Determination of the Concentration of a Strong Acid Two Different Ways: Titration and Gravimetric Titration

**Purpose:** To find the unknown concentration of a strong acid by using a strong base of known concentration.

**Method 1: Titration**
A titration is a process used to determine the volume of a solution needed to react with a given amount of another substance. In this method you will be determining the concentration of sulfuric acid by doing pH titration against a 0.25M solution of sodium hydroxide.

\[
2\text{OH}^- + \text{H}_2\text{SO}_4 \rightarrow 2\text{H}_2\text{O} + \text{SO}_4^{2-}
\]

When an H$_2$SO$_4$ solution is titrated with an NaOH solution, the pH of the acidic solution is initially low. As base is added, then change in the pH is quite gradual until close to the equivalence point. Near the equivalence point, the pH increases very rapidly, as shown in the figure below. The change in pH then becomes more gradual again, before leveling off with the addition excess base.

In this experiment, you will use a pH sensor to monitor pH as you titrate. The region of most rapid change will then be used to determine the equivalence point. The volume of NaOH titrant at the equivalence point will be used to determine the molarity of the H$_2$SO$_4$.

- You will find the moles of base used at the equivalence point
- From the balanced equation above, for every two moles of base you have one mole of acid. So you will convert moles of base to moles of acid.
- You will determine molarity of the acid by dividing moles by liters of acid originally pipetted.

**Method 2: Gravimetric Filtration**
You will use the titrated sample from Method 1 to determine its concentration in another manner. You will accomplish this by precipitating all of the sulfate present in your sulfuric acid by mixing a certain volume of a known concentration of barium nitrate with your acid. You will then weigh out the BaSO$_4$ formed. By using the mole ratio from the balanced equation you will determine the moles of SO$_4^{2-}$ in the unknown sample, which is equal to the moles of H$_2$SO$_4$ in the sample.

\[
\text{Ba(NO}_3\text{)}_2 (aq) + \text{H}_2\text{SO}_4 (aq) \rightarrow \text{BaSO}_4 (s) + 2\text{HNO}_3 (aq)
\]

**molecular equation**

\[
\text{Ba}^{2+} (aq) + \text{SO}_4^{2-} (aq) \rightarrow \text{BaSO}_4 (s)
\]

**net ionic equation**
PreLab Questions:
1. What chemicals are used in any titration? Which one goes in the buret?
2. How do you know when you have reached the equivalence point?
3. Once you have mLs of base used at the equivalence point, describe in detail how you would calculate the unknown concentration of the unknown acid.
4. Define the term gravimetry as it applies to the chemistry lab.
5. A student has a piece of filter paper that had an original weight of 1.165 g and after filtration/drying it was found to have a weight of 23.625 g (includes the precipitate). How many moles of sulfate were precipitated?
6. If the original volume of 25 mL of acid was used in question #4, what must the molarity of the H₂SO₄ sample be?

Materials:
LabPro
pH sensor
? M H₂SO₄
0.25M NaOH
250 ml beaker (H₂SO₄)
100 ml beaker
50 ml buret
Buret clamp
Utility clamp
Ring stand
Wash bottle w/ dH₂O
Funnel
Stir bar
Hot plate/stir
Balance
Erlenmeyer flask
0.40M Barium Nitrate solid
25 ml volumetric pipet/ pump

Procedures:
Method 1
1. Connect the pH sensor to the LabPro and connect to the computer. Open LoggerPro program. Then go to File→Open→Chem w/ Vernier→Acid-Base Titration
2. Use a the volumetric pipet to draw up 10 ml of the unknown H₂SO₄ and transfer to the 250 ml beaker. Then add enough distilled water to cover the pH sensor. The amount of water does not change the ORIGINAL concentration of the acid.
3. Place the beaker on the magnetic stirrer/hot plate and add the stir bar.
4. Fill the smaller beaker with about 70 ml of NaOH. Use a funnel to rinse the buret with a few ml of NaOH before pouring in the 50 ml. Fill the buret a little above the 0.00 ml level with the NaOH solution. Drain a small amount from the buret tip until the solution is exactly at the 0 line.
5. Submerge the pH sensor into the H₂SO₄ beaker and wait for the pH to stabilize. Take the initial reading. hit keep and enter 0 as the volume.
6. Add 0.5 ml, mix solution, keep and record 0.5 as the volume. Keep doing this at 0.5 ml increments.
7. Once you pass the sharp rise and the pH does not change, the titration is complete.
8. Make sure you keep all the data points for your graph.
9. Record the volume of NaOH before and after the drastic change in pH. Find the average of these numbers to find the equivalence point.

Method 2:
1. From the beaker you just used in the titration, pipet out 25 ml into the 100 ml beaker.
2. Record the mass of the filter paper to the 0.001 g.
3. Weigh out ____ g of Ba(NO₃)₂. This needs to be in excess for a precipitate to form, so you need to calculate the amount needed by finding the moles of Ba(NO₃)₂. The concentration of Ba(NO₃)₂ is 0.40M (and you have 25 ml of solution).
4. Using a hot plate, heat your solution to just boiling in order to flocculate your solid precipitate.
5. Remove immediately from heat and pour into the filter paper. Use dH₂O to include all precipitate from the flask.
6. Once the filtering is complete, transfer the filter paper to a paper towel and place in the designated spot. You will weigh out the dried solid tomorrow.
Data:

**Method 1:**

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<tr>
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<tbody>
<tr>
<td>Concentration of NaOH</td>
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<td>NaOH volume added before largest pH increase</td>
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<tr>
<td>NaOH volume added after largest pH increase</td>
<td>mL</td>
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<tr>
<td>Volume of NaOH added at equivalence point</td>
<td>mL</td>
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<tr>
<td>Moles NaOH</td>
<td></td>
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<td>mol</td>
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<tr>
<td>Moles H₂SO₄</td>
<td>mol</td>
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<tr>
<td>(1 mol acid to 2 mol base)</td>
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<td>Concentration H₂SO₄</td>
<td>mol/L</td>
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<td>Class average concentration H₂SO₄</td>
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**Method 2:**

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<tbody>
<tr>
<td>Initial mass of filter paper</td>
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<td>Mass of paper and precipitate</td>
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<td>Mass of precipitate</td>
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<tr>
<td>Moles of precipitate</td>
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<tr>
<td>Moles of sulfate ion</td>
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<tr>
<td>Moles of acid</td>
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<tr>
<td>Molarity of H₂SO₄</td>
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**Calculations:**

1. Show all calculations you did in Method 1 in order to determine the concentration of the acid.
2. Show all calculations you did in Method 2 in order to determine the concentration of the acid.

**PostLab Questions:**

3. For Method 1, discuss how your results would compare to the actual final result if the following had occurred:
   a. The buret was wet when you started the titration and you did not rinse it out with NaOH.
   b. The pipette was wet when you transferred the sulfuric acid and you did not rinse the acid before you started.
4. Compare the concentrations you found in each method.
5. If the barium sulfate is not dry when its mass is determined, will the calculated concentration of the acid be higher or lower than the actual value? Explain.
6. Based on your experience of these two methods, which procedure do you deem more accurate? Explain. (There is no right answer...just explain your point of view with a good argument)
7. Based on your experience of these two methods, which procedure do you deem more precise? Explain. (There is no right answer...just explain your point of view with a good argument)