $[C_2H_3O_2^-]$ are the molarities of Ag^+ and $C_2H_3O_2^-$ ions respectively, in the saturated solution.

$$K_{sp} = [Ag^+]\,[C_2H_3O_2^-] \qquad (2)$$

Equation (2) implies that in any system containing solid $AgC_2H_3O_2$ (s) in equilibrium with its ions, the product of $[Ag^+]$ times $[C_2H_3O_2^-]$ will at a given temperature have a fixed magnitude , independent of how the equilibrium system was initially made up.

The above equilibrium system can be established in many different ways. One, is by dissolving $AgC_2H_3O_2$ (s) in water. Reaction (1) will proceed to the right until the system reaches equilibrium. The concentration of Ag^+ at equilibrium may be determined by titration against a standard solution of potassium thiocyanate, KSCN. The concentration of $C_2H_3O_2^-$ can be calculated by the stoichiometry of reaction (1). From the two concentrations, K_{sp} is determined by using equation (2). In the last part of this experiment, you will apply the above method to calculate K_{sp}.

Another way to set up an equilibrium system is by mixing two solutions, one containing $AgNO_3$ and the other containing $NaC_2H_3O_2$. On mixing these solutions, the Ag^+ and $C_2H_3O_2^-$ ions in these solutions react to form $AgC_2H_3O_2$ (s), and reaction (1) proceeds to the left until equilibrium is reached. At that point, the condition in equation (2) will be satisfied. In the first part of this experiment, you will mix in different proportions known volumes of $AgNO_3$ and $NaC_2H_3O_2$. You will then measure the value of $[Ag^+]$ experimentally. The $[C_2H_3O_2^-]$ will be calculated from the initial composition of the system, the measured value of $[Ag^+]$, and the stoichiometric relationship between Ag^+ and $C_2H_3O_2^-$ that exist as reaction (1) proceeds to the left. You will again find K_{sp} for $AgC_2H_3O_2$ (s), by equation (2).

Finding the Concentration of Ag+ by Titration

You will titrate known volumes of filtrates obtained from $AgNO_3/NaC_2H_3O_2$ mixtures as well as from a saturated aqueous silver acetate solution, $AgC_2H_3O_2(aq)$, against a standard solution of potassium thiocyanate, KSCN. Addition of potassium thiocyanate to a filtrate obtained from any of the above solutions will cause the formation of the less soluble silver thiocyanate, AgSCN(s), precipitate.

Ferric alum solution, $FeAl(SO4)_3$, will be used as the indicator in this experiment. The addition of excess thiocyanate ion will react with the ferric alum indicator to form the red $FeSCN^{2+}$ complex ion indicating the complete precipitation of silver ions. In our experiment, you will be looking for a color change from colorless to a very pale salmon orange for the end point.

PROCEDURE

DAY 1 : Preparation of $AgNO_3/NaC_2H_3O_2$ mixtures

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 needed. Place each mixture in a clean, dry, and labeled 5-inch test tube.

	Mixture (1)	**Mixture (2)**
Volume of 0.200 M $AgNO_3$	6.00 ml	3.00 ml
Volume of 0.200 M $NaC_2H_3O_2$	4.00 ml	7.00 ml
Total volume of mixture	**= 10.00 ml**	**= 10.00 ml**

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

2) Clean three 25 ml Erlenmeyer flasks. Finally rinse the flasks with distilled water and let air dry for next lab period.

DAY 2: Volumetric Determination of Ag^+ ion concentration in saturated solutions of $AgC_2H_3O_2$

1) Check out from the stockroom the following items:
   - a buret.
   - two funnels
2) Clamp a funnel support that holds 4 funnels at once. Filter the two mixtures listed above into separate dry labeled 5-inch test tubes. Do not wet the filter paper with distilled water. Discard the used filter paper and the precipitate left on it in a special waste container labeled "Filter Paper and $AgC_2H_3O_2$ (s)"
3) Dispense **about 13 ml** of standard KSCN into a clean and dry 50 ml beaker. Record the molarity of KSCN solution on the report sheet.
4) Clean and rinse a 25 ml buret with distilled water. Make a final rinsing of the buret with about 3 ml portion of the standard KSCN solution and make certain to drain through the stopcock. Discard the rinsing.
5) Partially fill the buret to about the **15 ml 'mark'** with the standard KSCN. Record the initial reading of the buret on the report sheet. Enter all data in ink on the report sheet.
6) Use the 10 ml graduate cylinder to transfer 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 to it. The HNO_3 helps prevent hydrolysis of ferric ion so its color will not interfere with the end point.
7) Titrate the 5.00 ml portion of filtrate # 1 with standard KSCN. A precipitate of AgSCN(s) will form but it will not interfere with the endpoint. Titrate carefully since you will not be able to repeat. At the endpoint the aqueous layer above the AgSCN(s) will change from colorless to a very pale salmon color.

Disposal: **Discard the contents of the flask in the proper waste container labeled "Waste AgSCN".**

8) Now repeat procedures (6) and (7) for sample # 2. (Remember to rinse the 10 ml graduate cylinder with two small portions of the proper filtrate.)
9) Now filter about 10 ml of saturated silver acetate from the bottle in the back of the room. Measure 5.00 ml of the filtrate using the 10 ml graduate cylinder. Add 6 drops ferric alum and 6 drops DIL HNO_3 (nitric acid) and titrate to the end point.

Disposal: **Dispose of the left over of each of the silver acetate solutions not being titrated in the waste container labeled "Waste AgSCN".**

10) Carry out the calculations required for the determination of Ksp value for each of your titrations. Now determine your precision and accuracy.

Report Sheet Name _____

Exp 18: Solubility Product Constant of Silver Acetate First Last

Instructor's initial_____

Molarity of KSCN _____ M

Data:

	Mixture #1	**Mixture # 2**	**Saturated $AgC_2H_3O_2$ solution**
Volume of 0.200 M $AgNO_3$	6.00 ml	3.00 ml	
Volume of 0.200 M $NaC_2H_3O_2$	4.00 ml	7.00 ml	
Total volume of mixture	10.00 ml	10.00 ml	
Volume of filtrate titrated	5.00 ml	5.00 ml	5.00 ml

Volume of KSCN used:

	Mixture # 1	**Mixture # 2**	**Saturated $AgC_2H_3O_2$**
Final buret reading			
Initial buret reading			
Calculate volume of KSCN in ml.			

Instructor's Approval _____

Molarity of KSCN _____ M

Calculations: (You must show the setups.)

MIXTURE # 1

1) Total moles of Ag^+ added (from $AgNO_3$).

1) Answer _____moles Ag^+

2) Total moles of $C_2H_3O_2^-$ (from $NaC_2H_3O_2$).

2) Answer _____mole $C_2H_3O_2^-$

3) [Ag+] from titration data.

3) Answer: _____M

4) Moles of Ag^+ dissolved in 10.00 ml solution.

4) Answer _____mole Ag^+
(dissolved in 10.00 ml solution)

5) Moles Ag^+ in precipitate.

5) Answer _____mole Ag^+
(in precipitate)

6) Moles $C_2H_3O_2^-$ in precipitate.

6) Answer: _____mole $C_2H_3O_2^-$
(in precipitate)

7) Moles of $C_2H_3O_2^-$ dissolved in 10.00 ml solution.

7)Answer: _____mole $C_2H_3O_2^-$
(dissolved in 10 ml solution)

8) [$C_2H_3O_2^-$] in solution.

8) Answer _____ M

9) Ksp = [Ag+][$C_2H_3O_2^-$]
=

9) _____

Molarity of KSCN _____ M

Calculations: (You must show the setups.)

MIXTURE # 2

1) Total moles of Ag^+ added (from $AgNO_3$).

1) Answer _____molesAg^+

2) Total moles of $C_2H_3O_2^-$ (from $NaC_2H_3O_2$).

2) Answer _____mole $C_2H_3O_2^-$

3) [Ag+] from titration data.

3) Answer: _____M

4) Moles of Ag^+ dissolved in 10.00 ml solution.

4) Answer _____mole Ag^+
(dissolved in 10.00 ml solution)

5) Moles Ag^+ in precipitate.

5) Answer _____mole Ag^+
(in precipitate)

6) Moles $C_2H_3O_2^-$ in precipitate.

6) Answer: _____mole $C_2H_3O_2^-$
(in precipitate)

7) Moles of $C_2H_3O_2^-$ dissolved in 10.00 ml solution.

7)Answer: _____mole $C_2H_3O_2^-$
(dissolved in 10 ml solution)

8) [$C_2H_3O_2^-$] in solution.

8) Answer _____ M

9) Ksp = [Ag+][$C_2H_3O_2^-$]
=

9) _____

Molarity of KSCN _____ M

Calculations: (You must show the setups.)

Saturated $AgC_2H_3O_2$ solution:

1) [Ag+] from titration data.

1) Answer: _____M

2) [$C_2H_3O_2^-$] in solution.

2) Answer _____ M

3) Ksp = [Ag+][$C_2H_3O_2^-$]

=

3) _____

CONCLUSION:

1) Experimental value for K_{sp} of $AgC_2H_3O_2(s)$:

Mixture # 1 _____

Mixture # 2 _____

Saturated _____

2) Average experimental value of K_{sp}:

Setup:

Answer: _____

3) Find the precision of your experiment.

Setup:

Answer: _____

4) If the accepted value of K_{sp} for $AgC_2H_3O_{2(s)}$ is 2.0×10^{-3}, find the accuracy.

Setup:

Answer: _____%

QUESTIONS:

1) HCl is slowly added to a solution that is 0.250 M in Pb^{2+} and 0.00150 M in Ag^{+}. Which precipitate forms first, $PbCl_2$ or AgCl? Show your calculation. At what Cl^- ion concentration will the precipitate first appear? K_{sp} for $PbCl_2$ is 1.6×10^{-5} and K_{sp} for AgCl is 1.7×10^{-10}.

Setup:

_____forms, when

$[Cl^-]$ is _____ M

2) How many grams of silver sulfate can be dissolved in 450. ml of 0.200 M sodium sulfate solution? (Ksp for Ag_2SO_4 is 1.2×10^{-5})

Setup:

_____g