Name _____ Partner _____
Lab Section M Tu W Th F

Chemistry 130
Experiment 6: Molecular Shapes & Analyses

Part I: Molecular Shapes: Please don't eat the atoms!!

In this week's lab you will have the opportunity to visualize the geometry and shape defined by VSEPR theory and you will be practicing drawing Lewis electron-dot structures.
You should receive from your instructor 2 large gum drop, 10 small jelly beanss and 10 toothpicks.

Procedure:

1. Connect two small jelly beans with one toothpick. Obviously, the only way you can connect these is in a straight line. This geometry is called linear and is similar to any diatomic molecule, like O_2. Draw the Lewis dot structure and sketch the three-dimensional shape.

2. A. Connect three small jelly beans to a one large central gum drop. Place them all in the same plane, that is, *FLAT*. The angle defined by small- large-small should be 120°. This geometry is similar to SO_3. Sketch the three-dimensional structure and draw the Lewis electron-dot structure and for SO_3. [Remember our definitions: *geometry* is the electron positions, and *shape* is the atom positions.] Is there a difference between the geometry and the shape?

Geometry _____
Shape _____

2. B. Remove one of the small jelly beans. The remaining two small jelly beans and one large gum drop define a "bent" or "angular" molecule similar to SO_2. Note that the toothpick represents a non-bonding electron pair. Sketch the three-dimensional shape and draw the Lewis electron-dot structure for SO_2. Is there a difference between the geometry and the shape?

Geometry _____
Shape _____

3. A. Now connect four small jelly beans to one central large gum drop in the shape of a tetrahedron. Have your instructor or TA verify that you have the right shape. This geometry is similar to CH_4. Sketch the *three-dimensional structure* and draw the Lewis electron-dot structure for CH_4. [Remember the wedge and dotted line for projections in front of and behind your paper.]
Is there a difference between the geometry and the shape?

Geometry _____
Shape _____

3. B. Remove one of the small jelly beans. The remaining system of atoms is a trigonal pyramid. This shape is the same as that of an NH_3 molecule. Draw the three-dimensional structure and draw the Lewis electron-dot structure for NH_3. Is there a difference between the geometry and the shape?

Geometry _____
Shape _____

3. C. Remove another small jelly bean. You should have two small jelly beans connected to one large gumdrop. This is another "bent" or "angular" molecular shape. [Note that it is different from the shape in 2B. In 2 B the small-large-small angle was 120°; in this case the angle is about 109.5° - the tetrahedral angle.] This geometry and shape is similar to that for water. Draw the three-dimensional structure and draw the Lewis electron-dot structure for H_2O. Is there a difference between the geometry and the shape?

Geometry _____
Shape _____

Part II: Analysis of Commercial Antacid Tablets.

Hydrochloric acid (HCl) is one of the substances found in gastric juices secreted by the lining of the stomach. HCl is needed by the enzyme pepsin to catalyze the digestion of proteins in the food we eat. Heartburn is a symptom that results when the stomach produces too much acid .

Antacids are bases used to neutralize the acid that causes heartburn. Despite the many commercial brands, almost all antacids act on excess stomach acid by neutralizing it with weak bases. The most common of these bases are hydroxides, carbonates, or bicarbonates. The following table contains a list of the active ingredients found in several common commercial antacids, and the reactions by which these antacids neutralize the HCl in stomach acid.

Compound	Formula	Chemical Reaction
Aluminum hydroxide	$Al(OH)_3$	$Al(OH)_3$ (s) + 3 HCl(aq) -----> $AlCl_3$(aq) + 3 H_2O(l)
Calcium carbonate	$CaCO_3$	$CaCO_3$ (s) + 2 HCl(aq) -----> $CaCl_2$(aq) + H_2O(l) + CO_2(g)
Magnesium carbonate	$MgCO_3$	$MgCO_3$ (s) + 2 HCl(aq) -----> $MgCl_2$(aq) + H_2O(l) + CO_2(g)
Magnesium hydroxide	$Mg(OH)_2$	$Mg(OH)_2$ (s) + 2 HCl(aq) -----> $MgCl_2$(aq) + 2 H_2O(l)
Sodium bicarbonate	$NaHCO_3$	$NaHCO_3$ (aq) + HCl(aq) -----> NaCl(aq) + H_2O(l) + CO_2 (g)

In this experiment, several brands of antacids will be analyzed to determine how much acid is neutralized per tablet and the cost analysis of each tablet. The analytical procedure used is known as **back titration**. In this procedure, a known amount of HCl, which is in excess, will be reacted with a weighed portion of a ground antacid tablet. The HCl remaining after the antacid is neutralized

will be determined by **titration** with NaOH (a strong base) until all the acid is neutralized, which we test by a dye called **phenolphthalein**, which is pink in an acidic solution. How much HCl is neutralized by the antacid ($HCl_{neutralized}$) is the difference between the amount of HCl initially present in the excess ($HCl_{initial}$) and the amount of HCl titrated by the NaOH ($HCl_{titrated}$).

$$HCl_{initial} - HCl_{titrated} = HCl_{neutralized}$$

Procedure:

1. Clean, rinse, and fill a buret with NaOH solution. Record the initial NaOH volume reading from the buret (+0.02 mL). Do not try to get the reading to be 0.00 mL - just some reading between 0.00 and 2.00 mL!

Initial buret reading _____ mL _____ mL

2. Weigh an antacid table in a weighing boat. Transfer the tablet to a clean mortar and crush the tablet into a fine powder using the pestle.

Antacid Brand _____ _____

Weight of antacid tablet _____ g _____ g

3. Weigh about 0.2 grams (+0.01 g) of the ground up tablet powder and transfer it to a clean 125 mL Erlenmeyer flask.

Weight of powder _____ g _____ g

4. Transfer 20 mL of the HCl solution to the flask which contains your antacid.

Molarity of HCl solution (see label) _____ M.

5. Swirl the flask to help dissolve the antacid. Since the antacid tablet may contain inert ingredients, much of the tablet may not dissolve and the liquid may be cloudy. The active antacid ingredient will dissolve however and react with the acid very quickly while the liquid will remain cloudy.

6. Add 3 - 4 drops of phenolphthalein indicator to the flask and gently swirl the flask. You MUST add this color indicator! This color indicator is colorless in acidic solution but pink in basic solution.

7. Titrate the acid solution with the NaOH solution by adding NaOH solution *dropwise* until the color change occurs (called the phenolphthalein endpoint). Since the liquid is cloudy, the color change at the endpoint may be hard to detect, so watch very closely. As you add the NaOH solution, *swirl* the flask to promote mixing of the reagents. When you see a permanent color change in the combined solution, STOP adding the NaOH solution. Record the final NaOH volume (+0.02 mL).

Final buret reading _____ mL _____ mL

8. What is the total volume of NaOH solution added (difference between final and initial volumes)

_____ mL _____ mL

Molarity of NaOH solution (see label) _____ M.

9. **Repeat** this analysis on another brand of antacid tablet.

CALCULATIONS:

Brand of Antacid: _____ (your first one)

1. How many moles of HCl were added to the antacid powder? [our $HCl_{initial}$]

2. How many moles of NaOH were added in the titration?

3. How many moles of "excess" HCl were neutralized by the NaOH in the titration?

4. How many moles of HCl were neutralized by the antacid powder?
   [NOTE: moles neutralized = moles initial - moles titrated]

5. How many moles of HCl does one antacid pill neutralize? Remember that you only used 0.2 g of the powder - and not all of the pill.

Brand of Antacid: _____ (your second one)

1. How many moles of HCl were added to the antacid powder? [our $HCl_{initial}$]

2. How many moles of NaOH were added in the titration?

3. How many moles of "excess" HCl were neutralized by the NaOH in the titration?

4. How many moles of HCl were neutralized by the antacid powder?
   [NOTE: moles neutralized = moles initial - moles titrated]

5. How many moles of HCl does one antacid pill neutralize? Remember that you only used 0.2 g of the powder - and not all of the pill.

The recommended dosage for each of these antacids is two tablets.
The price for each type of antacid is: Tums - $4.29 for 72 tablets
Rolaids - $4.49 for 100 tablets
Alka-Seltzer - $4.79 for 36 tablets

Which of the two antacids that you used in this experiment would you recommend as the better buy? Careful - think about what needs to be considered.

Before leaving the lab, be sure to dispose of any laboratory waste in the correct container in the hood and please CLEAN YOUR GLASSWARE!!! Rinse all glassware with water and leave the items to dry on the bench for the next lab section.

The analysis of antacid tablets was adapted from:
http://www.sas.upenn.edu/~caramboc/AntacidLab.html