TOTAL REPORT GRADE 33/35

Introduction 3/3
- try to incorporate some references to scientific literature

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Experiment 1: Verification of Gas Laws.

Introduction:

The purpose of this lab is to verify Charles' and Boyle's gas laws, assuming ideal gas behavior. Rise of a temperature of the gas will lead to the increase of the gas' volume and decrease of a temperature of the gas will lead to the decrease of the gas' volume, proving the Charles' law ($V_1/T_1=V_2/T_2$). Increase of the gas' volume will lead to a decrease of the pressure and decrease of the gas' volume will lead to an increase of the pressure, proving the Boyle's law ($P_1V_1=P_2V_2$=Constant). Ideal gas called ideal, because in real life, gases do not behave ideally. For the gas to be ideal, two assumptions have to be made. Firstly, ideal gas molecules do not attract or repel each other. Secondly, ideal gas molecules themselves take up no volume.

Procedure:

Verification of Charle's Law

Procedure 3/3
- Good Job!

1. A 125 mL Erlenmeyer flask was obtained and ensured that it is clean and dry.
2. A rubber stopper with a hole was placed in the Erlenmeyer flask.
3. Position of the bottom of the stopper was marked with a white sticker.
4. A 600 mL beaker was filled to two-thirds with tap water (400 mL).
5. The beaker was placed on a hot plate.
6. The hot plate was turned on and the water in the beaker was heated to boiling.
7. The Erlenmeyer flask was clamped with an extension clamp and placed into the boiling water for six to seven (6 to 7) minutes.
8. A large ice bath was prepared.
9. The temperature of the air in the Erlenmeyer flask was determined using a digital thermometer.
10. A finger was placed over the hole on the stopper and the Erlenmeyer flask was removed from the hot water by disconnecting the extension clamp from the clamp holder.
11. The Erlenmeyer flask was lowered into the ice bath stopper facing downwards and covered with the finger on the hole.
12. The Erlenmeyer flask was submerged for five to six (5 to 6) minutes, so the temperature of the air inside the Erlenmeyer flask equilibrated to the temperature of the water.
13. The temperature of the ice bath was recorded.
14. The level of the water in the flask was matched with the level of the water in the ice bath by raising or lowering the flask.
15. The finger was placed over the hole in the rubber stopper and the flask was removed from the water bath.
16. The water from the Erlenmeyer flask was transferred to a graduated cylinder and its volume was noted.
17. The Erlenmeyer flask was filled to the white sticker mark with water.
18. The water inside the Erlenmeyer flask was measured using a graduated cylinder and noted.

Verification of Boyle's Law

1. The Gas Pressure Sensor was connected to the LabQuest 2.
2. The LabQuest 2 was turned on and New from the File menu was chosen.

don't include justification in your procedure,
only exactly what you did
justification can go in the discussion

3. The plunger of a plastic 20 mL syringe was moved to the 10 mL volume, as it allows for the gas' volume to be equally decreased and increased.
4. The 20 mL syringe was attached to the valve of the Gas Pressure Sensor.
5. Mode was taped on the Meter screen and the mode was changed to Events with Entry.
6. The Name of the variable and the Units for the variable were entered and confirmed by pressing OK.
7. The data collection was started.
8. The plunger was held at the initial volume mark of 10 mL.
9. Keep was taped and the volume was entered with a correction of +0.8 after the pressure reading stabilized. OK was pressed to proceed.
10. Steps 7 to 9 were repeated with the plunger being on the positions of 3 mL, 5 mL, 8 mL, 12 mL, 15 mL, 18 mL and 20 mL.
11. Steps 7 to 9 were repeated with the plunger being on the initial position of 10 mL.
12. Table word was tapped and, on the menu that appeared, the Strike Through Data was chosen.
13. The graph icon was tapped to return to the graph screen.
14. Analyze word was tapped and Curve Fit was chosen from the Analyze menu.
15. The menu below Fit Equation was opened and a Power (reciprocal) function was chosen to perform on the data. The reciprocal function was chosen, as it had the smallest deviation value from the data points collected.
16. OK word was selected to return to the graph screen.
17. The plotted points were carefully examined and the second 10 mL point was removed, as it had a higher deviation from the reciprocal trend line than the original point.

<u>Safety Precautions:</u>

- Protection glasses and a lab coat have to be worn during the lab.
- Hot objects, including hot plate, beaker with a boiling water, hot steam, should not be touched without the proper equipment.
- Toes covering shoes have to be worn during the lab.
- Long hair should be tied during the lab.
- After completing the practical part of the lab, the used material should be disposed according to the orders of the lab personnel.

<u>Observations:</u>

<u>Charles' Law:</u>

- The Erlenmeyer flask was tilted to 60°, while left in the ice bath without the rubber stopper being blocked. However, no air bubbles appeared.
- The Erlenmeyer flask partially filled with water, without any gas escaping.

T_1	56.5°C, 330.°K
T_2	7.80°C, 281.°K
V_{cw}	32.0 mL
V_1	149.0 mL
$T_{boiling\ water}$	99.8°C, 373.°K

Observations 2/2
- Include also things like colours and smells of solutions, if any

Data Tables 4/4

<u>Boyle's :Law:</u>

- It was decently easy to pull the plunger to the 20 mL marking, while almost impossible to move the plunger to the 0 mL marking.
- The Gas Pressure Sensor was getting off the Luer's lock thread, while little amount of pressure was applied.

Trial 1:

Volume (mL)	Pressure (kPa)
3.80	226.04
5.80	194.43
8.80	123.42
10.80	101.96
12.80	85.99
15.80	70.21
18.80	58.01
20.80	52.70

Trial 2:

Volume (mL)	Pressure (kPa)
3.80	226.06
5.80	192.08
8.80	127.88
10.80	102.29
12.80	87.05
15.80	69.98
18.80	59.38
20.80	53.38

Calculations: 4/4

Charles' Law:

V_2	149.0 mL - 32.0 mL = 117.0 mL
% Error	(V1/T1 - V2/T2)/(V1/T1)x100%= (149.0 mL/329.65°K - 117.0mL/280.95°K)/(149.0mL/329.65°K)x100%=

	7.865%

Verification of Charles' Law:
V_1/T_1= 149.0 mL/330.°K= 0.440
V_2/T_2= 117.0 mL/281.°K= 0.416

0.440-0.416= 0.024 => % Error

$V_1T_1=V_2/T_2$

<u>Boyle's Law:</u>

1. Calculate a Boyle's law constant.

$P_1V_1=P_2V_2$=Constant

P_1V_1= 5.80 mLx192.08 kPa= 1110

P_2V_2= 10.80 mLx101.96 kPa= 1101.

P_3V_3= 20.80 mLx52.70 kPa= 1096.

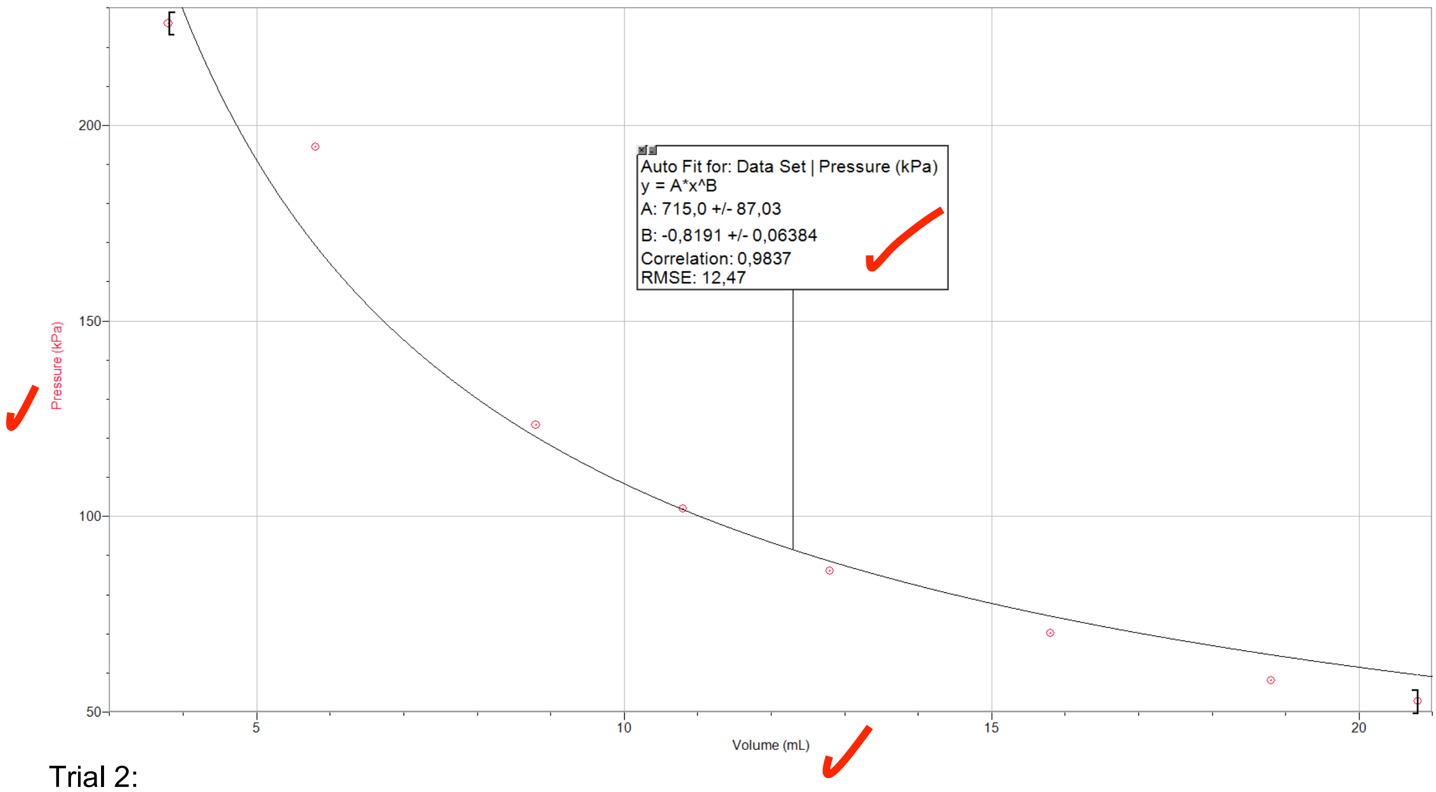
As $P_1V_1!=P_2V_2!=P_3/V_3$, an average value has to be calculated and considered a constant.

Constant= $(P_n/V_n + P_{n+1}/V_{n+1})/n$
Trial 1 Constant= 1071
Trial 2 Constant= 1081
% Error= ((1071-1081)/1071)x100%= 0.9337%

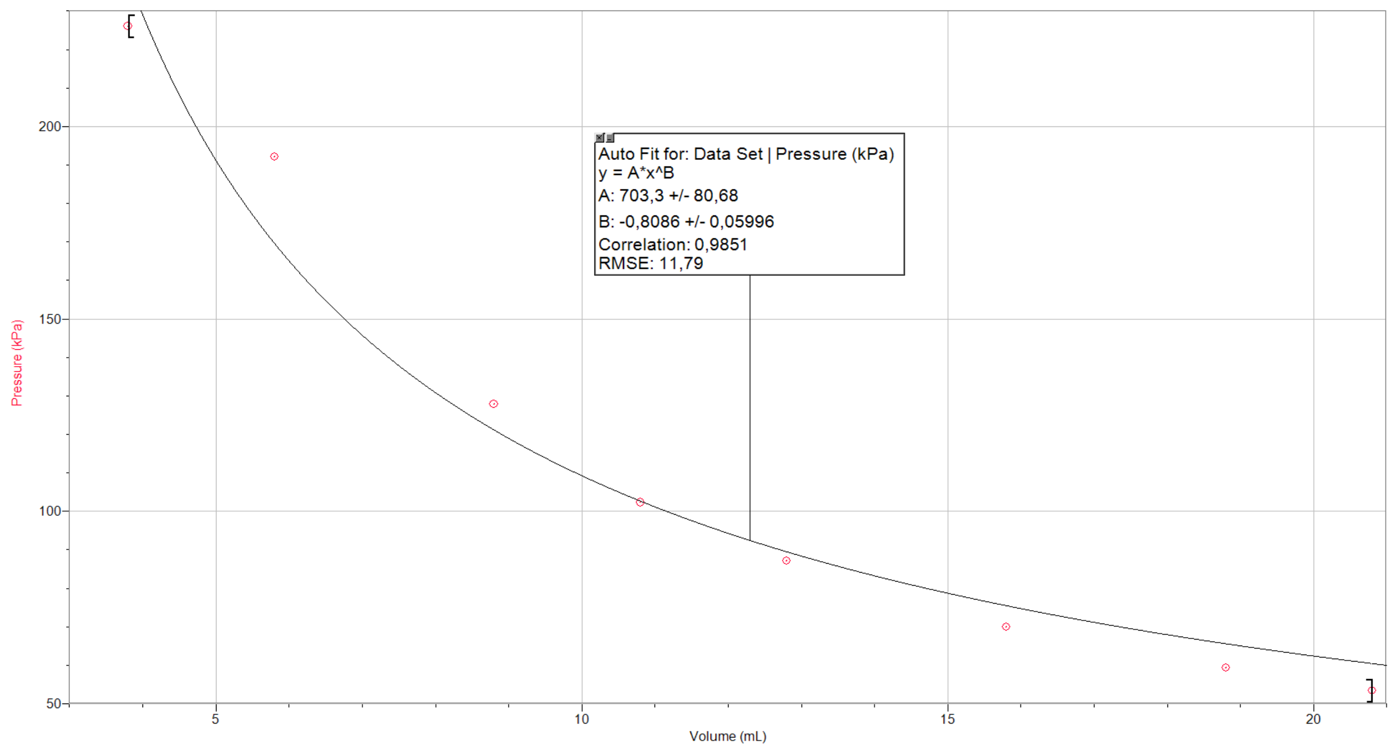
Graphs 6/6

Graphs:

Trial 1:



Trial 2:



Discussion:

In an overall, the hypothesis appeared to be correct. Water was pushed into the Erlenmeyer flask by the force of the decreasing air volume, so decrease of a temperature of the gas will lead to the decrease of the gas' volume. Percentage error of 7.865% ensures the theoretical part of the Charles' law. Nonetheless, it was almost impossible to measure the temperature of the gas inside the Erlenmeyer flask, as the electronic thermometer was

what were your exact constants? write them in the discussion too, not just the percent error not really an error as the temperature sensor portion of the electronic probe is only the very tip of the probe - the biggest source of error for Charles was if your flask was not completely dry prior to starting the experiment

Discussion 3/5
- Lots of discussion on Boyle's law which is really well done
You must include at least one scientific reference somewhere in your report (-1)
- Usually the easiest place to include this is in the introduction or discussion

partially measuring the temperature of the rubber stopper. Furthermore, the Erlenmeyer flask was too small to fit the electronic thermometer, so the electronic thermometer was, at some point, touching the bottom of the Erlenmeyer flask, which has a higher temperature compared to the gas stored in the Erlenmeyer flask. When this problem was solved by the partial removal of the electric thermometer, the upper part of it was under heavy streams of a steam that was coming from the boiling water. This could seriously affect the T_1 value retrieved during the experiment. Finally, the temperature of the gas inside the Erlenmeyer flask purposely raised to lower levels, compared to the temperature of the boiling water, as a high temperature of the gas would make it problematic to hold the rubber stopper closed with a finger during the transfer of the Erlenmeyer flask to the ice bath.

For the Boyle's law, hypothesis was proven as well. Decrease of the ideal gas pressure leads to an increase of the ideal gas volume and vice versa. This signifies the presence of a mathematical constant and a reciprocal relationship between pressure and volume. An equation for Boyle's law will have this form: f(x)=constant/x, or PV=k, if the constant has not been found. but your exact constants here too

An ideal gas assumption was made during the lab. This explains why each relationship has a different k value. While the plunger was moved to the different volume markings, particles of a gas inside the syringe moved as well. In the end, the pressure for the first and final measurements would be different, depending on the previous position of the plunger. If the plunger was on the markings with readings lower than 10 mL, the pressure readings would be higher, as the particles were located closer. On the contrary, the pressure readings would be lower, if the plunger was on the higher markings, due to the bigger distance between particles.

Furthermore, Boyle's law requires the temperature with atmospheric pressure to be constant. The syringe was held in non-isolated human hands during the experiment. This resulted in the rise of the temperature of the syringe and the gas inside of it from 24°C room temperature to 37°C standard human body temperature. The 11 °C change of the temperature could heavily affect the results. According to the readings of the Gas Pressure Meter, temperature rise changed the pressure inside the syringe. This should be a reason of the difference between the first and the seconds trials. The height of the syringe to the ground was constant, so the atmospheric pressure could not drastically change during the experiment.

It was almost impossible to pull the syringe plunger to the 0 mL marking, as it would make an amount of particles of the gas too condensed. According to graph, the behavior of the gas can be represented by the reciprocal function. Thus, as the volume approaches zero, the pressure inside the syringe would approach an infinity. This explains why it was impossible to achieve the marking of 0 mL on the syringe.

Lastly, the connection between the Gas Pressure Meter and the syringe could not have been properly tied and insulated. This could affect overall results and especially the uttermost syringe volume markings.

Conclusion:

The Boyle's and Charles' ideal gases laws appeared to be correct. Despite multiple potential errors and the ideal gas assumption, calculated Charles' law percentage error is inside acceptable 10%. The average constant for the Boyle's law in the first trial was found to be 1071. The average constant in the second trial was found to be 1081, which gives -0.9337 percentage error.

Conclusion 1/2
- What about your Charles law constant?

Sources:

1. Helmenstine, T. (n.d.). Know the Formula for Charles' Law. Retrieved from https://www.thoughtco.com/formula-for-charles-law-604281
2. Helmenstine, T. (n.d.). Understand the Boyle's Law Formula for Ideal Gases. Retrieved from https://www.thoughtco.com/formula-for-boyles-law-604280
3. What is the ideal gas law? (n.d.). Retrieved from https://www.khanacademy.org/science/physics/thermodynamics/temp-kinetic-theory-ideal-gas-law/a/what-is-the-ideal-gas-law

Raw data:

Charles's Law.

~~Initial gas volume: 123 ml~~

Trial 1

V_{cw}: 32 ml

T_1: ~~[illegible]~~ 56.5 °C

T_2: 7.8 °C

V_1: 50 ml + 30 ml + 49 ml = [illegible]

V_2: 149 ml − 32 ml = 117 ml

T of water: 99.8 °C

Trial 2.

V_{cw}:

T_1:

T_2:

V_1:

V_2:

$T_?$ of water:

Boyle's Law.

~~Independent variable (Volume~~

Trial I.

Volume (ml)	Pressure (kPa)
3.80	226.04
5.80	194.43
8.80	123.72
10.80	101.96
12.80	95.99
15.80	70.21
19.80	58.01
20.80	52.70

Trial II.

Volume (ml)	Pressure (KPA)
3.80	226.08
5.80	192.09
8.80	124.98
10.80	102.29
12.80	94.05
15.80	69.98
19.80	59.38
20.80	53.38

Lm