# E9-CONDUCTIMETRIC TITRATION & GRAVIMETRIC ANALYSIS OF A SULFATE

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. The reaction between sulfuric acid and barium hydroxide yields an insoluble product, barium sulfate, and water, as shown in the reaction equation below.

**Ba2+(aq) + 2 OH–(aq) + 2 H+(aq) + SO42–(aq) → BaSO4(s) + H2O(l)**

In this reaction, the total number of dissociated ions in solution is reduced dramatically during the reaction as a precipitate is formed. As 0.100 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. This results in a conductivity value that can be read by the interface. The unit of conductivity used in this experiment is the microSiemens per cm, or µS/cm.

In addition, you will capture the precipitate, and measure its mass. You will have two methods, therefore, of calculating the molar concentration of a barium hydroxide solution that is titrated with a sulfuric acid solution of known concentration.

# OBJECTIVES

In this experiment, you will

* Measure the conductivity of the reaction between sulfuric acid and barium hydroxide.
* Use conductivity values as a means of determining the equivalence point of the reaction.
* Measure the mass of a product of the reaction as a means of determining the equivalence point of the reaction gravimetrically.
* Calculate the molar concentration of a barium hydroxide solution.



Figure 1

You will conduct the titration in a conventional manner. You will deliver volumes of H2SO4 titrant from a buret. After titrant is added, and conductivity values have stabilized, you will manually enter the buret reading to store conductivity-volume data.

# MATERIALS

| LabQuest | magnetic stirrer |
| --- | --- |
| LabQuest App | stirring bar or Micro stirrer |
| Vernier Conductivity Probe | two ring stands |
| barium hydroxide, Ba(OH)2, solution | ring stand ring |
| 0.100 M sulfuric acid, H2SO4, solution | utility clamp |
| distilled water | filter paper |
| two 250 mL beakers | filter funnel |
| 50 mL graduated cylinder | balance, ±0.01 gram accuracy (or better) |
| 10 mL pipet and pipet bulb or pump | drying oven (optional) |
| 50 mL buret |  buret clamp |

Measuring Volume Using a Buret

 1. Obtain and wear goggles.

 2. Use a pipet bulb (or pipet pump) to transfer 10.0 mL of the Ba(OH)2 solution into a 250 mL beaker. Add 50 mL of distilled water. **CAUTION:** *The barium hydroxide solution is caustic. Avoid spilling it on your skin or clothing*.

 3. Place the beaker on a magnetic stirrer and add a stirring bar. If no magnetic stirrer is available, you will stir with a stirring rod during the titration.

 4. Set the selector switch on the side of the Conductivity Probe to the 0–20000 µS/cm range. Connect the Conductivity Probe to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.

 5. Measure out approximately 60 mL of 0.100 M H2SO4 into a 250 mL beaker. Record the precise H2SO4 concentration in your data table. **CAUTION:** *H2SO4 is a strong acid, and should be handled with care.*

 6. Set up a ring stand, buret clamp, and 50.0 mL buret to conduct the titration (see Figure 1). Rinse and fill the buret with the H2SO4 solution.

 7. Use a utility clamp to connect the Conductivity Probe to a ring stand, as shown in Figure 1. Position the Conductivity Probe in the Ba(OH)2 solution and adjust its position so that it is not struck by the stirring bar.

 8. On the Meter screen of the LabQuest, tap Mode. Change the data-collection mode to Events with Entry. Enter the Name (Volume) and Units (mL). Select OK.

 9. Conduct the titration carefully, as described below.

1. Start data collection. Before you have added any H2SO4 solution, tap Keep. Enter **0**, the volume in mL and select OK to save this data pair.
2. Keep track of your initial buret reading before beginning the experiment. It is convenient to begin at 0.00 mL but not necessary. Add 1.0 mL of 0.100 M H2SO4 to the beaker. Record the new buret reading and calculate the actual volume of acid that you have added so far. When the conductivity value stabilizes, tap Keep. Enter **1** (or your actual Vfinal – Vinitial) as the volume in drops and then select OK.
3. Continue adding 1.0 mL increments of H2SO4 solution, each time entering the buret reading of total volume used so far in the titration, until the conductivity has dropped *below 100 µS/cm*.
4. After the conductivity has dropped below 100 µS/cm, add one 0.5 mL increment and enter the buret reading.
5. After this, use 2-drop increments (~0.1 mL) until the minimum conductivity has been reached at the equivalence point. Enter new total volume value 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/cm again.

Now use 1.0 mL increments until the conductivity reaches about 1000 µS/cm, or 15 mL of H2SO4 solution have been added, whichever comes first.

 10. Stop data collection to view a graph of conductivity *vs.* volume.

 11. Examine the data on the displayed graph to find the *equivalence point*; that is, the volume when the conductivity value reaches a minimum. To examine the data pairs on the displayed graph, select any data point. Record the H2SO4 volume, at the point of minimum conductivity, in your data table.

 12. Filter and measure the mass of the barium sulfate precipitate.

1. Use a hot plate to warm the beaker of mixture containing the BaSO4 precipitate. Warm the solution to near boiling for about five minutes to help flocculate the particles.
2. While the mixture is heating, set up a ring stand and ring for the filter funnel. Measure and record the mass of a piece of fine-grade filter paper (Whatman # 5 or #40 or equivalent) and set the paper in the funnel. Dampen the paper with dH2O.
3. Allow the mixture to cool then filter it. The liquid can be slightly warm. Wash the precipitate residue out of the beaker with small amounts of distilled water, if necessary.
4. Dry the precipitate and filter paper in a drying oven for at least 15 minutes.
5. Cool the precipitate and filter paper to near room temperature. Measure and record the mass of the filter paper and precipitate.
6. Heat the precipitate again for five minutes, cool the precipitate, and weigh it.

Heat the precipitate a third time, for five more minutes, cool the precipitate and weigh it. If the masses of filter paper and precipitate are the same in the final two weighings, dispose of the filter paper as directed. If the final two weighings are not the same, check with your instructor to see if more drying time is needed.

 13. Rinse the Conductivity Probe with distilled water in preparation for the second titration.

 14. Print the graph directly from LabQuest, if possible. Alternately, transfer the data to a computer by copying the file to a thumb drive then loading and analyzing using Logger *Pro* software.

 15. Repeat the necessary steps to conduct a second titration. Conduct a third trial, if needed. Record the results in the data table.

# E9 - Conductimetric Titration and Gravimetric Determination of a Precipitate

Report Sheet

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

| **Data Table 1** | Trial 1 | Trial 2 | Trial 3 |
| --- | --- | --- | --- |
| Equivalence point (mL) |  |  |  |
| Mass of filter paper + precipitate (g) |  |  |  |
| Mass of filter paper (g) |  |  |  |
| Mass of precipitate (g) |  |  |  |

| Molarity of H2SO4 (M) |  |
| --- | --- |

DATA ANALYSIS & CALCULATIONS

 1. Use the titration results to calculate the moles of H2SO4 that were used to reach the equivalence point in each trial.

 2. Use your titration results to calculate the molar concentration (molarity) of the Ba(OH)2 solution using the molar amount of H2SO4 used in each trial.

 3. Convert the mass of the barium sulfate precipitate, formed in each trial, to moles.

 4. Use the moles of BaSO4 from 3 above to calculate the molarity of the Ba(OH)2 solution.

 5. Compare the results of your calculations from 2 and 4 above with the actual molarity of the Ba(OH)2 solution provided by the instructor. Which method of analysis, equivalence point or gravimetric determination, was more accurate in your experiment? Why?