Principles of Physical Science Laboratory Experiment #3

Name ___________________________ Date _______________
Partners _________________________ Section _____________

Boyle’s Law and Charles’ Law

Purpose:
The purpose of this laboratory experience is to learn and verify the relationship between volume, pressure, and temperature for gasses.

Equipment:
1. 600 mL beaker
2. Burette Clamp
3. Ring stand
4. Syringe
5. 2 – 1 kg mass, 1 – 2 kg mass
6. Hot plate
7. Thermometer
8. Ice

Theory:
The volume of a gas is directly proportional to its absolute temperature, if the pressure is kept constant. This is a statement of Charles’ law. If \( V_1 \) and \( V_2 \) are the initial and final volumes, and if \( T_1 \) and \( T_2 \) are the initial and final temperatures (K), than Charles’ law may be expressed as:

\[
\frac{V_1}{T_1} = \frac{V_2}{T_2}
\]

The volume of a gas is inversely proportional to the pressure, if the temperature is kept constant. This is a statement of Boyle’s law. If \( P_1 \) and \( P_2 \) are the initial and final pressures, then Boyle’s law may be expressed as:

\[
P_1V_1 = P_2V_2
\]

This exercise will allow you to experimentally verify these two gas laws. Measurements of volume will be made at different temperatures to study Charles’ law, and measurements of volume will be made at different pressures to study Boyle’s law. The data will be plotted on graphs in order to see the relationship between volume and temperature and the relationship between volume and pressure. To verify Boyle’s law the data should be a straight line if volume (Y-axis) is plotted as a function of the inverse of the pressure (1/PP, X-axis). To verify Charles’ law the data should be a straight line if volume (Y-axis) is plotted as a function of absolute temperature (°K, X-axis).

Procedure:

I. Boyle’s law

While you are doing the Boyle’s law experiment, you can save time by heating about 350 ml of water in a 600-ml beaker to boiling. This will be used later for the Charles law experiment.

Suspend a large syringe using a buret clamp attached to a ringstand. Place the syringe so that the flange rests on the clamp. Make sure the clamp is not so tight that the plunger cannot move freely. Remove the cap from the end of the syringe and pull the plunger out to the 50 ml mark. Replace the cap on the end of the syringe. Obtain two 1-kg weights and one 2-kg weight. Carefully balance a 1-kg weight on the syringe plunger. Read and record the volume showing on the syringe. Repeat the procedure with 2, 3, and 4 kg on the syringe plunger. Record the volume with each addition.
II.  Charles' Law

Open the end of the syringe and set the plunger at the 30-ml mark. Close the end of the syringe. Heat a 600-ml of water to boiling, if you have not already done so.

Keep the syringe on the ringstand and place the beaker of hot water under it. Adjust the height of the clamp holding the syringe so that the syringe is as far down in the beaker as possible. Wait about 2 minutes for the air in the syringe to come to the same temperature as the water. Record the water temperature and the volume on the syringe on your data sheet.

Raise the clamp and syringe out of the water. Replace the beaker of hot water with a beaker of hot tap water (or add ice to the boiling water). Lower the syringe into the water and wait 2 minutes for equilibration to occur. Record the temperature and the volume on the syringe.

Remove the clamp and syringe from the water. Replace the beaker of warm water with cold water. Wait 2 minutes and then record the temperature and the volume on the syringe.

Pour off about half of the water and fill the beaker with ice. Place the syringe in the water and record the temperature and volume as before.

(This lab was provided by Dr. Aaron Hutchison.)
Boyle’s Law and Charles’ Law

Data and Report

Boyles’ Law

<table>
<thead>
<tr>
<th>Number of Weight Units</th>
<th>1/(No. of Wt. Units)</th>
<th>Volume, ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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<td>4</td>
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</tbody>
</table>

1. On a spread sheet plot the above data, with P being the number of weight units (kilograms). 1/P should be on the X-axis and V should be on the Y axis. Draw a straight line which best fits the data points.

2. Are the data points reasonably close to the straight line? If not, can you think of a reason that Boyle’s law was not confirmed?

Charles Law

<table>
<thead>
<tr>
<th>Temp. °C</th>
<th>Temp. °K</th>
<th>Volume, ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

1. On a spread sheet plot the above data with T on the X-axis and V on the Y axis. Draw a straight line which best fits the data points.

2. Are the data points reasonably close to the straight line? If not, can you think of a reason that Charles’ law was not confirmed?