Molar Mass of a Gas

Introduction

The molar mass of several gases (oxygen, methane, argon, nitrogen and carbon dioxide are possible) will be determined by finding the mass of a measured volume of a presumed ideal gas at a specific temperature and pressure. The equation of interest is the rearranged ideal gas law

$$PV = \frac{m}{M}RT$$

P = pressure
V = volume
m = mass of gas
M = molar mass
R = ideal gas law constant
T = temperature

Procedure

The apparatus consisting of vacuum pump, y connectors, and manometer will be demonstrated. No trap is necessary since these gases will not harm the vacuum pump. Danger - Safety goggles are a must when working with vacuum apparatus!

1. Take a dry bulb from the heating oven, let it cool for 5 minutes, and evacuate it with the vacuum pump. Weigh the bulb on an analytical balance. Repeat until consistent results are obtained.
2. Fill the evacuated bulb with gas (oxygen, methane, argon, nitrogen or carbon dioxide). If using a tank, make sure the valve is set for slightly less than one atmosphere (14.7 psi) to reduce the chance of an explosion.
3. Weigh the bulb on an analytical balance (to 0.0001 g).
4. Connect the bulb to the manometer system and read the bulb gas pressure. Obtain the atmospheric pressure from the classroom barometer. This will allow you to obtain the pressure of the gas.
5. Evacuate the bulb again with the vacuum pump and check the mass. Repeat steps 1-4.
6. Evacuate the bulb a third time; check the mass and repeat steps 1-4.

Each group will obtain data for two gases. You should have at least 3 determinations for the molar mass of each gas.

At the end of the experiment each group will determine the volume of the bulb as follows.

1. Evacuate the bulb once again and weigh.
2. Submerge the bulb in a container of water.
3. Open the stopcock and allow the water to fill the bulb. Try to get all air bubbles out of the bulb. A long needle syringe may be helpful.
4. Weigh the bulb and water on a triple beam balance (not a top loader – it will exceed the capacity of the balance) and obtain the mass of water in the bulb.
5. Experimentally obtain the density of the water you used to fill the bulb and use this value to obtain the volume of the bulb.

Comments on write-up

1. Use the format of the worksheet

2. In general you will put your data into a spreadsheet, generate calculations for molar masses and errors, and then report the best value for the molar mass of each gas.

   For each individual determination compute the propagated error as a function of the scale errors for T, m, and P and the propagated error for V. Then compute the random error (standard deviation of the mean) for each molar mass. The best value will be the average plus or minus either the standard deviation of the mean (random error) or the largest propagated error -- whichever is largest. The format will be specified on the worksheet.

3. Also compute the % error for each gas, since the identities are known.