DETERMINING THE K_{SP} OF CALCIUM HYDROXIDE

LAB ADV COMP 23

From *Advanced Chemistry with Vernier,* Vernier Software & Technology, 2004

INTRODUCTION

Calcium hydroxide is an ionic solid that is sparingly soluble in water. A saturated, aqueous, solution of $Ca(OH)_2$ is represented in equation form as shown below.

$$Ca(OH)_2\ (s) \leftrightarrow Ca^{2+}\ (aq) + 2OH^-\ (aq)$$

The solubility product expression describes, in mathematical terms, the equilibrium that is established between the solid substance and its dissolved ions in an aqueous system. The equilibrium expression for calcium hydroxide is shown below.

$$K_{sp} = [Ca^{2+}][OH^-]^2$$

The constant that illustrates a substance's solubility in water is called the K_{sp}. All compounds, even the highly soluble sodium chloride, have a K_{sp}. However, the K_{sp} of a compound is commonly considered only in cases where the compound is very slightly soluble and the amount of dissolved ions is not simple to measure.

Your primary objective in this experiment is to test a saturated solution of calcium hydroxide and use your observations and measurements to calculate the K_{sp} of the compound. You will do this by titrating the prepared $Ca(OH)_2$ solution with a standard hydrochloric acid solution. By determining the molar concentration of dissolved hydroxide ions in the saturated $Ca(OH)_2$ solution, you will have the necessary information to calculate the K_{sp}.

OBJECTIVES

In this experiment, you will

- Titrate a saturated $Ca(OH)_2$ solution with a standard HCl solution.
- Determine the $[OH^-]$ for the saturated $Ca(OH)_2$ solution.
- Calculate the K_{sp} of $Ca(OH)_2$.

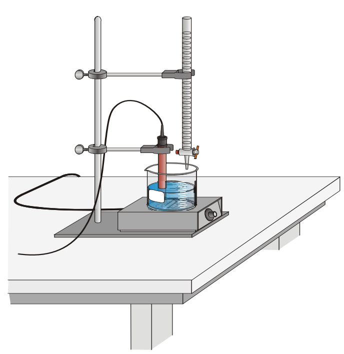

Figure 1

MATERIALS

Vernier computer interface
computer
Vernier pH Sensor
ring stand and ring
two 100 mL beakers
two 250 mL beakers
two 50 mL graduated cylinders
50 mL buret
saturated $Ca(OH)_2$ solution
0.050 M HCl solution
(optional) indicator solution
buret clamp
filter paper
filter funnel
magnetic stirrer and stirring bar

PROCEDURE

1. Obtain and wear goggles.

2. Obtain about 70 mL of a saturated calcium hydroxide solution. **CAUTION:** *Calcium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.*

3. Set up a ring stand, ring, filter funnel, and filter paper. Filter your sample of $Ca(OH)_2$ solution into a clean beaker. Measure out about 15 mL of the filtered solution into a 250 mL beaker. Record the precise volume of $Ca(OH)_2$ solution that you are using.

4. Obtain about 200 mL of 0.0500 M HCl solution. **CAUTION:** *Handle the hydrochloric acid with care. It can cause painful burns if it comes in contact with the skin.*

5. Connect a pH Sensor to Channel 1 of the Vernier computer interface. Connect the interface to the computer using the proper interface cable.

6. Set up the beaker of $Ca(OH)_2$ solution on a magnetic stirrer. If you are not using a magnetic stirrer, use a glass stirring rod to stir the solution throughout the titration.

7. Use a utility clamp to suspend the pH Sensor on a ring stand as shown in Figure 1. Position the pH Sensor in the $Ca(OH)_2$ solution, and adjust its position so that the sensor is not struck by the magnetic stirring bar.

8. Connect a buret to the ring stand. Rinse and fill the buret with the 0.0500 M HCl solution.

9. Start the Logger *Pro* program on your computer. Open the file “23 Ksp” from the *Advanced Chemistry with Vernier* folder.

10. Conduct the titration carefully. The guidelines below are general suggestions; use your judgment in conducting the titrations to get the best results.
    a. Before you have added any of the HCl titrant, click **Collect** and monitor pH for 5-10 seconds. Once the displayed pH reading has stabilized, click **Keep**. In the edit box, type "0" (for 0 mL added). Press the ENTER key to store the first data pair.
    b. Add a small amount of the titrant, up to 0.50 mL. When the pH stabilizes click **Keep**. Enter the current buret reading and press ENTER to save the second data pair.
    c. Continue adding the HCl solution in increments that lower the pH consistently, and enter the buret reading after each increment.
    d. When you reach the equivalence point, continue adding the HCl solution until the pH value remains constant.
11. When you have finished collecting data, click **Stop**. Choose Store Latest Run from the Experiment menu to save the results of the first trial.
12. Follow the steps below to find the *equivalence point*, which is the largest increase in pH upon the addition of a very small amount of HC1 solution. A good method of determining the precise equivalence point of the titration is to take the second derivative of the pH-volume data, a plot of Δ^2pH/Δvol^2.
    a. Open Page 3 by clicking on the Page window on the menu bar.
    b. Analyze the second derivative plot and record the volume of HC1 at the equivalence point.
13. Dispose of the reaction mixture as directed. Rinse the pH Sensor with distilled water in preparation for the second titration.
14. Repeat the necessary steps to titrate a second sample of the filtered $Ca(OH)_2$ solution. Conduct a third trial if directed by your instructor. Print a copy of the graph (or graphs) that you will use in your data analysis.

DATA TABLE

Trial	Equivalence point (mL)
1	
2	

DATA ANALYSIS

1. Calculate the [OH$^-$] from the results of your titrations. Explain your calculations.

2. Calculate the $[Ca^{2+}]$. Explain your calculations.

3. Calculate the K_{sp} for calcium hydroxide. Explain your calculations.

4. Find the accepted value of the K_{sp} for calcium hydroxide and compare it with your value. Discuss the discrepancy and suggest possible sources of experimental error.