Worksheet – Experiment 1

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

Procedure – Charles' Law:

Procedure as described in the lab manual (Dr. Rashmi Venkateswar, Verification of Gas Laws, University of Ottawa, 2018).

Procedure – Boyle's Law:

1. A 20mL plastic gas syringe, and a Vernier Gas Pressure Sensor were obtained.
2. The Gas Pressure Sensor was connected to the LabQuest 2, and the set- up directions specified in the lab manual were followed accordingly.
3. The data collection mode on the LabQuest 2 was structured so that the independent variable was Volume (V), measured in mL, and so that the dependant variable was Pressure (P), measured in kPa.
4. An air sample was prepared by positioning the plunger at the 20mL mark.
5. The 20mL plastic syringe was attached to the valve of the Gas Pressure Sensor.
6. Once attached, the syringe was turned until resistance was felt, to ensure that it was locked into place on the sensor.
7. The plunger was pushed down in 1mL intervals. After each interval, the volume and the pressure displayed on the sensor were recorded onto the LabQuest 2 data collection sheet.
8. Step 7 was repeated until the syringe was unable to be pushed any further.

Discussion:

Charles' Law:

According to Charles' Law, gases expand and contract by a constant amount for a given change in temperature. Charles' Law states that the volume of any gas at a constant pressure is directly proportional to the temperature in Kelvin ("Relating Pressure, Volume, Amount, and Temperature: The Ideal Gas Law", n.d). According to the data gathered in **Table 1,** and the subsequent calculations performed, it was found that the volume of a gas, at a constant pressure, is directly proportional to the temperature of said gas, in degrees Kelvin. The experiment therefore proves the validity of Charle's Law. The data in this lab was collected by following the procedure for the Verification of Charles's Law, as outlined in the lab manual, and recording the resulting volume and temperature of the gas. Then, in order to find k, the volume of gas (in mL) was divided by the temperature of gas (in K). The values of k for this experiment were calculated to be 0.415 and 0.466, with a percent error of 12.2% (absolute value). The results of this experiment predominantly align with what was expected, meaning that the experiment was carried out with reasonable accuracy. The magnitude of the percent error could be due to the fact that the correct clamps needed to suspend the Erlenmeyer flask in the hot water were not available, and so the flask was not able to fully submerge in the boiling water. This could have resulted in the gas inside the flask not reaching a sufficient temperature, and therefore skewing the results of the experiment. Also, the ice bath specified in Step 7 of the procedure was initially around 9 °C, instead of the recommendation of 6 °C which may have had an impact on the subsequent steps of the experiment. Other limitations of this experiment include using an analog thermometer instead of a digital thermometer resulting in greater reading inaccuracy. Finally time constraints may have prevented subsequent repeated trials of the experiment which may have yielded more accurate results. Thus, the percent error in the experiment could be reduced by ensuring that the proper equipment is available before conducting the lab, and maintaining the ice bath closer to the specified temperature throughout the lab.

Boyle's Law:

Using the data collected during this experiment, the Boyle's Law constant was determined to be 2.00. This value calculated by multiplying each volume (converted from mL to L) by its corresponding pressure (in kPa). The k values calculated were all very close, ranging from 1.97-2.03, verifying that this is indeed the correct Boyle's Law constant. The mathematical relationship outlined in Boyle's Law is that the pressure of a given gas is inversely proportional to its volume (Olmsted, Williams & Burk, 2018). This relationship is clearly displayed in **Figure 1**, which is a graphical representation of the data from this experiment. Boyle's law also requires that certain conditions need to be met for other gas variables. These conditions are that the amount of gas and temperature have to be fixed. In the experiment, the amount of gas was fixed at 20mL using the plastic syringe, while the temperature remained constant at around 25°C. It was also ensured that the hot plate used in the experiment was not near the syringe or pressure sensor, as this could alter the temperature of the gas, as well as potentially damage the equipment. The primary source of error encountered during this experiment arose from difficulties in reading the digital numbers displayed on the pressure sensor. This occurred as a result of trouble in keeping the syringe's plunger pushed down, therefore causing the values displayed on the sensor to fluctuate. This issue could have been avoided by obtaining a syringe that was pushed down automatically/mechanically, instead of being pushed and held down manually. This would ensure that the pressure value displayed on the sensor would be more accurate and stable, and therefore easier for scientists to read.

Conclusion:

Charles' Law:

The values of k for this experiment were calculated to be 0.415 and 0.466, with a percent error of 12.2%. These results validate Charles's Law, as they demonstrate that the volume of a gas at constant pressure is directly proportional to the temperature.

Boyle's Law:

The Boyle's Law constant was experimentally determined to be 2.00, with all k values calculated ranging from 1.97-2.03, verifying that this is the correct Boyle's Law constant. This experiment also determined that the mathematical relationship illustrated by Boyle's Law is that the pressure of a given gas is inversely proportional to its volume., in other words; that when the volume of a gas increases, the pressure decreases.

Reference(s):

Dr. Rashmi Venkateswar, Verification of Gas Laws, University of Ottawa, 2019.

Olmsted,Williams, and Burk, Chemistry: 3rd Canadian Edition, 2018

Relating Pressure, Volume, Amount, and Temperature: The Ideal Gas Law. (n.d.). Retrieved September 26, 2019, from https://opentextbc.ca/chemistry/chapter/9-2-relating-pressure-volume-amount-and-temperature-the-ideal-gas-law/

Additional Data, Charles' Law:

Temperature (℃)	Temperature (K)	Volume (mL)
T_1= 100	T_1= 373.15	V_1= 155
T_2= 9	T_2= 282.15	V_{cw}= 23.5
		V_2= 131.5

Table 1: Data collected during the "Verification of the Charle's Law Experiment" that shows how the volume of a gas is inversely proportional to temperature.

Sample Calculations, Charles' Law:

$\mathbf{V_2 = V_1 - V_{cw}}$

Given: V_1 = 155mL; V_{cw} = 23.5mL; V_2= ?

V_2 = 155mL - 23.5mL

Therefore, V_2 = 131.5mL

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

Given: V_1 = 155mL; V_2 = 131.5mL; T_1 = 373.15K; T_2= 282.15K

% Error = {[(155mL / 373.15K)-(131.5mL /282.15K)]/(155mL/ 373.15K)} x 100%

Therefore, % Error = |-12.2| = 12.2%

Additional Data, Boyle's Law:

Volume (mL)	Pressure (kPa)
20.0	101.34
19.0	107.11
18.0	111.55

17.0	117.64
16.0	123.10
15.0	132.26
14.0	141.26
13.0	153.54

Table 2: Data obtained during the "Verification of Boyle's Law Experiment" that shows the inverse relationship between pressure and the volume of a gas.

Additional Graphs, Boyle's Law:

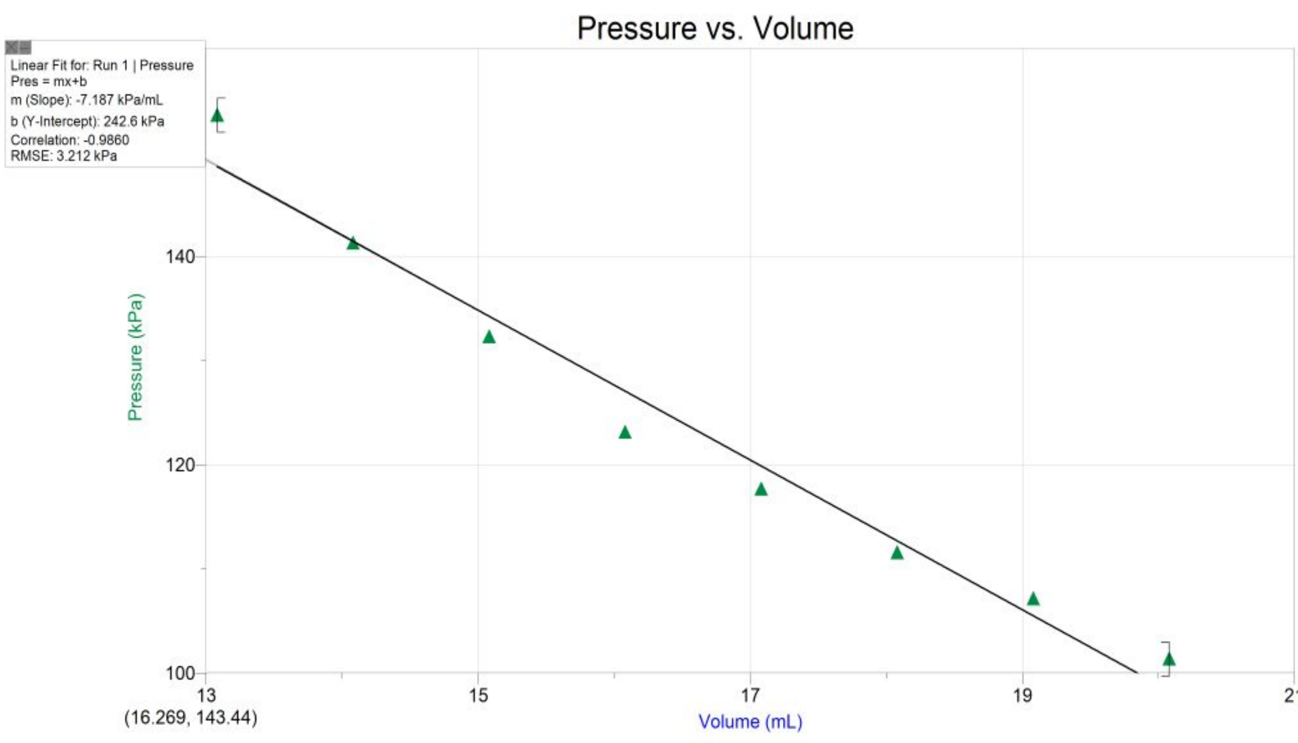

Figure 1: A graphical representation of the Pressure of air as a function of its Volume.

Sample Calculations, Boyle's Law

k= P x V

Given: $V = 0.020$ L; $P = 101.34$ kPa; k= ?

k= (101.34 kPa) (0.020 L)

Therefore, k = 2.03