Gas Laws Lab - Boyle in a Bottle

name: ___________________________________

80/1200

We will examine several relationships between gas pressure, volume, temperature, and mass.

			
Robert Boyle	Jacques Charles	Joseph Louis Gay-Lussac	Arden P. Zipp

In 1662, Robert Boyle wrote: "*For a fixed amount of an ideal gas kept at fixed temperature, pressure and volume are inversely proportional.*"
At constant temperature, Pressure and Volume are inversely proportional.

In 1780 Jacques Charles wrote "*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.*"
At constant pressure, Volume and Temperature are directly proportional.

In 1802, the French chemist Joseph Louis Gay-Lussac wrote "*The pressure for a fixed mass of gas is directly proportional to the gas's temperature.*"
At constant volume, Pressure and Temperature are directly proportional.

The author of this lab is Dr. Arden P. Zipp, of SUNY Cortland. He was my teacher. He is the man that started my love & understanding of chemistry. He would probably have said he doesn't belong on this page, but I think he does.

You can do these 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 gauge.

ALWAYS Point the bottles away from your classmates when pumping them up; keep your goggles on at all times! High Pressure is invisible — but can be dangerous!

Write the combined gas law using large letters and numbers in this space →

Fill in this chart	formula	Show a simple graph of this relationship	Name this relationship as ***inversely or directly*** *proportional. Or both.*
The combined gas law:			
The combined gas law with constant temp:			
The combined gas law with constant pressure:			
The combined gas law with constant volume:			

Experiment 1 Pressure and Mass of gases		Mass of empty bottle _______________g
Trial	Pressure	Mass of JUST THE GAS
1	psi	grams
2	psi	grams
3	psi	grams
4	psi	grams
5	psi	grams
6	psi	grams

Experiment 2 — Pressure and Volume are Inversely Proportional

Obtain a bottle with special cap with valve stem. Get a 10 cm^3 syringe with the rubber cap used to seal the syringe (it's labeled 10 cc). 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 VOLUME of SYRINGE carefully. Check Bottle Pressure with gauge.

Slowly remove some air from the bottle, ONLY enough air is removed that you see the syringe move. Measure the pressure in the bottle again , and the corresponding syringe volume. Repeat ten times. Only let out a little bit of air, enough to move the syringe a touch, or else you will run out of pressure before ten trials.

<u>Make sure that the syringe volume changes a little bit each time you measure</u>, and remember to reset the hand pressure gauge each time by pressing the button. Put data below.

Trial	Measured Bottle Pressure psi	Syringe Volume cm^3	P x V = (2 SF)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
AVERAGE CONSTANT with units →			

Experiment 3 — Pressure and Temperature are directly proportional

Pump up the bottle to about 65 psi on the bicycle pump as fast as you can. Your partner shall hold the bottle like a football, pointing the cap away from human beings. Note the temperature change.

Once at the MAXIMUM of 65 psi detach bottle from pump. While pointing away from people, let the air out as fast as you can by twisting the cap ONE HALF TURN, as shown by teacher. Watch for the cloud that might form!

Demonstrations with Low Pressure inside a Bell Jar

Watch the effects of very low pressure inside of the bell jar.

First, shaving cream in a beaker, goes into the bell.

As the pressure inside the bell drops, the volume of the shaving cream ______________________________

Second, a small balloon goes into the bell.

As the pressure inside the bell drops, the volume of the balloon ___________________________________

Third, a beaker of water goes into the bell.

What is the temperature of the water at the start? ________________________________

What is the pressure inside the bell when the water boils? _______________________________

What is the temperature of the boiling water? _____________________________

Boiling water is a little more complicated than you might have previously thought.

Pure water boils 100°C or 373 K at ____.

If you can control the pressure pushing down on the surface of the water (like inside the bell), does it take

less energy or more energy to boil water at LOW PRESSURE? _________________________

Boiling water is "two fold". Energy is required to blow the water molecules apart, and energy is required to propel the water molecules from the liquid phase into the air as a gas. If we reduce the air pressure from above the surface, the BP drops dramatically.

Estimate the boiling point in centigrade/Kelvin of water at these conditions			
Normal Pressure	Very low pressure	1.50 atm	3.00 atm
100°C / 373 K			

Lab Questions

1. Using a FULL SENTENCE, state the relationship between pressure and temperature.
2. Using a FULL SENTENCE, state the relationship between pressure and volume.
3. Using a FULL SENTENCE, state the relationship between volume and temperature.

4. Draw a small graph showing pressure as a function of volume, the title is: Pressure as a function of volume.

5. Draw a small graph showing pressure as a function of temperature, the title is: Pressure as a function of temperature.

6. Draw a small graph showing volume as a function of temperature, the title is: Volume as a function of temperature.

Make the graphs for #4, #5, #6 and #7

about this size, use LABELS + TITLES

Y as a function of X

7. Draw a small graph showing YOUR DATA from the lab titled Mass as a function of pressure.

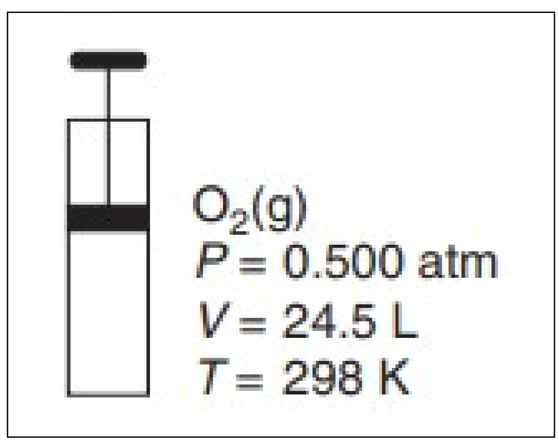
8. In experiment 2, did your P X V remain exactly the same for all ten trials? Should it have? If P x V = a constant, then why isn't it on your data table? Explain what happened to your data.

9. Write out 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 explain it to them. Really.

10. A 44.8 Liter sample of air at standard temperature and pressure is heated until the gas warms to 112°C. If the volume stays constant, what is the new gas pressure?

11. When a 35.3 Liter sample of air at standard temperature and pressure is heated, the gas warms to 385 Kelvin. If the volume expands to 91.2 Liters, what is the new gas pressure?

12. The diagram represents a cylinder with a moveable piston. It contains 24.0 g of oxygen gas. The starting conditions are listed next to the diagram. What is the volume of this gas 255 K and 1.00 atm? You must write the correct formula for full credit.



This lab	includes	points
cover page	Title, Define these two words: ideal gas and real gas.	3
9 questions	Do these on white paper, 8 x 2 points each	24
On graph paper	Make a large graph titled: Bottle Pressure as a function of syringe volume from your data. (title, axis labels, units, best fit <u>curved</u> line)	5
Conclusion on your last page	1 Explain what you measured and what you did in the 4 parts of the lab. 2 List the points of the KMT. Are each of these points always true for real gases? Explain why or why not where appropriate. 3 Tell under what conditions of pressure and temperature real gases act most ideal. 4 Write the formulas for 3 different gases at STP. Write which is most ideal and which is least ideal. 5 Explain what it mean that boiling water is a "two-fold" process.	8
Due: ____		40 points