Molecular Weight of a Volatile Liquid

One of the important applications of the Ideal Gas Law is found in the experimental determination of the molecular weight of gases and vapors. In order to measure the molecular weight of a gas or vapor, we need simply to determine the mass of a given sample of the gas under known conditions of temperature and pressure. If the gas obeys the Ideal Gas Law,

$PV = nRT$

and since the number of moles, n, is equal to the mass , g, of the gas divided by its gram-molecular weight, M, substituting we have:

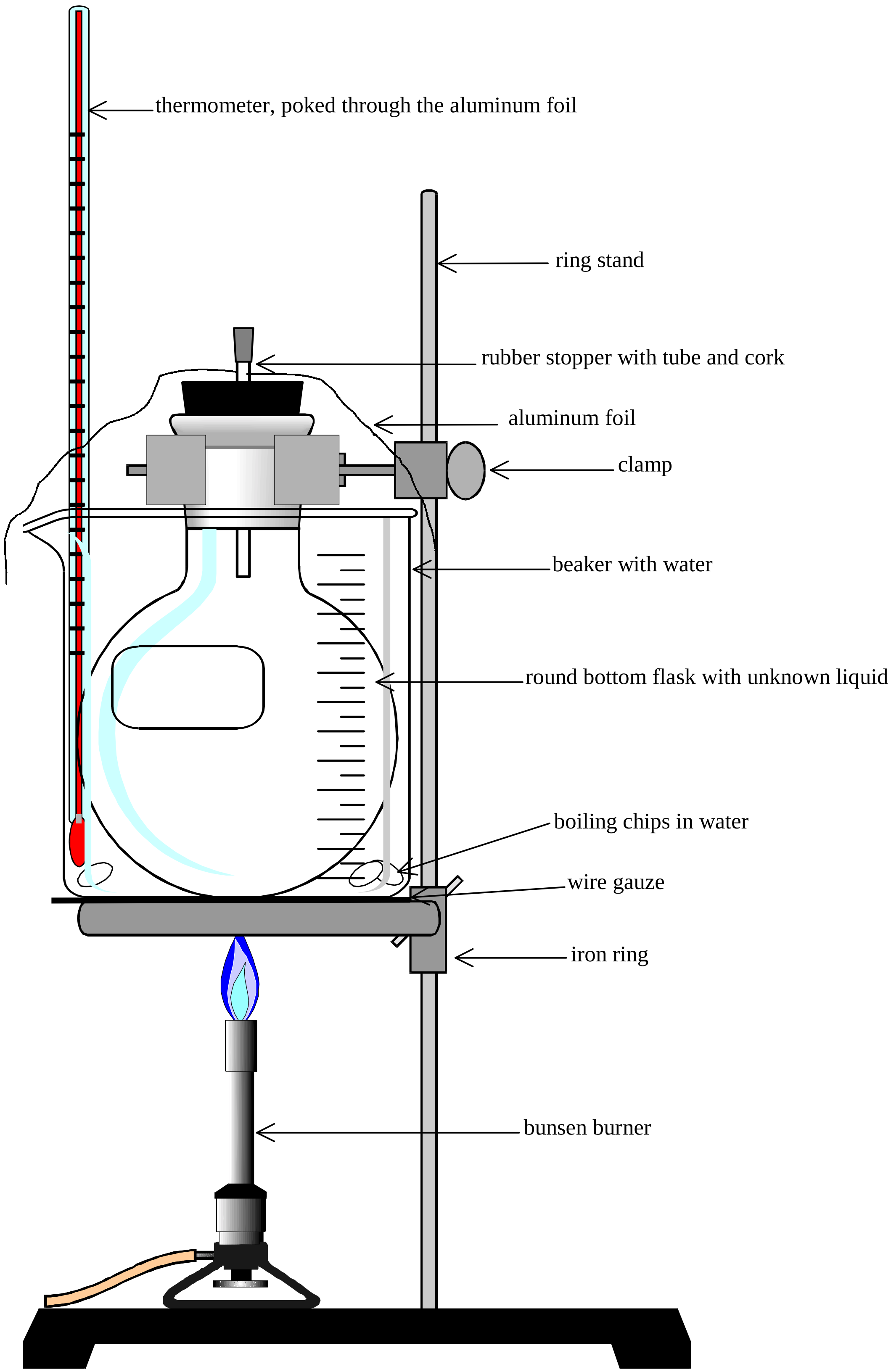
1) $PV = \frac{gRT}{GMW}$ 2) $GMW = \frac{gRT}{PV}$

<u>Remember that in all gas law problems, temperature must be in K.</u>

This experiment involves measuring the gram-molecular weight of a volatile liquid by using the above equation. A small amount of the liquid is introduced into a weighed flask. The flask is then placed in boiling water, where the liquid will vaporize completely, driving out the air and filling the flask with vapor at atmospheric pressure and the temperature of the boiling water. If we cool the flask so that the vapor condenses, we can measure the weight of the vapor and calculate a value for M.

EXPERIMENTAL PROCEDURE:

1. Obtain a round bottom flask, a stopper and tube and small cork, and an unknown liquid. Support the flask on an evaporating dish or in a beaker at all times. With the stopper loosely inserted in the neck of the flask, weigh the empty dry flask on the balance. Pour about 5 mL of the unknown liquid into the flask. Assemble the apparatus as shown in the following diagram:



thermometer, poked through the aluminum foil
ring stand
rubber stopper with tube and cork
aluminum foil
clamp
beaker with water
round bottom flask with unknown liquid
boiling chips in water
wire gauze
iron ring
bunsen burner

Drape the entire assembly with aluminum foil but be careful that there is no possibility for condensed water to drip into the flask? Why? Poke a hole in the foil near the lip of the beaker so that the steam will escape as far from the neck of the flask as possible. Make sure there is sufficient water in the 1000 mL beaker to cover most of the round bottom flask.

2. Add a few boiling chips to the water in the 1000 mL beaker and heat the water to boiling. **Make sure that the cork is not inserted in the tubing in the neck of the flask.** Watch the liquid level in your flask; the level should gradually drop as vapor escapes through the cap. After all the liquid has disappeared and no more vapor comes out of the cap, continue to boil the water gently for 5 to 8 minutes. Measure the temperature of the boiling water. Shut off the burner and wait until the water has stopped boiling (about 1/2 minute) and then loosen the clamp holding the flask in place. Be careful not to burn yourself. Slide out the flask, and immediately insert the small cork into the tubing to seal the flask.

3. Immerse the flask in a beaker of cool water to a depth of about 4 cm. After holding the flask in the water for about 2 minutes to allow it to cool, carefully remove the cork for not more than a second or two to allow air to enter, and again insert the cork. (As the flask cools, the vapor inside condenses and the pressure drops, which explains why air rushes in when the stopper is removed.)

4. Dry the flask with a towel to remove the surface water. Loosen the cork momentarily to equalize any pressure differences, and reweigh the flask. Read the atmospheric pressure from the barometer.

5. Repeat the procedure using another 5 mL of your unknown sample. It is not necessary to wash or dry the flask at this point, simply put another 5 mL of your sample into the flask. Repeat steps 2, 3 and 4.

6. Empty and wash the flask (do not dry it), rinse with distilled water. Fill the flask with distilled water, insert the stopper and glass tube without the small cork. Wipe off any overflow water from the outside of the flask and then insert the small cork into the glass tube. Weigh the flask on a balance capable of measuring this size mass. While weighing, support the flask using a cork ring. Measure the temperature of the water inside the flask. Look up the density of the water (use the Density of Water Table in Appendix VI at the end of this book). Calculate the volume of the flask using the density formula.

7. Calculate the gram-molecular weight of the unknown liquid.

Remember to discard all heavy metal wastes and organic wastes in the appropriate container. Your instructor will provide specific instructions for today's lab.

Lab #11

Molecular Weight of a Volatile Liquid

Name ___________________________________ Section ___________

DATA SHEET

	TRIAL 1	TRIAL 2
Mass of flask and stopper, in grams	____________________	____________________
Mass of flask, stopper, and condensed vapor, in grams	____________________	____________________
Mass of flask, stopper, and water, grams	____________________	____________________
Temperature of boiling water bath, in °C	____________________	____________________
Barometric Pressure, in mm Hg	____________________	____________________

CALCULATIONS AND RESULTS

Density of H_2O at (________°C), in g / mL	____________________	____________________
Mass of water in flask	____________________	____________________
Pressure of vapor, P, in atm	____________________	____________________
Volume of flask (volume of vapor), V, in L	____________________	____________________
Temperature of vapor, T, in K	____________________	____________________
Mass of vapor, g, in grams	____________________	____________________
Gram-molecular weight of unknown, as found by substitution into equation (2).	____________________	____________________
Average gram-molecular weight	____________________	____________________
Unknown #	____________________	____________________

Lab #11

PRESTUDY

A

NAME ____ SECTION ______________

Molecular Weight of a Volatile Liquid

1.(3 points) Convert 2.069 atm to torr.

2.(4 points) A sample of an unknown liquid is vaporized in a flask having a volume of 265 mL at 99.9 °C. The vapor has a mass = 0..725 g, and exerts a pressure = 745 torr. Calculate the gram molecular weight of the unknown liquid.

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3.(3 points) Suggest 3 possible sources of experimental error in this experiment.

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Lab #11

PRESTUDY

B

NAME ____ SECTION ______________

Molecular Weight of a Volatile Liquid

1.(3 points) Convert 865.0 torr to atm.

2.(4 points) A sample of an unknown liquid is vaporized in a flask having a volume of 298 mL at 100.0°C. The vapor has a mass = 0.687 g, and exerts a pressure = 775 torr. Calculate the gram molecular weight of the unknown liquid.

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3.(3 points) Suggest 3 possible sources of experimental error in this experiment.

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