Experiment 38

Calculating a Solubility Product Constant

INTRODUCTION

In a previous experiment, you used the colour of a solution as a measure of its equilibrium constant. In this experiment, you will calculate the solubility product constant for calcium hydroxide, which is a base. Recall that to analyse a base, you need an acid solution and an indicator.

PROBLEM

What is the solubility product constant for calcium hydroxide?

APPARATUS AND MATERIALS

Per pair of students:

1 24-well plate
3 1-mL micro-tip pipettes and labels
1 balance
1 toothpick
dropper bottles of:
- saturated solution of calcium hydroxide
- phenolphthalein
- 0.050 0 mol/L solution of hydrochloric acid

SAFETY

Calcium hydroxide and hydrochloric acid are corrosive. However, in the concentrations used here, they present little risk. Wash any spills off your skin and clothing.

PRELAB ASSIGNMENT

1. Write the equilibrium equation for the solubility of calcium hydroxide.
2. Write the solubility product constant expression for calcium hydroxide.
3. Think about why you need to analyse only the hydroxide ions.

PROCEDURE

1. Label and fill a pipette with saturated calcium hydroxide solution. Measure and record its mass.
2. Label and fill a pipette with hydrochloric acid solution. Measure and record its mass.
3. In a 24-well plate, fill a well about $\frac{1}{4}$ full with the calcium hydroxide solution.
4. Add 2 drops of phenolphthalein to this well using a pipette.
5. Titrate the calcium hydroxide solution with the hydrochloric acid solution by adding the hydrochloric acid solution drop by drop, stirring constantly.
6. As soon as a permanent colour change occurs, stop adding the hydrochloric acid solution. If you overshoot, add a few more drops of calcium hydroxide solution to the well and resume adding the hydrochloric acid solution more carefully.
7. Measure and record the mass of each pipette.
8. Repeat Steps 1 to 7 twice. Depending on the volume of solution used, you may not need to refill the pipettes.

ANALYSIS

1. For the first set of data, calculate the mass of calcium hydroxide solution used and the mass of hydrochloric acid solution used.
2. As the solutions are dilute, assume their densities are close to 1.00 g/mL. Thus, calculate the volume of each solution used.
3. Using the volume and concentration, find the amount, in moles, of hydrochloric acid used.
4. (a) Write a net ionic equation for the neutralization of the hydroxide ions by the acid.
   (b) How many moles of hydroxide ions were in your solution?

5. Find the concentration of the hydroxide ions.
6. Repeat Steps 1 to 5 for the second and third sets of data. Find the average. Use this average in the remaining calculations.
7. From the equilibrium equation for the solubility of calcium hydroxide, calculate the concentration of calcium ions.
8. Substitute the values from Steps 6 and 7 into the solubility product constant expression to find the solubility product constant for calcium hydroxide.

Optional: Use a computer spreadsheet program for these calculations.

EXERCISES

1. How does your value for the solubility product constant compare to the accepted value?
2. Your result could have been affected by a measurement you did not make. What is this measurement?
3. Can you describe a way to find the solubility product constant of a compound that does not use a titration?
4. Give three reasons why you were given calcium hydroxide to analyse rather than some other compound.

EXTENSION

1. (a) Use your answer to Exercise 3 to find the K_{sp} of calcium hydroxide.
   (b) Use a pH meter to find the pH of the original solution of calcium hydroxide. From the pH value, calculate the concentration of the hydroxide ions. Compare this value to the value you found by titration.