Dougherty Valley HS Chemistry - AP
Solutions – Determining the Ksp of Calcium Hydroxide

Worksheet #11

Name: **Period:** **Seat#:**

Required Sections: (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.)

Prelab: Prelab Questions, Materials, Reagent Table, Procedures, and set up Data Tables before you get to class.

During Lab: Data section – Fill out your data table that is already set up from the prelab.

Post-lab: Calculation section, Discussion Questions Section (both done in lab notebook), Post-Lab Two Pager (done on separate worksheet).

REMINDER - USE R-15 TO ENSURE YOU FOLLOW ALL GUIDELINES/EXPECATIONS/ REQUIREMENTS

Background

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 $Ca(OH)_2$.

Materials – *don't forget to use an MSDS to do your reagent table! Remember that a * means it should be in your reagent table!*

Chemicals

- * 0.050* M hydrochloric acid, HCl, solution (*approximate)
- * Saturated calcium hydroxide, $Ca(OH)_2$, solution

Equipment

- Chromebook, Graphical Analysis
- Vernier wireless pH sensor
- Stir station and magnetic stir bar
- Ring stand w/ clamp
- 250mL beaker
- 50mL graduated cylinder
- 50mL burette w/clamp
- Distilled H_2O
- Filter paper and funnel

Google Folder with Most MSDS Files
https://tinyurl.com/2cyva3ku
To help speed up your reagent table!

Flinn's MSDS Website
https://www.flinnsci.com/sds/
For anything that isn't in my Google folder.

Procedure – *Remember to make a flow chart, include diagrams/drawings of steps/equipment etc. Google "flow chart procedures" if you are not familiar with how to make a flow chart. You aren't just drawing boxes around all your sentences!*

1) Obtain and wear goggles.

2) Obtain 15 mL of a saturated calcium hydroxide solution into a 250 mL beaker. Record the precise volume of $Ca(OH)_2$ solution that you are using. Your teacher will have filtered the solution first to ensure there was as little solid as possible. **WARNING**: *Calcium hydroxide: Do not eat or drink when using this product—harmful if swallowed. Causes skin irritation*.

3) Set up your ring stand, clamps, burette, stir station, and pH probe as shown in Figure 1. Your teacher may have set up some or all of this for you ahead of time.

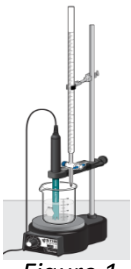

Figure 1

4) Record the specific concentration oh HCl your teacher told you is being used. Ensure that your burette is rinsed twice and then filled with HCl. Your teacher may have done this ahead of time for you. **WARNING**: *Hydrochloric acid solution,* HCl: *May be harmful if swallowed, inhaled, or in contact with skin. Causes skin and eye irritation*.

5) Launch Graphical Analysis. Connect the pH Sensor to your Chromebook, computer, or mobile device.

6) Set up the beaker of $Ca(OH)_2$ solution on the Stir Station.

7) Position the pH Sensor in the $Ca(OH)_2$ solution, add a magnetic stirring bar, and adjust the position of the sensor so that it is not struck by the magnetic stirring bar. You may add distilled water as needed to achieve enough depth to protect the stir bar. **YOUR TEACHER MUST CHECK YOUR PLACEMENT BEFORE YOU TURN ON YOUR STIR BAR!**

8) Set up the data-collection mode.
   a. Click or tap Mode to open Data Collection Settings. Change Mode to Event Based.
   b. Enter **Volume** as the Event Name and **mL** as the Units. Click or tap Done.

9) Conduct the titration carefully. The guidelines below are general suggestions; ***use your judgment in conducting the titrations to get the best results! Look at your graph as you are titrating!***
   a. Click or tap Collect to start data collection.
   b. Before you have added any of the HCl titrant, click or tap Keep and enter **0** as the burette volume in mL. Click or tap Keep Point to continue.
   c. Add a small amount of the titrant, up to 0.50 mL. When the pH stabilizes, select Keep. Enter the current burette reading, and then click or tap Keep Point to continue.
   d. Continue adding the HCl solution in increments that lower the pH consistently, and enter the burette reading after each increment.
   e. When you reach the equivalence point, continue adding HCl until the pH value remains constant.

10) Click or tap Stop to stop data collection and view a graph of pH *vs*. volume. Dispose of the reaction mixture as directed. Rinse the pH Sensor with distilled water in preparation for a second titration.

11) Examine your titration data to identify the region where the pH made the greatest decrease. The equivalence point is in this region.
   a. To examine the data pairs on the graph, click or tap any data point. As you tap each data point, the pH and volume values are displayed. **Note**: You can also adjust the Examine line by dragging the line.
   b. Identify the equivalence point as accurately as possible and record this information.

12) Repeat the necessary steps to titrate a second, and/or third, sample of the filtered $Ca(OH)_2$ solution. **Note**: The previous data set is automatically saved.

13) If time and materials allow, you may try to titrate using bromothymol blue indicator instead of the pH probe. Add 5 drops of bromothymol blue to a new sample of 15mL $Ca(OH)_2$. The solution will go from blue (basic due to the bromothymol blue), to green pH 7. Record the volume of HCl added to achieve the green pH 7. Do not average this trial in with your other data, but rather compare the percent error from the probe trials to the indicator trial.

14) Export, download, or print a graph of each titration.

Disposal and Cleanup

Your teacher will provide disposal and cleanup instructions.

Data Table

1. Make your own data table! Remember, you need to make sure your data table has all required elements! A sample is provided below.
2. Glue in a copy of your Logger Pro graph below your data table.

Trial	Equivalence point (mL)
1	Sample
2	

Calculations - *Show all calculations, use proper dimensional analysis, units everywhere, proper sig figs, etc.*

1. Calculate the $[OH^-]$ from the results of your probe titrations.
2. Calculate the $[Ca^{2+}]$.
3. Calculate the K_{sp} for calcium hydroxide.
4. The accepted value for the K_{sp} for calcium hydroxide is 5.5×10^{-6}. Calculate your percent error.
5. Repeat Calculations 1-4 for the titration using bromothymol blue indicator if time allowed.

Post Lab Discussion Questions – *Do not recopy the questions, just paraphrase them into your answer.*

1. Using the accepted K_{sp} value, what is the molar solubility of $Ca(OH)_2$?
2. How might a student go about increasing the molar solubility of $Ca(OH)_2$? Give a specific example.
3. How might a student go about decreasing the molar solubility of $Ca(OH)_2$? Give a specific example.
4. How many mL of a 0.10 M $CaCl_2$ solution would need to be added to a saturated $Ca(OH)_2$ solution in order for the pH to become 11? Use the accepted K_{sp} for $Ca(OH)_2$ to do your calculations.