Lab 5: Molar Mass of CO_2

Name ______________________________

Objective: Experimentally determine the molar mass of CO_2.

Pre-Lab:

1. Answer the following questions on a separate piece of paper and hand it in before beginning lab:
   a) Since you are measuring pressure in mmHg, which value of R should you use?
   b) Suppose you have a stoppered flask containing CO_2 gas at room temperature and pressure. If the volume of your stoppered flask is 300.0 mL, the pressure in the room is 770 mm Hg, and the temperature in your work area is 22.0°C, how many moles of CO_2 are in the flask?
   c) How many grams of CO_2 are in the flask (described in part b)?
   d) Why do we measure the volume of the flask with water rather than using the volume listed on the side?

Procedures:

1. Obtain a thermometer and **gently** clamp it at your work area.

2. Weigh an empty Erlenmeyer flask with a rubber stopper firmly capping it. Record the mass.

3. Place a small piece of solid CO_2 (dry ice) in the flask (use about twice the amount you calculated in pre-lab question c). Watch the flask while the CO_2 sublimes (don't move the flask too much), stoppering the flask immediately after all the solid CO_2 disappears.

4. Wait until the flask is equilibrated to room temperature (around 5-10 minutes), and then "burp" it by lifting one side of the stopper, and then quickly pushing it back in. This is to ensure that the pressure is the same inside and outside the flask.

5. Dry off any accumulated moisture from the outside of the flask, weigh the stoppered flask (on the same scale) and record the mass.

6. To determine the volume of the flask: fill the flask all the way to the brim with water and stopper it while holding it over a sink. If there is any air trapped inside, try again until only water is present inside the stoppered flask. The volume of the water should be the same as the volume of the air in the stoppered flask. Dry off the outside of the flask completely. Measure the volume of water in a graduated cylinder in batches and add up the volumes to get the total volume of all the water in the flask. Record this as the stoppered flask volume.

7. Read the thermometer in your work area and record the temperature.

8. Read the barometer in the lab and record the pressure in mmHg. Ask me if you need help with the barometer.

Data:

Mass of empty stoppered flask ____________________

Mass of flask, stopper and CO_2 ____________________

Stoppered flask volume ____________________

Temperature ____________________

Atmospheric pressure ____________________

Analysis:

The mass of CO_2 obtained by subtraction of the two masses is incorrect! That is because we said the flask was empty at the start of the lab, but it really had air in it, which was pushed out by the subliming CO_2. When we weigh solids or liquids, the mass of displaced air is negligible, but when we displace air with another gas, the mass of the air isn't negligible. So we need to calculate the mass of the air that is displaced and include that in the calculation of CO_2 mass.

Show all calculations in your lab notebook and put copies in your report!

1. Determine **the mass of air in the flask** by multiplying the flask volume by 0.00115 g/mL (the density of air at room temperature).

Mass of air in flask ____________________

2. Subtract the mass of air from the mass of the empty stoppered flask to get **the mass of flask and stopper without air**.

Mass of flask and stopper without air ____________________

3. Subtract the mass of flask and stopper without air from the mass of flask, stopper and CO_2 to get **the mass of CO_2**.

Mass of CO_2 ____________________

4. Convert **temperature to Kelvins**.

Temperature (K) ____________________

5. Use the ideal gas law, atmospheric pressure, the temperature in Kelvins and the volume of the flask to calculate **the number of moles of CO_2 gas in the flask**.

Moles CO_2 ____________________

6. Divide the mass of CO_2 gas in the flask by the number of moles of gas in the flask to calculate **the experimental molar mass of CO_2**.

Experimental molar mass of CO_2 ____________________

7. Calculate **the theoretical molar mass of CO_2** from the periodic table. We will consider this to be the true value of the molar mass of CO_2, because it is based on the averaged results of many experiments.

Theoretical molar mass of CO_2 ____________________

8. Determine your **absolute error in the molar mass of CO_2** by subtracting the true value from your value.

Absolute error in experimental molar mass of CO_2 ____________________

9. Determine your **percent error in the molar mass of CO_2** by taking the absolute value of the absolute error and dividing by the true value. This gives the percent as a decimal, which you can then convert to a percent.

Percent error in experimental molar mass of CO_2 ____________________

10. An error of 5% is reasonable for this procedure. If yours is greater than 5%, explain what you think happened to increase your error in your discussion section.

Postlab Questions:

1. Why was excess dry ice used in step 3 of the procedure?
2. Why do gas laws use degrees Kelvin rather than degrees Celsius?
3. Were you surprised at how accurately the mass of a molecule of CO_2 could be determined with such simple equipment?