Work Sheet – Experiment 1

Experiment Title: "Do I Dare Disturb the Universe?" Verification of Gas Laws

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Submitting Author's Partner:

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Date Experiment Performed: 09/20/2019

Date Experiment Submitted: 09/27/2019

(The report for Experiment 1 does not require an Introduction)

Attach here (if required, indicate the appropriate document(s)):

Medical or other Acceptable Document: ______

Change of Lab Day Form: ______

Change of Lab Section Form: ______

Late Pass: ______

Procedure – Charles' Law:

As outlined in the lab manual.

Procedure – Boyle's Law:

1. Obtain a syringe that can contain a volume of at least 20mL, and a gas pressure sensor.
2. If LabQuest2 device is not set up already, read through the given lab manual to properly set up device for this experiment.
3. Connect the gas pressure sensor to the LabQuest2 device.
4. Slowly push in the syringe to the gas pressure sensor, ensure that excessive force is not applied.
5. Grasp the body of the syringe and pull or push the plunger so that 10mL of air is being measured.
6. Record the pressure reading displayed on LabQuest2.
7. Push the plunger in so that 5mL of air is being measured and record the data from LabQuest2.
8. Pull the plunger out so that 15mL of air is being measured and record the data from LabQuest2.
9. Pull the plunger out so that 15mL of air is being measured and record the data from LabQuest2.
10. Trail 1 is complete. Repeat steps 5-9 for the second trail.
11. Disconnect the syringe from the gas pressure sensor then disconnect the gas pressure sensor from LabQuest2.
12. Put away the appropriate materials.

Discussion:

Charles' Law

Charlie's Law is based on the direct relation between the volume of gasses and their temperature. The law states that the volume of a gas is directly proportional to its temperature, that gasses contract when they are cooled and expand when they are heated.

To verify Charles' law, an experiment was conducted where an Erlenmeyer flask was heated to 100°C with constant pressure inside the flask. The flash was then immediately cooled in an ice bath. This allowed water to enter the flask which was a result of the gas contracting as it was cooled. The volume of the water entered was then measured once taken out of the flask to determine the change in volume in the flask from the change in temperature. The data table below has the recordings of the volumes and temperatures throughout the experiment.

Data Type	Data
V1 ; Volume of Erlenmeyer Flask to measured marking (mL)	150 mL
Vcw ; Volume of Water in Erlenmeyer Flask (mL)	45 mL
V2 ; Volume of Erlenmeyer Flask at T2 (mL)	105 mL
T1 ; Temperature of Boiled Water (°C)	100 °C
T2 ; Temperature of Ice Bath (°C)	5 °C

Looking at the data, an equation can tell the correlation between temperature and volume change. To determine a constant, the total temperature must be divided by the total volume change.

$m = V1\text{-}V2/T1\text{-}T2 = 150\text{ mL}-105\text{ mL}/100\text{ °C} -5\text{ °C} = 45\text{ mL} / 95\text{ °C} = \mathbf{0.474\text{ mL} / \text{°C}}$

This experiment shows that 0.474 mL of volume is changed for every degree. Since the law states that the relation is directly proportional, a linear function can be formulated.

$y = mx+b \quad V = mT+b$

$0 = m*(-273.15) + b \qquad b = 273.15m$

$V = mT + 273.15m$

The section of *Charles' Law and Temperature* in the lab manual (Venkateswaran, 2019) has data for the temperature of gas with 0 mL volume (absolute zero), which is -273.15 °C. When isolated for the b value, the final equation came to be V = mT+273.15m, which represents Charles' Law of Temperature.

Calculating percent error in this experiment, the constant value (m) in this experiment is compared with the data given in *Table 1 Volume-Temperature Data* in the lab manual (Venkateswaran, 2019). The constant between mL / K is to be 2

% error = [(V1/T1-V2/T2) / (V1/T1)] x 100%

% error = [(150/100 – 105/5) / (150/100)] x 100% = **4.76%**

The percent error for this lab 4.76 %, mainly originating from experimental errors such as measuring the temperature of the water which may have been uneven throughout the ice bath and the flask not being heated exactly to 100°C since it was hovering over the hot plate.

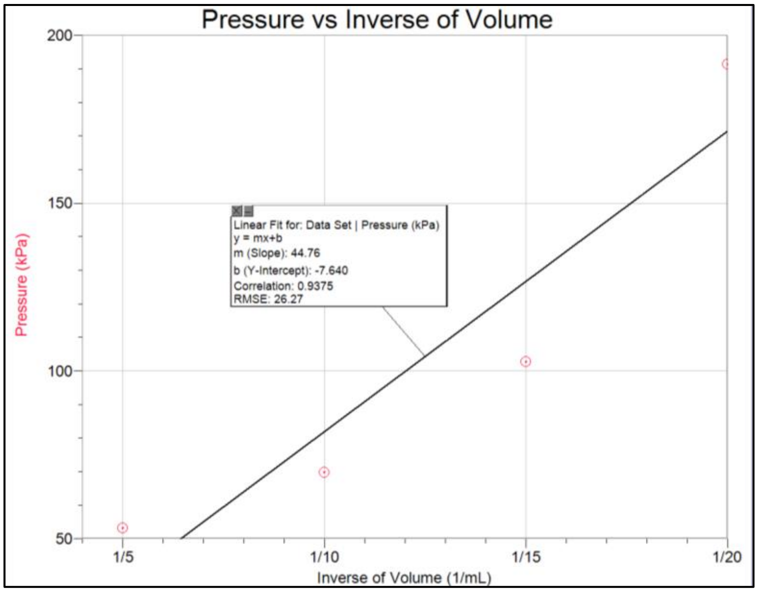
This experiment has confirmed Charles' Law of temperature written in the lab manual (Venkateswaran, 2019), being that the volume of gas is directly proportional to the temperature of a gas at constant pressure.

<u>Boyle's Law</u>

Boyle's Law is based on the relationship between volume of gas and its pressure. The law is that the volume of gas at constant temperature is inversely proportional to the pressure of the gas, the constant being **$P \propto 1/V$**. A plunger was used to push o r pull air in or out of the syringe so that the pressure could be measured.

Volume (mL) being Inserted	**Inverse Volume (1/mL)**	**Pressure (kPa)**			
		Trial 1	**Trial 2**	**Trial 3**	**Average**
20	1/20	191.20 kPa	191.40 kPa	191.61 kPa	191.40 kPa
15	1/15	102.54 kPa	103.49 kPa	102.00 kPa	102.68 kPa
10	1/10	70.36 kPa	69.93 kPa	68.93 kPa	69.74 kPa
5	1/5	53.05 kPa	53.54 kPa	52.97 kPa	53.19 kPa

This lab consisted of two trials so that the average of both trails can be used for graphing. This reduces the percent error such as inaccurate readings of the pressure due to the slight displacement (positive or negative) of the plunger when measuring the required volume. Doing this provides a more accurate relation between multiple readings of the dependent variable and the same value of the independent variable. The data from the table above (Inverse Volume and Average Pressure) is graphed below to show the linear relation between these two values to prove Boyle's Law. The software used for graphing the data is Logger Pro.



Looking at this graph, an equation can be derived with the data provided from the line of best fit.

y=mx+b P=m(1/V) + b **P=44.76(1/V) -7.64**

It's shown that m = 44.76 which is the constant for the Boyle's Law lab. Using this equation, percent error can be determined.

Experimental Value at x = 1/10 is: 69.74

Theoretical Value at x =1/10 is: P=44.76(2)-7.64 = **81.88**

% error = | (Experimental Value – Theoretical Value) / (Theoretical Value) | x 100%

% error = | (69.74-81.88) / (81.88) | x 100% = **14.83%**

The percent error in this lab is 14.83% due to the experimental errors taking place during the lab. Using the equation, the theoretical value of pressure at 1/10mL inserted is 81.88 kPa yet the experimental value is 69.74 kPa. There are certain conditions that had to be met for this experiment to stay true to Boyle's law, yet some external variables caused some inaccurate data. These include the warmth of the hand increasing the temperature of the syringe as it is being measured, faulty pressure readings because of shaky hands, and the syringe not being attached properly to the gas pressure sensor. Due to this, multiple trails were conducted to find the average pressure so some of the errors would be mitigated. For a more accurate reading, rubber gloves should be worn, and steadier syringes and plungers should be used.

<u>Conclusion:</u>

This lab proved Charles' Law as volume of gas and it's surrounding temperature were directly proportional to each other, which was known by finding the change in volume of air inside a Erlenmeyer flask from heating it around boiling water then cooling it in an ice bath. The lab also proved Boyle's Law as the of volume was inversly proportional to the pressure, which was proven by inserting air into an gas pressure sensor using a syringe by increments of 5mL then measuring the pressure in LabQuest2, following graphing the data to produce a curve, then graphing the slope of inverse of volume to pressure to produce a linear slope.

Reference(s):

"What in the World ISN'T Chemistry", General Chemistry Laboratory Manual, Dr. Rashmi Venkateswaran, 2019

Appendix:

Sample Calculations, Charles' Law

1. Find the value of V2:

$V_2 = V_1 - V_{cw}$
$V_2 = 150 mL - 45 mL$
$V_2 = 105 mL$

2. Derive an equation:

$m = V_1 - V_2 / T_1 - T_2$

$m = 150 \text{ mL} - 105 \text{ mL} / 100\ °C - 5\ °C$

$m = 45 \text{ mL} / 95\ °C$

$m = 0.474 \text{ mL} / °C$

$y = mx + b$

$V = mT + b$

Using the values associated with absolute zero to find b.

$0 = m*(-273.15) + b$

$b = 273.15m$

$V = mT + 273.15m$

3. Determine percent error for this experiment:

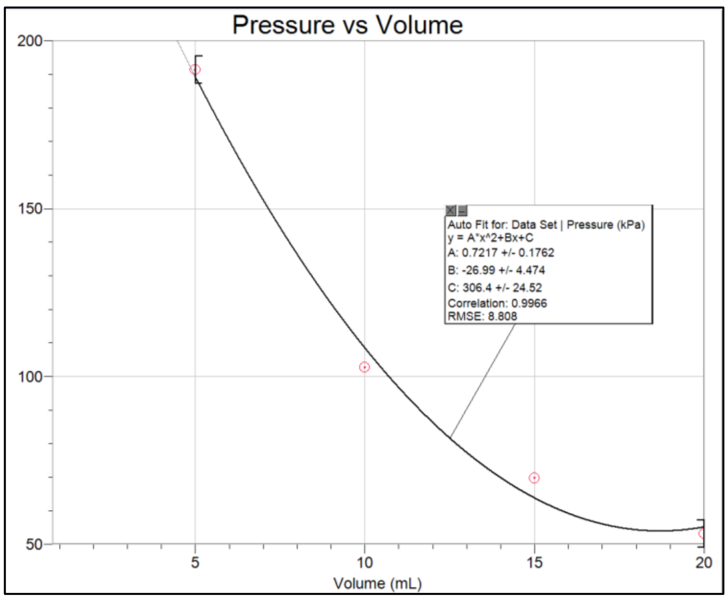
$\% \text{ error} = [(V_1/T_1 - V_2/T_2) / (V_1/T_1)] \times 100\%$

% error = [(150/100 – 105/5) / (150/100)] x 100%

% error = **4.76%**

Additional Data, Boyle's Law

Additional Graphs, Boyle's Law



Graph of Pressure vs. Volume
from Data in Boyle's Law

Sample Calculations, Boyle's Law

1. Find average value of all trials for all data sets:

   For 20mL: (191.20 + 191.40 + 191.61)/ 3 = 191.40
   For 15mL: (102.54 + 103.49 + 102.00)/ 3 = 102.68
   For 10mL: (70.36 + 69.93 + 68.93)/ 3 = 69.74
   For 5mL: (53.05 + 53.65 + 52.97)/ 3 = 53.19

2. Determine percent error from this experiment:

   Experimental Value at x = 1/10 is: 69.74

   Theoretical Value at x =1/10 is: P=44.76(2)-7.64 = 81.88 (taken from y value on graph for given x value)

% error = | (Experimental Value – Theoretical Value) / (Theoretical Value) | x 100%

% error = | (69.74-81.88) / (81.88) | x 100% = **14.83%**