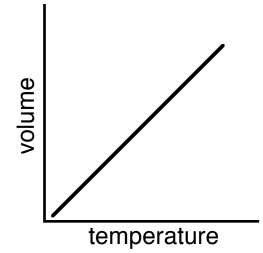
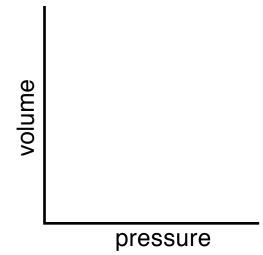
Boyle's Law Lab: *Can you take the pressure?* Name: ________________ Partner: __________

According to Charles's Law, as the temperature increases, the volume also increases. That is, the temperature and volume vary **directly**. A graph of volume (mL) vs temp (K) would be a straight line, passing through the origin, as shown at right:



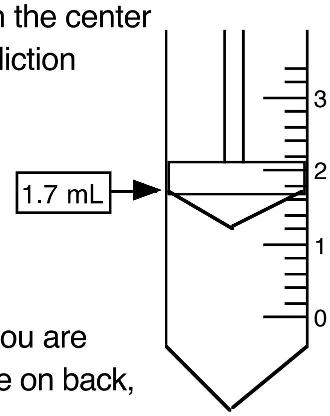
From what you've learned about gases, you have probably come to appreciate that pressure and volume do not vary directly; as the pressure on a gas sample increases, the volume decreases (and visa versa). Think about pushing in on the plunger of the closed-end syringe: the more pressure you apply, the smaller the volume gets. Think also about placing an air filled balloon in the bell jar and then turning the vacuum pump on to pump air out. As the pressure in the bell jar decreases, the volume of the balloon increases. Another way of saying this is to say that pressure and volume vary **inversely**. How do you think a graph of volume vs. pressure would look? **Right now, sketch your idea on the axes at right:**



In this lab you will use the same syringes as you used before, but rather than subject them to a variety of temperatures, you will subject them to a variety of pressures.

Procedure:

1. Obtain a pressurized soda bottle. Note that inside the bottle is a closed end syringe with a trapped volume of air. What do you predict would happen to this volume if some of the pressure is let out of the bottle? Use the back of the tire gauge to push down slightly on the center valve stem until the piston in the syringe just starts to move. Was your prediction correct?



2. Use the tire gauge to take a pressure reading, as was shown in class. Remember, push the tire gauge in fully and don't block the path of the measurement bar. Record the gauge pressure in the table on back.

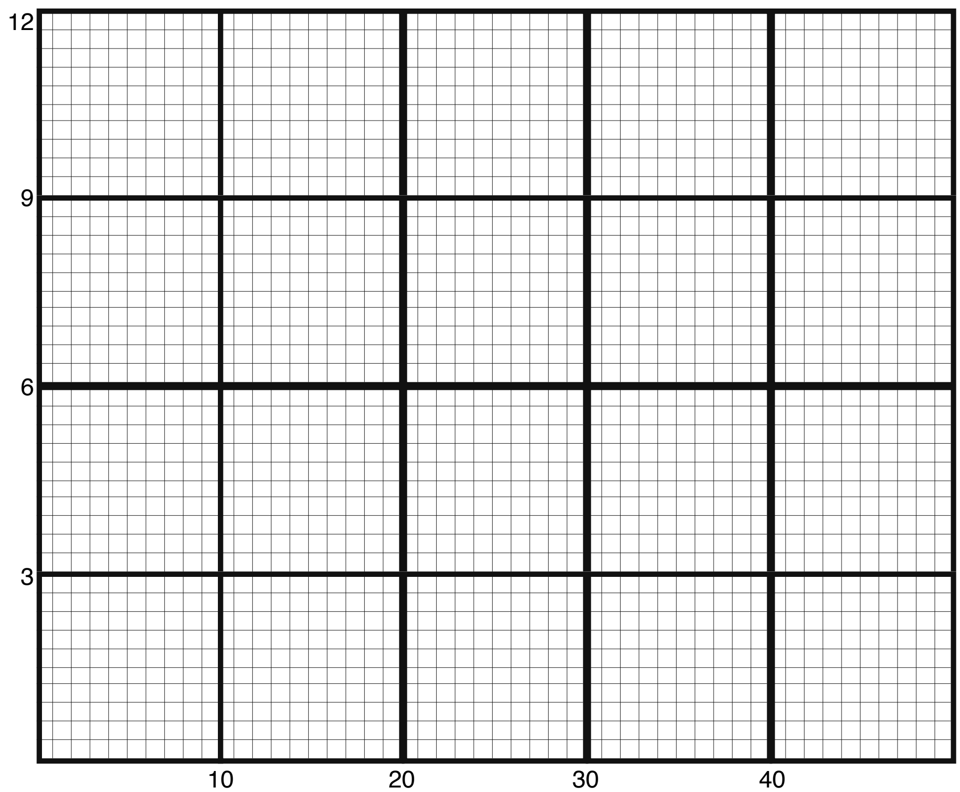
3. Now take a precise volume reading of the air in the syringe. Make sure you are reading at the correct place as shown at right. Record this volume in the table on back, alongside the pressure gauge reading.

4. Again, press down lightly on the center of the valve stem to let some more air out. This time, **let enough air out to make the volume of the syringe change by a tiny amount**. Repeat steps 2 and 3 above. ↖ *very important!* ↗

5. Repeat this process three more times to get a total of five pressure/volume readings.

Graph:

On the back-page, plot the data points using the x-axis for gauge pressure and the y-axis for air volume. You will have to decide how best to scale the axes, but have the origin be 0,0 and plan it out so that the data fill the graph as much as possible. Once the points are plotted, draw a best fit straight or curved line, whichever seems appropriate. (Do not do a connect-the-dot). How accurate were you at predicting the shape of the line?



Calculations:

One way of stating mathematically that two properties vary inversely is to say that their product is a constant (that when you multiply the two values, you always get the same number: in other words: $P_1V_1 = P_2V_2 = P_3V_3$ ...).

Recopy your data from the front side onto the table below and then calculate the products, writing them in the spaces provided: How consistent are our results? How much did P x V stay constant?

pressure (psi)	volume (mL)	P x V

The reason your results were not consistent was because of the tire gauge. The pressure values it gives are not <u>actual</u> pressures; they are <u>relative</u> pressures. The gauge tells you how many extra psi were in the bottle, above and beyond atmospheric pressure. This means that all your pressure gauge reading for this lab are too low (by about 15 psi).

Rather than saying "about 15 psi" for atmospheric pressure, let's call it "X" and use two of your data lines above to get an experimental value for X. If, for example, your first and second data lines looked like the sample at right, you would have already noticed that P_1V_1 didn't equal P_2V_2. But that's because the P values were both too small by an amount X. If we set up the equality incorporating X, we have:

pressure (psi)	volume (mL)	P x V
48.0	2.0	96
24.5	3.1	76

(sample data)

$(48.0 + \boldsymbol{X}) \times 2.0 = (24.5 + \boldsymbol{X}) \times 3.1$	this distributes out to: $96 + 2.0\boldsymbol{X} = 76 + 3.1\boldsymbol{X}$

(example calculation)

Combining like terms gives: $1.1\boldsymbol{X} = 20$, which simplifies to $\boldsymbol{X} = 18$ (pretty close to the standard value of 14.7 psi)

Repeat these calculations below using your data. First do it using the <u>first and fourth</u> data lines, then do it again using the <u>first and last</u> data lines:

<u>first and fourth data lines</u>

Ans: ______

<u>first and last data lines</u>

Ans: ______

Questions

1. What was the class average for atmospheric pressure in the room? ___________

   What is the actual atmospheric pressure the day you did this lab? ___________

   What is your % error? ___________

2. When some of the pressure was released from the bottle, the syringe plunger moved up. Why did this happen? And don't say "because the pressure decreased..." Explain why in terms of the gas particles moving around inside and outside the syringe before and after the pressure was released. (You may want to use the word "collisions")

3. Explain what is "incorrect" about the tire gauge:
(re-read explanation under the graph)

4. If the gauge reports "67 psi" for your bicycle tire, what is the actual pressure in the tire? _______
   (Assume standard atmospheric pressure, 14.7 psi)

5. If the pressure gauge reported values in mmHg instead of psi, and the gauge reading for the bottle was 1250 mmHg, what would the actual pressure be?

   Ans: ________

6. Use the data table at right to reproduce your <u>first and second</u> & <u>first and last</u> calculations for the lab:

pressure (psi)	volume (mL)
46.0	2.3
25.2	3.2
18.3	4.3
14.6	4.6
11.7	5.2

<u>first and second data lines</u>

Ans: _____

<u>first and last data lines</u>

Ans: _____

7. If the gas sample had a volume of 2.7 mL at a gauge pressure of 41.5 psi, what volume should it have at a gauge pressure of 18.6 psi? (Assume standard atmospheric pressure, 14.7 psi)

   Ans: ________

8. Tire manufactures often warn customers to let air out of their tires in the Spring. Why?

Ans to #4-7 (IRO+1): 4.56 15.5 28.0 82 145 2010 Units: psi, psi, psi, mmHg, mL