Experiment #8
Determining the K_{sp} of Calcium Hydroxide

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CHE-1210L, Section 89226, Spring Semester 2024
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Goal of the Experiment

The K_{sp} of a substance is a mathematical description of a compound's ability to dissolve in water. In this experiment a saturated solution of calcium hydroxide ($Ca(OH)_2$) is used to calculate the K_{sp} using hydrochloric acid (HCl) as the titrant. Calcium hydroxide is known to be slightly soluble in water, meaning the K_{sp} is useful to determine the amount of dissolved ions.

Chemistry Principle

Using a saturated solution of $Ca(OH)_2$ and a standard HCl solution with a known molarity means the solution can be titrated and monitored with a pH meter. Adding HCl to the $Ca(OH)_2$ a mL at a time allows the graphing program to record the drop in pH and calculate the equivalence point.

At the equivalence point, the moles of HCl will equal the moles of OH^- ions in the solution. This means the concentration of OH^- and subsequently Ca^{2+} can be calculated.

The equilibrium expression for calcium hydroxide is: $K_{sp} = [Ca^{2+}][OH^-]^2$. From this equation, $[OH^-]$ is determined by dividing the moles of HCl added by the initial volume of $Ca(OH)_2$. Once that value is known, $[Ca^{2+}]$ is half the amount of $[OH^-]$.

The experimental value can then be compared to the known value provided in Appendix C of Chemistry by Silberberg and Amateis, which is 6.5×10^{-6}.

Results and Discussion

The experiment consisted of three trials using the pH meter and methyl orange as an indicator. This provides two ways to gauge the progress of the reaction. An initial pH reading of the $Ca(OH)_2$ solution was taken as a baseline. Then, the HCl was titrated into the $Ca(OH)_2$ and methyl orange solution beginning with 2-3mL of HCl and then decreasing to 1mL once the readings on the pH meter started to drop. The color change of the solution also helped to determine when the amount of titrant added should be lowered. Finally, the HCl was added in increments of .5mL or less to accurately capture the equivalence point. HCl was added until the pH readings stabilized again.

Based on the three trials, the equivalence point was reached at an average of 21.5 mL of HCl added. Calculating the moles of HCl based on the given concentration of 0.08814024 M gives an average value of 1.89×10^{-3} moles HCl.

Using this data to determine K_{sp} gives an average K_{sp} of 2.697×10^{-5} and a standard deviation of 0.3558, or 35.58%.

Conclusion

The percent error between the experimentally determined K_{sp} value and the value provided by the textbook is approximately 341%. Based on the high percent error but low standard deviation, the data collected was precise and consistent, but wildly inaccurate based on the accepted K_{sp} value.

This suggests there was an error in the setup of the experiment. The initial concentrations of the stock solution of HCl or $Ca(OH)_2$ may have been incorrect or mislabeled. There could have been dilution in the buret or flask that was used during titration. The pH meter may not have been calibrated properly and inaccurately recorded the readings during the experiment.

A fresh stock solution of ~0.1M HCl and saturated $Ca(OH)_2$ would be prepared before attempting this experiment again. Additionally, proper lab practices would be reviewed for titrating with these solutions.