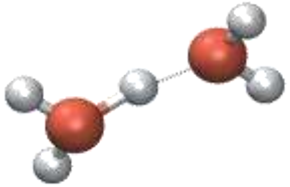

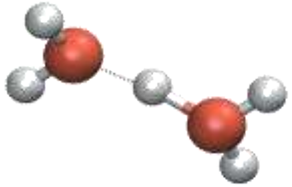

Experiment 6:

Analysis of Antacids
(تحليل مضادات الحموضة)

BY

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Purpose:

- To determine the neutralizing effectiveness per gram of a commercial **antacid** tablets.

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- All anacids have one purpose: to neutralize the excess hydrogen ion in the stomach to relieve acid indigestion

Antacids

❖ **Antacid** is a medicine that neutralize the excess HCl acid in your stomach to relieve acid indigestion (عسر الهضم الحمضي) and heartburn.

❖ *when antacid dissolved in water, it forms a basic solution, thus the* reaction is actually an Acid/Base reaction.

❖Stomach cells secrete **hydrochloric acid**, (0.155 M HCl) to digest the food.

❖ Generation of too much acid (due to overheating, الإفراط في الأكل) → "heartburn (حرقة المعدة)".

NOTES

- overeating may lead to an excess of stomach acid, leading to acid indigestion and a pH lower than normal.
- An excess of acid can, on occasion, cause an irritation of the stomach lining, particularly the upper intestinal tract, causing “heartburn.”
- An antacid reacts with the hydronium ion to relieve the symptoms.
- Excessive use of antacids can cause the stomach to have a pH greater than 2, which stimulates the stomach to excrete additional acid, a potentially dangerous condition.

Would a little bit of NaOH be equally effective???

$HCl + NaOH \rightarrow H_2O + NaCl$

Antacids are formulated to reduce acidity while avoiding physiological side-effects.

Commercial Antacids use a variety of chemicals

❖ **Sodium Bicarbonate(baking soda):** based antacids: Alka Seltzer

$$NaHCO_3 + \underline{1}HCl \rightarrow NaCl + H_2CO_3$$

$$H_2CO_3 \rightarrow H_2O + CO_2$$

The release of CO_2 gas from the action of sodium bicarbonate on hydronium ion causes one to “belch, تجشؤ”

❖ **Calcium** - based antacids: Tums, Rennies

$$CaCO_3 + \underline{2}HCl \rightarrow CaCl_2 + H_2CO_3$$

❖ **Aluminum** - based antacids: Maalox, Mylanta

$$Al(OH)_3 + \underline{3}HCl \rightarrow AlCl_3 + 3H_2O$$

❖ **Magnesium** - based antacids: Mylanta, Milk of Magnesia

$$Mg(OH)_2 + \underline{2}HCl \rightarrow MgCl_2 + 2H_2O$$

Milk of Magnesian is an aqueous suspension of slightly soluble magnesium hydroxide.

❖ **Magnesium carbonate, $MgCO_3$**

Table 17.1 Common Antacids

Principal Active Ingredient(s)	Formulation	Commercial Antacid
$CaCO_3$	Tablet	Tums, Titralac, Chooz, Maalox
$CaCO_3$, $Mg(OH)_2$	Tablet	Rolaids, Di-Gel, Mylanta
$MgCO_3$, $Al(OH)_3$	Tablet	Gaviscon Extra Strength
$Mg(OH)_2$, $Al(OH)_3$	Tablet	Gelasil, Tempo
$NaHCO_3$, citric acid, aspirin	Tablet	Alka-Seltzer
$Mg(OH)_2$	Tablet	Phillips' Milk of Magnesia
$Mg(OH)_2$	Liquid	Phillips' Milk of Magnesia
$Mg(OH)_2$, $Al(OH)_3$	Liquid	Mylanta Extra Strength
$MgCO_3$, $Al(OH)_3$	Liquid	Gaviscon Extra Strength

- The more **common (faster relief) commercial antacids** that buffer excess acid in the stomach are those containing calcium carbonate ($CaCO_3$) and/or sodium bicarbonate ($NaHCO_3$).

  → A HCO_3^-/CO_3^{2-} buffer system is established in the stomach with these antacids.

- To decrease the possibility of the stomach becoming too basic from the antacid, **buffers** are often added as part of the formulation of some antacids.

  -Buffers: substances in an aqueous system that are resisting changes in acidity or basicity

- Rolaids™, is an antacid that consists of a combination of $Mg(OH)_2$ and $CaCO_3$ in a mass ratio of 1:5.

  → Thus providing the effectiveness of the hydroxide base and the carbonate/bicarbonate buffer.

Exercise:

Baking soda ($NaHCO_3$) is often used as an antacid. It neutralizes excess hydrochloric acid secreted by the stomach. Milk of magnesia, $Mg(OH)_2$ which is an aqueous suspension of magnesium hydroxide, is also used as an antacid:

Which is the more effective antacid per gram, $NaHCO_3$ or $Mg(OH)_2$?

Hint, write a balanced equation for the reaction of each antacid with HCl, and then calculate moles HCl /g antacid.

Answer: after carrying out the required chemical **Stoichiometry (الحسابات الكيميائية)**, u will find that $Mg(OH)_2$ is more effective antacid than that of $NaHCO_3$

Chemical background.

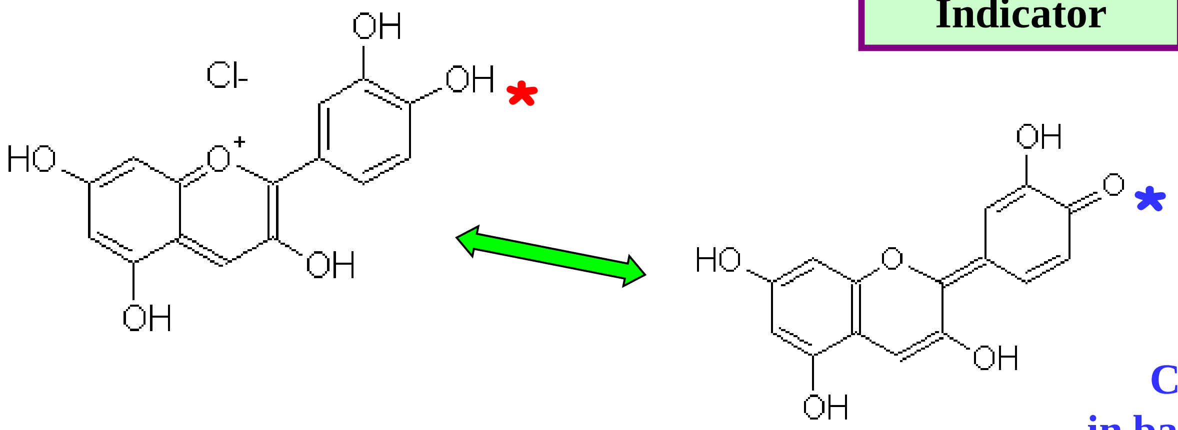
What is Indicator?

❖A molecule whose conjugate acid or conjugate base has a different color, depending on the pH of the soliution

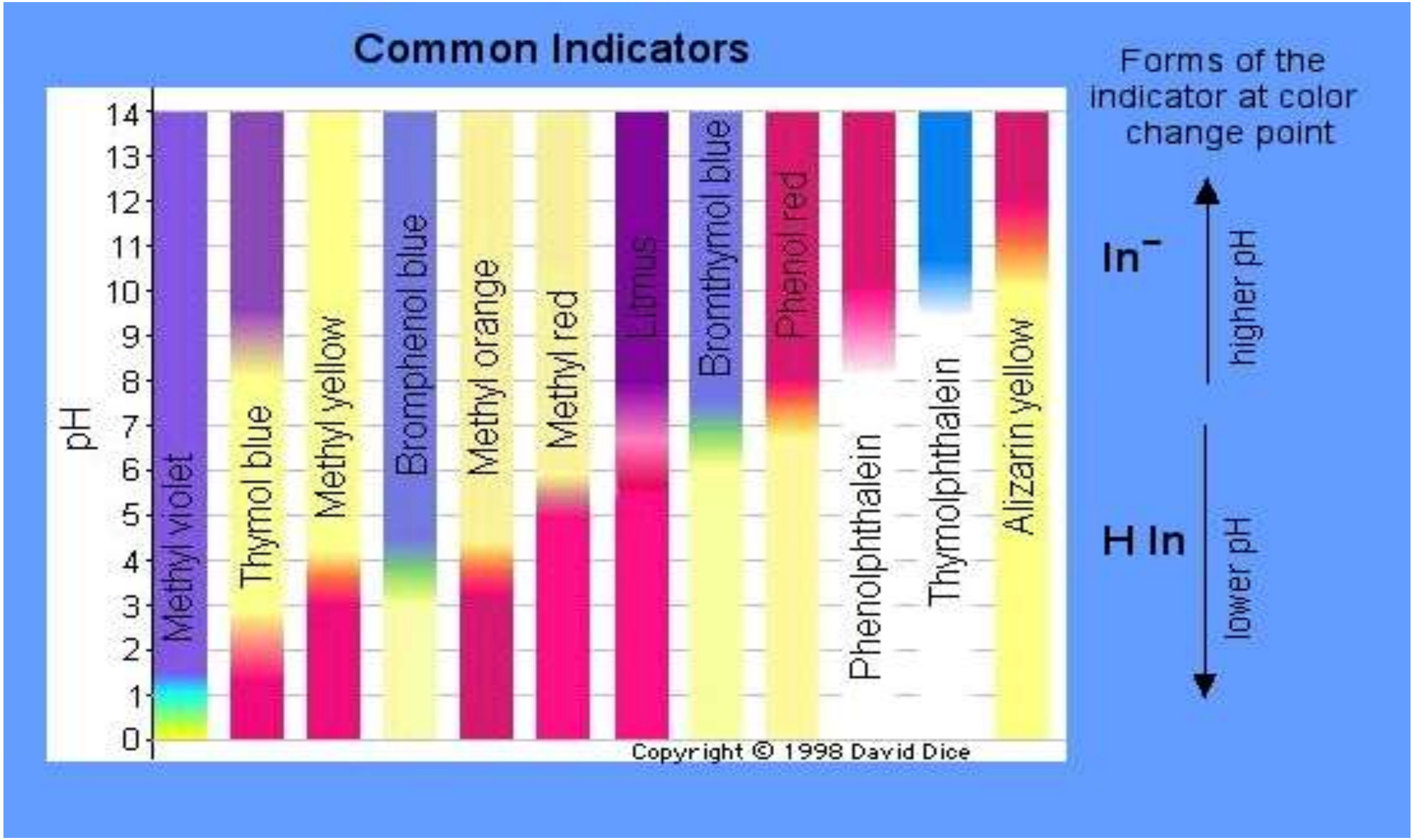
❖**Used to detect the endpoint of a titration**.

Cabbage Juice Indicator

Cyanidin chloride in acidic solution gives a red color.



Cyanidin in basic solution gives a blue color.

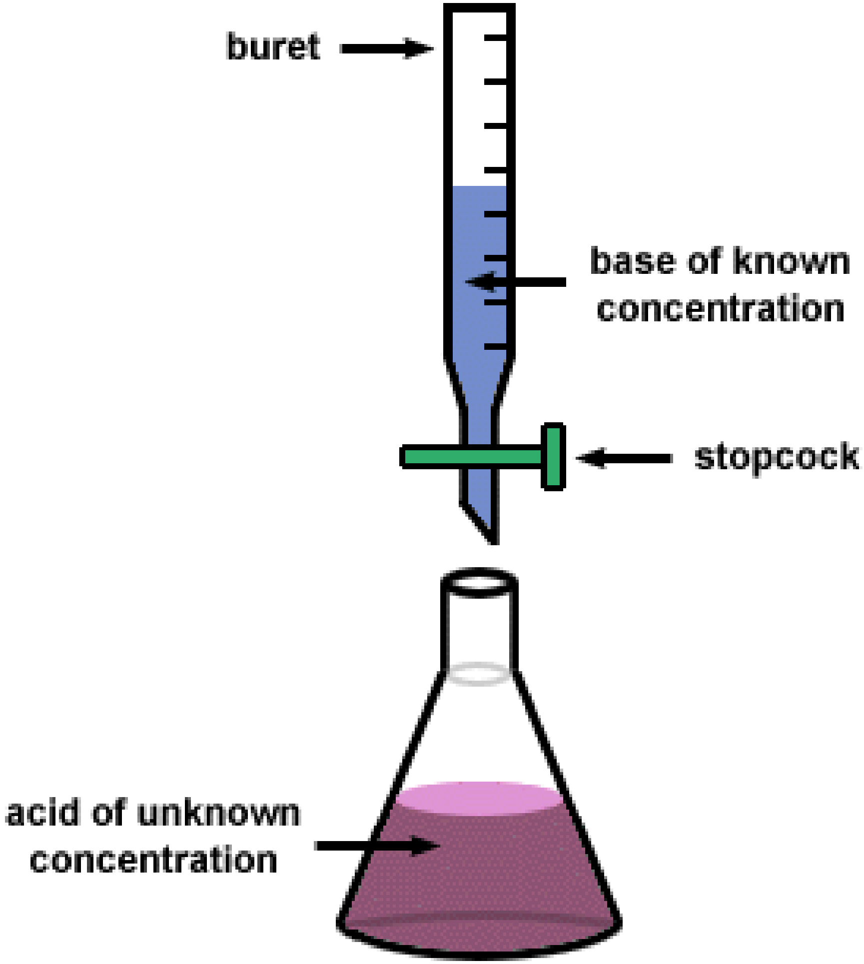

Common Indicators
Forms of the indicator at color change point
In⁻
higher pH
H In
lower pH
pH
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Methyl violet
Thymol blue
Methyl yellow
Bromphenol blue
Methyl orange
Methyl red
Litmus
Bromthymol blue
Phenol red
Phenolphthalein
Thymolphthalein
Alizarin yellow
Copyright © 1998 David Dice

What is Titration?

- **A titration** involves delivery (from a buret) of a measured volume of a solution of known concentration (the *titrant*) into a solution (in Erlenmeyer flask) of the *analyte*

- An experiment where **a known volume of an unknown concentration** of acid or base is **neutralized with a known volume and known concentration** of base or acid, respectively, to determine the concentration of the unknown

Typical Titration Set-up ()



At end point of titration

mole $_{acid}$ = mole $_{base}$

$$M_{acid} \times V_{acid} = M_{base} \times V_{base}$$

known

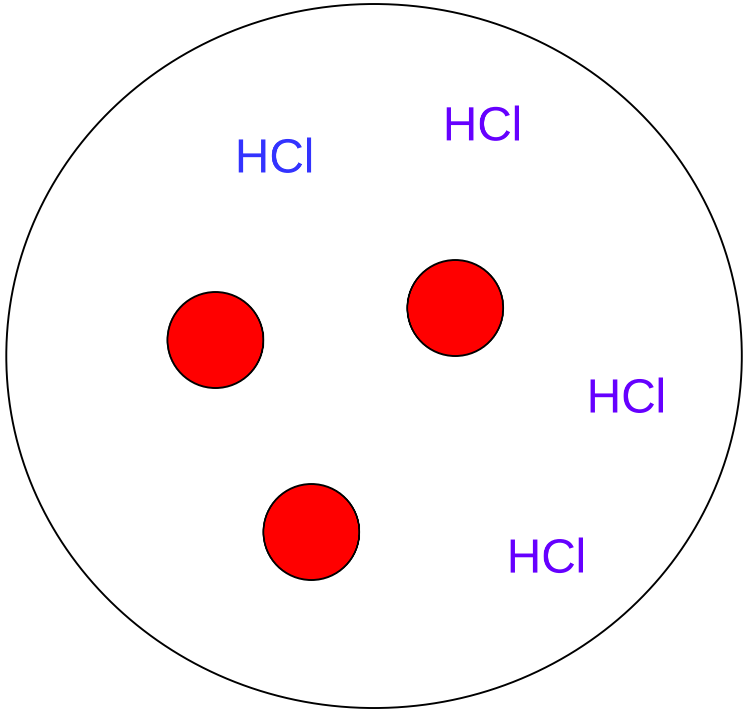
Read from buret

Then:

$$M_{acid} = M_{base} \times (V_{base} / V_{acid})$$

Back Titration (معايرة راجعة)

Dissolve a measured amount of antacid tablet in an excess HCl standard solution, (a simulated stomach environment), then *The unreacted HCl is back titrated with a standardized NaOH solution*.



- **$-n_{Acid}$** = total moles for the initial quantity of HCl.
- **$-n_{antacid}$** = The of moles of HCl neutralized by Antacid Tablet.
- -Back titration of unreacted HCl with the titrant NaOH

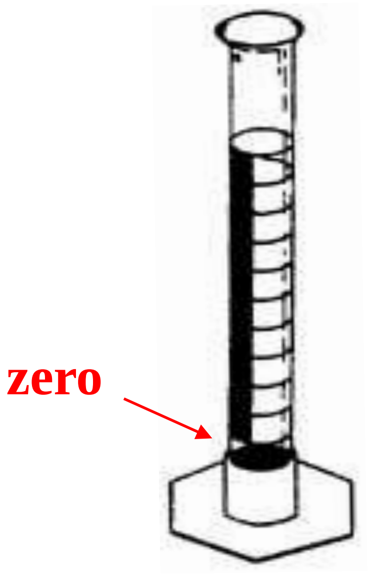
n_{Base} = The moles of NaOH used to neutralize the remaining HCl (which was not neutralized by the antacid).

$$n_{HCl} = n_{antacid} + n_{NaOH}$$

$$n_{antacid} = n_{HCl} - n_{NaOH}$$

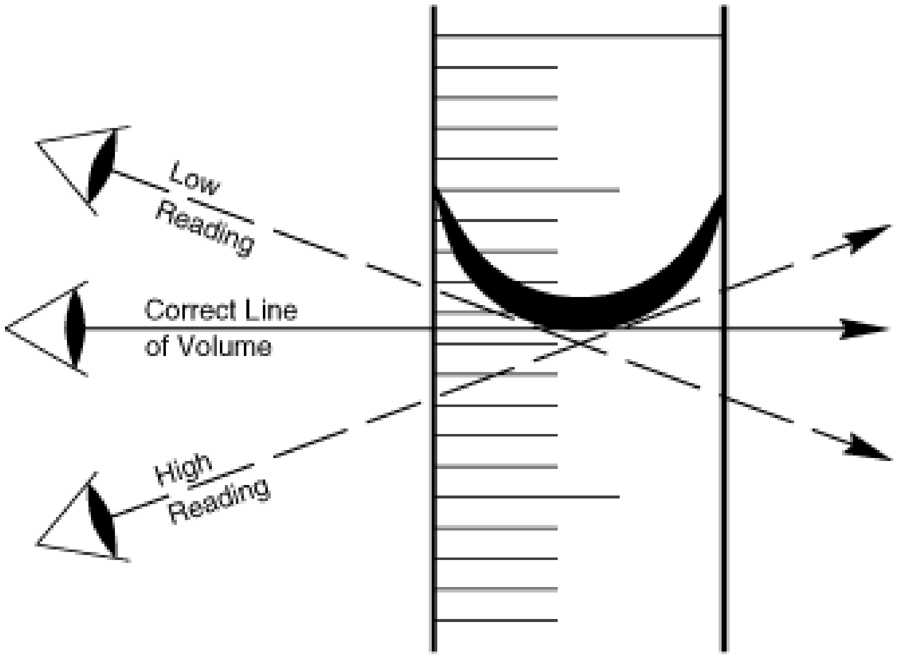
Differences in Glassware

Viewing the Meniscus of buret



Graduated Cylinder

Buret, reads 2 digits at the wright of the comma such as 10.56 mL



*NOTE: A graduated cylinder is NOT accurate enough to measure the volume HCl, while buret and pipet (ماصة) are suitable for measuring accurate volumes of liquid solutions

❖ **Procedure overview (نظرة عامة على الإجراء): to determine the amount of base in an antacid sample using back titration (معايرة راجعة)**

1. *The sample is dissolved, and the buffer components of the antacid are eliminated with the addition of an excess of standard solution of HCl.*

Reminder. *At this point, all moles of base in the antacid (whether or not a buffer is present) have reacted with the standardized HCl solution.*

2. The unreacted HCl is back titrated with a standardized NaOH solution.

3. Moles base in the antacid = total moles HCl – moles NaOH consumed in back titration

4. Determine the moles of base in the antacid per gram of antacid. This provide the data required for a comparison of the antacid effectiveness of commercial antacids.

Experimental Procedure

- At least two analyses (trials) should be completed per antacid sample

- Be aware of the number of significant figures when recording data.

Part A. Dissolving the Antacid

Step 1. Determine the mass of antacid for analysis

If your antacid is a tablet, grind the antacid tablet with a mortar and pestle. Measure and record the mass (±0.001 g). Add about 0.2 g of the pulverized commercial antacid (or 0.2 g of a liquid antacid) to the a 250-mL Erlenmeyer flask. Record the mass in the **report sheet**.

Step 2. Prepare the antacid for analysis.

Pipet 25.0 mL of a standardized 0.1 *M* HCl solution into the flask and swirl. Record the actual molar concentration of the HCl on the ***Report Sheet***. Heat the solution to near boiling for about 1 minute to remove dissolved CO_2 using a hot plate or a direct flame and a gentle swirl. Add 4–8 drops of **bromophenol blue indicator**. If the solution is blue, pipet an additional 10.0 mL of 0.1 *M* HCl into the solution and boil again. Record the *total* volume of HCl that is added to the antacid.

Notes:

a. Bromophenol blue is yellow at a pH less than 3.0 and blue at a pH greater than 4.6.
b. A standard solution (titrant, محلول معياري): the concentration of NaOH is accurately known

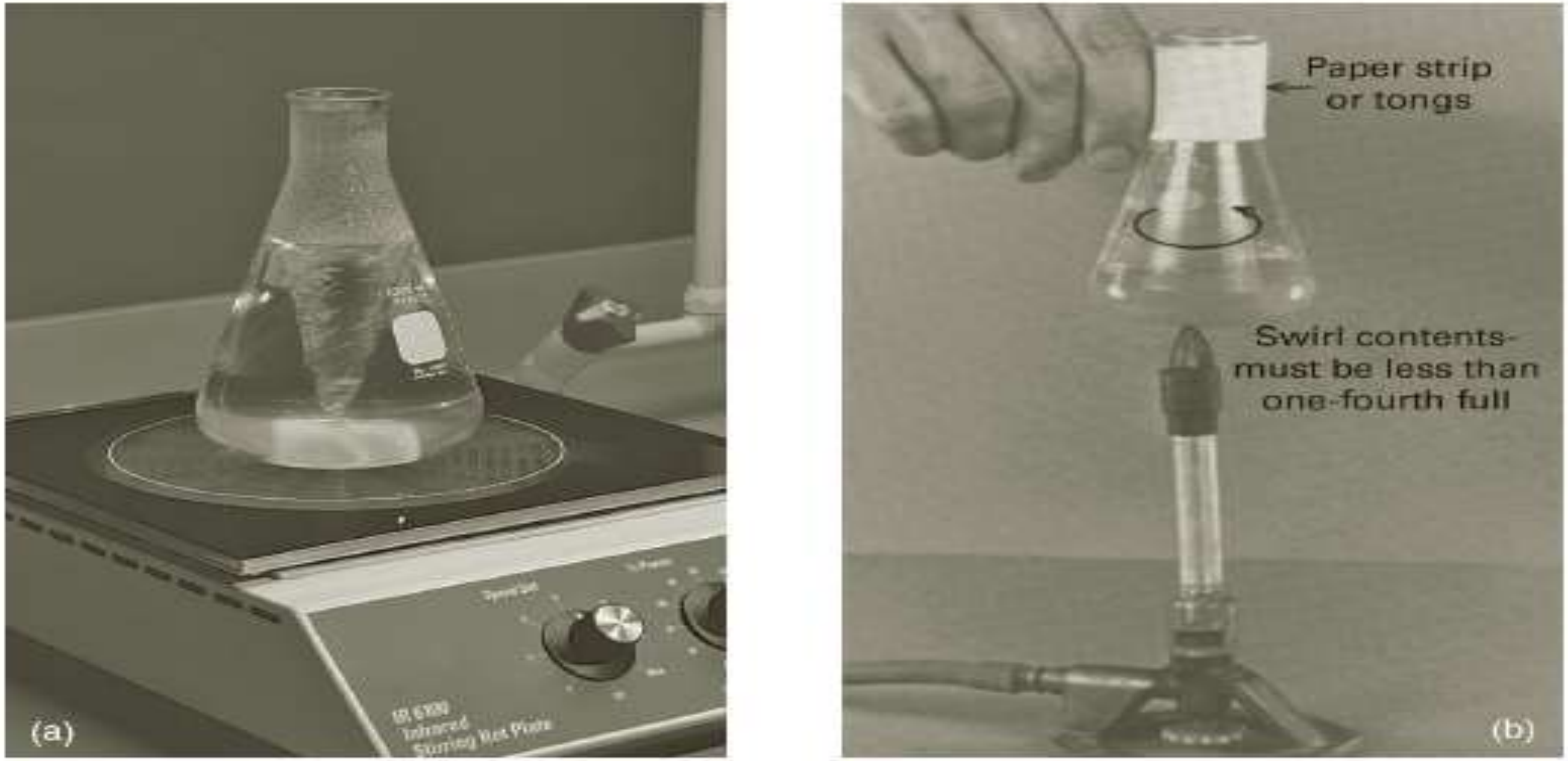


Figure 17.2 Gently heat the sample to remove CO_2 gas.

B. Analyzing the Antacid Sample

1. **Prepare the buret for titration.** Rinse the clean buret with two 3-mL portions of the standardized NaOH solution and drain through the buret tip. Record the actual molar concentration of the NaOH on the ***Report Sheet***. Fill the buret with the NaOH solution; be sure no air bubbles are in the buret tip. read and record its initial volume, using all certain digits *plus* one uncertain digit.

2. Titrate the sample. Titrate the cooled solution of the antacid sample with the NaOH solution to a faint blue endpoint. When a single drop of NaOH solution changes the sample solution from yellow to blue, **stop.** Wait for 10–15 seconds and then read and record the final volume of NaOH solution in the buret.

Reminder:

a) Read the buret to the correct number of significant figures.

b) Endpoint: *the point in the titration when an indicator changes color*

3. Repeat the titration of the same antacid one more time.

4. Analyze another antacid. Perform the experiment, in duplicate, for a second antacid. Record all data on the *Report Sheet*.

C. Calculations

1. Determine the number of total moles of HCl added to the antacid sample.

2. How many moles of NaOH titrant were required to neutralize the *unreacted* acid?

3. Calculate the number of moles of base in the antacid sample.

4. Calculate the number of moles of base in the antacid sample *per gram* of sample, or mol base in antacid/g of antacid sample, mol/g

Chemical Calculations

tablet[$Mg(OH)_2/CaCO_3$] + HCl → neutralized tablet + excess acid → acidic solution

$$Mg(OH)_2 + 2\,HCl \rightarrow Mg^{2+} + 2\,Cl^- + 2\,H_2O$$

$$CaCO_3 + 2\,HCl \rightarrow Ca^{2+} + 2\,Cl^- + CO_{2(g)} + H_2O$$

unreacted HCl + NaOH → neutral solution

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

$$V_{H^+} \times M_{H^+} = n_{H^+} = n_{OH^-} = V_{OH^-} \times M_{OH^-}$$

$$\text{or} \quad n_{H^+} = V_{OH^-}\,[OH^-]$$

$$n_{HCl\ total} = n_{HCl\ neutralized\ by\ tablet} + n_{HCl\ neutralized\ by\ NaOH}$$

$$(V_{HCl} \times M_{HCl}) = (n_{HCl\ neutralized\ by\ tablet}) + (V_{OH-} \times M_{OH-})$$

$$\text{or} \quad (n_{HCl\ neutralized\ by\ tablet}) = (V_{HCl} \times M_{HCl}) - (V_{OH-} \times M_{OH-})$$

Example. A 25.0 mL of 0.1089 M HCl is added to a 0.2222 g powder of Baking soda ($NaHCO_3$) antacid, then few drops of bromophenol blue indicator is added. The unreacted HCl is back titrated with 6.25 mL of 0.0987 M NaOH solution. **Given the chemical equation: $NaHCO_3 + HCl \rightarrow NaCl + H_2CO_3$.** Calculate the mol base in antacid **/** mass of antacid sample (g), OR (mol/g).

Solution:

$$n_{antacid} = n_{HCl} - n_{NaOH}$$

- $-n_{Acid}$ = total mol HCl = $V_{HCl} \times M_{HCl}$ = 0.0250 L x 0.1089 M = 0.002178
- $-n_{Base}$ = mol NaOH consumed in back titration of the unreacted HCl =
  = $V_{NaOH} \times M_{NaOH}$ = 0.00625 L x 0.0987 M = 0.000615
  =
- $n_{antacid}$ = mol base in antacid tablet = 0.002178 - 0.000615 = 0.00156
- Then , mol base in antacid / mass of antacid sample (mol/g) = 0.00156 mol/0.2222 g
  = 0.00702 mol antacid/g antacid

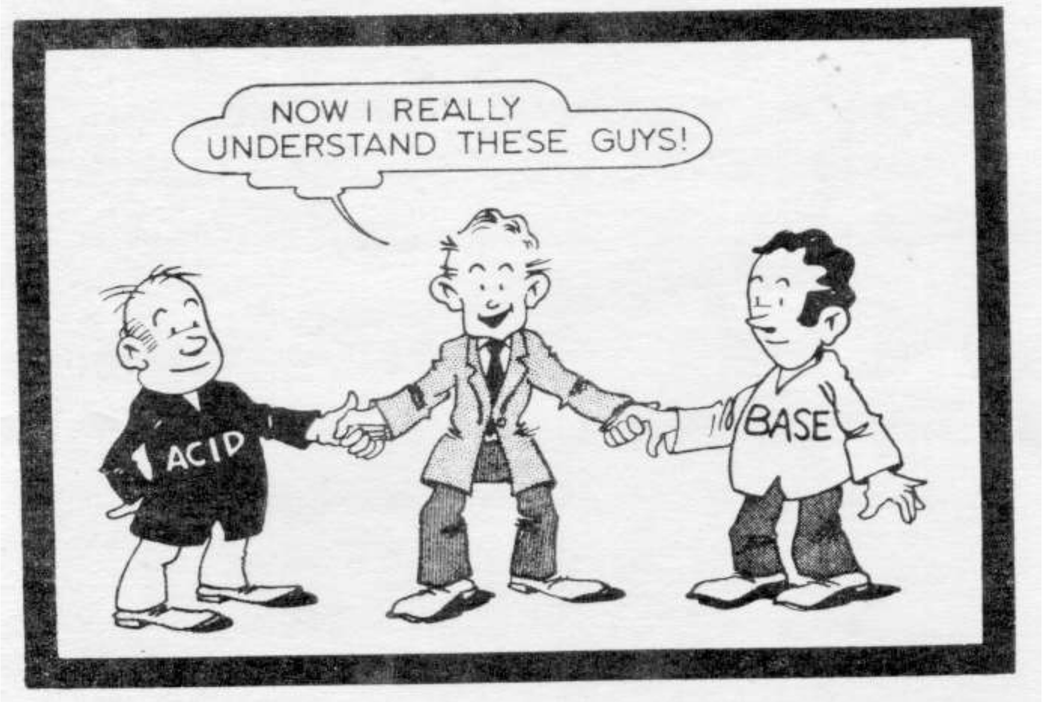
Hazards

HCl - strong acid, pH < 0

NaOH - strong Base, pH > 14

Wash off skin with large amounts of water.

Use baking soda for acid spills and acetic acid then baking soda for base spills.



Experiment 17. *Prelaboratory Assignment of* Antacid Analysis

1. Write a balanced equation for the reaction of the active ingredient in Tums with excess acid. See Table 17.1.

2. Identify the two most common anions present in antacids.

3. a. How much time should be allowed for the titrant (standard solution) to drain from the buret wall before a reading is made?

b. Experimental Procedure, Part B.2. Bromophenol blue is the indicator used in detecting the endpoint for the antacid analysis in this experiment. What is the expected color change at the endpoint?

4. a. How many moles of stomach acid would be neutralized by one tablet of Tums Ultra 1000 that contains 1000 mg of calcium carbonate?

$CaCO_3(aq) + 2H_3O^+(aq) \longrightarrow Ca^{2+}(aq) + CO_2(g) + 3H_2O(l)$

b. Assuming the volume of the stomach to be 1.0 L, what will be the pH change of the stomach acid resulting from the ingestion of one Tums ultra 1000 tablet that contains 1000 mg of calcium carbonate.

5. a. A commercial antacid was analyzed to determine the amount of antacid present in the sample. Complete the following table for Trial 1 of the analysis. (See ***Report Sheet***.) Record calculated values with the correct number of significant figures.

A. Dissolving the Antacid *Calculation Zone*

3. Mass of antacid sample (*g*) = 0.204

4. Total volume of HCl added (*mL*) ___25.0

5. Molar concentration of HCl (*mol/L*) __0.0978

B. Analyzing the Antacid Sample

1. Molar concentration of NaOH (*mol/L*) __0.0902

2. Buret reading, *initial* (*mL*) _3.85

3. Buret reading, *final* (*mL*) ___10.60

4. Volume of NaOH added (*mL*) _______

C. Calculations

1. Moles of HCl added, total (*mol*)

2. Moles of NaOH added (*mol*)

3. Moles of base in antacid sample (*mol*)

4. mol base in antacid **/** mass of antacid sample (mol/g)

Post Laboratory Questions

1. Part A.1. The antacid tablet for analysis was not finely pulverized before its reaction with hydrochloric acid. Will this technique error increase or decrease the reported amount of antacid in the sample? Explain.

2. Part A.2. The HCl(*aq*) solution has a lower concentration than what is indicated on the reagent bottle. Will this result indicate the presence of more or fewer moles of base in the antacid? Explain.

3. Part A.2. All of the CO_2 is not removed by gentle boiling after the addition of HCl. Will the reported amount of antacid in the sample be too high, too low, or unaffected? Explain. *Hint:* Remember that $CO_2(g)$ is an acidic anhydride.

Too low. The residual CO_2 will react with the additional NaOH inferring a higher amount of excess HCl and therefore a lesser amount of antacid. The reported amount of antacid in the sample will be reported too low.

4. Part A.2. "If the solution is blue, pipet an additional 10.0 mL of 0.1 *M* HCl into the solution and boil again. Repeat as often as necessary." Explain why the solution would be blue and, if it is, why more HCl must be added.

5. Part B.1. An air bubble was initially trapped in the buret but was dispensed during the back titration of the unreacted HCl (Part B.2). As a result of this technique error, will the reported amount of antacid in the sample be too high or too low? Explain.

6. Part B.2. The bromophenol blue endpoint is surpassed in the back titration of the excess HCl with the sodium hydroxide titrant. As a result of this technique error, will the reported amount of antacid in the sample be too high or too low? Explain.

***7.** A few of the "newer" antacids contain sodium citrate, $Na_3C_6H_5O_7$, as the effective, but more mild antacid ingredient.

a. Write a balanced equation representing the antacid effect of the citrate ion, . Assume that the completely neutralizes (protonates) the citrate ion.

b. Will 500 mg of $Na_3C_6H_5O_7$ (258.1 g/mol) or 500 mg of $Mg(OH)_2$ (58.32 g/mol) neutralize more moles of hydronium ion? Show calculations. see the answer:

a. $C_6H_5O_7^{3-}(aq) + 3\,H_3O^+(aq) \rightarrow H_3C_6H_5O_7(aq) + 3\,H_2O(l)$

b. $0.500\text{ g } Na_3C_6H_5O_7 \times \dfrac{\text{mol}}{258.1\text{ g } Na_3C_6H_5O_7} \times \dfrac{3\text{ mol } H_3O^+}{1\text{ mol } Na_3C_6H_5O_7}$

$= 5.81 \times 10^{-3}\text{ mol } H_3O^+$

$0.500\text{ g } Mg(OH)_2 \times \dfrac{\text{mol}}{58.32\text{ g } Mg(OH)_2} \times \dfrac{2\text{ mol } H_3O^+}{1\text{ mol } Mg(OH)_2} = 1.71 \times 10^{-2}\text{ mol } H_3O^+$

Therefore, 500 mg of $Mg(OH)_2$ neutralizes more moles of hydronium ion (acid) than does 500 mg of $Na_3C_6H_5O_7$.