Gas Laws Lab - Boyle in a Bottle name: ________________________________ 80/1200

During this lab we will examine several relationships between pressure, volume, and temperature of gases (and also mass). Robert Boyle wrote in 1662 that:

For a fixed amount of an ideal gas kept at fixed temperature,
Pressure and volume are inversely proportional.

We will do an experiment that will hopefully prove that this is true (part 1). In part two we will examine the relationship between pressure and temperature, which was first described by the French chemist Joseph Louis Gay-Lussac in 1802. He wrote:

The pressure for a fixed mass of gas is directly proportional to the gas's temperature.

In part three of this lab we will look at the relationship between pressure (with fixed volume) and mass of a gas. This has no name.

The last of the three main gas laws is known as Charles' Law, named from the work of the 1780's by Jacques Charles (though it was also discovered independently from our friend John Dalton (the billiard ball model of the atom guy). It states:

At constant pressure, the volume of a given mass of an ideal gas increases or decreases by the same factor at its temperature on the absolute scale.
(volume and temperature (in Kelvin) are directly proportional)

You can do these three experiment in any order. For safety, do not pump up the soda bottles with the bicycle pumps past 65 psi (pounds per square inch) on the pump gauges. Since the bicycle gauges and the hand held pressure gauges all measure the increase in pressure above normal. When they are registering zero, the actual pressure is really normal pressure, or 14.7 psi. We will need to <u>add 14.7</u> psi to every one of our pressure readings to get actual pressures.

Part 1 procedure… Obtain a bottle with special cap with valve stem inserted. Get a 10 cm^3 syringe, with a rubber cap to seal it. Get a bicycle pump. Carefully measure syringe open to exactly 10 cm^3, and put on the rubber cap. Put syringe into soda bottle and close up. Pump up the soda bottle to a maximum of 65 psi on the bicycle gauge. Remove pump from bottle.

Read the actual pressure with the hand-held gauge, adding 14.7 psi to this reading. Carefully measure the new volume in the syringe (which is squished smaller by the increase pressure inside the bottle). Record data in data table.

Slowly remove some air from the bottle, enough to see the syringe move (just enough to be measurably different than previously). Measure the pressure in the bottle, and the syringe volume. Repeat ten times. If you run out of air pressure before ten trials, re-pump the bottle, get enough readings.

Make sure that the syringe volume changes each time, and remember to reset the hand pressure gauge each time by pressing the button. Put data into the large data tables attached.

trial:	1	2	3	4	5	6	7	8	9	10
pressure reading in bottle psi										
add in the air pressure	+14.7 psi to every reading above									
total pressure in the bottle										
syringe volume cm^3										
PV =										

It is this data, the total bottle pressure as a function of syringe volume, that you will graph on graph paper. Your data may be imperfect, but your curve should be best fit, just right perfectly smooth curve. Labels with units, and a nice title are required.

Part 2… Pressure & Temperature
Reattach pump to soda bottle. One student pumps it up to 65 psi (add 14.7 psi for actual pressure) as fast as you can. The rest of the team holds the bottle, noting any temperature changes. Once at the MAXIMUM of 65 psi (~ 80 psi), detach bottle from pump, and let the air out as fast as you can by twisting the cap as shown by teacher.

Increasing pressure makes the bottle temperature ________________________.

By releasing the pressure, lowering pressure makes the bottle feel _____________.

Part 3… Pressure and mass
For this, you have to mass the bottle at any of 7 different pressure readings.

Remove syringe, cap the bottle tightly, pump to about 65 psi (~ 80 psi) and then mass the bottle. Release some air recheck pressure, then mass again, repeat. Fill in data table.

Pressure & Mass trial:	1	2	3	4	5	6	7
Psi (total)							
mass in grams							

Lab questions....

1. Write the formula for the combined gas law. Explain the general relationship between pressure, volume, and temperature of a sample of a gas. What is this formula for?

2. Explain why Boyle's Law $P_1V_1 = P_2V_2$ is the proper formula to use if temperature is a constant in a gas experiment.

3. Rewrite the formula omitting the volume, as if it were a constant (which is called the Gay-Lussac law). And then, Rewrite the combined gas law again, omitting the pressure as if it were a constant (which is called Charles' Law).

4. Calculate the average gas constant for your bottle/syringe sample. Using this gas constant, what would be the expected volume of your syringe if your bottle pressure was pumped up to 95.0 psi?

5. For your sample, did your P X V constant remain the same for all ten trials? Why, or why not? Should it have been a constant?

6. For the Part two data, make and title a small graph (just 2 lines in an "L" shape, on loose leaf) each about 3 inches long entitled: "pressure as a function of temperature for a gas sample". Write one sentence stating this relationship.

7. For the Part three data, make a similar small graph on loose leaf, titled: pressure as a function of mass for a sample of gas". Write one sentence stating this relationship.

8. Explain how pressure changes the temperature and how pressure changes to temperature in parts 2 and 3 of the lab (and from questions 6 + 7 above).

9. Write Avogadro's Hypothesis. In private, read it aloud 4 times, with style. If possible, orate it once at an appropriate volume in the commons during your lunch time (preferably while standing on a chair), or share it with another adult at school and help them understand it.

this lab	includes	points
cover page	title, fun subtitle, and a single sentence intro 2 sentence intro	1
questions above	on loose leaf	18
BIG graph	Pressure as a function of syringe volume graph on graph paper (title, labels, units, curved best fit line)	3
last page	Write a complete conclusion explain the combined gas law, Boyle's law, what did you measure? What did you calculate? What can you state about the KMT and then, conclude about gases in general?	3