Determination of the Solubility Product of an Ionic Compound
AP Chemistry

Background:
The solubility product constant, K_{sp}, is a particular type of equilibrium constant. The equilibrium is formed when an ionic solid dissolves in water to form a saturated solution. The equilibrium exists between the aqueous ions and the undissolved solid. A saturated solution contains the maximum concentration of ions of the substance that can dissolve at the solution's temperature.

A knowledge of the K_{sp} of a salt is useful, since it allows us to determine the concentration of ions of the compound in a saturated solution. This allows us to control a solution so that precipitation of a compound will not occur, or to find the concentration needed to cause a precipitate to form. The solubility product which will be determined by this experiment is that of the strong base, calcium hydroxide, $Ca(OH)_2$.

Materials and Equipment:

Calcium nitrate, $Ca(NO_3)_2$, 0.10 M
Sodium hydroxide, NaOH, 0.10 M
(2) 96-well micro-wellplates
50-mL beaker
Small dropper bottles for $Ca(NO_3)_2$, NaOH, and H_2O
(2) disposable pipets for mixing

Note: Hold the droppers vertically when dispensing the drops. Discard the first drop as it may contain an air bubble.

Procedure:

Part A: $[Ca(NO_3)_2]$ varies, [NaOH] held constant

1. Arrange a micro-wellplate so that you have 12 wells up and down.
   a. Put 5 drops of 0.10 M $Ca(NO_3)_2$ in well #1 in the first row.
   b. Place 5 drops of water in each of the wells #2 though #12 in the first row.
   c. Next add 5 drops of 0.10 M $Ca(NO_3)_2$ to well #2.
   d. Use an empty pipet to mix the solution thoroughly by drawing the solution into the pipet and then squirting it back several times. (Calculation hint: the solution in this well, #2, is now 0.050 M in Ca^{2+} ion.)
2. Use your empty pipet to remove the solution from well #2 and put 5 drops of this solution into well #3. Put the remaining solution back in well #2.
3. Mix the solution in well #3 as before. Continue this serial dilution procedure, adding 5 drops of the previous solution to the 5 drops of water in each well down the row until you fill the last one, #12. Mix the solution in well #12, and discard 5 drops. Determine the concentration of solution in each well. (Hint: the concentration of calcium ions in well #12 is 4.9×10^{-5} M.)
4. Place 5 drops of 0.10 M NaOH in each of the wells #1 through #12. When the NaOH is added to each well, the initial concentrations of the reactants are halved, as each solution dilutes the other. Use an empty pipet to mix each of these combined solutions by drawing each solution up into the pipet and squirting it back into the well. (Hint: the concentration of Ca^{2+} ions in well #12 is 2.4×10^{-5} M.)
5. Allow three or four minutes for the precipitates to form, then observe the pattern of precipitation. At one point the concentration of both ions becomes too low to have any precipitate form. We will assume that the first well with no precipitate represents a saturated solution.

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Part B: [NaOH] varies, [$Ca(NO_3)_2$] held constant

6. To check your results, repeat the procedure but use a serial dilution of the NaOH.
    a. In a different row, put 5 drops of 0.10-M NaOH in well #1.
    b. Put 5 drops of distilled water in wells #2 through #12.
    c. Add 5 drops of the 0.10-M NaOH solution to well #2.
    d. Use an empty pipet to mix the solution by pulling the solution into the pipet and then squirting it back several times. The solution in this well, #2, is now 0.050 M in OH- ion.
    e. Continue this serial dilution to well #12, and then remove 5 drops from well #12.
7. Add 5 drops of 0.10 M $Ca(NO_3)_2$ to each of the wells, and mix each with an empty pipet or stirrer. Again, determine the well where no more precipitate appears.

Cleanup: Solutions can be safely flushed down the drain.

Determination of K_{sp} of Calcium Hydroxide Lab Key; AP Chemistry / Vonderbrink #13

Data Table:

Determination of the Solubility Product of an Ionic Compound **Name(s):**

AP Chemistry **Date:** **Pd:**

Data and Results: Also describe the relationship between Q and Ksp in that well after mixing (<, >, =)

Well #	Part A & *Part B*	[Ca^{2+}] after dilution & *[OH^-] after dilution*	[Ca^{2+}] after base added & *[OH^-] after Ca^{2+} added*	[OH^-] after addition & *[Ca^{2+}] after addition*	Part A Observations: Precipitate?	Part A Observations: Relationship between Q and K_{sp}	*Part B Observations: Precipitate?*	*Part B Observations: Relationship between Q and K_{sp}*
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Calculations: Show one example for each.

1. Calculate the concentration of each ion in the first well where no precipitation appeared in Part A.

2. Write the equation for the dissolution of $Ca(OH)_2$ and write the solubility product expression.

3. Calculate the value of the solubility product for Parts A and B.

4. Average your results, and calculate % error.

Discussion Questions:

1. How was the well chosen to calculate the solubility product? Why?

2. Does this method give values that are too low or too high? Why?

3. Give 2 ways to make this method more accurate.