Lab #20: Determination of the K_{sp} of a Chemical Reaction Lab Exercise

Name: _____

Chemistry II

Partner: _____

10 points

USE BLUE/BLACK INK!!!!

Date: _____ Hour: _____

Goal:

The goal of this lab is to use micro techniques to determine the solubility product constant for the reaction of calcium nitrate and sodium hydroxide.

Background/Introduction:

In this lab, the micro technique of serial dilution will be used. A micro well plate will be where the reaction takes place instead of a test tube or beaker in order to keep reaction amounts small. Because amounts are so small, proper technique is VERY important. When using a dropper, make sure it contains NO air bubbles and is used vertically. Discard the first drop each time. Also, because the technique can take some getting used to, the procedure is fairly short, and the trials may be repeated.

Research questions (Please answer on a separate sheet and attach):

1) What is meant by the solubility product constant, K_{sp}?
2) What is a saturated solution?
3) Explain how Q is related to K_{sp}.
4) Explain how Q and K_{sp} can be used to determine when a precipitate will form.
5) Write and balance the equation of aqueous solutions of calcium nitrate reaction with sodium hydroxide.
   - include states of matter
   - also write the net ionic equation
   - explain why one of the products is made of spectator ions
6) The ionic compound silver chromate is not very soluble in water.
   a) Write and balance the equilibrium equation of silver chromate dissociating in water.
   b) Write the solubility product expression for silver chromate.
   c) If a 0.10 M solution of silver chromate is diluted by a factor of 2, what is the new concentration?
   d) The dilution of 0.10 M silver nitrate by a factor of 2 is carried out 5 times in a row (called a serial dilution). What is the final concentration?
   e) The value of the K_{sp} for silver chromate is 1.1×10^{-12}. In a saturated solution of silver chromate, the silver ion concentration is found to be 2.5×10^{-4} M. What is the chromate ion concentration in moles per liter? Show your work!

Materials:

5 mL 0.10 M calcium nitrate solution	5 mL 0.10 M sodium hydroxide solution
5 droppers	1 96-well micro well plate
12 toothpicks	4 10 mL beakers
1 test tube brush	1 permanent marker
1 30 mL beaker	1 calculator

_____ _____

_____ _____

Hazards:

_____

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Procedure:

1) Physically and chemically clean, dry, and label the beakers.
    a) label one 10 mL beaker 0.10 M calcium nitrate
    b) label another 10 mL beaker 0.10 M sodium hydroxide
    c) label the third 10 mL beaker distilled water for diluting
    d) label the fourth 10 mL beaker distilled water for rinsing
    e) label the 30 mL beaker waste
2) Obtain the solutions in the 10 mL beakers.
3) Arrange the micro well plate so that there are 12 wells across from left to right.
4) Perform a serial dilution of calcium nitrate
    a) Put 5 drops of 0.10 M calcium nitrate solution in well #1 in the first row. NOTE: Hold the dropper vertically when dispensing the drops! Make sure no air bubbles are in the end of the dropper. Discard the first drop into the 30 mL waste beaker, as it may contain an air bubble.
    b) Place 5 drops of distilled water in each of the wells #2 through #12 in the first row.
    c) Add 5 drops of 0.10 M calcium nitrate to well #2.
    d) Use an empty dropper to mix the solution in well #2 thoroughly by drawing the solution into the dropper and squirting it back several times. NOTE: The solution in well #2 is now 0.050 M Ca^{2+} ions.
    e) Use the dropper to remove solution from well #2 and add 5 drops from well #2 into well #3.
    f) Put the remaining solution back into well #2.
    g) Rinse the dropper by drawing some distilled water for rinsing up and squirting it into the sink several times.
    h) Repeat 4d to mix the solution in well #3.
    i) Continue the serial dilution process, adding 5 drops of the previous solution to the 5 drops of distilled water in each well down the row all the way through well #12
    j) After mixing the solution in well #12, discard 5 drops into the waste beaker.
    k) Determine the concentration of solution in each well. Verify that the concentration of calcium ions in well #12 is 4.9×10^{-5} M.
5) Combine the calcium nitrate solutions with sodium hydroxide
    a) Using a new dropper, place 5 drops of 0.10 M sodium hydroxide in each of the wells #1 through #12. NOTE: When the sodium hydroxide is added to each well, the initial concentrations of the reactants are halved, as each solution dilutes the other.

b) Either use a dropper to mix each of the combined solutions by drawing each solution up into the dropper and squirting it back into the well OR mix them thoroughly with a toothpick. Verify that the calcium ion concentration in well #12 is 2.4×10^{-5} M.

6) Observe any precipitates
   a) Allow three or four minutes for any precipitates to form.
   b) Describe any precipitates that form.
   c) At one point, the concentration of both ions becomes too low to have any precipitate form. The first well with no precipitate represents a saturated solution.
7) Check results by diluting sodium hydroxide and reacting it with calcium nitrate
   a) Repeat steps 3-6, using the other side of the micro well plate, and using 0.10 M sodium hydroxide instead of 0.10 M calcium nitrate
   b) Add 5 drops of 0.10 M calcium nitrate to each well as in step 5
   c) Repeat step 6
8) Clean up!

Data:

Data Table 1: Calcium Ion Serial Dilutions

Well #	**Initial Ca^{2+} ion concentration**	**Ca^{2+} ion concentration after adding NaOH**	**OH^- concentration after mixing**	**Observation of reaction and description of precipitate**
1	0.10 M			
2	0.050 M			
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Data Table 2: Hydroxide Ion Serial Dilutions

Well #	**Initial OH^- ion concentration**	**OH^- ion concentration after adding $Ca(NO_3)_2$**	**Ca^{2+} concentration after mixing**	**Observation of reaction and description of precipitate**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Post-Lab Calculations, Analysis, and Questions (answer on separate paper and/or the computer–no need for a separate conclusion):

1. What was the first well during the calcium nitrate dilution that had no precipitate?
2. Fill in all the concentrations in Data Table 1 and Data Table 2. Show your work for one row in each table.
3. Using the concentrations of the first well in Data Table 1 with no precipitate, calculate the solubility product constant, K_{sp}, of calcium hydroxide.
4. Using the concentrations of the first well in Data Table 2 with no precipitate, calculate the solubility product constant, K_{sp}, of calcium hydroxide.
5. How do the two K_{sp} values compare to each other?
6. Use a reference to look up the actual K_{sp} of calcium hydroxide. List the reference you used.
7. Average your two K_{sp} values and calculate your percent error.
8. Does this method give values that are too high or too low?
9. Would the results be better if the concentrations of the last well where precipitation occurs were averaged with the first well where there is no precipitate? (Try it and show your work.)
10. What are the positives and negatives of using micro techniques?
11. Discuss any problems you had during this lab and ways the lab could be improved.

Lab handout based on the experiment "Determination of the Solubility Product of an Ionic Compound" in Laboratory Experiments for Advanced Placement Chemistry (Second Edition) by S.A. Vonderbrink (Flinn Scientific, 2006)