

## MOLAR MASS OF BUTANE DETERMINED EXPERIMENTALLY

Reminder – Goggles must be worn at all times in the lab!

### PRE-LAB DISCUSSION:

In this particular lab, we are going to try to determine the molar mass of butane,  $C_4H_{10}$ , experimentally. A simple calculation using a periodic table would give us the correct answer for the molar mass of butane, but you are going to see how close you can come to this accepted value in the lab. To accomplish this, we will use the ideal gas law,  $PV = nRT$  which can be rearranged to solve for  $n$ , the number of moles:

$$n = PV/RT$$

We are trying to find the molar mass, which has units of grams/mole. We will measure the mass of the butane released from the pressurized container, and we will measure the volume of the gas that we collect at room conditions by water displacement. We merely need to plug our conditions of volume, temperature, and pressure into the ideal gas law in order to find  $n$ , the number of moles of butane collected. Once we know the mass, and the number of moles, we will divide the mass,  $g$ , by the number of moles,  $n$ .

Butane is a flammable gas, and at NO TIME during this lab should there be any use of an open flame or other source of heat!

### CLAIM:

We should be able to determine the molar mass of butane experimentally, collecting the gas by water displacement and applying the ideal gas law,  $PV = nRT$ .

### PROCEDURE:

1. Determine an initial mass for the butane container provided by your instructor. As always, remember to record a mass to three places past the decimal.
2. Set up the water bath for collecting a gas. Your instructor has set one up as a demonstration model. Filling the gas-collecting bottle with water at the beginning of the experiment can be a problem. The easiest way to do this is to fill the bottle with water until it overflows, then place a glass plate over the top and hold it on tightly. Then turn the bottle over (with the glass plate still on) and place in the water bath. After it is in the water, carefully slide the glass plate off the bottle. Try to have almost no bubbles in the gas collecting bottle before doing the procedure.
3. Connect one end of the tube to the butane container, and place the other securely in the gas-collecting bottle.
4. Release butane from the pressurized container until the gas-collecting bottle is NEARLY emptied of water. Be sure to keep the butane container UPRIGHT as you dispense the gas into the collecting bottle! If you accidentally empty the entire gas-collecting bottle of its water, you will have to repeat the entire procedure beginning with re-weighing the butane container.
5. As soon as you finish dispensing butane into the collecting bottle, carefully pull the venting tube out of the collecting bottle. Do this BEFORE you pull the tube off of the top of the butane bottle. If you fail to do this, the atmospheric pressure will push the remaining water out of the gas collecting bottle, and you will have to start over.
6. Now move the bottle up or down so that the water levels both inside the bottle and outside of the bottle are the same (be careful not to raise the mouth of the bottle above the water level). **THIS IS VERY IMPORTANT!** If you don't do this simple step, the pressures inside and outside the bottle are not equal, and you will have incurred an avoidable source of error.
7. Remove the gas collecting bottle again using a glass plate to avoid loss of water. Using a 100 ml graduated cylinder, measure the volume of the gas collected in the bottle. This may be done indirectly by:
  - a) Measuring the water left in the gas-collecting bottle with a 100 mL graduate.
  - b) Measure the total volume of the bottle by completely filling the bottle to the top with water, and measuring that volume out into a 100 mL graduated cylinder.
  - c) Subtracting the volume of water remaining after the lab from the total volume of the gas-collecting bottle. Record the butane volume in the Data section.
8. Using a thermometer, take the temperature of the water in the trough and record the value.
9. Read the barometric pressure in the lab in mm Hg (torr) and record this value.
10. Reweigh the pressurized butane container, recording its new mass

**EVIDENCE:**

**Mass**

1. Beginning mass of butane container \_\_\_\_\_ grams
2. Final mass of butane container \_\_\_\_\_ grams
3. **M** = Mass of butane collected (line 1 – line 2) \_\_\_\_\_ grams

**Volume**

4. TOTAL volume of the gas collecting bottle \_\_\_\_\_ mL
5. Volume of water remaining after gas collection \_\_\_\_\_ mL
6. Volume of butane collected (line 4 – line 5) \_\_\_\_\_ mL
7. **V** = Volume of butane, converted to liters (line 6 ÷ 1000) \_\_\_\_\_ L

**Temperature**

8. Temperature of water bath in °C \_\_\_\_\_ °C
9. **T** = Temperature of water in K \_\_\_\_\_ K

**Pressure**

10. Barometric pressure in mm Hg \_\_\_\_\_ mm Hg
11. Vapor pressure of water at the above temperature  
(see the table of values on the next page) \_\_\_\_\_ mm Hg
12. Pressure of dry butane (line 10 – line 11) \_\_\_\_\_ mm Hg
13. **P** = Pressure of dry butane in atmospheres (line 12 ÷ 760) \_\_\_\_\_ atm

**Calculations (Show your work)**

1. Calculate the number of moles of butane collected, using  $n = \frac{PV}{RT}$
2. Calculate the experimental molar mass of butane by dividing the mass (**M**) by  $n$ , the number of moles.
3. Calculate the accepted value for the molar mass of butane using a periodic table.

# Water Vapor Pressure Table

Temperature (°C)	Pressure (kPa)	Pressure (mm Hg)
0	0.61	4.58
1	0.66	4.95
2	0.71	5.33
3	0.76	5.70
4	0.81	6.08
5	0.87	6.53
6	0.93	6.98
7	1.00	7.50
8	1.07	8.03
9	1.15	8.63
10	1.23	9.23
11	1.31	9.83
12	1.40	10.50
13	1.50	11.25
14	1.60	12.00
15	1.70	12.75
16	1.82	13.65
17	1.94	14.55
18	2.06	15.45
19	2.20	16.50
20	2.34	17.55
21	2.49	18.68
22	2.64	19.80
23	2.81	21.08
24	2.98	22.35
25	3.17	23.78
26	3.36	25.20
27	3.56	26.70
28	3.78	28.35
29	4.00	30.00
30	4.24	31.80
31	4.49	33.68
32	4.75	35.63