

Lab #9: Determination of the Molar Mass
of Volatile Liquids Lab Exercise
Chemistry II
10 points

Name: _____

Partner: _____

Date: _____ Hour: _____

USE BLUE/BLACK INK!!!!

Goal:

The goal of this lab is to experimentally determine the molar masses of several volatile liquids.

Introduction/Background:

The ideal gas law relates four measurable properties of a gas: pressure, volume, temperature, and number of moles. In this experiment, the ideal gas law will be used to determine the molar mass of gases and volatile liquids.

The number of moles of any pure substance is equal to its mass divided by its molar mass. By combining this idea with the ideal gas law, the formula for the molar mass of an ideal gas is

$$\text{molar mass} = \frac{mRT}{PV}$$

The molar masses of several volatile liquids with boiling points well below the boiling point of water will be determined in this lab. A small sample of each liquid will be placed in a plastic pipet. The pipet will then be heated in boiling water to vaporize the liquid. The air and excess vapor will escape, leaving the pipet filled only with the volatile liquid vapor at atmospheric pressure and at the temperature of the boiling water. The pipet is then removed and cooled to condense the vapor. Once cooled, the pipet is massed. By massing the same pipet filled with distilled water, the volume of the pipet is calculated. The molar mass of the volatile liquid is then determined from the equation above using the mass of the condensed vapor, the volume of the pipet, the atmospheric pressure, and the temperature of the boiling water.

Research questions: (If more room is needed to answer a question, additional pages may be attached.)

1) What does the term volatile liquid mean? _____

2) Read through the complete procedure. Why is a hot plate being used in this experiment instead of a Bunsen burner? _____

3) What four measurements are needed to calculate the molar mass of a gas? _____

- 4) Draw the structures of ethyl alcohol, acetone, and isopropyl alcohol:
- 5) What are the actual molar masses of ethyl alcohol, acetone, and isopropyl alcohol?
- 6) Read through the following lab data similar to our experiment:

chemical = methyl alcohol

temperature of boiling water bath	99.5 °C
barometric room pressure	738 mm Hg
temperature of room temp. water bath	24.0 °C
density of water at room temperature	0.9973 g/mL
mass of empty pipet #1	1.557 g
mass of pipet and condensed methyl alcohol	1.571 g
mass of pipet and distilled water	16.001 g

- (a) What is the mass of the condensed methyl alcohol?
- (b) What is the mass of the water in the filled pipet?
- (c) Using the given density of water, what is the volume of the pipet?
- (d) Using the equation given in the Introduction/Background, what is the experimental molar mass of methyl alcohol?
- (e) What is the actual molar mass of methyl alcohol?
- (f) What was this student's percent error?

Materials:

- | | |
|--------------------|---------------------------------|
| 9 mL acetone | 9 mL isopropyl alcohol |
| 9 mL ethyl alcohol | 1 balance |
| 1 barometer | 1 permanent marker |
| 2 400 mL beakers | 1 piece of tubing |
| 1 pair of pliers | 3 plastic pipets |
| 1 pair of scissors | 2 boiling stones |
| 1 test tube clamp | 1 hot plate |
| 1 ring stand | 1 digital thermometer |
| 3 10 mL beakers | 1 stopwatch |
| 1 100 mL beaker | 1 ruler |
| 1 test tube brush | 1 10 mL tall graduated cylinder |

Hazards:

The student safety contract applies. _____

Procedure:

1. Prepare a hot water bath
 - a. Fill a 400 mL beaker with tap water
 - b. Set up a hot water bath on the hot plate using the 400 mL beaker
 - c. Clamp a thermometer in the water
 - d. Turn on the hot plate to start the water heating
2. Prepare the pipets
 - a. Use pliers to pull the thin stems of the plastic pipets into very fine “capillary” tips
 - b. Cut the pipet tip using scissors so the capillary tip is less than 1 cm long
 - c. Label the pipets #1, #2, and #3 with a permanent marker
 - d. Mass each pipet
3. Draw 2-3 mL of ethyl alcohol into each of the pipets
4. Heat the filled pipets
 - a. Insert the tips of the pipets containing ethyl alcohol into a short piece of tubing
 - b. Secure the tubing with a test tube clamp
 - c. Lower the pipets into the boiling water bath (bulbs down), making sure the entire bulb of each pipet is below the water line
 - d. Heat the pipets in the boiling water for at least 5 minutes

5. Physically and chemically clean a 100 mL beaker
6. Fill a second 400 mL beaker with room temperature tap water
7. Record the temperature of the boiling water and the barometric pressure of the room.
8. Check for complete transformation from liquid to gas
 - a. Remove the pipets from the water bath.
 - b. Inspect each pipet
 - c. If any liquid remains in the pipet bulb, heat the pipet for another minute
9. Mass the condensed ethyl alcohol
 - a. Cool the pipets by lowering them into the 400 mL beaker of room temperature water.
 - b. Dry the pipets.
 - c. Mass each pipet
10. Mass the pipets filled with distilled water
 - a. Pour some distilled water into the clean 100 mL beaker
 - b. Clean pipet #1 with the distilled water from the beaker several times
 - c. Fill pipet #1 with distilled water
 - d. Dry the outside of pipet #1
 - e. Mass pipet #1
 - f. Repeat steps a-e for pipets #2 and #3
11. Empty the pipets into the sink.
12. Repeat steps 3 through 12 for acetone and isopropyl alcohol.
13. Clean up

Data:

Temperature of boiling water bath _____ °C

Barometric pressure _____ mm Hg

Temperature of room temperature water bath _____ °C

Balance # _____

Data Table 1 - Pipets

	Pipet #1	Pipet #2	Pipet #3
Mass of empty pipet			
Mass of pipet + H ₂ O			
Mass of H ₂ O			
Volume of pipet			

Data Table 2 - Volatile Liquids

	Pipet #1	Pipet #2	Pipet #3
Ethyl Alcohol	/	/	/
Mass of pipet and condensed ethyl alcohol			
Mass of condensed ethyl alcohol			
Molar mass of ethyl alcohol			
Acetone	/	/	/
Mass of pipet and condensed acetone			
Mass of condensed acetone			
Molar mass of acetone			
Isopropyl alcohol	/	/	/
Mass of pipet and condensed isopropyl alcohol			
Mass of condensed isopropyl alcohol			
Molar mass of isopropyl alcohol			

RECORD ADDITIONAL DATA ON A SEPARATE SHEET

Post-lab calculations (answer most on the data tables; show work here or on a separate sheet and attach; no need for a conclusion):

1) Determine the mass of the condensed liquid for each trial for each liquid. Enter the values in Data Table 2.

2) Use the CRC Handbook of Chemistry and Physics to determine the density of water at the temperature of the room temperature water bath used in your experiment.

Density of water at room temperature from
CRC Handbook of Chemistry and Physics _____ g/mL

3) Use the density found in question 2 and the mass of water in each filled pipet to calculate the volume of each pipet. Record each volume in Data Table 1.

4) Determine the mass of the liquid used in each trial. Record the masses in Data Table 2.

5) Average the three trials for each liquid.

6) Use the averages to calculate the molar mass of each liquid.

7) Calculate your percent error for each liquid.