BOYLE’S LAW EXPERIMENT

Short Description:

In this experiment, we will explore the relation between the pressure \((P)\) and volume \((V)\) of an ideal gas given by the Boyle’s law:

\[
PV = nRT
\]

We will measure the pressure of a gas confined in a plastic syringe. The measuring device, a pressure sensor (naturally), will feed the pressure data directly to DataStudio. You will read the volume off the scale on the syringe and enter this by hand.

Equipment: Pasco pressure sensor with syringe, one thermometer

Preliminary Question:

1) We will plot a graph of \(P\) vs. \(V\) in this experiment, for fixed temperature. What do you expect this graph to look like?

\[
P \quad V
\]

Procedure

Open the file: “Boyle Law.ds” contained in the T:\DataStudio folder. First, check to see if the pressure sensor will give us the value of atmospheric pressure today. With the syringe disconnected from the sensor, click Start and then, when the Keep button appears, click it. Type in any value you wish for the volume. You can now look in the table to see what value for the pressure the detector read. Click on the red square button to stop.

Atmospheric pressure: ________

Did the sensor give a reasonable value for the atmospheric pressure?

If so, go on to the next part, if not check fully the set up and try again or ask for assistance.
With the syringe not connected to the pressure sensor, move the syringe plunger to the position of 30mL. The actual value for the volume is given by considering also the volume of the tubing, which needs to be added to each measurement. The volume of the tubing is approximately 0.5mL. Connect the syringe tubing to the pressure sensor as shown by your instructor.

Click Start and Keep to record your first value of the pressure. With the syringe at 30mL, when it’s asked for the numerical value of the volume, enter 30.5mL instead (to account for the tubing) and hit Enter to record it. Do not hit Stop.

Then push the plunger in by 3mL, wait for equilibrium to settle in, and take another reading by clicking on the Keep button. Continue this way until the volume of 9.0mL (it might be hard hold the syringe in position due the high pressure). Click the Stop button to finish taking data and leave the syringe connected. Record your data in the table below.

2) Record here the room temperature: \( T = \) ________

PART 1: Convert \( P \) and \( V \) to SI units and calculate the products \( PV \) for each set of data.

<table>
<thead>
<tr>
<th>Volume(mL)</th>
<th>Volume(m(^3))</th>
<th>( P ) (Pa)</th>
<th>( PV ) (Pa ( \cdot ) m(^3))</th>
<th>Number of Moles</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.5mL</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>27.5mL</td>
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<tr>
<td>24.5mL</td>
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<tr>
<td>21.5mL</td>
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<tr>
<td>18.5mL</td>
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<tr>
<td>15.5mL</td>
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</tr>
<tr>
<td>12.5mL</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5mL</td>
<td></td>
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</tr>
</tbody>
</table>

3) Are your values for the number of moles constant, increasing or decreasing?

4) Why do you think this happens?

5) Which of the above values do you think is the most accurate value?

\( n_{Best} = \) __________

Pull the plunger back to the initial volume of 30mL and record the pressure:

6) \( P = \) ____kPa.

7) Compare this value of the pressure with the previous value of the pressure taken at 30mL and explain the difference:

To analyze your data, first look at the plot of \( P \) vs. \( V \).

8) Does your data look like your prediction in the graph?
PART 2: Display the plot of $P$ vs $V$ on DataStudio (not Excel) using the Graph command. Fit your data to an inverse function and record the value of “$A$”, the proportionality constant.

9) $A = \square \ (kPA \cdot mL)$ \hspace{1cm} A = \square \ (Pa \cdot m^3)$

The proportionality constant $A$ has the meaning of $nRT$ in the Ideal Gas Law, from this calculate the average number of mole obtained from the fit.

10) $n_{\text{Fit}} = \square$

Compare $n_{\text{Best}}$ with the expected value. To calculate the expected value, use the information that one mole at standard ambient temperature ($T=25 \degree C$) and atmospheric pressure occupies a volume of 24.5 liters.

11) $n_{\text{Expected}} = \square$

What is the percentage error between the two?

12) Percentage error: $= \left( \frac{|n_{\text{Best}} - n_{\text{Exp}}|}{n_{\text{Exp}}} \right) \times 100 = \square$

Questions:

1. Consider the plot $P$ vs $V^m$. If you wanted to get a straight-line graph in this experiment as we usually do, which value of $m$ will allow for this?

   $$m = \square$$

2. What sources of error are there in this experiment?

3. How can they be minimized?

Print a copy of your graph of $P$ vs. $V$, including the fit. Delete all you data acquired with DataStudio and **DO NOT** save your file.