Determining the ideal gas constant, *R*, using a butane lighter

Introduction

The ideal gas law is used to predict the behavior of gases at low pressures and moderate temperatures.

$$pV = nRT$$

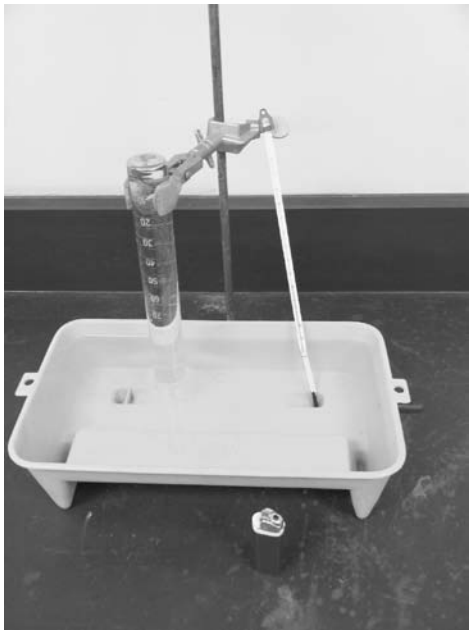
The ideal gas constant is given the symbol *R*, and is equal to 0.08206 atm·L/mol·K.

In this experiment, you will determine the value of *R* by using a sample of gas from a butane lighter. Butane is a hydrocarbon with a molecular formula of C_4H_{10}.

By rearranging the ideal gas law, $pV = nRT$ to $R = pV / nT$ you can calculate the value of *R* by measuring *p*, *V*, *n*, and *T*.

Procedure

- Obtain a butane lighter and completely peel off any sticker on its outside. Determine the initial mass of the lighter. Record this value on the data sheet.
- Fill a pneumatic trough with tap water. Submerge your clean 100-mL graduated cylinder in the water, let it fill up, and then invert. Make sure there are *no air bubbles* in the cylinder. Carefully clamp the cylinder in place.



- Place the end of the butane lighter just inside the opening of the graduated cylinder, and slowly release butane from the lighter until the cylinder contains approximately 95.0 mL of gas. Do not record the volume of gas yet! Be sure to not exceed 100.0 mL!

- ✎ Allow the butane to reach room temperature (about 1 – 2 minutes), and then slowly (and carefully) raise or lower the cylinder until the water level inside and outside the cylinder is equal.
- ☞ This last step ensures that the gas pressure is exactly equal to atmospheric pressure.
- ✎ Measure and record the volume of the gas on your data sheet in the cylinder to the nearest 0.1 mL.[1]
- ✎ Record the current atmospheric pressure on your data sheet.[2] Be sure to record the units!
- ✎ Using a thermometer, determine the temperature of the water in the trough, and record this value on the data sheet. We will assume this temperature is equal to the temperature of the gas inside the cylinder.
- ✎ Dry the butane lighter using a paper towel and/or a kim-wipe. You will probably need to *tap* or *flick* the lighter to remove every last drop of water! Determine the final mass of the lighter, and record its value on the data sheet.

Any water left inside the butane lighter will lead to a large error in your calculation of R!

- ✎ Repeat the experiment two more times.
- ✎ Complete the data sheet.

[1] Try and estimate this as best as you are able!

[2] There should be an electronic barometer on the center bench.

Data sheet

Name: _____

	Trial 1	Trial 2	Trial 3
Initial mass of lighter (g)	_____	_____	_____
Final mass of lighter (g)	_____	_____	_____
Mass of butane used (g)	_____	_____	_____
Water temperature (°C)	_____	_____	_____
Pressure of gas *(Be sure to include the units)*	_____	_____	_____
Volume of gas (mL)	_____	_____	_____

	Trial 1	Trial 2	Trial 3
Pressure of gas (atm)	_____	_____	_____
Volume of gas (L)	_____	_____	_____
Moles of butane (mol)	_____	_____	_____
Temperature of gas (K)	_____	_____	_____
Gas constant, *R* *(Be sure to include the units)*	_____	_____	_____
Average value of *R* *(Be sure to include the units)*		_____	

Calculations:

Note: 1 L = 1000 mL, 25.4 mmHg = 1 inHg, 1 atm = 760 mmHg (all are exact conversions)

More calculations:

Questions

Please show all work to receive credit!

1. A sample of gas at a pressure of 1.3 atm and a volume of 45 L is compressed until its volume becomes 4.5 L. What is its new pressure?

2. 34.5 mL of a gas at a temperature of –12 ºC is warmed up to 119 ºC. What will its volume change to?

3. Calculate the pressure of 13.80 g of oxygen gas (O_2) at a temperature of 131 ºC and a volume of 82.4 L using the ideal gas equation.