43 A SOLUBILITY PRODUCT CONSTANT
EXPERIMENT

PURPOSE

To determine the solubility product constant (K_{sp}) of lead(II) chloride.

BACKGROUND

From everyday experiences you are familiar with several substances that are very soluble in water. Table sugar (sucrose) and salt (NaCl) are examples of soluble compounds. Many other substances, such a limestone ($CaCO_3$) and gasoline, are quite insoluble. *Solubility* and *insolubility* are relative terms, however. Almost all substances have at least a slight solubility in water. If you put a slightly soluble substance in water, a dynamic equilibrium is established between the dissolved substance and its solid form. In this equilibrium, the rate of dissolution of ions from the solid equals the rate of precipitation of the ions from the solution. How can you express in numerical terms the fraction of dissolved substance in the solution? One way is to use the K_{sp}, the solubility product constant.

In this experiment, you will find the K_{sp} of a slightly soluble salt, lead(II) chloride ($PbCl_2$). You will precipitate Pb^{2+} ions as lead(II) chromate ($PbCrO_4$) from a saturated solution of lead(II) chloride. The amount of lead chromate precipitated will tell you the concentration of Pb^{2+} ions in the saturated solution. When you know the concentration of lead ions, you can calculate the concentration of chloride ions and compute the K_{sp} for lead(II) chloride.

MATERIALS (PER PAIR)

safety goggles
2 250-mL beakers
1 100-mL graduated cylinder
1 ring stand
1 ring support
1 wire gauze
1 glass stirring rod
1 filter funnel
1 plastic wash bottle
centigram balance
drying oven/heat lamp
1 gas burner
saturated lead(II) chloride solution, $PbCl_2(aq)$ [T]
0.5*M* potassium chromate, K_2CrO_4 [T]
filter paper (e.g., Whatman #42)
distilled water

SAFETY FIRST!

In this lab, observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the procedure, refer to the list below for its meaning.

Caution: Wear your safety goggles. (All steps.)

Caution: Lead compounds and chromate compounds are toxic. (Steps 2–9.)

Caution: Execise extreme care when working with a hot water bath and an open flame. Before beginning, ensure that there is no danger that the beaker will be capsized. Remember that cold equipment looks the same as hot equipment. Do not touch the beaker with your bare hands. (Step 3.)

Note: Return or dispose of all materials according to the instructions of your teacher. (Step 9.)

PROCEDURE

As you perform the experiment, record your data in Data Table 1.

1. Place a filter paper in a clean, dry 250-mL beaker. Determine the combined mass to the nearest 0.01 g and record the measurement in Data Table 1. Remove the filter paper from the beaker.
2. Slowly, to avoid disturbing the crystals, decant 100 mL of clear supernatant from the saturated $PbCl_2$ solution into the beaker. Add 20 mL of 0.5*M* K_2CrO_4 to the solution in the beaker.
3. Using a gas burner, heat the mixture in the beaker to the boiling point while occasionally stirring. Allow the mixture to cool, undisturbed, for 5 minutes.
4. Using the filter paper from Step 1, assemble a filtration setup (refer to Figure 2.2).
5. Decant the liquid from the beaker into the filter funnel. Avoid transferring the precipitate to the filter paper. Wash the precipitate in the beaker by adding 30 mL of distilled water and swirling the mixture gently. Again decant the liquid into the filter funnel. Repeat the washing procedure once more.
6. Place the filter paper and any solid material retained on it in the beaker that contains the washed precipitate.
7. The contents of the beaker will now be dried according to your teacher's instructions.
8. Determine the combined mass of the beaker and its dry contents to the nearest 0.01 g and record the measurement.
9. Dispose of the filtrate and precipitate as instructed by your teacher.

Name ______________________ Class ______________ Date ______________

OBSERVATIONS

DATA TABLE 1: DETERMINATION OF THE MASS OF LEAD(II) CHROMATE	
mass of beaker + filter paper	
mass of beaker + filter paper + precipitate	
mass of precipitate ($PbCrO_4$)	
volume of saturated $PbCl_2$ solution used	
gram formula mass $PbCrO_4$	
gram formula mass $PbCl_2$	

ANALYSES AND CONCLUSIONS

1. In a saturated aqueous solution of lead(II) chloride, an equilibrium is established between the solid lead(II) chloride and its ions. Write the balanced chemical equation that describes this equilibrium.

2. Write a balanced equation for the reaction of Pb^{2+} ions and CrO_4^{2-} ions.

3. Calculate the number of moles of $PbCrO_4$ you obtained in the experiment.

4. Determine the concentration (mol/L) of Pb^{2+} ions in the saturated $PbCl_2$ solution.

5. Find the Cl^- concentration (mol/L) in the saturated solution.

6. Set up the solubility product expression and calculate the K_{sp} for $PbCl_2$.

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7. Calculate the percent error in your results. Use a chemistry handbook to look up the accepted K_{sp} values for $PbCl_2$ and $PbCrO_4$.

8. Suggest likely sources of error in this experiment.

9. Barium ions are extremely toxic. Yet patients in hospitals are required to drink a suspension of barium sulfate in order to have their stomachs and intestinal tracts X-rayed. Find the K_{sp} value for barium sulfate and explain why patients are not at risk with this treatment.