

USING CONDUCTIVITY TO FIND AN EQUIVALENCE POINT

LAB CND 3.CALC

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INTRODUCTION

In this experiment, you will monitor conductivity during the reaction between sulfuric acid, H_2SO_4 and barium hydroxide, $\text{Ba}(\text{OH})_2$, in order to determine the equivalence point. From this information, you can find the concentration of the $\text{Ba}(\text{OH})_2$ solution. You will also see the effect of ions, precipitates, and water on conductivity. The equation for the reaction in this experiment is:



Before reacting, $\text{Ba}(\text{OH})_2$ and H_2SO_4 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 H_2SO_4 is slowly added to $\text{Ba}(\text{OH})_2$ 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 .

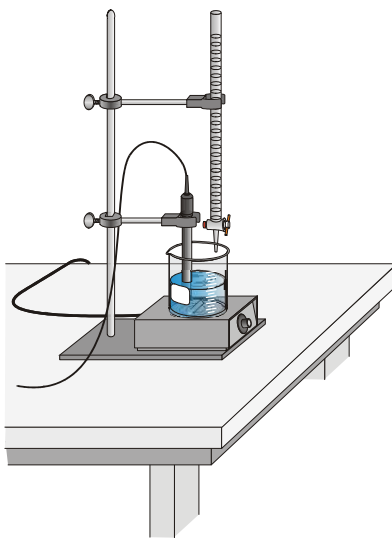


Figure 1

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 $\text{Ba}(\text{OH})_2$, prior to the addition of H_2SO_4 .
- As H_2SO_4 is slowly added, producing BaSO_4 and H_2O .
- When the moles of H_2SO_4 added equal the moles of BaSO_4 originally present.
- As excess H_2SO_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	60 mL of 0.0200 M H_2SO_4
TI Graphing Calculator with DataMate	50 mL of $\text{Ba}(\text{OH})_2$, unknown solution
Conductivity Probe	100-mL graduated cylinder
ring stand	50-mL burette
utility clamp	two 250-mL beakers
stirring rod	phenolphthalein (optional)

SAFETY

- Always wear an apron and goggles in the lab.
- H_2SO_4 is a strong acid. Handle it with care.
- $\text{Ba}(\text{OH})_2$ is toxic. Handle it with care.

PROCEDURE

1. Measure out approximately 60 mL of 0.020 M H_2SO_4 into a 250-mL beaker. Record the precise H_2SO_4 concentration in your data table. Obtain a 50-mL burette and rinse the burette with a few mL of the H_2SO_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_2SO_4 solution so it fills the burette tip *and* leaves the H_2SO_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 $\text{Ba}(\text{OH})_2$ 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 $\text{Ba}(\text{OH})_2$, and stirring bar as shown in Figure 1. The Conductivity Probe should extend down into the $\text{Ba}(\text{OH})_2$ 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 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 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 .
 - 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 H₂SO₄ titrant, press **ENTER** and type in “0” as the conductivity value (in μS). Press **ENTER** to save the first data pair for this experiment.
 - c. Add 1.0 mL of 0.0200 M H₂SO₄ to the beaker. When the conductivity value stabilizes, press **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 H₂SO₄ solution, each time entering the burette reading, until the conductivity has dropped *below 100 μS*.
 - e. After the conductivity has dropped below 100 μS, 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 μS again.
 - g. Now use 1.0-mL increments until the conductivity reaches about 1000 μS, or 25 mL of H₂SO₄ solution has been added, whichever comes first.
9. Press **STO▶** when you have finished collecting data.
10. Examine the data on the displayed graph to find the *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 H₂SO₄ 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 H_2SO_4 added at the equivalence point. Use the molarity, M, of the H_2SO_4 and its volume, in L.
2. Calculate the moles of $\text{Ba}(\text{OH})_2$ at the equivalence point. Use your answer in the previous step and the ratio of moles of $\text{Ba}(\text{OH})_2$ and H_2SO_4 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 $\text{Ba}(\text{OH})_2$, calculate the concentration of $\text{Ba}(\text{OH})_2$, in mol/L.

DATA AND CALCULATION TABLE

Molarity of H_2SO_4		M
Volume of H_2SO_4	mL =	L
Volume of $\text{Ba}(\text{OH})_2$	mL =	L
Moles of H_2SO_4		mol
Moles of $\text{Ba}(\text{OH})_2$		mol
Molarity of $\text{Ba}(\text{OH})_2$		M