Name _____ Date _____ Class _____

Molar Mass of Butane

Lab 29
APPLICATION

Text reference: ***Chapter 10***

Introduction

Every pure substance is composed of a distinct combination of atoms and is identified by its own molecular formula. The sum of the atomic masses of the atoms in this molecular formula is the substance's formula mass. The same number, measured in grams, is the substance's molar mass.

Butane, with the molecular formula C_4H_{10}, is a gas at normal room conditions. It can be liquefied by placing it under pressure, as in a disposable butane lighter. When the valve is opened the liquid butane quickly escapes and changes into a gas. Butane also is extremely insoluble in water, so it can be bubbled through water with very little of it going into solution. Because of these properties, a refill cylinder for a butane lighter is a good source of butane gas, and water displacement is a good method of collecting a measurable sample of it.

In this investigation you will collect some butane gas in a container by means of water displacement. You will determine the volume of the gas collected and, from that volume, the number of moles of butane. The mass of the gas collected will be obtained by taking the difference between the mass of the refill cylinder before and after butane is released from it. From the mass and the number of moles of the gas collected you can then calculate the mass of one mole, or the molar mass, of butane.

Pre-Lab Discussion

Read the entire laboratory investigation and the relevant pages of your textbook. Then answer the questions that follow.

1. What is the difference between the formula mass and the molar mass of a substance? Include the appropriate units for each. _____

2. Describe the procedure known as water displacement. When is it used? _____

3. Why should there be no flames in the laboratory when this investigation is being done? _____

Lab 29
APPLICATION

Name _____

4. Describe the piece of equipment known as a pneumatic trough. What is its purpose during the investigation? _____

5. Why is the insolubility of butane important in this investigation?

6. Why is it important to make sure that the flask is filled to the very top with water before it is turned upside down? _____

7. What is the volume occupied by one mole of any gas at STP? Do you think the volume would be larger or smaller at laboratory conditions? _____

Problem

How can you determine the molar mass of butane gas?

Materials

safety goggles
laboratory apron
laboratory balance
butane refill cylinder
2 pieces rubber tubing
pneumatic trough
flask, 500-mL
glass square

Safety

Wear your goggles and lab apron at all times during the investigation. Butane is very flammable, so make certain there are no open flames or matches in the laboratory.

Note the caution alert symbols here and with certain steps of the Procedure. Refer to page *xi* for the specific precautions associated with each symbol.

Procedure

1. Put on your goggles and lab apron. This investigation requires you to work carefully with your partner. Decide now which one of you will handle the flask and which one will handle the butane cylinder.

2. Determine the mass of a dry butane refill cylinder. Record the mass in your Data Table.
3. Fill the pneumatic trough with water to a level about 2 cm above the shelf. Connect one piece of rubber tubing to the overflow spout of the trough, and place the other end of it in the sink. (See Figure 29–1.)

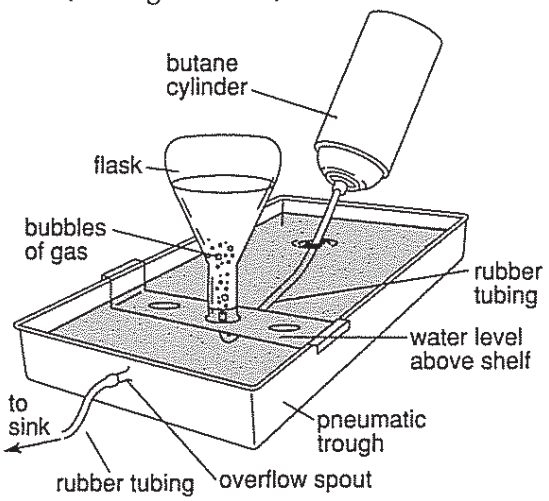

Figure 29–1

4. Fill a 500-mL flask completely (to the very top) with water. Cover the mouth of the flask with a glass square, carefully invert the flask, and place it in the trough so the mouth is under water, pointing down. Make sure that there are no air bubbles in the flask. Remove the glass square from the mouth of the flask and set the flask over one of the holes in the shelf. One student should hold the flask vertical and steady while the other handles the butane cylinder.
5. Connect one end of the second piece of rubber tubing to the butane refill cylinder and insert the other end of the tubing a few centimeters into the neck of the flask, so that the gas will rise into the flask when the valve is opened. **CAUTION:** *Butane is highly flammable. Do not bring any flames into the laboratory, or use any electrical equipment, during this investigation.*
6. Holding the gas refill above the trough, press the valve of the cylinder to release the butane, and fill the round portion of the flask with gas exactly to the 500-mL mark. Make sure not to release any of the gas outside of the flask.
7. When the flask is filled, release the valve and carefully disconnect the rubber tubing from it.
8. Lift the flask off the shelf in the pneumatic trough, and place the glass square over its mouth. Turn the flask right side up and carry it to the fume hood. Remove the glass square and stand the flask upright.
9. Making sure that the butane cylinder is dry, measure its mass on the same balance used previously. Record the value in your Data Table. Clean up your work area and wash your hands before leaving the laboratory.

Lab 29 APPLICATION

Name _____

Observations

DATA TABLE

initial mass of butane cylinder	
final mass of butane cylinder	
mass of butane gas	
volume of butane	

Calculations

1. Determine the mass of butane used and record it in the Data Table.

2. Using the molar volume given to you by your teacher for the conditions in your laboratory, determine the number of moles of butane gas collected.

3. From the mass and the number of moles of butane gas collected, calculate the mass per mole of butane—its molar mass.

Critical Thinking: Analysis and Conclusions

1. Calculate the formula mass of butane (C_4H_{10}) using a chart of atomic masses. *(Applying concepts)*

2. Determine your percent error (*Interpreting Data*).

3. If a small air bubble had been in the flask before you filled it with butane, how would it have affected your results? Explain. *(Making predictions)* _____

4. What other sources of experimental error might have affected your results in this investigation? How? *(Interpreting data)* _____

Name _____

Lab 29 APPLICATION

5. Why were you unable to use the standard molar volume (22.4 L/mol) in this investigation? *(Making comparisons)* _____

_____

_____

_____

Critical Thinking: Applications

1. How would you alter this investigation to determine the molar volume of a gas that is soluble in water? *(Designing experiments)* _____

_____

2. Propane gas tanks for barbecues are filled by weight. Can you expect a fair measurement this way? Explain. *(Making judgments)* _____

_____

Going Further

1. Under your teacher's supervision, determine experimentally the molar mass of another gas, for example, propane. Report your findings.