Boyle's law is a gas law, stating that the pressure and volume of a gas have an inverse relationship, when temperature is held constant.

Independant variable: volume of gas
Dependant variable: pressure of gas
Controlled variable: temperature and amount of gas

Procedure:

1. Prepared the table and put on our protection glasses.
2. Prepared labquest 2 to set up data-collection mode.
3. Set up the gas pressure sensor as well as an air sample and connected to our labquest 2.
4. Attached the 20 mL syringe to the valve of the gas pressure sensor turned it halfway to lock the syringe into place on the sensor.
5. Started data collection and held the plunger at our initial volume mark of 2.0 mL.
6. Recorded our volume + 0.8 mL into our data-collection after the pressure reading stabilized.
7. Moved the plunger by increasing the volume of air in the syringe by 2.0 mL until the volume reached 20 mL.
8. For our final volume, we moved the plunger back to the original volume mark and then decided which volume measurement to keep.
9. We plotted our data points onto a graph and examined the points to determine a mathematical relationship
10. Cleaned up our workspace and returned all the equipment to their designated place

Do I Dare Disturb the Universe?

Verification of Boyle's Law

CHM1311-10F
Lab Performed: Sept 22nd, 2017

Lab Coordinator: Dr. Rashmi Venkateswaran

Introduction:

Boyle's Law, that was discovered in 1662 by Robert Boyle, has became a basic principle in chemistry and has involved in our everyday lives. He discovered the relationship between pressure and volume of a sample of gas, assuming temperature and amount of gas remains constant. Gas laws are present in order to assist scientist to find volumes, amount, pressure and temperature in matters of gas, one of the gas laws include Boyle's Law. Kinetic molecular theory helps to explain the properties of gasses such as pressure, volume and temperature by considering motion and molecular composition. As a result of its high kinetic energy, gases have weak intermolecular forces in comparison to liquids or solids, allowing it to conform to its surrounding by adapting to different pressures and taking the shape of containers. This theory concludes that pressure is due to collisions between molecules moving at different velocities. According to **Boyle's Law; PV=nRT isn't this ideal gas law???** if the volume is decreased, the pressure increases proportionally.

The volume of gas is affected by pressure, temperature and amount of gas and the primary objective of this lab was to determine the validity of Boyle's Law, which states that an inverse relationship exists between the pressure and volume of a fixed sample of gas at a constant temperature. This was done using the gas pressure sensor and a gas filled syringe to understand the relationship between gas and pressure and the effect on pressure when the volume of gas increases. With the results, the constant value of K will be calculated through the equation:

$$K = P \times V = \text{Pressure (kPa)} \times \text{Volume (mL)} \quad [1]$$

Question:

Is there a relationship between the volume and pressure of a sample of gas when its temperature remains constant?

Hypothesis

If the external pressure exerted on the gas increases, then the volume of the gas will decrease, because the relationship between pressure and volume is inversely proportional.

Materials:

- 1 20 mL Gas Syringe
- LabQuest 2
- USB Stick
- Vernier Gas Pressure Sensor

Variables:

Independent Variable	Volume of Gas (mL)
Dependent Variable	Pressure of Gas (kPa)
Controlled Variable	Temperature of Gas Amount of Gas (mols)

Procedure:
**Refer to Verification of Boyle's Law, page 4, Dr. Rashmi Venkateswaran for the LabQuest 2 Procedure

Lab Procedure:

1. Prepared the table and put on our protection glasses.
2. Prepared LabQuest 2 to set up data-collection mode.
3. Set up the Gas Pressure Sensor and connected it to LabQuest 2.
4. Attached the 20 mL gas syringe to the valve of the Gas Pressure Sensor and turned it halfway to lock the syringe into place.
5. Started the data collection and held the plunger at our initial volume mark of 2.0 mL.
6. Recorded our volume + 0.8 mL into our data-collection after the pressure reading stabilized.
7. Moved the plunger by increasing the volume of air in the syringe by 2.0 mL until the volume reached 20 mL/
8. For the final recording, moved the plunger back to the original 2.0 mL mark and then decided which pressure measurement best fit the data.
9. Plotted our data points onto the LabQuest graph and added a curve to determine a mathematical relationship between the points.
10. Cleaned up the workplace and returned the equipment to their designated place.

Observations:

Data Table - Trial #1:

#	Volume of Gas (mL)	Pressure of Gas (kPa)
1	2.08	99.47
2	4.08	55.11
3	6.08	38.18
4	8.08	29.46
5	10.8	24.24
6	12.8	20.11
7	14.8	17.89
8	16.8	15.96
9	18.8	14.10
10	20.8	13.08
Strikethrough Data	2.08	99.65

Data Table - Trial #2:

#	Volume of Gas (mL)	Pressure of Gas (kPa)
1	2.08	96.95
2	4.08	54.40
3	6.08	38.45
4	8.08	28.94
5	10.8	23.61
6	12.8	20.23
7	14.8	17.56
8	16.8	15.51
9	18.8	14.80

10	20.8	13.16
Strikethrough Data	2.08	104.55

Data Table - Trial #3:

#	Volume of Gas (mL)	Pressure of Gas (kPa)
1	2.08	99.28
2	4.08	57.53
3	6.08	37.61
4	8.08	29.71
5	10.8	23.98
6	12.8	20.78
7	14.8	17.98
8	16.8	15.83
9	18.8	15.25
10	20.8	13.21
Strikethrough Data	2.08	102.69

Qualitative Observations:

- ❖ After passing the gas volume mark of 10.8 mL, it got significantly harder to increase the measurements by 2.8 mL.
- ❖ At 2.8 and 4.8 mL, the pressure plunger stayed put but when it reached 6.8 mL. It started to pull back, making it harder to increase the volume.

Calculations:

The following calculations use the data collected from Trial 1 to determine Boyle's Law constant

K = Pressure (kPa) x Volume (mL)

1. K1 = (99.47)(2.08)

= 2.79 x 10^2

2. $K2 = (55.11)(4.08)$
$= 2.65 \times 10^2$

3. $K3 = (38.13)(6.08)$
$= 2.32 \times 10^2$

4. $K4 = (29.46)(8.08)$
$= 2.38 \times 10^2$

5. $K5 = (24.24)(10.8)$
$= 2.62 \times 10^2$

6. $K6 = (20.11)(12.8)$
$= 2.57 \times 10^2$

7. $K7 = (17.89)(14.8)$
$= 2.65 \times 10^2$

8. $K8 = (15.96)(16.8)$
$= 2.68 \times 10^2$

9. $K9 = (14.10)(18.8)$
$= 2.65 \times 10^2$

10. $K10 = (13.08)(20.8)$
$= 2.72 \times 10^2$

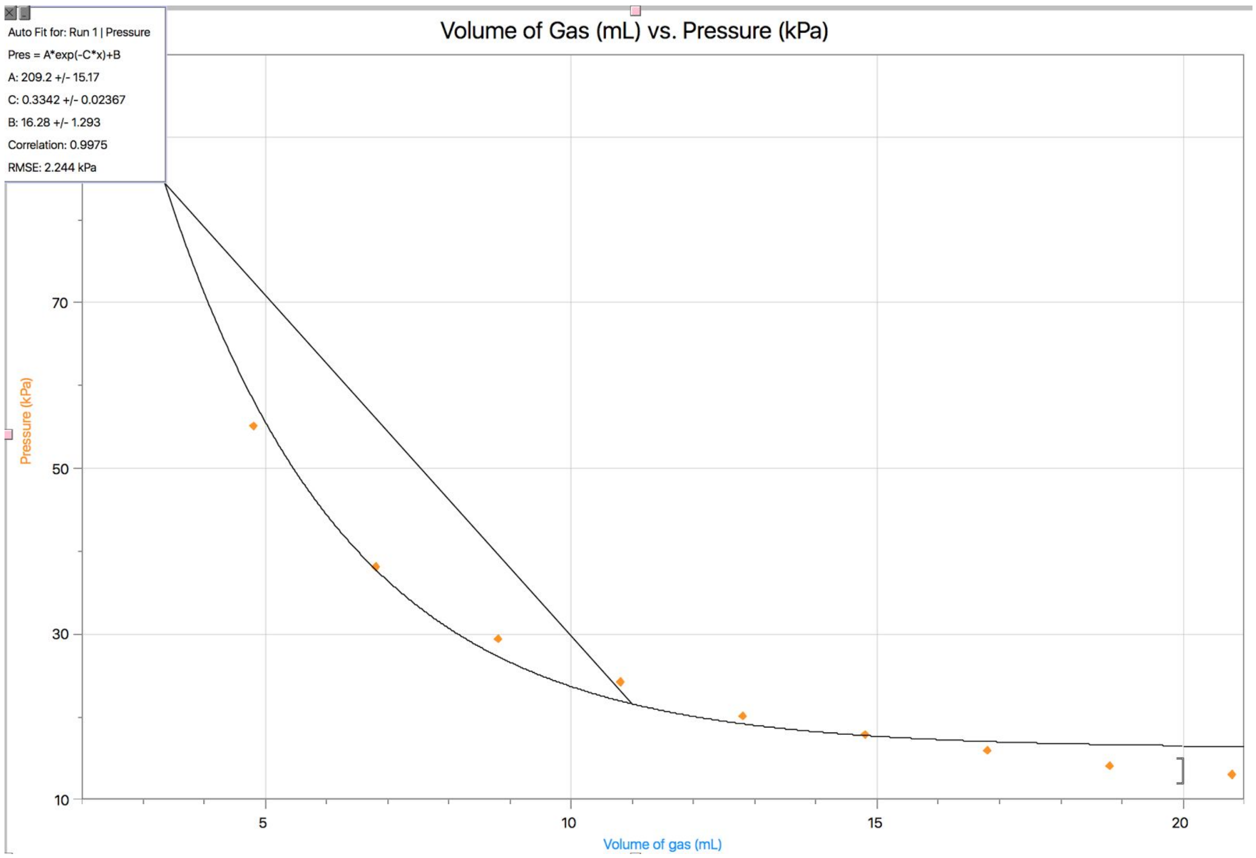
Average $K = K1 + K2 + K3 + K4 + K5 + K6 + K7 + K8 + K9 + K10 / 10$
$=(2.79 \times 10^2) + (2.65 \times 10^2) + (2.32 \times 10^2) + (2.38 \times 10^2) + (2.62 \times 10^2) +$
$(2.57 \times 10^2) + (2.65 \times 10^2) + (2.68 \times 10^2) + (2.65 \times 10^2) + (2.72 \times 10^2)$
$= 2.60 \times 10^2$

∴ The K constant value for Trial 1 is 2.60×10^2

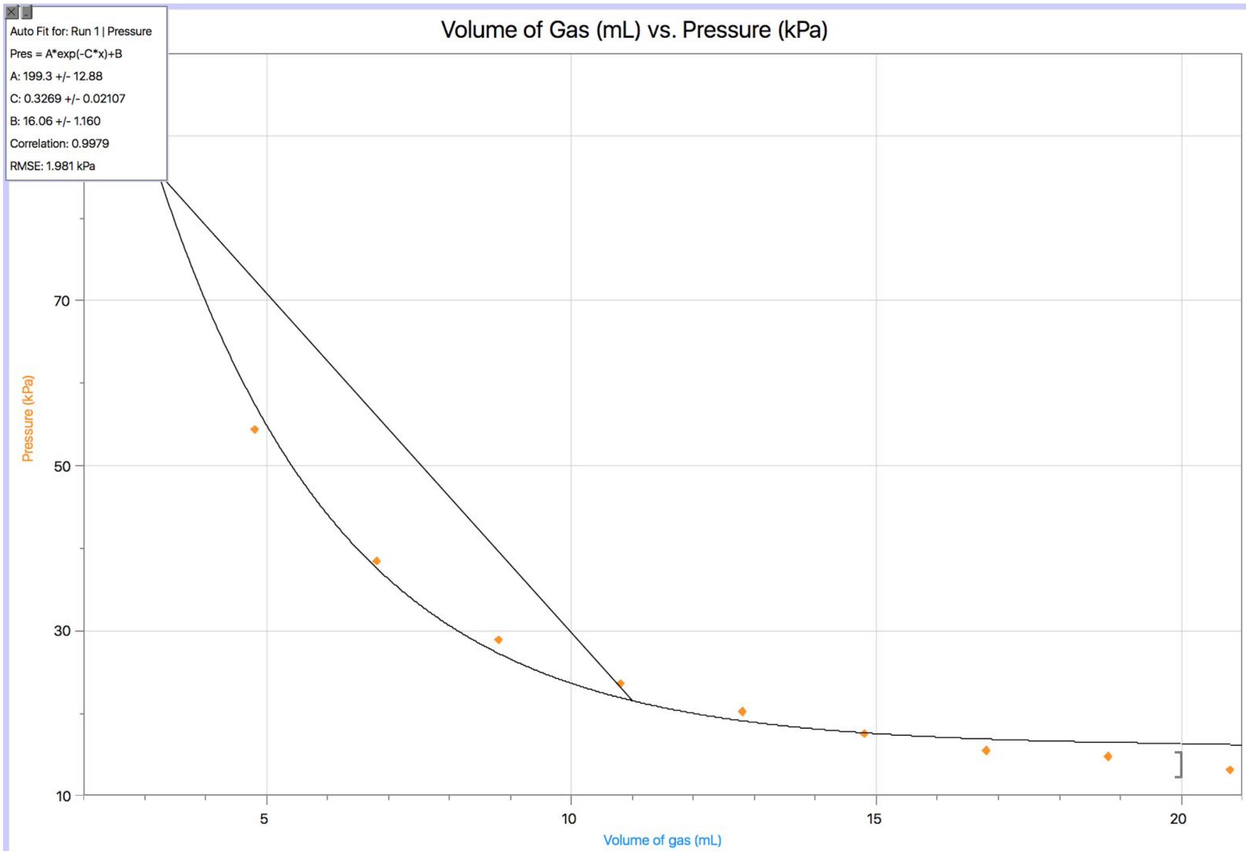
Calculated Results:

Volume Marks (mL)	**Constant “K” Value**		
	Trial #1	Trial #2	Trial #3
2.08	2.79 x 10^2	2.02 x 10^2	2.07 x 10^2
4.08	2.65 x 10^2	2.22 x 10^2	2.35 x 10^2
6.08	2.32 x 10^2	2.34 x 10^2	2.29 x 10^2
8.08	2.38 x 10^2	2.34 x 10^2	2.40 x 10^2
10.8	2.62 x 10^2	2.55 x 10^2	2.59 x 10^2
12.8	2.57 x 10^2	2.59 x 10^2	2.66 x 10^2
14.8	2.65 x 10^2	2.60 x 10^2	2.66 x 10^2
16.8	2.68 x 10^2	2.61 x 10^2	2.66 x 10^2
18.8	2.65 x 10^2	2.78 x 10^2	2.87 x 10^2
20.8	2.72 x 10^2	2.74 x 10^2	2.75 x 10^2
Average K value	2.60 x 10^2	2.48 x 10^2	2.53 x 10^2

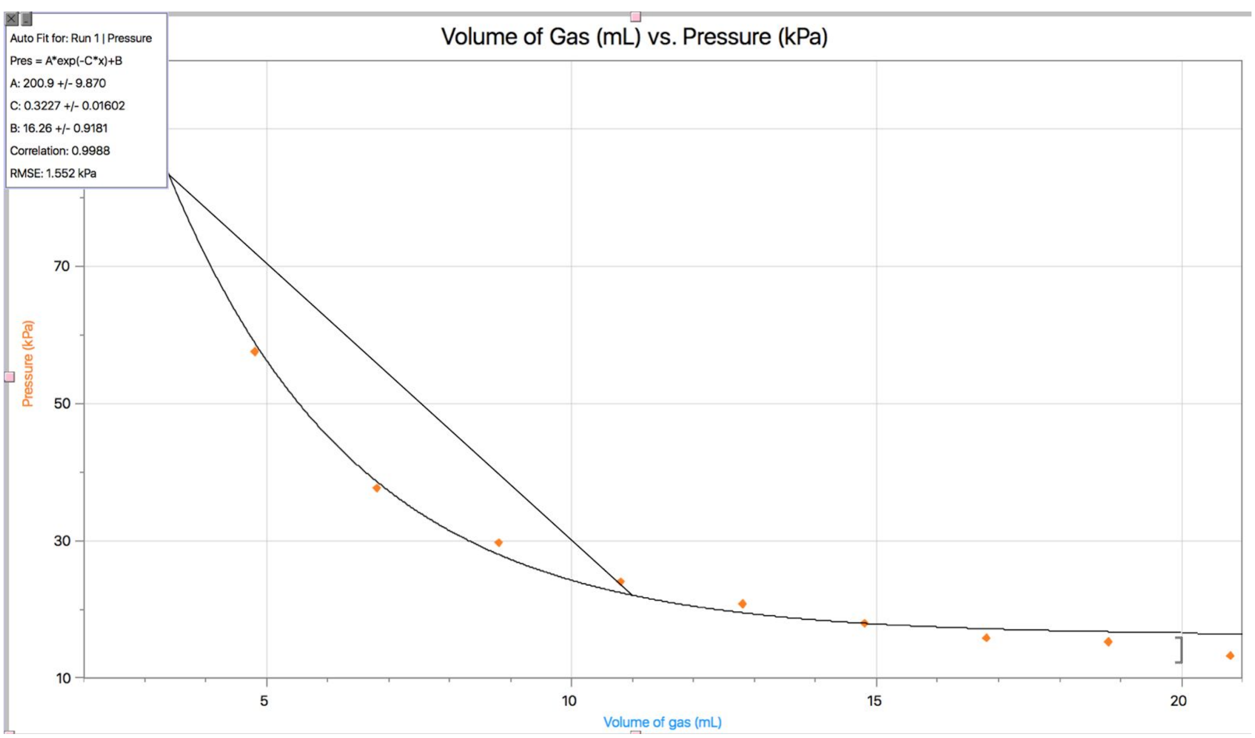
Data Processing - Graphs:



Graph 1 - Trial 1 Data



Graph 2 - Trial 2 Data



Discussion:

Questions that need to be answered:

1. Using your data, calculate a Boyle's law constant. Explain how you determined the constant.
2. Describe the mathematical relationship illustrated by Boyle's law, and use the constant you calculated in Step 1 to write an equation for Boyle's law.
3. You were directed to take your first and last measurements at the same mark on the syringe. Speculate about the importance of taking multiple readings of the dependent variable for the same value of the independent variable.
4. Boyle's law requires certain conditions be met for other gas variables. What are these variables? Did you take these variables into consideration? What did you do to ensure they remained constant? Does this affect your results? If so, how? If not, why not?

Boyle's Law explains that P1V1 = K and P2V2 = K, so by definition, P1V1 = P2V2. However, the average K values from each trial did not come out to be the same answer after our calculations had been completed, resulting in sources of errors being present while performing our lab.

The first error we came across was how difficult it was to keep the tip of the plunger at the chosen volume. It was hard to have the volume remain constant, as every time we'd pull the plunger back further, there was more resistance. In the first trial, this caused us to loose the grip on the plunger, resulting in inconsistent data.

The first error caused the inconsistency of the pressure reading on LabQuest 2. Because it was hard to keep the plunger at a constant volume, this resulted in the fluctuation of the pressure reading. The lab manual procedure advised us to wait until the pressure reading stabilized before recording the value, but the reading was always changing.

Since the second error is a result of the first error, we can avoid both errors if there was a mechanism put into place, which would be capable of keeping the plunger at a constant volume, this would allow us to observe a stabilized pressure reading.

The final procedural error was there was no measurement of the temperature around the syringe being taken account of. Boyle's Law is only valid when temperature remains constant, however for our lab we were to just assume this. Not knowing the temperature of the room is another possible reason for why our K values were not constant for each trial.

To fix this error, we could add in the lab procedure to have a thermometer, which would be able to tell you the temperature when you're measuring the pressure in the syringe. This would allow us to stay true to Boyle's Law and perform our experiment more accurately. If the experiment was done in a confined space or room, keeping the temperature constant and measuring it would be a lot easier.

Conclusion:

To answer our initial question, is there a relationship between the volume and pressure of a sample of gas when its temperature remains constant, we were able to prove our hypothesis to be true after completing the experiment. By using a Gas pressure sensor and a gas syringe, we were able to prove that as the volume increases, the pressure decreases, resulting in a inversely proportional relationship between the two variables.

References

https://owlcation.com/stem/Examples-of-Boyles-Law
https://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Physical_Properties_of_Matter/States_of_Matter/Properties_of_Gases/Gas_Laws/Gas_Laws%3A_Overview