

## Lab #7: The Ideal Gas Law

### Objectives:

1. To experimentally determine the molar mass of butane by using the ideal gas law.

### Background Information:

The Ideal Gas Law can be used to determine the molar mass of a gas. First, we can determine the mole of the gas by rearranging the formula ( $PV = nRT$ ). Then, use the formula relating mass and moles to calculate molar mass ( $n = \frac{m}{M}$ ).

Since normal air consists of small amount of water vapour, in order to obtain the pressure of a dry gas over water, we must subtract the vapour pressure of water from the atmospheric pressure. This is accordance to the Dalton's Law of Partial Pressures.

$$P_{\text{dry gas}} = P_{\text{atmosphere}} - P_{\text{water vapour}}$$

Vapour pressure is highly dependent on temperature. Therefore, we have to look up a reference table for the vapour pressure at a given temperature. In this lab, we are collecting butane gas over a basin of water. Hence, we must calculate its pressure by subtracting the atmospheric pressure from the vapour pressure we look up from the reference table (see procedure below).

### Materials:

Disposable Butane Lighter	Electronic Balance	Barometer
Basin of Water	Thermometer	100 mL graduated cylinder

### Procedure:

1. Submerge butane lighter in basin of room temperature water and press lever to release gas for about 45-60 seconds. Remove lighter from water, shake excess water off and dry off outside very well.
2. Take the mass of the dry butane lighter and record in the observation table.
3. Fill a 100 mL graduated cylinder completely with water from the basin or the tap. Place thumb over opening and invert cylinder into water in basin. Be sure no air bubbles are trapped in the cylinder.
4. Position the butane lighter under water and below the opening of the graduated cylinder. Press the lever and release butane gas into the graduated cylinder. The gas will displace the water in the cylinder. Do not allow any of the butane gas to escape through the outside of the cylinder. Collect about 80 mL of butane gas, and hold it in the basin while completing the next two steps.
5. Remove the butane lighter, shake and dry well as in step 1. Take the mass of butane lighter and record in the observation table. (If the final mass of the lighter is bigger than its initial mass, more shaking to eliminate the excess water is required.)
6. By raising and lowering the graduated cylinder in the basin, adjust the level of water inside and outside the cylinder until they are the same. Read the volume of gas collected and record in observation table.
7. Repeat steps 2-8 for four total trials.
8. Record the temperature of the air in the room.
9. Record the atmospheric pressure (from your teacher).
10. Look up the vapour pressure of water at the temperature recorded from the Internet at ([http://en.wikipedia.org/wiki/Vapor\\_Pressure\\_of\\_Water\\_at\\_Various\\_Temperatures](http://en.wikipedia.org/wiki/Vapor_Pressure_of_Water_at_Various_Temperatures)) and record in the observation.

**Observations:**

	<b>Trial 1</b>	<b>Trial 2</b>	<b>Trial 3</b>	<b>Trial 4</b>
Initial mass of butane lighter				
Final mass of butane lighter				
Volume of butane collected				

Temperature of Room: \_\_\_\_\_

Atmospheric Pressure: \_\_\_\_\_

Water Vapour Pressure at Measured Temperature (from the reference table): \_\_\_\_\_

**Analysis:**

1. Calculate the mass of the butane collected for each trial and record them in your data table.
2. Calculate the partial pressure of butane. Show work.
3. Use the rearranged ideal gas law given in the background information to determine the molar mass ( $M$ ) in g/mol of butane for **each** trial.
4. Calculate the average molar mass of butane from your best and consistent trials.

**Evaluation:**

1. Butane has the formula  $C_4H_{10}$ . What is its theoretical molar mass?
2. Calculate the molar mass percent error using the average experimental value determined for butane.
3. Describe two sources of error and how they affected your experimental molar mass.
4. Do you think the same experimental technique could be used to determine the molar mass of any gas? Explain your answer.

**Conclusion:**

Summarize what you have learned from this lab.