USING CONDUCTIVITY TO FIND AN EQUIVALENCE POINT

LAB CND 3.CALC

INTRODUCTION

In this experiment, you will monitor conductivity during the reaction between sulfuric acid, H₂SO₄ and barium hydroxide, Ba(OH)₂, in order to determine the equivalence point. From this information, you can find the concentration of the Ba(OH)₂ solution. You will also see the effect of ions, precipitates, and water on conductivity. The equation for the reaction in this experiment is:

\[ \text{Ba}^{2+}(aq) + 2 \text{OH}^-(aq) + 2 \text{H}^+(aq) + \text{SO}_4^{2-}(aq) \rightarrow \text{BaSO}_4(s) + \text{H}_2\text{O}(l) \]

Before reacting, Ba(OH)₂ and H₂SO₄ are almost completely dissociated into their respective ions. Neither of the reaction products, however, is significantly dissociated. Barium sulfate is a precipitate and water is predominantly molecular.

As 0.0200 M H₂SO₄ is slowly added to Ba(OH)₂ of unknown concentration, changes in the conductivity of the solution will be monitored using a Conductivity Probe. When the probe is placed in a solution that contains ions, and thus has the ability to conduct electricity, an electrical circuit is completed across the electrodes that are located on either side of the hole near the bottom of the probe body (see Figure 1). This results in a conductivity value that can be read by the interface. The unit of conductivity used in this experiment is the microsiemens, or μS.

Figure 1
Prior to doing the experiment, it is very important for you to hypothesize about the conductivity of the solution at various stages during the reaction. In each of the following situations: Do you expect the conductivity reading to be high or low? Do you expect the conductivity readings to increase or decrease?

- When the Conductivity Probe is placed in Ba(OH)$_2$, prior to the addition of H$_2$SO$_4$.
- As H$_2$SO$_4$ is slowly added, producing BaSO$_4$ and H$_2$O.
- When the moles of H$_2$SO$_4$ added equal the moles of BaSO$_4$ originally present.
- As excess H$_2$SO$_4$ is added beyond the equivalence point.

**PURPOSE**

The purpose of this experiment is to determine the equivalence point of the reaction and the concentration of the barium hydroxide from the conductivity of the reaction mixture. The effect of ions, precipitates, and water on conductivity will also be observed.

**EQUIPMENT/MATERIALS**

- LabPro interface and AC adapter
- TI Graphing Calculator with DataMate
- Conductivity Probe
- ring stand
- utility clamp
- stirring rod
- 60 mL of 0.0200 M H$_2$SO$_4$
- 50 mL of Ba(OH)$_2$, unknown solution
- 100-mL graduated cylinder
- 50-mL burette
- two 250-mL beakers
- phenolphthalein (optional)

**SAFETY**

- Always wear an apron and goggles in the lab.
- H$_2$SO$_4$ is a strong acid. Handle it with care.
- Ba(OH)$_2$ is toxic. Handle it with care.
PROCEDURE

1. Measure out approximately 60 mL of 0.020 M H\textsubscript{2}SO\textsubscript{4} into a 250-mL beaker. Record the precise H\textsubscript{2}SO\textsubscript{4} concentration in your data table. Obtain a 50-mL burette and rinse the burette with a few mL of the H\textsubscript{2}SO\textsubscript{4} solution. Use a utility clamp to attach the burette to the ring stand as shown in Figure 1. Fill the burette a little above the 0.00-mL level of the burette. Drain a small amount of H\textsubscript{2}SO\textsubscript{4} solution so it fills the burette tip and leaves the H\textsubscript{2}SO\textsubscript{4} at the 0.00-mL level of the burette. Dispose of the waste solution in this step as directed by your teacher.

2. Measure out 50.0 mL of Ba(OH)\textsubscript{2} of unknown concentration using a 100-mL graduated cylinder. Transfer the solution to a clean, dry 250-mL beaker. Then add 120 mL of distilled water to the beaker.

3. Plug the Conductivity Probe into Channel 1 of the LabPro or interface. Set the selector switch on the side of the Conductivity Probe to the 0-2000 range. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

4. Arrange the burette, Conductivity Probe, beaker containing Ba(OH)\textsubscript{2}, and stirring bar as shown in Figure 1. The Conductivity Probe should extend down into the Ba(OH)\textsubscript{2} solution to just above the stirring bar, so the hole in the probe end is completely submerged.

5. Turn on the calculator and start the DATAMATE program. Press CLEAR to reset the program.

6. Set up the calculator and interface for the Conductivity Probe.
   a. Select SETUP from the main screen.
   b. If the calculator displays the Conductivity Probe in CH 1, proceed directly to Step 7. If it does not, continue with this step to set up your sensor manually.
   c. Press ENTER to select CH 1.
   d. Select CONDUCTIVITY from the SELECT SENSOR menu.
   e. Select CONDUCT 2000 (MICS) from the CONDUCTIVITY menu.

7. Set up the data-collection mode.
   a. To select MODE, press ▲ once and press ENTER.
   b. Select EVENTS WITH ENTRY from the SELECT MODE menu.
   c. Select OK to return to the main screen.
8. You are now ready to perform the titration. This process goes faster if one person manipulates and reads the burette while another person operates the calculator and enters volumes.
   a. Select START to begin data collection.
   b. Before adding H\textsubscript{2}SO\textsubscript{4} titrant, press \texttt{ENTER} and type in “0” as the conductivity value (in \(\mu\text{S}\)). Press \texttt{ENTER} to save the first data pair for this experiment.
   c. Add 1.0 mL of 0.0200 M H\textsubscript{2}SO\textsubscript{4} to the beaker. When the conductivity value stabilizes, press \texttt{ENTER} and enter the current burette reading. You have now saved the second data pair for the experiment.
   d. Continue adding 1.0-mL increments of H\textsubscript{2}SO\textsubscript{4} solution, each time entering the burette reading, until the conductivity has dropped \textit{below} 100 \(\mu\text{S}\).
   e. After the conductivity has dropped below 100 \(\mu\text{S}\), add one 0.5-mL increment and enter the burette reading.
   f. After this, use 2-drop increments (~0.1 mL) until the minimum conductivity has been reached at the equivalence point. Enter the volume after each 2-drop addition. When you have passed the equivalence point, continue using 2-drop increments until the conductivity is greater than 50 \(\mu\text{S}\) again.
   g. Now use 1.0-mL increments until the conductivity reaches about 1000 \(\mu\text{S}\), or 25 mL of H\textsubscript{2}SO\textsubscript{4} solution has been added, whichever comes first.

9. Press \texttt{STO} when you have finished collecting data.

10. Examine the data on the displayed graph to find the \textit{equivalence point}—that is, the volume when the conductivity value reaches a minimum. As you move the cursor right or left on the displayed graph, the volume (X) and conductivity (Y) values of each data point are displayed below the graph. Record the H\textsubscript{2}SO\textsubscript{4} volume of the point with the minimum conductivity value in the data table.

11. Dispose of all solutions as directed by your instructor. Rinse off and dry the Conductivity Probe.

12. (optional) Print a copy of the graph conductivity vs. volume.
DATA SHEET

Name ________________________
Name ________________________
Period _______ Class ___________
Date ___________

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PROCESSING THE DATA

1. Calculate moles of H₂SO₄ added at the equivalence point. Use the molarity, M, of the H₂SO₄ and its volume, in L.

2. Calculate the moles of Ba(OH)₂ at the equivalence point. Use your answer in the previous step and the ratio of moles of Ba(OH)₂ and H₂SO₄ in the balanced equation (or use the 1:1 ratio of moles of H⁺ to moles of OH⁻ from the equation).

3. From the moles and volume of Ba(OH)₂, calculate the concentration of Ba(OH)₂, in mol/L.

DATA AND CALCULATION TABLE

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<th>Molarity of H₂SO₄</th>
<th>M</th>
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<tbody>
<tr>
<td>Volume of H₂SO₄</td>
<td>mL = L</td>
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<tr>
<td>Volume of Ba(OH)₂</td>
<td>mL = L</td>
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