ACID-NEUTRALIZING CAPACITY OF ANTACID TABLETS

The stomach’s acidic interior is generated by "stomach acid" (essentially 0.1 M hydrochloric acid). This acid is necessary for digestion but too much stomach acid can cause discomfort. One way of relieving excess acidity in the stomach is to neutralize some of the acid with a weak base or "antacid". Most antacids contain some kind of carbonate (for example, NaHCO$_3$ or CaCO$_3$) that react with strong acid to make carbonic acid, H$_2$CO$_3$, which then dissociates to water and carbon dioxide gas:

\[ H_2CO_3 (aq) \rightarrow H_2O (l) + CO_2 (g) \]

Many commercial preparations are available in tablet form. These tablets generally contain binders and flavouring agents in addition to the weak base, so we cannot just assume that a bigger tablet is more effective. Instead, we can determine the exact number of moles of base in a tablet by reacting it with acid; this will be the tablet’s acid neutralizing capacity (ANC).

Instead of titrating the antacid directly with an acid, you will employ **back-titration**: adding a known excess of acid to the tablets and then titrating the excess acid carefully with a standard solution of strong base. There are two good reasons for this procedure: 1) most antacid tablets dissolve very slowly in water but much faster in acids (since they react as they dissolve), and 2) carbon dioxide from the air and from the breath dissolves in water and acts as an acid (reacting immediately to neutralize any basic solution - thus it is best to avoid leaving basic solutions standing in the air for long periods of time).

**Dilutions**

You will need to know how to accurately dilute stock solutions to obtain solutions of desired concentration. You must realize when you are diluting a solution that the actual amount of solute is constant. Therefore, the number of moles of solute remain unchanged.

\[
\text{Initial moles before dilution} = \frac{\text{final moles after dilution}}{\text{final volume}}
\]

\[
M_i \times V_i = M_f \times V_f
\]
Procedure
This is an individual lab. In preparation for this procedure, read Appendix C for directions on the proper use of a pipet. Also, ensure that you have recorded the average molarity of your previously standardized 0.1 M NaOH on page 40 before submitting your oxalic acid report.

(A) Standardization of the Stock HCl Solution
Pipet a 10.00 mL aliquot of ~1 M stock HCl solution into a clean 100.0 mL volumetric flask. Dilute to the mark with distilled water, cap, and mix the solution thoroughly. Pipet 25.00 mL of this dilute HCl from the volumetric flask into a clean Erlenmeyer flask. Add 3-5 drops of phenolphthalein indicator and titrate with your previously standardized 0.1 M NaOH. Record the exact volume of 0.1 M NaOH used to reach the endpoint. Repeat the titration twice more.

(B) Titration of the Remaining Excess HCl Solution
Pipet 25.00 mL of ~1 M stock HCl solution into a clean, dry 100 mL beaker. Place the recommended dosage of antacid tablets in the HCl solution, being very careful not to splash the acid out of the beaker. The tablets may be difficult to dissolve so take a glass stirring rod and carefully break them up. There are often ingredients in these tablets that will not dissolve in acid or water so do not be surprised if there are still some finely divided particles left. Once you are certain the tablets have dissolved as much as they are going to (the bubbling will have stopped), pipet 10.00 mL of this antacid-HCl solution into a clean 100.0 mL volumetric flask. Dilute to the line with distilled water, cap and mix well.

Now pipet 25.00 mL of the dilute antacid-HCl solution into a clean Erlenmeyer flask, add 25 mL of distilled water and 4-6 drops of modified methyl orange indicator. Titrate with your standardized 0.1 M NaOH until the colour changes from red-purple to green. Record the exact volume of 0.1 M NaOH used to reach this point. Repeat the titration twice more.
Calculations

Using the data from Part (A), calculate the molarity of the dilute HCl solution and of the original stock HCl solution for each trial. Then, calculate the average molarity of the stock HCl solution.

Using the data from Part (B), calculate the molarity of the dilute antacid-HCl solution and of the original antacid-HCl solution for each trial. Then, calculate the average molarity of the original antacid-HCl solution.

To find the ANC of the antacid tablet(s), calculate the number of moles of acid left in the antacid-HCl solution. Subtract this from the number of moles of acid present in the beaker before the antacid was added. This gives the number of moles of acid that reacted with the antacid.
Part A: Standardization of the stock HCl solution

10.00 mL stock HCl

25.00 mL dilute HCl

stock HCl

100.0 mL dilute HCl prepared

Titrate with standardized NaOH using phenolphthalein indicator

Part A Calculations
1) \( M_{\text{dilute HCl}} \times V_{\text{dilute HCl titrated}} = M_{\text{NaOH}} \times V_{\text{NaOH}} \)
2) \( M_{\text{stock HCl}} \times V_{\text{stock HCl}} = M_{\text{dilute HCl}} \times V_{\text{dilute HCl prepared}} \)

Part B: Titration of the remaining excess HCl solution

10.00 mL antacid-HCl

25.00 mL dilute antacid-HCl

antacid-HCl (acid remaining after stock HCl reacted with the antacid tablet)

100.0 mL dilute antacid-HCl prepared

Titrate with standardized NaOH using modified methyl orange indicator

Part B Calculations
1) \( M_{\text{dilute antacid-HCl}} \times V_{\text{dilute antacid-HCl titrated}} = M_{\text{NaOH}} \times V_{\text{NaOH}} \)
2) \( M_{\text{antacid-HCl}} \times V_{\text{antacid-HCl}} = M_{\text{dilute antacid-HCl}} \times V_{\text{dilute antacid-HCl prepared}} \)
**Acid-Neutralizing Capacity of Antacid Tablets**

**DATA SHEET:**
Name: _______________________

**Individual Report**
Lab Section: _______________

**Part A:**  **Standardization of the stock HCl solution**

HCl solution: ______________

NaOH Molarity = ______________

<table>
<thead>
<tr>
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<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
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<tbody>
<tr>
<td>Final volume reading ($V_f$)</td>
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<tr>
<td>Initial volume reading ($V_i$)</td>
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<tr>
<td>Volume ~0.1 M NaOH used</td>
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<tr>
<td>Observations</td>
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**Part B:**  **Titration of the antacid tablets**

Brand of antacid tablets ______________

Number of tablets/bottle ____________

Cost of antacid tablets _____________

NaOH Molarity = ______________

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**Instructor's signature:**  ______________________
Acid-Normalizing Capacity of Antacid Tablets: Formal Report

Computer generated / typed INDIVIDUAL REPORTS
1. **Title Page** – Title of the experiment, student name, lab section number

2. **Objective Statement** – What will be determined and how (experimental method).
   - Standardization of NaOH
   - Part A – Standardization of the Stock HCl Solution
   - Part B – Titration of the Antacid Tablet

3. **Data Section – Table Format**
   - Acid used: HCl solution A, B, C, etc
   - Standardization of NaOH data, including the average molarity of the NaOH
   - Part A – Volumes of NaOH
   - Part B – Volumes of NaOH
   - Brand name of tablet
   - Price of tablets / how many in the bottle

4. **Calculation Section** – Show sample calculations (one for each type):
   - NaOH molarity
   - Average NaOH molarity
   - M_{stock} HCl
   - Average M_{stock} HCl
   - M_{antacid-HCl}
   - Average M_{antacid-HCl}
   - Cost per tablet
   - Total moles of H^+ added to the beaker before neutralization by the tablet
   - Total moles of H^+ left in the beaker after neutralization by the tablet
   - Total moles of H^+ neutralized by the antacid tablet
   - Number of moles of H^+ neutralized for a cost of $1.00
   - Ratio: moles of H^+ neutralized per $1.00, comparing “Gas-B-Gone” to your brand of tablet:
     - “Gas-B-Gone” - $7.49/160 tablets, neutralizes 1.10 x 10^{-2} moles H^+ per tablet

5. **Results / Conclusions**
   - Results – Use tables where appropriate
   - Concluding Statement:
     - the molarity of your NaOH solution
     - the ANC of your brand of antacid tablet
     - comparison of your brand to “Gas-B-Gone” – how many times better one brand is over the other

6. **Appendix** - Signed data sheets for the “Standardization of a Sodium Hydroxide Solution” experiment and the “Acid Neutralizing Capacity of Antacids” experiment
Acid Neutralizing Capacity of Antacid Tablets: Pre-lab questions

1. The stomach contains an acid that is similar to what acid solution?

2. Define the term back-titration.

3. Why is the back-titration method used? (Give two good reasons.)

4. What two indicators will be used in this experiment? List the colour change for each of the indicators.

5. The antacid tablets will be dissolved in an acid solution. What acid solution will be used?

6. What does the abbreviation ANC stand for?

7. Give the dissociation equation for carbonic acid.

8. When you dilute a solution by the addition of water, the volume changes. What remains constant?

9. Use the equation \( M_i \times V_i = M_f \times V_f \) to calculate the final molarity of a solution when 20.00 mL of a 1.584 molar solution is diluted to a final volume of 250.0 mL.

10. Define standardization.

11. In the manual you are told the concentration of HCl is ~1 M. Why is it necessary to standardize this solution?

12. Why is it necessary to dilute the stock HCl solution before titrating it with ~0.1 M NaOH?