Laboratory OF GENERAL CHEMISTRY

Presented By :
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Experiment 5: Analysis of Antacids (تحليل مضادات الحموضة)

Purpose:

► To determine the neutralizing effectiveness per gram of a commercial antacid tablets

► All acids 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 heartburn and indigestion (عسر الهضم الحمضي).

❖ 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 overeating (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

$$NaHCO_3 + 1HCl \rightarrow NaCl + H_2CO_3$$

$$H2CO_3 \rightarrow H_2O + CO_2$$

► 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

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2CO_3$$

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

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

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

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

► 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 $Mg(OH)_2$?

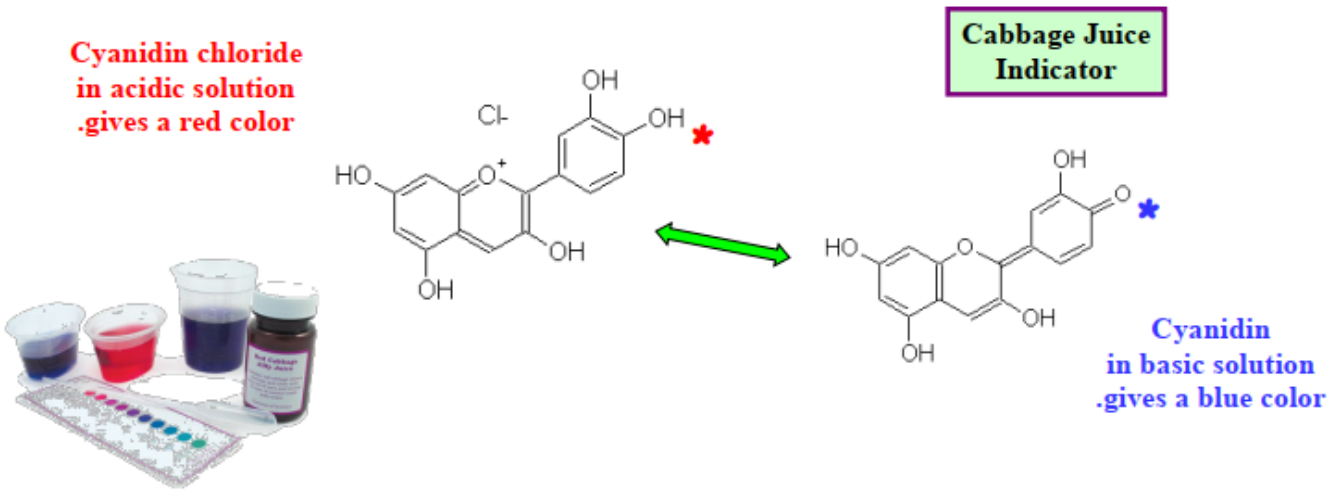
Hint, write a balanced equation for the reaction of each antacid with HCl, and then calculate moles HCl /g antacid.

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.**



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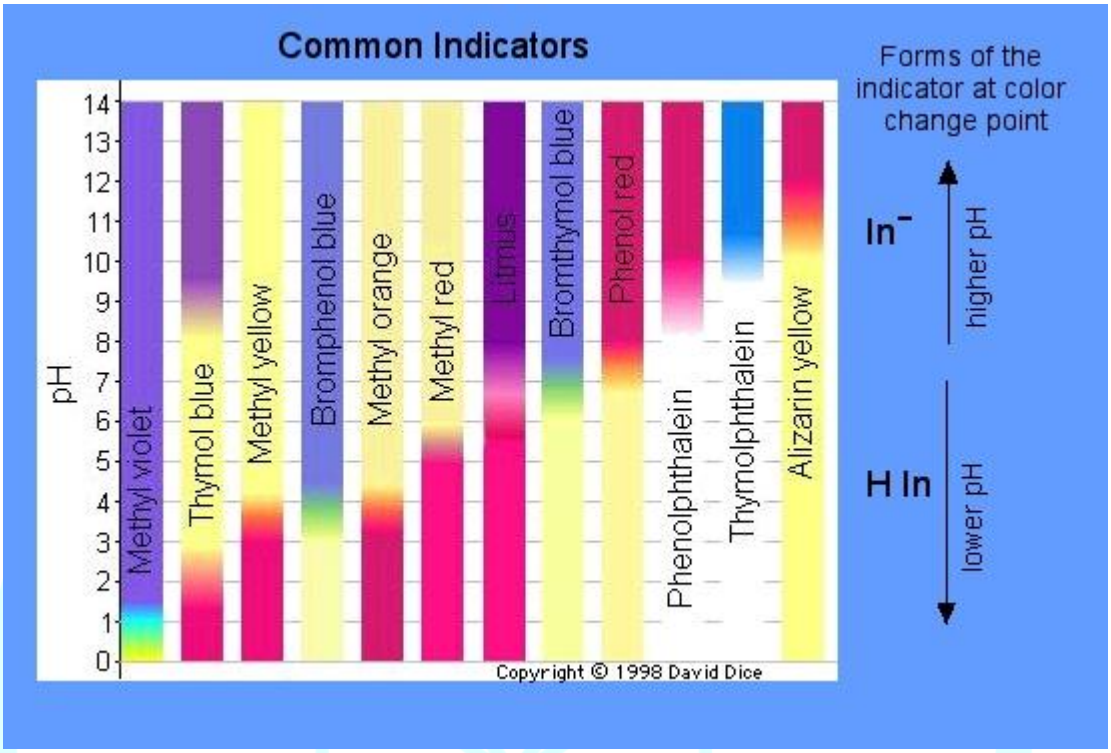

What is Titration?

► **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.

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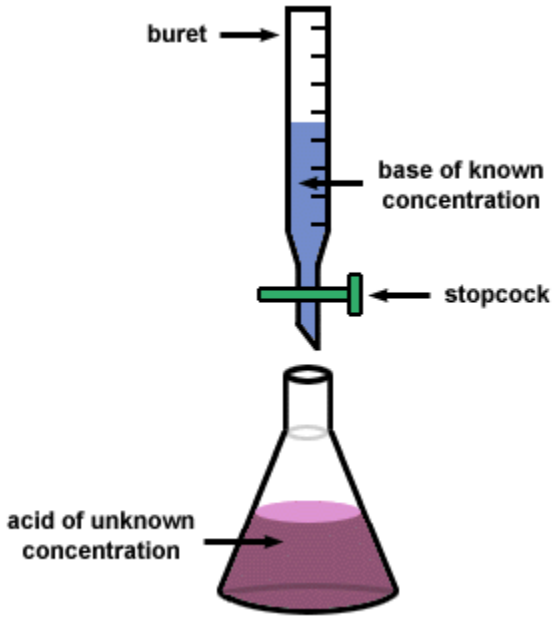
Typical Titration Set-up



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 large HCl standard solution, (a simulated stomach environment),then The unreacted (left) HCl is back titrated with a standardized NaOH solution.

► n_{Acid} = total moles for the initial quantity of **HCl.**

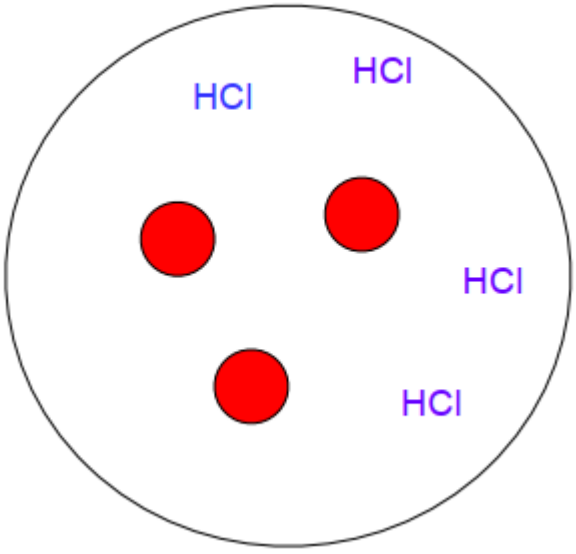
► $n_{antacid}$ = The of moles of HCl neutralized by Antacid Tablet.

► 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).

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

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



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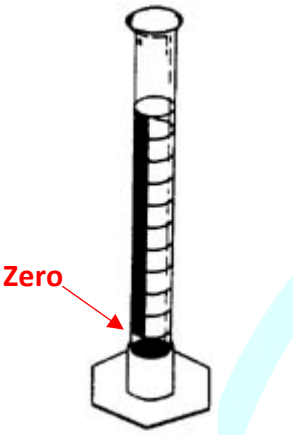
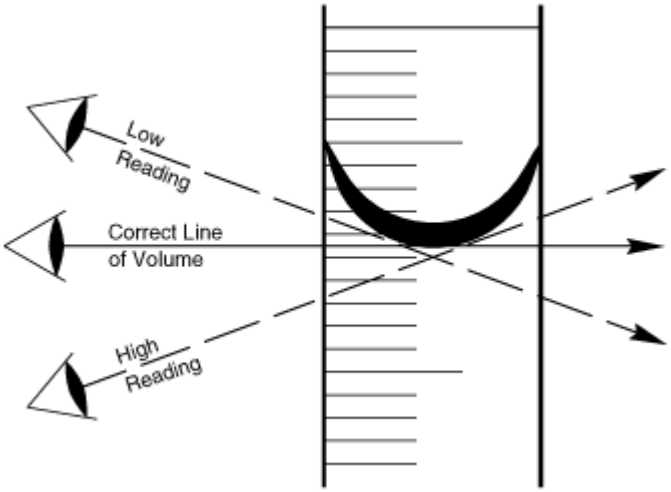
Differences in Glassware



Graduated Cylinder

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

Viewing the Meniscus of buret



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(محلول معياريtitrant): the concentration of NaOH is accurately known.

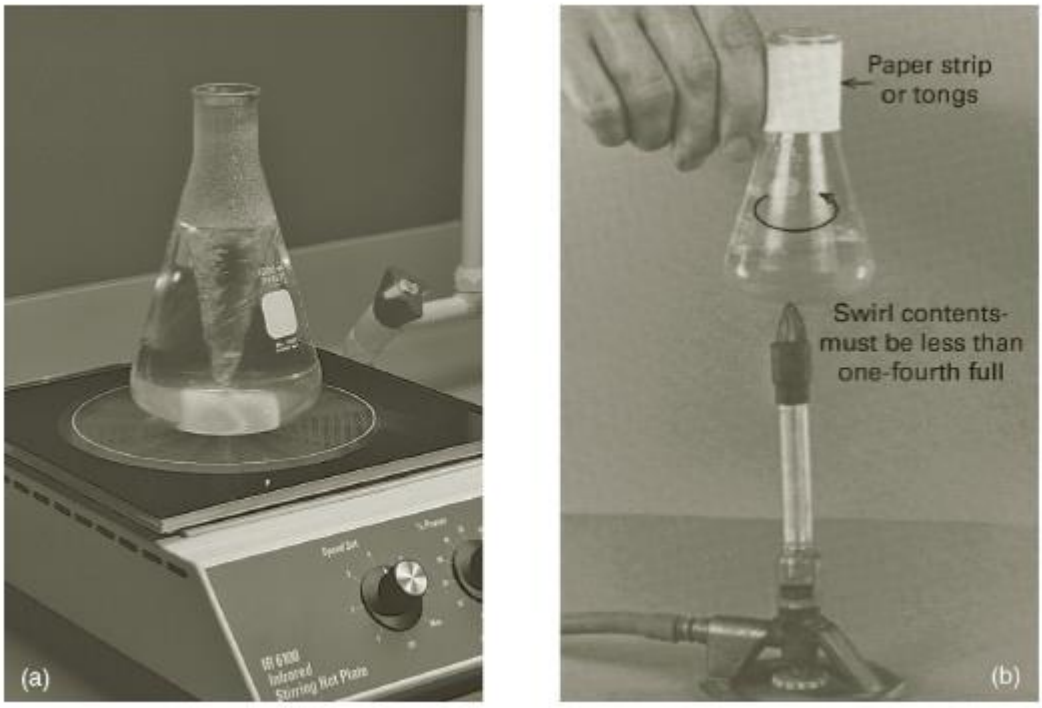


Figure 17.2 Gently heat the sample to remove CO_2 gas.

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

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

$$CaCO_3 + 2\ HCl \rightarrow Ca2^+ + 2\ Cl^- + CO_2(g) + H_2O$$

• unreacted HCl + NaOH → neutral solution.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

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

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

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

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

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

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.