Upset Stomach

Overindulging in food or drink can lead to acid indigestion, a discomforting ailment that results from the excess excretion of hydrochloric acid, HCl, by the stomach lining. An immediate remedy is an over-the-counter antacid, which consists of a base that can neutralize stomach acid. In this experiment, you will add an antacid to a simulated upset stomach. Not all the antacid will be neutralized, however, and so you will then determine the effectiveness of the antacid by determining the amount of acid that remains.

The active ingredient in Tums is calcium carbonate, $CaCO_3$, a base. There are also other ingredients, such as binders present in each tablet. On average, a 1.3 gram tablet contains 0.5 g of calcium carbonate.

HCl is neutralized by calcium carbonate as illustrated below:

$$CaCO_3\,(s) + H^+\,(aq) \leftrightarrow Ca^{2+}\,(aq) + HCO_3^-\,(aq)$$
$$HCO_3^-\,(aq) + H^+\,(aq) \leftrightarrow H_2CO_3\,(aq) \leftrightarrow CO_2\,(g) + H_2O\,(l)$$

To determine the ability of Tums to neutralize acid, we are first going to dissolve the tablet in an excess amount of acid of known concentration. Some of the HCl will be neutralized by the carbonate, but there will be some remaining. We will then perform a titration with NaOH to figure out the amount of excess acid. Then, from this, we can calculate how much acid reacted with the antacid. This method of analysis is called a back-titration.

The reactions above are reversible, which means that CO_2 dissolved in water will produce some carbonic acid. This acid will react with the NaOH we are titrating and give us inaccurate results. Therefore it is important to boil the solution when the carbonate reacts with acid, to remove CO_2 as a gas.

Safety!

This is a fairly safe lab. Eye protection, however, must be worn at all times when you or your lab partners are working with solutions of hydrochloric acid, HCl, or sodium hydroxide, NaOH. You may also want to wear gloves to protect your skin, which may sting if it comes in contact with the hydrochloric acid or feel slippery if in contact with the sodium hydroxide. If either of these solutions gets onto your skin, tell your instructor and proceed to rinse skin thoroughly with running water.

Purpose: In this experiment, you will measure the acid-neutralizing strength of antacid.

Procedure:

You will work in pairs, but each student should perform one of the titrations.

1. In a 125 mL Erlenmeyer flask, pipet in exactly 50.00 mL of ________M HCl. You will be using a 25.00 mL pipet.

2. Take 1 tablet of Tums. Crush it up into small pieces with a mortar and pestle.

3. Dissolve the Tums in the acid in the Erlenmeyer flask and boil this solution for 2 minutes.

4. Add ________ M NaOH to the buret. Your instructor will show you how to prepare and read the buret.

5. After boiling, add 3 drops of phenolphthalein indicator to the Erlenmeyer flask. An acidic solution would normally be clear at this point, however since we are using wintergreen Tums, it will be green.

6. You are now ready to titrate. Slowly add the NaOH from the buret while constantly swirling the Erlenmeyer flask. Titrate until the solution remains violet for 30 seconds. (Normally phenolphthalein turns pink in basic solution). This is the end-point of the titration. Make sure you record the final volume of the buret.

Data table:

	Trial 1	**Trial 2**
Amount of HCl added in liters		
Final Volume of buret		
Initial Volume of buret		
Volume of NaOH dispensed		
Volume of NaOH in liters		
Average volume of NaOH in liters	$\frac{\text{Trial 1 + Trial 2}}{2} =$	

Calculations:

1) Using the average volume of the 2 titrations, calculate the number of moles of NaOH that were added from the buret.
The equation for molarity is Molarity = moles/volume
Solving for moles we get:

Moles NaOH = (Molarity NaOH)(Volume NaOH) = ________M x _______L = ________molNaOH

***This number is equal to the number of moles of HCl that were neutralized by the NaOH since they react in a 1:1 ratio.**

Moles of NaOH = Moles of HCl that were neutralized = __________moles $HCl_{\text{neutralized by NaOH}}$

2) Calculate the number of moles of HCl that you started with. (This is referring to the 50.00 mL of HCl you added with the pipette)

Moles HCl = (Molarity HCl) (Volume HCl) = ________M x 50.00 mL = _______moles HCl_{started}

3) Calculate the number of moles of HCl that were neutralized by the antacid. This can be found by taking the number of moles of acid that you began with (from #2) and subtracting the number of moles HCl that were in excess (from #1).

_____moles HCl_{started} - ______moles $HCl_{\text{neutralized by NaOH}}$ = ______moles $HCl_{\text{neutralized by Tums}}$

4) Given that the molarity of stomach acid is approximately 0.16 M, calculate the volume of stomach acid that could be neutralized by 1 tablet of Tums. Volume = moles/molarity

Volume = ______moles $HCl_{\text{neutralized by Tums}}$/ 0.16M = _______L of stomach acid neutralized by Tums

5) To determine a percent error for your titration, use the number of moles of HCl neutralized by the tablet to determine the mass of the calcium carbonate in the tablet. The ratio of $CaCO_3$ to HCl is 1:2. The molar mass of $CaCO_3$ is 100 g/mol.

$$\text{mg } CaCO_3 = \text{\_\_\_\_\_ moles } HCl_{\text{neutralized by Tums}} \times \frac{1 \text{ mol } CaCO_3}{2 \text{ mol HCl}} \times \frac{100 \text{ g}}{1 \text{ mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \qquad \text{mg}$$

Compare this value to the known value (750 mg) and calculate a percent error.

$$\% \text{ error} = \frac{(\text{measured} - \text{known})}{\text{known}} \times 100\% = \frac{(\text{\_\_\_\_\_\_ mg} - 750 \text{ mg})}{750 \text{ mg}} \times 100 = \qquad \%$$