LabQuest
3

The Molar Mass of a Volatile Liquid

One of the properties that helps characterize a substance is its molar mass. If the substance in question is a volatile liquid, a common method to determine its molar mass is to use the ideal gas law, $PV = nRT$. Because the liquid is volatile, it can easily be converted to a gas. While the substance is in the gas phase, you can measure its volume, pressure, and temperature. You can then use the ideal gas law to calculate the number of moles of the substance. Finally, you can use the number of moles of the gas to calculate molar mass.

OBJECTIVES

In this experiment, you will

- Evaporate a sample of a liquid substance and measure certain physical properties of the substance as it condenses.
- Determine the molar mass of an unknown liquid.

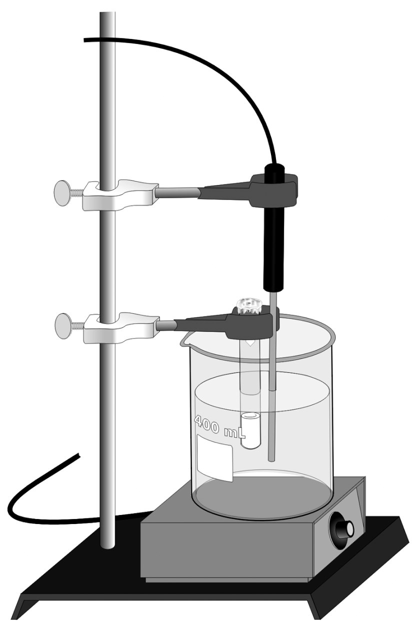

Figure 1

MATERIALS

LabQuest	unknown volatile liquid
LabQuest App	fume hood
Temperature Probe	test tube, 13 × 100 mm, and holder
(optional) Vernier Gas Pressure Sensor	two utility clamps
two 400 mL beakers	hot plate
ring stand	analytical balance
aluminum foil	needle
ice	tissues or paper towels

PROCEDURE

1. Obtain and wear safety glasses. Conduct this experiment in a fume hood or well-ventilated area.
2. Trim a piece of aluminum foil so that it just covers the top of a small, 13 × 100 mm, test tube. Use a needle to make a small hole in the middle of the foil. Measure the mass of the test tube and foil on the analytical balance.
3. Prepare a hot-water bath by warming about 300 mL of tap water in a 400 mL beaker. Keep the beaker on a hot plate once the water is warm.
4. Use a second 400 mL beaker to prepare an ice-water bath.
5. Connect the Temperature Probe to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
6. Obtain a liquid sample of an unknown volatile compound. Pour about 0.5 mL of the liquid into the test tube and quickly cover the test tube with the aluminum foil. Place the test tube in the hot-water bath. Make sure that the foil is above the water level (see Figure 1).
7. Immerse the Temperature Probe in the hot water bath (see Figure 1). Do not allow the tip of the probe to touch the beaker. This will give you a more accurate reading of the water bath temperature. You will monitor the temperature readings during the experiment. There is no need to store and graph data.
8. Heat the beaker of water to boiling and maintain the boiling as your sample of liquid vaporizes. Note that some of your sample will escape the test tube through the needle hole in the foil. This process also serves to flush the air out of the test tube.
9. Keep the test tube in the boiling-water bath for one minute *after* all of the liquid in the test tube has vaporized. Watch the temperature readings and record the temperature of the boiling-water bath, which will be used in the ideal gas law calculations.
10. Use a test-tube holder to *quickly* transfer the test tube to the ice water bath. Cool the test tube for about one minute, then remove it and dry it completely. Measure the mass of the test tube and the aluminum foil top.
11. Record the barometric pressure in the room.
12. Rinse out the test tube and fill it to the top with tap water. Cover the test tube with aluminum foil. Measure and record the mass of the test tube, water, and foil.
13. Repeat steps 2-12 with a different test tube and the same unknown liquid.

Google Doc, Before Lab: Purpose and Data table (for 2 trials)

Google Doc, After Lab:

Analysis:

- calculate the molar mass of your unknown compound twice using both sets of data (including uncertainty)
- after your teacher gives you the actual molar mass, compute the percent difference between your experimental value and the actual value
- compute the class average value and the experimental uncertainty (as we discuss in class)

Evaluation questions:

1. Consider the class average and your own experimental value. Was your experimental result within experimental uncertainty of the actual result? Was the class average within experimental uncertainty? Which was closer to the actual value? Is that what you would have expected? Why?
2. Which measurement or value contributed the most to the experimental uncertainty? (Consider percentages)
3. Did the class results tend to be higher than the actual molar mass or lower?
4. Describe at least three systematic errors in your experiment. As you think about systematic errors, consider your answer to # 3. If the experimental molar mass tended to be higher than actual, consider primarily systematic errors that would have led to that being the case; if the experimental molar masses were lower than actual, consider the errors that could have led to that being the case. If you believe one systematic error to be more important than the others in affecting the final outcome, make that clear.
5. Finally, if you know you made any mistakes in your own experiment, explain the human errors here and indicate what effect they would have had on your experimental result.