Lab 4: Gas Laws

Determining the Molar Mass of a Low-Boiling Liquid

Procedure Overview

- Weigh a clean, dry gas density flask with its cap on
- Obtain an unknown sample from your TA and record the ID # in your lab notebook
- Assemble the experimental setup and have your TA check it before igniting the Bunsen burner
- Heat your setup until the water boils and continue boiling for 5 minutes
- Remove the heat, immediately cap the flask, and let it cool
- Record the mass of the flask/cap/sample (which will have condensed)
- Repeat for a total of 3 runs
- After weighing the flask/cap/sample in the third run, use the partial vacuum in the flask to fill the flask with water (your TA will help you fill the neck of the flask)
- Record the mass of the flask/cap/water

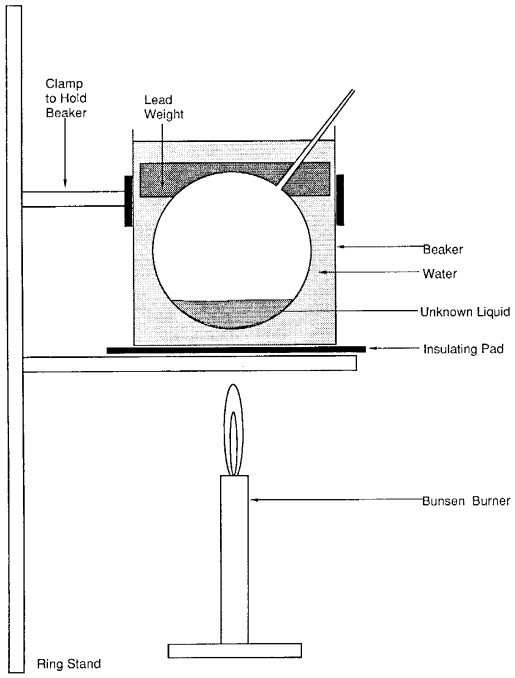

Figure 4-1. Schematic of apparatus setup.

Materials for Molar Mass
To be checked out from the stockroom:
None

Note: You are required to leave your UW Student ID card, and also a photo ID (e.g., driver's license) if your UW ID does not have a photo on it, with the stockroom while you have items checked out.

From your lab drawer:
Gas density flask
Rubber policeman
400 mL beaker
Lead ring

Provided in the lab:
Unknown liquid (from your TA)
Trough
Tongs
Digital thermometer

Procedure

1. **Fill a metal trough with tap water.**

   Allow it to come to room temperature. This will be used in step 8.

2. **Mass of capped gas density flask and air.**

   Wash and dry the outer surface of the gas density flask and cap the flask with a rubber policeman. If your flask is wet on the inside, exchange it for a dry one at the stockroom. Weigh the capped flask as accurately as possible on the balance and record the mass to three decimal places.

3. **Setup of the apparatus according to Figure 5-1**.

   Remove the cap from your gas density flask. Your TA will introduce ~2 mL of the unknown liquid into your density flask with a syringe. Record the number of your unknown. Place the flask in a 400 mL beaker and hold it down with a lead ring. Fill the beaker with tap water to within an inch of the top of the beaker. The opening of the flask should extend above the water level. Place the beaker on a metal ring covered with wire gauze at a height that will allow you to heat it with a Bunsen burner; place a clamp or iron ring around the top of the beaker to help stabilize it. At this point have your TA check your setup. After the TA has approved your setup, begin heating the water with the Bunsen burner. **The rubber policeman remains off during the entire heating operation.**

4. **Vaporization of the unknown**.

   The liquid in the flask will have vaporized before the water reaches the boiling point. It is necessary to heat the remaining vapor so that its temperature equals that of the boiling water. Heat the flask for at least five minutes after the onset of vigorous boiling so that thermal equilibrium is achieved. Turn off the Bunsen burner, and quickly cap the flask with the rubber policeman, taking care to avoid splashing the boiling water or knocking over the beaker. Carefully slide the cap down until it covers a quarter of an inch or more over the neck. **The seal**

must be vacuum tight. Do not remove the flask from the boiling water until it has been capped.

Note: The trapped sample was a gas at 100°C. The molar mass of the sample must be determined when the sample is a vapor, since you will be using the ideal gas law. The temperature, T, of the sample is 100°C at the moment you trapped the gas.

5. **Mass of the sample and the gas density flask**.

   Remove the lead ring from the beaker (using tongs) and then remove the flask. Allow the flask to stand until it reaches room temperature. (The outside may be cooled with tap water and then dried.) Weigh the capped flask, with its contents, to three decimal places. Some liquid will be visible in the flask. This is formed by the condensation of vapor as the flask cools, and is not an indication that liquid remained during step 3. Handle the flask very gently. There is a partial vacuum in the flask at this point; if it were to break, the flask would implode.

6. **Determination of the pressure**.

   The barometric pressure and the temperature of the laboratory should be measured. Check **Appendix D** for instructions on reading the barometric pressure.

7. Repeat steps 3–5 of the procedure two more times. Uncap the flask, and have your TA place more of the unknown sample in the flask. You do not need to remove the sample that is left over from the previous run. For your third run, do not uncap the flask after weighing it until you have performed step 7 below.

8. **Volume of the flask**.

   The volume of the flask must be determined in order to calculate the molar mass. After your last run, take the capped flask and place the tip under water. Carefully remove the rubber policeman from the density flask. As the cap is removed, the partial vacuum created by the condensed vapor will suck water into the flask. The flask will fill almost completely with water. Your TA can finish filling the neck of the flask using a syringe. After the water-filled flask reaches room temperature, replace the rubber policeman. Using the thermometer, measure the temperature of the water used to fill the flask. Dry the outside of the flask, and weigh it. By subtracting the mass of the flask filled with air from the mass of the flask filled with water, the mass of water can be calculated. Determine the density of water at room temperature using the table provided in **Appendix E**, which shows the variation in the density of water as a function of temperature; then use this density to find the volume of water, and thus the volume of the flask.

   The water may be removed from the flask with an aspirator after completion of the experiment. Your TA will demonstrate this technique. Return this “empty” flask to the stockroom, where it can be exchanged for a dry flask. Leave a dry flask in your drawer for the next person.

Before You Leave the Lab

1. Upon completing the work (includes all requested calculations), show your work to your TA.
2. Clean your lab bench and have your TA check your equipment drawer, lab bench, and lab notebook.
3. Obtain your TA’s signature in your lab notebook and turn in the copies of your lab pages notebook associated with this experiment, along with the post-lab report if instructed to do so.

Information to Enter in your Notebook during the Lab

- Identification # of your unknown
- Mass of flask/cap/air
- Mass of flask/cap/sample for each of the 3 runs
- Barometric pressure and temperature in the laboratory
- Sample temperature
- Water (room) temperature (i.e., the water that is used to determine the volume of the flask)
- Mass of flask/cap/water
- The names of the possible unknown compounds
- Any notes or observations that will help you remember what happened during the experiment (helpful when you work on your post-lab report or need to explain your results)
- Sample calculations – demonstrating that you know what to do with your data once you leave the lab