Module 8; Titration

Introduction

Titration is the process wherein a known volume of one solution is completely reacted by adding a carefully measured second solution (the *titrant*). Typically, when the first solution is completely reacted, the mixture will undergo a visible change to indicate the *endpoint* (complete reaction) has been reached. Titrations are used to determine the concentration of an unknown solution.

Although titrations are possible with any type of reaction that produces a visible change, *acid-base titrations* are most common. As the name implies, an acid-base titration is one in which carefully measured volumes of acid and base solutions are used to neutralize each other. A small amount of indicator (a compound that changes color in an acidic or basic environment) is added to signal the endpoint. In this experiment, you will use an HCl solution (acid) to determine the concentration of a NaOH solution (base). The neutralization reaction of HCl and NaOH is:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

You will be given a HCl solution whose concentration is unknown. This will be poured into a burette, a device capable of dispensing precise volumes of liquid (see illustration). A known amount of NaOH solution will be placed in an Erlenmeyer flask using a pipet. A drop or two of phenolphthalein solution will be added. Phenolphthalein is an acid-base indicator that is colorless in acidic solution and pink in basic solution. You will carefully add NaOH to the HCl. When the HCl solution just turns pink, you will have completely neutralized the HCl. Then you will note the volume of the NaOH solution you added.

The concentration of the NaOH will be in molarity (mol NaOH / L of solution). Therefore, the number of moles of NaOH added will be:

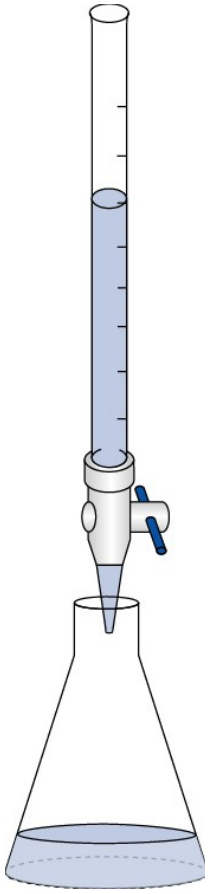
$$\text{mol NaOH} = \text{L sol'n} \times \frac{\text{mol NaOH}}{\text{1 L NaOH}} = \text{mol NaOH}$$

The stoichiometry of the reaction tells you that:

$$\text{mol NaOH} \times \frac{\text{1 mol HCl}}{\text{1 mol NaOH}} = \text{mol HCl}$$

Since you know the volume of HCl solution added, you can then calculate the molarity of the solution:

$$\text{Molarity of HCl sol'n} = \frac{\text{mol HCl}}{\text{L HCl sol'n}}$$



The titration set-up. The solution of known concentration (the titrant) is placed in the burette. A known volume of the solution with unknown concentration is placed in the Erlymeyer flask. (The simulator you will be using does it the opposite way; the unknown is placed in the burette. That works too.)

Pre-Laboratory Questions

Consider the following titration: 0.0250 L of HCl are placed in an Erlenmeyer Flask. 40.05 mL of 0.250M NaOH are added from the buret to reach the end point. What is the concentration of the HCl in the Erlenmeyer Flask?

a. First, figure out how many moles of NaOH were added to the flask. (Start with 40.05 mL. Remember that 0.250 M means 0.250 moles / 1 L.)

Show your calculation. Use units with numbers. Report your answer with three sig. figs.

b. Then figure out how many moles of HCl are in the Erlenmeyer flask. Use the balanced equation mole relationship from the introduction of this lab.

Show your calculation. Use units with numbers. Report your answer with three sig. figs.

c. Finally, calculate the concentration of HCl in molarity. Use the moles you calculated for HCl (b.) and use 0.0250 L since that is the volume of HCl. Remember that M = mol/L or: molarity is equal to moles ÷ L.

Show your calculation. Use units with numbers. Report your answer with three sig. figs.

Procedures and Data

Use the following link to watch the titration procedure carefully. It is a three minute video with music only (no speaking). I suggest you use a split screen so that you can follow directions while recording data for the experiment.
https://www.youtube.com/watch?v=8UiuE7Xx5l8

Fill in this table:

1) You will be using two pieces of glassware in this experiment. Name them (refer to introduction if needed).

The “top” glassware	
The “bottom” glassware	

2) Answer these questions regarding the titration experiment

What color* is the base, NaOH, in the buret?	
What color is the acid, HCl, in the Erlenmeyer flask (or conical flask)?	
What is the name of the indicator used?	
What does a “pink” color mean when the indicator is used?	
Why does the pink color disappear when indicator is added?	
What does it mean at the end point when the color no longer disappears?	

*Remember: “clear” is not a color.

Data and Calculations

Now you can calculate the concentration of your unknown Acid: You will need three pieces of data from your experiment in the video. Fill them in the table here:

1) Molarity of Base in **M** (take a look at the small beaker from which the presenter filled the burette).	
2) Volume of Acid in mL (take a look at the Erlenmeyer flask/Conical flask). Recall that $1cm^3$ = 1 mL	
3) Volume of base added in mL (You learned about uncertainty in measurement in Module 1). Apply that knowledge to this question. The presenter in the video missed reading the uncertainty (the last estimated digit between the minor lines on the burette). He indicated the uncertainty in the burette to one decimal place (as seen at the end of the video), which is incorrect. Using good chemistry measurement skills, provide the correct value with all significant figures and the unit for the base volume after titration is complete.	

Now do your calculations. Show your work here:

Liters of base	Hint: You know how many mL of base was used (from #3 above). Recall that 1000 mL = 1 L. Do a conversion starting with mL base.	
moles of base	Hint: Start with the L of base you just found. Use the molarity (from #1 above) as a conversion factor. (Recall M = moles/L)	
moles of acid	Hint: This is a conversion. If you look at the balanced equation in the introduction, you will see that 1 mole NaOH =1 mole HCl	
L of acid	Hint: You recorded the volume of acid above in #2. Convert that to L.	
Molarity of unknown acid.	Hint: Molarity is defined as moles/L. You've calculated moles of acid and L of acid. Now calculate molarity of acid. Show work with units.	