

Chemistry Lab Report 1

“Do I Dare Disturb the Universe?”

Verification of Gas Laws

Chalres' and Boyle's Law

Introduction:

Gases and ideal gases are equitably different. Gases are affected if there is a shift in the pressure, volume and temperature. Charles' and Boyle's Law are defined differently, while each one has their own limitations. "Gases contract when they are cooled and expand when they are heated." To the contrary ideal gases are defined as, "The particles of a gas are so small and far apart, that essentially they do not have any volume and they do not have any attraction to one another." We work with ideal gases in the lab to make our calculations and experiment simpler, because in real life gases contract this is difficult to measure in real life. Even though we are aware gasses do not have negligible volume, as stated in the ideal gas, we use this to make the experiment is unchallenging. This can be expressed in the following equation:

$$PV=nRT$$

In this equation one can solve for the unknown variable if you have all other values. For example, if one is trying to calculate moles (n) you can rearrange the equation to $n=(PV)\div(RT)$ only if you have the values for the pressure (kPa), volume (L) and temperature (K), R in this equation is a constant.

In this experiment I will be verifying if Charles' and Boyle's Law are correct. Charles' Law states, "The volume occupied by any sample of gas at a constant pressure is directly proportional to the temperature in Kelvin." This means that volume and temperature are proportional if the pressure of the gas remains constant. Charles' Law can be expressed by the following equation:

$$V_1 \div T_1 = V_2 \div T_2$$

The explanation to this equation is, if you divide your initial volume by your initial temperature (in Kelvin) it will equal the final volume divided by your final temperature (in Kelvin). Further into the experiment I had to calculate V_2 . I did this by subtraction V_{cw} from V_1 and this value equals V_2 . (V_{cw} in this case was the volume of water in the graduate cylinder). The process to calculate the percent error in the measurements and calculations one must use the equation:

$$((V_1 \div T_1) - (V_2 \div T_2)) \div (V_1 \div T_1) \times 100\% = \% \text{ Error}$$

When I divide my final volume by my final temperature and subtract that from my initial volume divided by my initial temperature and divide this value by my initial volume divided by my initial temperature and multiply it by 100, (to receive my perfect) I will calculate my percent error. Note: all temperature values must be in Kelvin (273.15 K), to calculate the temperature in Kelvin one must add 273.15 K to one's temperature in degree Celsius ($^{\circ}C$). The limitation to Charles' Law is if the pressure is not constant the measurements for volume and temperature will not be valid. Constant pressure must be achieved for volume and temperature to be directly proportional.

In Boyle's experiment, Boyle's Law states, "If a fixed amount of gas is trapped in a container and then the volume of the container is changed, the pressure exerted on or by the gas in the

container will change.” This means that volume and pressure are inversely proportional if the temperature remains constant. Boyle’s Law can be deduced by the equation:

$$P \propto (1/V)$$

This equation means that the pressure is inversely proportional to the volume if the temperature is held constant. We can further manipulate this equation to be:

$$P = k(1/V)$$

Once we obtain this equation we can multiply both sides of the equation by the volume to get the equation:

$$PV=K$$

This equation means if you multiply the chosen volume and the given pressure by each other one will obtain the value for the constant (K). Another way to express this equation is by saying $P_1V_1=P_2V_2$. When you multiply the initial pressure and initial volume by each other it will be equal to the final pressure and final volume multiplied together. The limitations according to Boyle’s Law is, “The temperature of the trapped gas must remain constant.” If this condition is not met then pressure and volume are not inversely proportional.

Procedure:

The procedure is as described in the lab manual for Charles’ Law (Dr. Rashmi Venkateswaran, What in the World Isn’t Chemistry, 2018, Exp. 1, p. 6)

The procedure for Boyle’s Law:

1. Connect the syringe to the gas pressure sensor, and connect the Gas Pressure Sensor to the LabQuest 2.
2. Enter the name and units of your variable (Volume in mL)
3. Pick an initial volume (10mL)
4. Align and hold the syringe to the marking of 10mL and wait for the pressure to stabilize (as shown on the LabQuest 2) NOTE: add 0.8mL to each volume (10mL+0.8mL = 10.8mL)
5. Once you receive the calculated pressure given by the gas pressure sensor write down the pressure associated with the volume in a table
6. Repeat steps three to five seven times, each time with a new volume. Do not forget to add 0.8mL to each volume

Data and Observations:

During the experiment when my partner and I were boiling the beaker filled with water (which contained the Erlenmeyer flask submerged in), as the temperature increased we noticed the water started to boil (bubbles). As soon as we placed the Erlenmeyer flask into the ice bath (stopper facing downwards) we noticed the water started to fill the Erlenmeyer flask. The data I received in Charles' Law is the initial temperature of the Erlenmeyer flask is 100°C . The final temperature of the ice bath, as recorded, was 14°C . The recordings for the initial volume was 152mL and the final volume (refer to calculations) was 121 mL.

Charles' Law

Volume (mL)	Temperature ($^{\circ}\text{C}$)
$V_1 = 152$	$T_1 = 100$
$V_2 = 121$	$T_2 = 14$

When I later proceeded to calculate my calculations, I observed that as temperature decreases the volume also decreases, you can reinforce this statement by referring to the above table. As the temperature decreased the volume decreased as well (both variables are proportional)

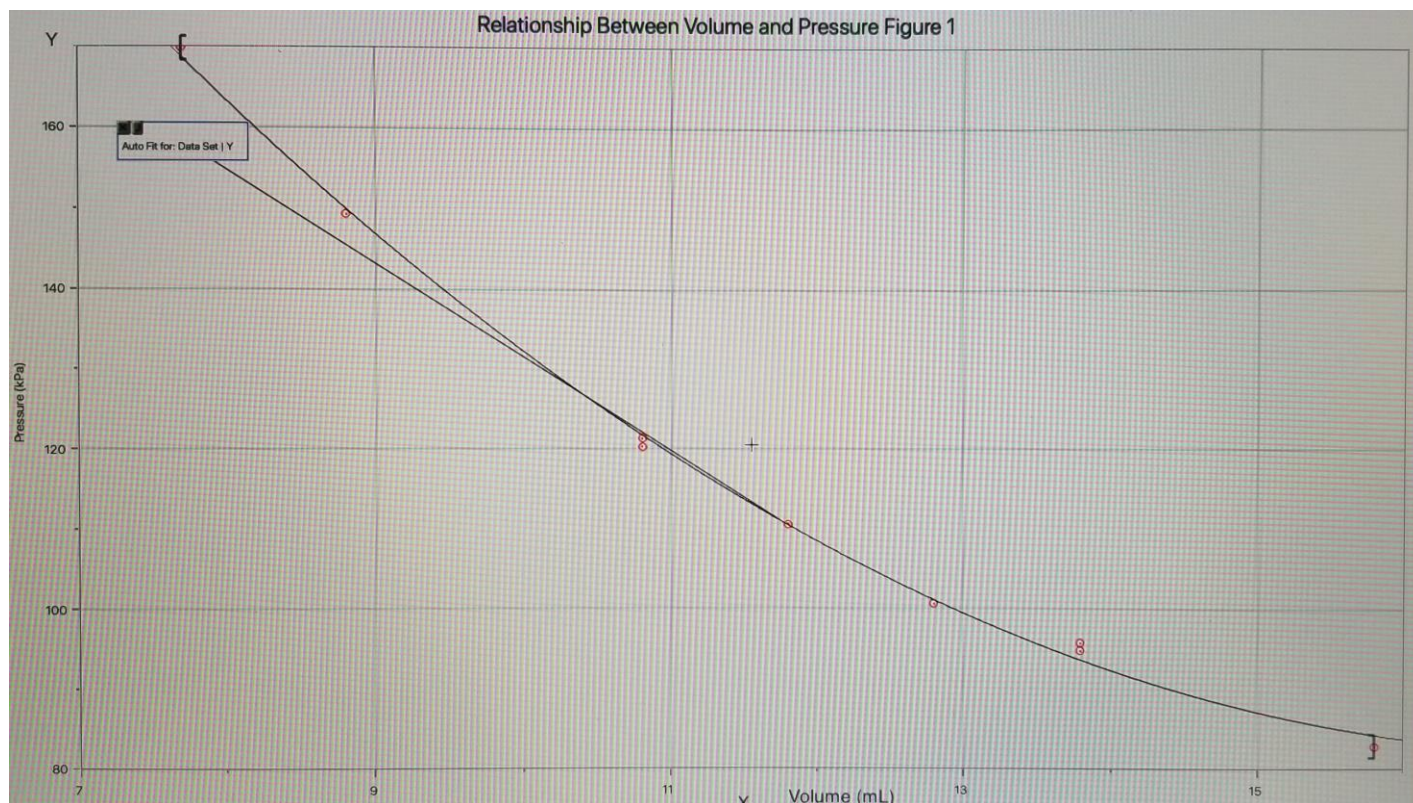
The data I received in Boyle's Law 1st trial:

Volume (mL)	Pressure (kPa)
10.8	120.25
12.8	100.58
11.8	110.56
8.8	149.27
7.7	169.74
15.8	82.85
13.8	95.74

The data I received in Boyle's Law 2nd trial:

Volume (mL)	Pressure (kPa)
10.8	121.28
9.8	133.42
14.8	88.59
16.8	77.61
6.8	194.31
5.8	225.06
13.8	94.77

I observed, in the above data given, that volume and pressure are inversely proportional. As the volume decreased the pressure increased. This reinstates Boyles' Law and confirms that it is in fact true.



This graph displays the relationship between volume and pressure related to Boyle's Law. As the volume increases the pressure decrease. The independent variable is volume measure in mL (x-axis) and the dependent variable is pressure measured in kPa (y-axis).

Note: Y-axis is increasing by 20kPa (starting at 80kPa), X-axis is increasing by 2mL (starting at 7mL).

Calculations:

Charles' Law

$$1. \quad V_2 = ? \quad V_1 - V_{cw} = V_2$$

$$152 \text{ mL} - 31 \text{ mL} = 121 \text{ mL}$$

$$V_2 = 121 \text{ mL}$$

$$2. \quad V_1 \div T_1 = V_2 \div T_2$$

$$3. \quad (152\text{mL})/(373\text{k}) = (121\text{mL})/(287\text{k})$$

This is true, both sides are equal to 0.41 mL/k

$$4. \quad ((V_1 \div T_1) - (V_2 \div T_2)) \div (V_1 \div T_1) \times 100\% = \% \text{ Error}$$

$$\% \text{ Error} = ((0.152\text{mL})/(373\text{k}) - (0.121\text{mL})/(287\text{k})) \div (0.152\text{mL})/(373\text{k})$$

$$= -0.034 \times 100\%$$

$$= -3.45\%$$

Boyle's Law Table Relationship Between Volume and Pressure to Determine Constant

Volume (mL)	×	Pressure (kPa)	=	Constant (k)
10.8		120.25		1298.7
12.8		100.58		1287.42
11.8		110.56		1304.60
8.8		149.27		1313.57
15.8		82.85		1309.03
7.8		169.74		1323.97
13.8		95.74		1321.21

This table represents the constant (k) which was calculated by multiplying the volume with the pressure.

$$PV=K$$

$$(120.25\text{kPa})(10.8) = 1298.7$$

$$K_{\text{average}} = 1308.36$$

I calculated the average by adding all the k values I obtained in the above table (Boyle's Law Table Between Volume and Pressure to Determine Constant) and then divided the sum by seven (number of entities).

$$K_{\text{average}} = 1287.424 + 1289.7 + 1304.608 + 1313.576 + 1321.212 + 1309.03 + 1323.972$$

$$= 9158.52 \div 7$$

$$= 1308.36$$

Discussion:

In Charles' Law the data I received corresponded well to the equations (refer to introduction). My initial volume (152mL) and initial temperature (100°C) and my final volume (121mL) and my final temperature (14°C). With this information I can ensure and say that the volume and temperature are proportional, as stated in Charles' Law. If the temperature decreases then the volume will also decrease. I predicted that as the temperature decrease the volume with also decrease, with the data I received I was able to calculate V_2 and when I did, the volume I calculated was 121mL. This number is significantly smaller than my initial volume. This is accurate and correct because my final volume relates to my final temperature (14°C). As the temperature decreased my volume should have also decreased, which it did. In Boyle's Law the data I received also corresponded to the equations (refer to introduction). When I depicted different volumes, measured in mL (independent variable) I predicted that the pressure

(dependent variable) would be inversely proportional. The data I received ensured that my predictions were correct. As the volume decreased the pressure increased and as the volume increased the pressure decreased (refer to table in data and observations). This tells me that Boyle's Law is in fact true. The limitations to this experiment are not setting the syringe to the appropriate amount and not waiting for the LabQuest 2 to stabilize its pressure.

I determined the constant (K) by multiplying every P value (pressure) by the V value (volume) to determine the K (constant). $PV = K$. This equation comes from, $P = k(1/V)$ which states that pressure and volume are inversely proportional. When I multiplied both sides by V, I got the equation $PV = K$. When I calculated the constant (K) I received a value of $K = 1308.36$ (refer to calculations). I measured 10 mL and 13 mL twice during the experiment. During my 1st trial, 10 mL I received a pressure of 120.25 kPa and 13 mL I received a pressure of 95.74 kPa. For my 2nd trial, 10 mL I received a pressure of 121.28 kPa and 13 mL I received a pressure of 94.77 kPa. The importance of measuring at least two values twice is to ensure my measurements are correct. Therefore, I will know my calculations are accurate. For the two volumes I measured twice, the pressure I received for each were very similar to each other. This ensure my data results are accurate and no to little mistakes were made. If there was a large difference between the first and the second measurements of the dependent and independent variables, I would realize there is a flaw in my measurement and perform the trial again to see where I went wrong to fix my mistake and receive the correct value. Boyle added one important condition to his law: the temperature of the trapped gas must remain constant. This means that the temperature must remain constant in order for volume and temperature to be inversely proportional. If the temperature is not held constant then the law is not valid (volume and pressure will not be inversely proportional). In order for Boyle's law to remain true one must ensure the temperature (Kelvin) is held constant. I ensured the temperature remained constant throughout the experiment. I perform this by testing and measuring two of the exact same volume measurements (10 mL and 30 mL) twice. When I received very similar measurements for pressure this reinforced that the temperature remained constant. If the pressure had a large difference I would change locations or wait till the temperature is not in constant flux. Based on my experiment the volume remained constant, therefore my results were not affected because during my second trial I received similar data.

Conclusion:

Moreover, the results I received for Charles' Law was $V_1 = 152$ mL, $T_1 = 100^\circ\text{C}$ and $V_2 = 121$ mL, $T_2 = 14^\circ\text{C}$ with a -3.45% error. These results confirmed Charles' Law which states that volume and temperature are proportional, if the pressure is help constant. The results I received for Boyles' Law for my initial volume (10.8mL) I received a pressure of 120.25kPa and for my final volume (13.8mL) I received a pressure reading of 95. 74kPa. This confirmed Boyle's Law which states that volume and pressure are inversely proportional, if the temperature remained constant.

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Charles' Law

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- Temperature of erlenmeyer flask = 100°C (T_1)

Procedure

- 1 - fill $\frac{2}{3}$ of a 600 mL beaker
- 2 - place it on the hot plate
- 3 - place a stopper on a 125 mL erlenmeyer flask and place a marker right under the stopper (where it ended)
- 4 - using a clamp immerse the erlenmeyer flask into the beaker
- 5 - keep in boiling H_2O for 6-7 minutes
- 6 - keep finger on stopper (stopper facing down) and place into ice bath
- 7 - remove finger and keep erlenmeyer flask in ice bath for 5 min
- 8 - temperature of ice bath is 14°C (T_2)
- 9 - when H_2O level is matched, place finger over stopper and place H_2O into a graduated cylinder
- 10 - volume of H_2O in graduate cylinder is 31 mL (V_{cw})
- 11 - volume of erlenmeyer flask (filled with H_2O till stopper) is 152 mL (V_1)

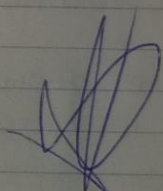
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Boyle's Law

2nd trial

	Volume (+0.8mL)	Pressure
1	9mL	133.42 Kpa
2	14mL	88.59 Kpa
3	13mL	94.77 Kpa
4	10mL	121.28 Kpa
5	16mL	77.61 Kpa
6	6mL	194.31 Kpa
7	5mL	225.06 Kpa



Bibliography

Dr. Rashmi Venkateswaran, What in the World Isn't Chemistry Lab Manual, 2018, Exp. 1, p. 6

Boyle's Law, Andrew staroscik, 2011- 2018, <http://scienceprimer.com/about>

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