

Titration of An Antacid

Introduction

Titration is an analytical/quantitative chemical technique where one solution of known concentration (aka standard solution) is slowly added to a known volume but unknown concentration of another solution. Generally, this involves the addition of an unknown amount of base to a known amount of acid. The volume of the base is measured in a buret, image at right.

Titration takes advantage of acid-base indicators. Indicators are organic dyes which change color depending on the pH of the solution, e.g.:

Phenolphthalein: colorless @ pH 8.2	red @ pH 10
Bromothymol blue: yellow @ pH 6.0	blue @ pH 7.6
Methyl red: red @ pH 4.2	yellow @ pH 6.2
Bromocresol purple: yellow @ pH 5.2	purple @ pH 6.8
Congo red: blue @ pH 3.0	red @ pH 5.2

The pH at which the color of the indicator changes \equiv the titration endpoint. Indicators are chosen to change color within ± 1 pH unit as close as possible to the equivalence point. If conditions are such that an indicator won't work, e.g., doesn't change close enough to the equivalent point, the analyte is highly colored and interferes with indicator color change, a pH meter can be used to follow the titration (that's another experiment).

Titration Technique

Clean the buret with soap and water; rinse well. Rinse buret with 5-10 mL of the standard solution (base) and partially drain through the valve tip. Do NOT allow the buret to empty and put air bubbles in the tip. Safely fill the buret with your standard solution (base) and place in buret clamp on the ring stand. Drain excess standard out and pour it in the waste container. Record the volume on the buret in ink (remember "0" is on the top and "50" is on the bottom of the buret). Obtain your unknown acid sample[s]: for a solid, mass it on the balance, then pour into an Erlenmeyer flask and add water as necessary per instructions. For a liquid, pipet the solution into your Erlenmeyer flask. Add indicator (phenolphthalein in most CHEM 121/122 titrations) -- 2-4 drops. NOTE: this step is the easiest to forget and the easiest to diagnose.

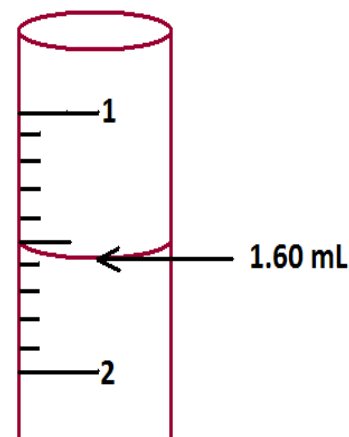
Using your WEAK hand, straddle the buret with your index and middle fingers on and under the back of the stop-cock and your thumb on the front of the stop-cock. Using your STRONG hand, grasp the outside of the Erlenmeyer flask by the neck, insert the buret tip into the neck and begin swirling the solution vigorously without spilling. Begin adding standard solution (base) to the analyte flask with swirling.



In the beginning you may add base fairly rapidly -- as you get closer to the endpoint, add base slower, i.e., drop-by-drop. With phenolphthalein, add enough base with swirling to get the whole solution to turn pink/fuschia for 30 seconds, then back to colorless. This is the ideal end point. Record your final volume on the buret in ink in your lab book.

NOTE: A crude way in which to see if you've gone WAY over the end point is to swirl the pink solution, take a deep breath and hold it in for approximately 15 seconds, then exhale rapidly into the sample. Do this 3 times. If the solution goes colorless, you're barely over -- if not, you're WAY over. Either way, stop, record your data in ink and go on to the next sample. What's the reaction, here? Dispose of your sample appropriately.

When reading the buret, REMEMBER: read your buret numbers DOWN! See below. The application of this type of technique and data is discussed later in lecture and lab. Example of reading a meniscus in a buret. This buret reading is 1.60 mL, at right. A sample data sheet for the use of this form of reading the buret is tabulated, below:



Sample Data Sheet		
Final (where you finished) Std Volume:	36.34 mL	(why 50 on bottom)
Initial (where you started) Std Volume:	1.25 mL	(why 0 on top)
Volume Std used (for the experiment):	35.09 mL	(how much actually used)

When you have completed the experiment, remember to dispose of your titrating solution down the sink with lots of water, wash the buret, drain it, leave the valve OPEN and return it to the cabinet with the remaining burets.

Experimental Methodology

Antacids are very common over-the-counter (OTC) aids which combat "acid indigestion" and "heart burn". Typically, these states occur during stress which causes the release of HCl in greater amounts than usual into the stomach. (The usual rate of HCl production is about "1-22 mmol of HCl per hour, ... 'excess' production is only about 10 mmol of HCl per hour greater than that of normal HCl production [1].") Occasionally, the acidic stomach contents make their way partially back up the esophagus (reflux) and cause discomfort by eroding that tissue. People with hyperacidity are quite vulnerable to ulcers.

Antacids are bases, i.e., they react with the [excess] HCl in the stomach in a neutralization reaction. One of the more common antacids is Tums (CaCO₃) which reacts with HCl as follows:



It is the CO_2 which one "burps" after taking Tums.

When I first had students doing this experiment, I had them compare the acid neutralizing capability of Tums and Roloids. The idea was that one of them wasn't as good a neutralizer. Since that time, the manufacturer has changed the formulation. Now, I use this experiment to introduce you to the concept of titration.

Experimental

Materials		
1 Tums Tablet	1 buret	1% phenolphthalein
1-Erlenmeyer flask	Pestle/mortar	1M HCl
Glass stirring rod	1 ring stand	Distilled water
1 M NaOH	1 buret clamp	Hot plate

Method

Place your antacid tablet in the mortar and pulverize it with the pestle. Rinse the powder into the Erlenmeyer flask with 10 mL distilled water. Add 15 mL 1 M HCl to the mixture. If the mixture does not dissolve, place it on a hot plate and heat gently for about 10 minutes. After the 10 minutes, remove it from the hot plate and allow it to cool to room temperature. After the solution is at room temperature, add 2-3 drops of the phenolphthalein solution to your antacid/water/acid solution (NOTE: if you have a pink tablet, ask your professor for a different indicator than phenolphthalein).

Obtain a buret, ring stand and buret clamp. Assemble the stand and clamp. Pour about 5 mL 1 M NaOH into the buret and rinse the buret. Drain the NaOH through the tip, stopping before the buret completely empties. Fill the buret slightly above the "0", drain TO "0" and record this as your initial volume in mL in the data sheet, below.

Begin titrating the solution with the NaOH until you reach the endpoint. In this case, the endpoint is reached when the solution turns pink for 30 seconds, than colorless.

At the end point of the titration, the following equation will be quite useful:

$$C_1V_1 = C_2V_2$$

Where C_1 is equal to the concentration of titrant (in the buret) and V_1 is the volume of the titrant added to reach the endpoint of the titration (from your data sheet, below). C_2 equals the

concentration of the analyte (in the Erlenmeyer flask) and V_2 equals the volume of the analyte in the flask.

It must then follow that the volume in mL of the titrant times the concentration of the titrant in molarity is equal to the number of mmol of titrant added to reach the end point. THIS IS ALSO EQUAL TO THE NUMBER OF MMOL OF ANALYTE!

In the case of this experiment, the number of mmol of analyte is equal to the number of mmol HCl neutralized by the NaOH. Also remember that the following equation is helpful in calculating the number of mmol of titrant (and, hence, of analyte in this case) in this experiment:

$$\text{mL} * \frac{1\text{L}}{1000\text{mL}} * M * \frac{1000\text{mmol}}{1\text{mol}} = \text{mmol}$$

Remember to record your data below in the data table:

	Record Your Data (In INK!)
Antacid (active ingredient)	
Final volume NaOH (mL)	
Initial volume NaOH (mL)	
Volume of NaOH to neutralize excess HCl (mL)	
mmol HCL (in the 15 mL you started with)	
mmol HCl neutralized by NaOH	
mmol HCl neutralized by antacid	

Based only on your (and a classmate's) results, would you take this antacid? Why or why not?

References

[1] Roberts, J.L., Hollenberg, J.L. and Postma, J.M.: General Chemistry in the Laboratory, 3d Edition. (Freeman: Oxford) © 1991, p. 315.

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