LAB-- Honors** [15 pts]* ***Name_____
Boyle's Law--P vs V ***Lab Partner***_____
(modified from Chemistry-- Experimental Foundations) ***Period***_____

Pre-Lab Tasks: *For this section, you may write down your thoughts here, but they will not be graded.*

TASK A: Unscrew the cap on the syringe and pull the plunger out to the 60 mL mark. Screw the cap back on. Now, push the plunger in as hard as you can. Notice that as you decrease the volume further and further, it gets harder and harder to push in the plunger. Think about why it gets harder and harder to push the syringe in. (Think in terms of molecules and collisions.)

TASK B: Remove the cap and push the plunger all the way in. Now screw on the cap. Attempt to remove the plunger from the syringe. Think about why is it so difficult to remove the plunger. Again, you may write down a few thoughts here. *(Hint: What is inside the syringe? What is outside the syringe? Compare the pressures of inside to outside.)*

Procedure:

1) Take your syringe, unscrew the cap, move the plunger until it is set at 60 mL. Put the cap back on.
2) Securely clamp the syringe to the ring stand. The syringe tip must be firmly resting on the platform of ring stand. The volume markings should be clearly visible.
3) Carefully center a textbook on top of the plunger. *(Any textbook will do, but you will need a total of 6 textbooks of the same text to complete the lab.)* Read the volume of the trapped gas in the syringe when a load of one book is on the plunger. Read volume to the nearest ml.
4) Now add another textbook and record the volume. Continue adding books until a pressure of six books is obtained. Repeat 3 & 4 for a second trial, then average volumes.

Data: [1 pt]

Pressure (in # of books)	**Trial 1 Volume (ml)**	**Trial 2 Volume (ml)**	**Average Volume (ml)**	$\frac{1}{\text{Vol}}$ **(in 1/ml)** (Write values decimals and keep 2 sig figs.)
1				
2				
3				
4				
5				
6				

Analysis: [5 pts] ***Make two graphs.***

1) **P vs V Graph:** Make a graph of **P vs V** using the **top one third** of the graph paper. Plot the pressure (in books) on the y-axis and the volume (in ml) on the x-axis. *(Axes do NOT have to go through the origin).* Put in your points and draw a **"best fit"** smooth **curve** through the points.
2) **P vs 1/vol Graph:** Make a graph of **P vs 1/vol** (P on y-axis) on the next ⅓ of the graph paper. *(Leave the bottom ⅓ of the paper empty).* **The axes MUST go through the origin**. (Thus, each scale must start at zero and be evenly spaced out all the way.) Put in your points, and draw a "best fit" **straight line**. Now, extend this straight line down below the x-axis until it intersects the y-axis. On the y-axis, extend the pressure scale (in books) downward as far as is necessary to read the value of the y-intercept (this will extend into the bottom ⅓ of the paper).

Before moving on, make sure each graph includes
a descriptive title and axes are labeled with correct quantities and units.

Post Lab Questions: [9 pts] **Write all answers on a separate sheet of paper.**

1) [0.5 pt] At this point, you might be wondering why your line (in 2nd graph) does not go through the origin. Let's figure out why.
   - If the line did go through the origin, it would mean that when P = 0, 1/vol = 0.
   - 1/vol would be equal to zero when the volume is equal to ∞ (1/∞ = zero)
   - Would a gas have infinite volume when there was zero pressure? *Yes-- the gas should have an infinite volume because there would be no pressure to "hold" the gas molecules together*.
   - So, why doesn't our gas have infinite volume when the P is equal to zero? *The problem is that when our pressure was zero, it meant that there were zero books on the plunger. But this is not zero pressure because there is atmospheric pressure pushing on the syringe at all times!!*
   - Thus, the line does not go through the origin. However, the y-intercept is the point at which 1/vol is equal to zero. Thus, this is where there is truly zero pressure. This is helpful because now we know that the difference between the pressure of zero books and the y-intercept value is equal to the atmospheric pressure. Determine your value for the atmospheric pressure by answering the following questions.

   a) What is your **y-intercept value, in books?** *(This should be a negative value.)*
   b) The atmospheric pressure is the negative of your y-intercept value. What is the value of the **atmospheric pressure, in books?** *(This should be a positive value.)*

2) [1 pt] Your 2nd graph that plotted P vs 1/V gave a straight line. Thus, you should be able to write an equation for this line. The general equation for a straight line is $y = mx + b$. Now, convert this general equation of a line into the equation for your line with these variables: $\mathbf{P_{\#\ of\ books}}$, **V,** $\mathbf{P_{atmospheric}}$ **, m.**

HINTS: *To help you answer this question, ask yourself the following questions:*
-- What is plotted on the y-axis of your 2nd graph?
-- What is plotted on the x –axis of your 2nd graph?
-- What is the value of b in terms of $P_{atmospheric}$*?*

3) [1 pt] Rearrange the equation you just got and solve it for m. *Do not substitute in any numerical values—write it with the same variables*.

4) [1 pts] Since "m" is the slope, it should be a constant. Let's see if that is true.

   a) Choose one set of P and V values from your data chart. By plugging in those values into your equation above, calculate the value of m. Don't forget to plug in your $\mathbf{P_{atmospheric}}$ value where needed. *(NOTE: Make sure you use your volume values-- not your 1/vol values!!)*
   b) Repeat the same process with another set of P and V values. *Your two "m" values should be similar. If not, check calculations*.

5) [0.5 pts] Look at the equation you wrote in question #3. Now, write the equation again but substitute $\mathbf{P_{total}}$ in for $(\mathbf{P_{\#\ of\ books} + P_{atmospheric}})$.

6) [1 pts] This final equation you wrote in #5 proves that there is an inverse relationship between P_{total} and V. Explain how this equation shows an **inverse relationship** between P_{total} and V. *(HINT: What is constant in the equation and how must P and V change with respect to each other?)*

7) [1.5 pts] In pre-lab Task A, you determined that as you decreased the volume of the gas inside the syringe, the pressure of the gas inside the syringe increased. Explain why by discussing molecules and collisions.

8) [1.5 pts] In pre-lab TASK B, you determined that it was very difficult to pull the plunger out. Explain why. *(Hint: What is inside the syringe? What is outside the syringe? Compare the pressures inside to outside by discussing molecules and collisions.)*

9) [1 pt] During the lab, every time a book was added to the plunger, the plunger slowly moved downward, but eventually it stopped moving. Why does the plunger eventually come to a stop?