Honors Chemistry
Lab - The Molar Mass of Butane Gas, C_4H_{10}

Name _____
Date _____

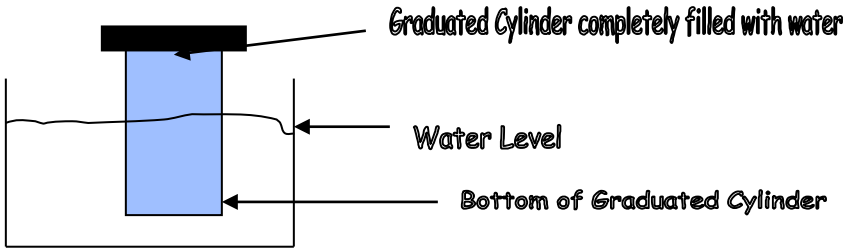
Purpose: To experimentally determine the molar mass of butane gas.

Materials: Thermometer, Big Water Bucket, Funnel, Butane lighter, 50 mL or 100 mL graduated cylinder, Balance

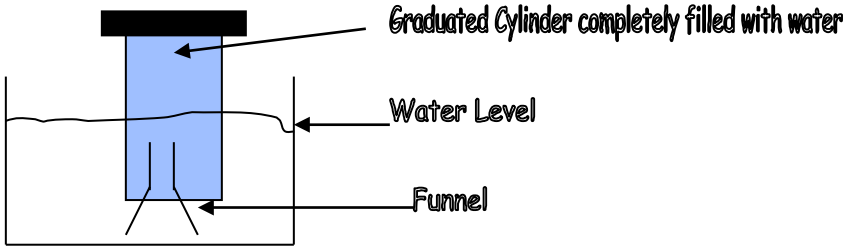
Safety: Goggles

Procedure:

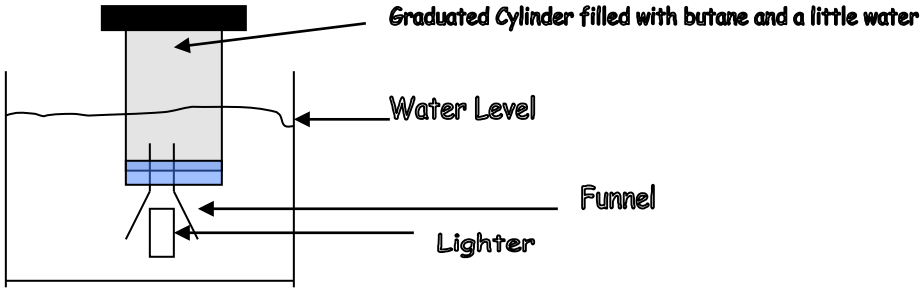
1. Mass the butane lighter.
2. Fill the bucket 2 inches from the top with water
3. Fill the graduated cylinder to the tippy tippy top
4. Place hand over the top of the graduated cylinder and invert into the bucket underneath the water. See picture below. The graduated cylinder should have no air once it has been inverted.



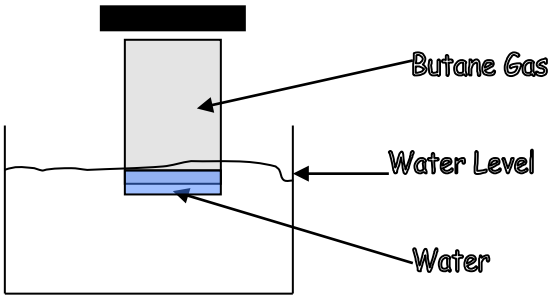
5. Place funnel underneath the graduated cylinder keeping the graduated cylinder underneath the water line. See picture below.



6. One person is to continue holding the graduated cylinder to keep it from falling.
7. Place thermometer in the bucket and allow the temperature to equalize for about 3 minutes.
8. Record the temperature of the water.
9. Place the butane lighter underneath the water and beneath the funnel. Light the lighter until 40-45 mL for 50 mL graduated cylinder or 90 –95 mL for 100 mL graduated cylinder of the water in the funnel is displaced.



10. Lift the graduated cylinder until the level of butane is level with the water level in the bucket. See picture.



11. Record the volume of butane in the graduated cylinder.
12. The instructor will provide the atmospheric pressure from the weather channel.
13. Determine the partial pressure of water using the temperature of the water and the chart for vapor pressure of water.
14. Shake out the butane lighter. Do NOT depress the plunger on the lighter or your results will be VERY flawed. Ensure that the lighter is completely dry before massing.
15. Pour the water down the drain and return all materials to proper locations.

Data Table:

Initial Mass of the Butane Lighter	**21.77 grams**
Temperature of the Water	**21.0°C**
Volume of Butane in the graduated cylinder	**164 mL**
Atmospheric Pressure	**29.76 in Hg**
Final Mass of the Butane Lighter	**21.44 grams**

Calculations

1. Determine the mass of butane in the graduated cylinder.

Subtract the initial mass minus the final mass:

$$21.77\ grams - 21.44\ grams = 0.33\ grams$$

2. Determine the atmospheric pressure in mm Hg.

Convert in Hg to mm Hg

$$\frac{29.76\ in\ Hg}{1}\ x\ \frac{2.54\ cm\ Hg}{1\ in\ Hg}\ x\ \frac{1\ m\ Hg}{100\ cm\ Hg}\ x\ \frac{1000\ mm\ Hg}{1\ m\ Hg} = 755.\mathbf{9}04\ mm\ Hg$$

Bolded number is the last significant figure – 4 significant figures

3. Determine the vapor pressure of water using the chart provided.

2.49 kPa – convert to mmHg

$$\frac{2.49\ kPa}{1}\ x\ \frac{760\ mmHg}{101.3\ kPa} = 18.\mathbf{6}81145\ mmHg$$

Bolded number is the last significant figure – 4 significant figures

4. Determine the pressure of the dry butane in the graduated cylinder. Which gas law should you use?

Use Dalton's Law of Partial Pressures

$$P_{Total} = P_{Butane} + P_{water\ vapor}$$

$$P_{total} = 755.904\ mm\ Hg$$
$$P_{water\ vapor} = 18.681145\ mm\ Hg$$

$$P_{butane} = P_{total} - P_{water\ vapor} = 755.904\ mmHg - 18.681145\ mmHg = 737.\mathbf{2}228\ mmHg$$

Bolded number is the last significant figure – 4 significant figures

5. Determine the volume of the butane in the graduated cylinder.

164 mL – convert to Liters

$$\frac{164\ mL}{1}\ x\ \frac{1\ L}{1000\ mL} = 0.164\ L$$

Three significant figures

6. Determine the moles of butane using which gas law?

Ideal Gas Law – PV = nRt
P = 737.2228 mmHg (4 significant figures)
V = 0.164 L (three significant figures)
R = 62.4 L*mmHg/ mole*K (infinite signficicant figures)
T = 21.0°C = 294.0K (4 signiciant figures)

$$n = \frac{PV}{RT} = \frac{(737.2228\ mmHg)(0.164\ L)}{\left(62.4\ \frac{L * mmHg}{mole * K}\right)(294.0\ K)} = 0.00659\mathbf{0}383\ moles$$

Bolded number is the last significant figure – 3 significant figures

7. Determine the molar mass, M = m/n.
M = 0.33 grams (2 significant figures)
N – 0.006590383 moles (3 significant figures)

$$M = \frac{m}{n} = \frac{0.33\ grams}{0.006590383\ moles} = 50.0729\frac{g}{mole} = 50.\ grams/mole\ or\ 5.0\ x\ 10^1\ grams/mole$$

8. Determine the percent error.

Molar Mass of Butane C_4H_{10} = 58.123 g/mole

$$Percent\ Error = \frac{|accepted - experimental|}{accepted}\ x\ 100 = \frac{\left|58.123\frac{g}{mole} - 50.\frac{g}{mole}\right|}{58.123\frac{g}{mole}}\ x\ 100 = 13.98\%$$

Temp. (°C)	Pressure (kPa)	Temp. (°C)	Pressure (kPa)
−20	0.10	30	4.24
−10	0.26	40	7.38
−8	0.31	50	12.33
−6	0.37	60	19.92
−4	0.44	70	31.16
−2	0.52	80	47.36
0	0.61	90	70.11
1	0.66	95	84.53
2	0.71	96	87.67
3	0.76	97	90.94
4	0.81	98	94.3
5	0.87	98.5	96.00
6	0.93	99.0	97.75
7	1.00	99.2	98.45
8	1.07	99.4	99.16
9	1.15	99.6	99.88
10	1.23	99.8	100.60
11	1.31	100.0	101.32
12	1.40	100.2	102.04
13	1.50	100.4	102.78
14	1.60	100.6	103.52
15	1.71	100.8	104.26
16	1.82	101	105.00
17	1.94	102	108.78
18	2.06	103	112.67
19	2.20	104	116.67
20	2.34	105	120.8
21	2.49	110	143.2
22	2.64	120	198.5
23	2.81	130	270.1
24	2.98	140	361.4
25	3.17	150	476.0
26	3.36	170	792.0
27	3.56	200	1555
28	3.78	250	3978
29	4.00	300	8592