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

<u>Written by:</u>

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Experiment 1: Verification of Gas Laws

Introduction:

Gases surround men and are a necessity to their everyday lives. Science not only teaches society why gases are important, but why gases react the way they do. The ideal gas law is deeply taken into consideration when obtaining data regarding gases.

$$PV = nRT$$

The law states that gases do not act ideally, and because of this, it will affect how precise measurements will be when dealing with gases.

Jacques Charles and Robert Boyle change chemists' views on the nature of gases, and this shapes how society now reacts to gases. Charles' law and Boyle's law both are affected by temperature and it is evident in measurements when dealing with gases. Charles' law states that gases react relatively to temperature; when the temperature rises the gas expands, and when cooled the gas will contract.

$$\frac{V1}{T1} = \frac{V2}{T2}$$

Alternatively, Boyle's law mentions how both volume and pressure is inversely related; when the volume of the container containing the gas rises, the pressure falls. This holds true only when the temperature is constant.

$$P_1V_1 = P_2V_2$$

Procedure:

As described in the lab manual (Verification of Gas Laws, T. S. Eliot)

Data:

Charles' Law

Data	Trial 1	Trial 2
T_1 - Initial temperature of air in the Erlenmeyer flask	100℃ (373.15 K)	100℃ (373.15 K)
T_2 - Final temperature of air in the Erlenmeyer flask	3℃ (276.15 K)	7℃ (280.15 K)
V_{CW}	26 mL	41.5 mL
V_1	150 mL	150 mL
V_2	124 mL	108.5 mL

Calculations / Data Analysis:

Trial 1

$T_1 = 100°C = 373.15\ K$

$T_2 = 3°C = 276.15\ K$

$V_{CW} = 26\ mL$

$V_1 = 150\ mL$

$V_2 = ?$

$V_1 - V_{CW} = V_2$

$150\ mL - 26\ mL = 124\ mL$

$V_2 = 124\ mL$

$$\frac{V1}{T1} = \frac{V2}{T2}$$

$$\frac{V1}{T1} = \frac{150mL}{373.15K} = 0.402\ mL/K \qquad \frac{V2}{T2} = \frac{124mL}{276.15K} = 0.449\ mL/K$$

$$\%\ Error = \left| \frac{\frac{V1}{T1} - \frac{V2}{T2}}{\frac{V1}{T1}} \right| \times 100\%$$

$$\%\ Error = \left| \frac{0.402mL/K - 0.449mL/K}{0.402mL/K} \right| \times 100\%$$

% Error = 0.047 x 100%

% Error = 4.7%

Trial 2

$T_1 = 100°C = 373.15\ K$

$T_2 = 7°C = 280.15\ K$

$V_{CW} = 41.5\ mL$

$V_1 = 150\ mL$

$V_2 = ?$

$V_1 - V_{CW} = V_2$

$150\ mL - 41.5\ mL = 108.5\ mL$

$V_2 = 108.5\ mL$

$$\frac{V1}{T1} = \frac{V2}{T2}$$

$$\frac{V1}{T1} = \frac{150mL}{373.15K} = 0.402\ mL/K \qquad \frac{V2}{T2} = \frac{108.5mL}{280.15K} = 0.387\ mL/K$$

$$\%\ Error = \left| \frac{\frac{V1}{T1} - \frac{V2}{T2}}{\frac{V1}{T1}} \right| \times 100\%$$

$$\%\ Error = \left| \frac{0.402mL/K - 0.387mL/K}{0.402mL/K} \right| \times 100\%$$

% Error = 0.037 x 100%

% Error = 3.7%

Average of Trial 1 and 2

Formula: $X_Y = (A + B) / 2$

$V_1 = 150$ mL

$\frac{V1}{T1} = \frac{V2}{T2}$

$T_1 = 100℃$

$T_1 = 373.15K$

$\frac{V1}{T1} = \frac{150mL}{373.15K} = 0.402$ mL/K

$\frac{V2}{T2} = \frac{116mL}{278.15K} = 0.418$ mL/K

$V_2 = 116.25$ mL

$V_2 = 116$ mL

$\% \text{ Error} = \left| \frac{\frac{V1}{T1} - \frac{V2}{T2}}{\frac{V1}{T1}} \right| \times 100\%$

$\% \text{ Error} = \left| \frac{0.402mL/K - 0.418mL/K}{0.402mL/K} \right| \times 100\%$

% Error = 0.016 x 100%

% Error = 1.6%

$T_2 = 5℃$

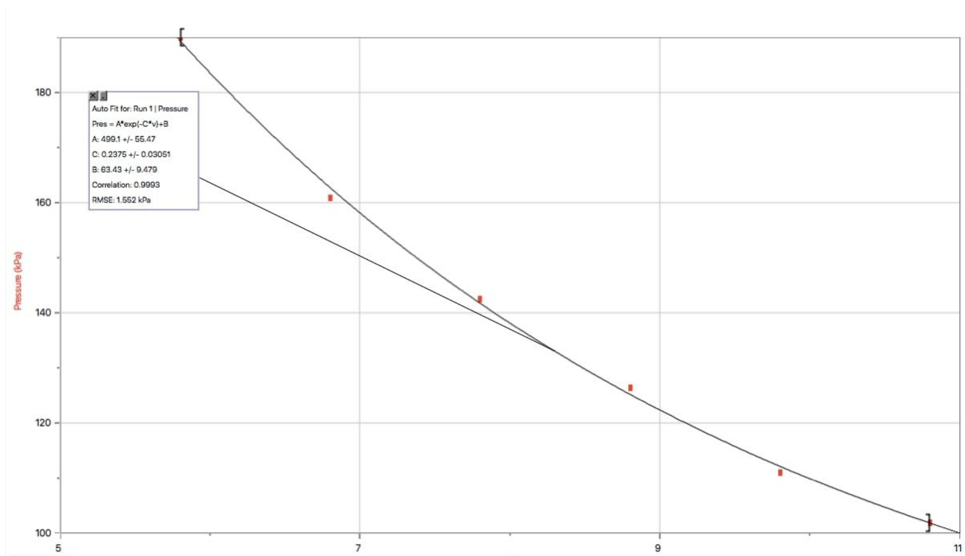
$T_2 = 278.15K$

Procedure:
As described in the lab manual (Verification of Gas Laws, T. S. Eliot)

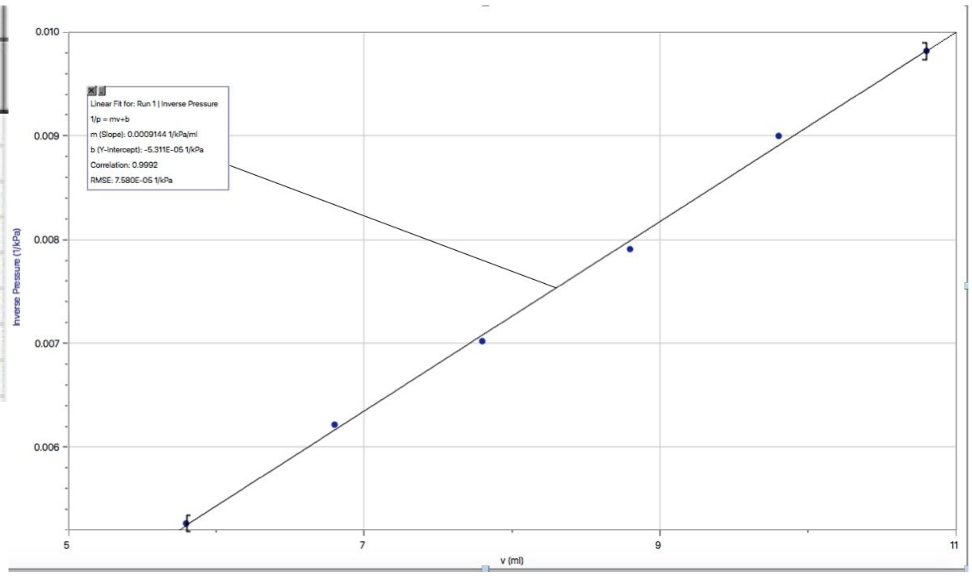
Data:
Boyle's Law

Volume (mL)	Pressure (kPa)
~~10.8~~	~~101.01~~
9.8	111.11
8.8	126.47
7.8	142.55
6.8	160.87
5.8	189.99
10.8	101.88

v (ml)	Pressure (kPa)
~~10.80~~	~~101.39~~
~~10.80~~	~~101.01~~
9.80	111.11
8.80	126.47
7.80	142.55
6.80	160.87
5.80	189.99
10.80	101.88



Run 1		
V (ml)	Pressure (kPa)	1/p (1/kPa)
~~10.80~~	~~101.39~~	
~~10.80~~	~~101.01~~	
9.80	111.11	0.009
8.80	126.47	0.008
7.80	142.55	0.007
6.80	160.87	0.006
5.80	189.99	0.005
10.80	101.88	0.010



Calculations / Data Analysis:

$P_1V_1 = (101.88\text{kPa})(10.8\text{mL}) = 1100.30$
$P_2V_2 = (111.11\text{kPa})(9.8\text{mL}) = 1088.88$
$P_3V_3 = (126.47\text{kPa})(8.8\text{mL}) = 1112.94$
$P_4V_4 = (142.55\text{kPa})(7.8\text{mL}) = 1111.89$
$P_5V_5 = (160.87\text{kPa})(6.8\text{mL}) = 1093.92$
$P_6V_6 = (189.99\text{kPa})(5.8\text{mL}) = 1101.94$

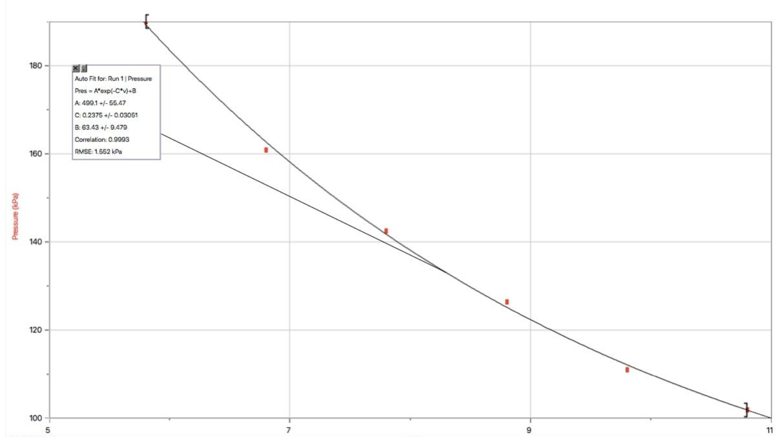
$\text{constant} = (P_1V_1 + P_2V_2 + P_3V_3 + P_4V_4 + P_5V_5 + P_6V_6) / 6$
$\text{constant} = 1101.65$
$\text{constant} = 1.1 \times 10^3$

1. In order to determine the constant one must calculate the PV value for each trial. Once that is complete, calculate the average by dividing the sum of all the PV values by the total number of PV values listed (in this case 6). That number will be the constant.
2. Boyle's Law completely relies on the temperature being constant, and that so makes the volume and pressure inversely related; when the volume increases the pressure decrease and vice versa. The equation for Boyle's Law is $P_1V_1 = P_2V_2$, considering the constant that is determined in this experiment, the equation would be $P_1V_1 = P_2V_2 = 1.1 \times 10^3$.
3. It is important to take multiple measurements of the same value because one may be more accurate than the other. For the volume 10.8 mL, the verdict is to use 101.88kPa as

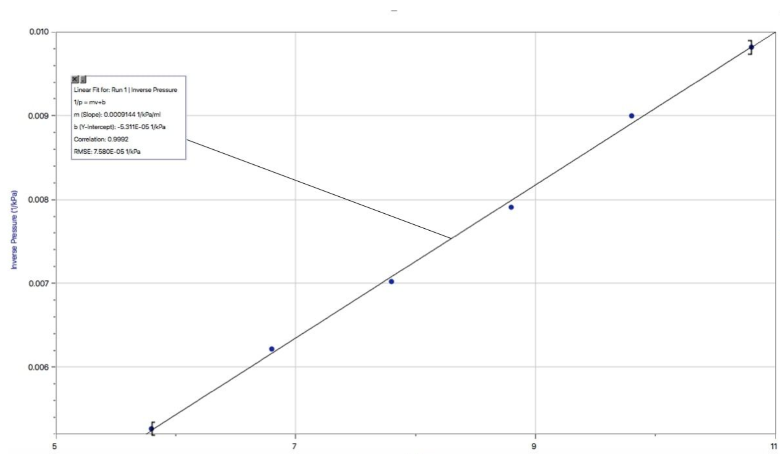
the pressure rather than 101.01kPa, this is due to the fact that when using LabQuest, the results are more stable with the reading of 101.88kPa rather than 101.01kPa. This made the decision clear that using 101.88kPa is the better choice due to its more precise reading.

4. The main condition that needs to be met is the temperature and how it must be constant. Boyle's law fully relies on the temperature being constant, if this is true then all measurements will be exact and precise. This is taken into consideration when following the procedures due to the fact that when conducting the lab, it is a given that not all conditions will be exact, especially temperature, and that will affect the results.
5.

v (ml)	Pressure (kPa)
~~10.80~~	~~101.39~~
~~10.80~~	~~101.01~~
9.80	111.11
8.80	126.47
7.80	142.55
6.80	160.87
5.80	189.99
10.80	101.88



Run 1		
v (ml)	Pressure (kPa)	1/p (1/kPa)
~~10.80~~	~~101.39~~	
~~10.80~~	~~101.01~~	
9.80	111.11	0.009
8.80	126.47	0.008
7.80	142.55	0.007
6.80	160.87	0.006
5.80	189.99	0.005
10.80	101.88	0.010



Discussion:

In this experiment, there are several sources of error that affect the results of the data collected.

When following the procedures for Charles' Law, a requirement is to measure the temperature of the ice bath, as well as the volume of the water in the Erlenmeyer flask. These measurements could not have been precise. When measuring the temperature of the ice bath during Trial 1, the temperature of the water was 5℃, this is very close to the maximum temperature which was 6℃, also the temperature went down to 3℃ rather than increase. The measurement of water is also another problem due to the fact that the finger was what was stopping the water from coming out. This affects the results of the experiment due to the fact that the beaker must be lifted slightly in order to stop it with the finger. This results in the measurements of the water being off. These results may have contributed to the percent error as a result of Trial 1.

The procedure for Boyle's Law have sources of error due to the fluctuating results given from the LabQuest. This is due to the temperature of the lab as well as other external forces that contribute to the pressure and volume of the syringe. These measurements resulted in the data being slightly off, which is why the plotted points on the graph was not completely linear.

Conclusion:

In this experiment we evaluated both Charles' and Boyle's Law and the factors that contributes to their results. The values that were obtained in the experiment resulted in a percent error of 4.7% in Trial 1 and 3.7% in Trial 2. It was determined that temperature plays a major role in both laws, and that it should always be taken accounted for when dealing with gases.

References:

Eliot, T. S. , "*Do I dare disturb the universe?", Verification of Gas Laws.*

Raw Data:

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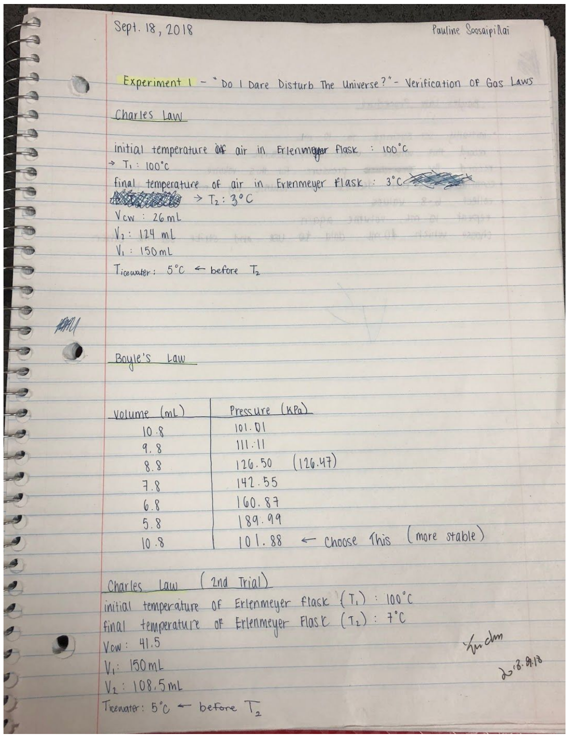

Sept. 18, 2018

Pauline Soosaipillai

Experiment 1 - "Do I Dare Disturb The Universe?" - Verification of Gas Laws

Charles Law

initial temperature of air in Erlenmeyer flask : 100°C
→ T_1 : 100°C
final temperature of air in Erlenmeyer flask : 3°C
→ T_2 : 3°C
V_{cw} : 26 mL
V_2 : 124 mL
V_1 : 150 mL
$T_{icewater}$: 5°C ← before T_2

Boyle's Law

Volume (mL)	Pressure (KPa)
10.8	101.01
9.8	111.11
8.8	126.50 (126.47)
7.8	142.55
6.8	160.87
5.8	189.99
10.8	101.88 ← Choose This (more stable)

Charles Law (2nd Trial)
initial temperature of Erlenmeyer flask (T_1) : 100°C
final temperature of Erlenmeyer Flask (T_2) : 7°C
V_{cw} : 41.5
V_1 : 150 mL
V_2 : 108.5 mL
$T_{icewater}$: 5°C ← before T_2

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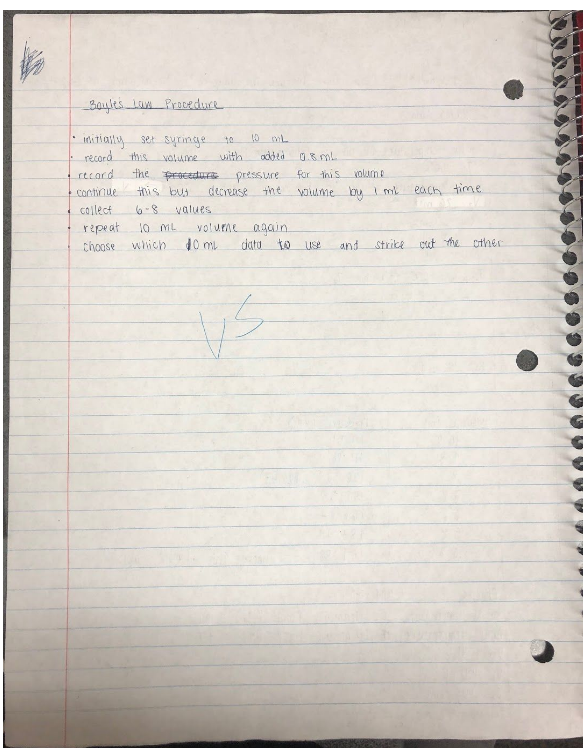
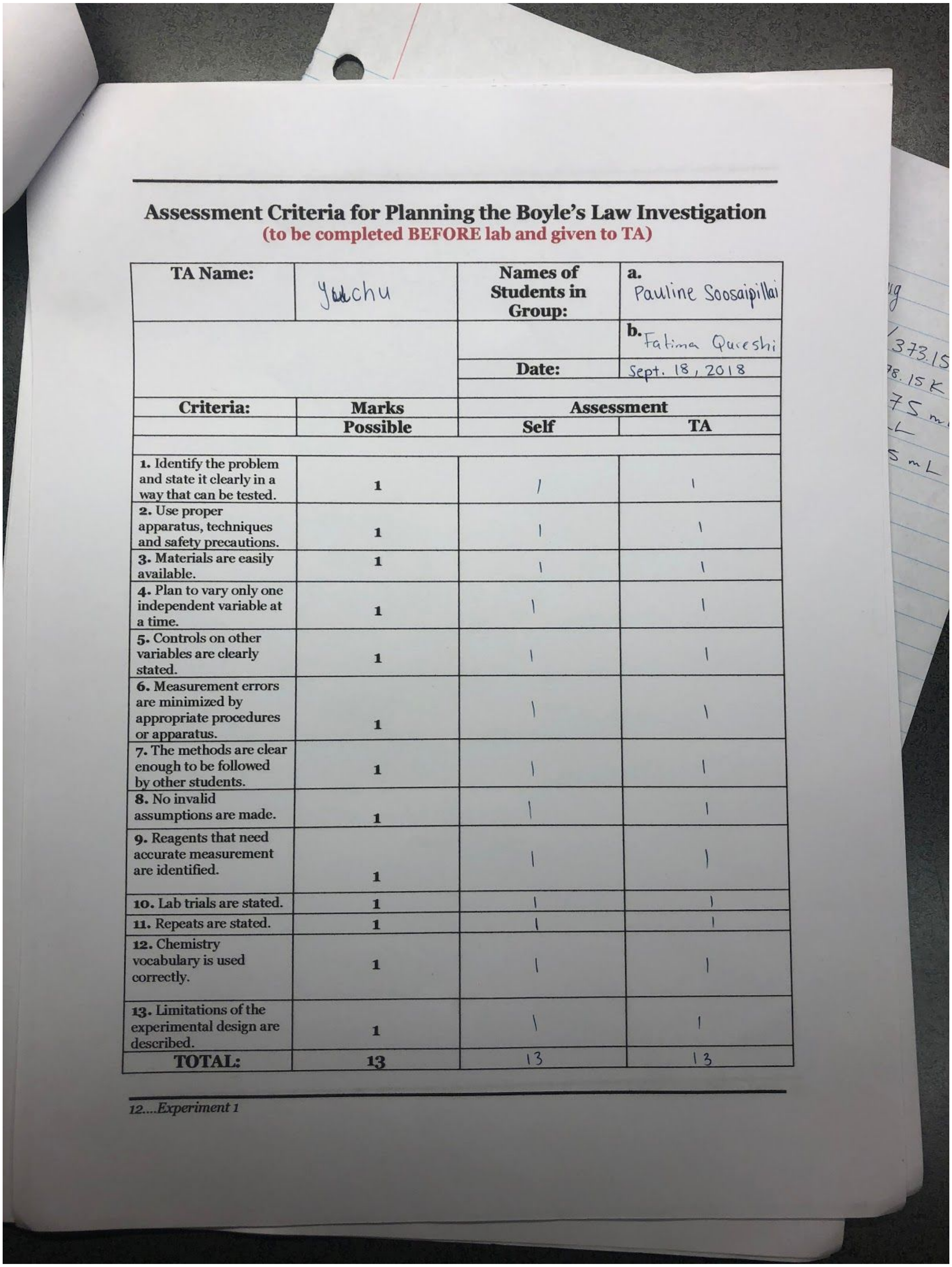


Boyle's Law Procedure

- initially set syringe to 10 mL
- record this volume with added 0.8 mL
- record the ~~procedure~~ pressure for this volume
- continue this but decrease the volume by 1 mL each time
- collect 6-8 values
- repeat 10 mL volume again
- choose which 10 mL data to use and strike out the other

VS

Assessment



Assessment Criteria for Planning the Boyle's Law Investigation
(to be completed BEFORE lab and given to TA)

TA Name:	Yuchu	**Names of Students in Group:**	**a.** Pauline Soosaipillai
			b. Fatima Qureshi
		Date:	Sept. 18, 2018
Criteria:	**Marks Possible**	**Assessment** Self	TA
1. Identify the problem and state it clearly in a way that can be tested.	**1**	1	1
2. Use proper apparatus, techniques and safety precautions.	**1**	1	1
3. Materials are easily available.	**1**	1	1
4. Plan to vary only one independent variable at a time.	**1**	1	1
5. Controls on other variables are clearly stated.	**1**	1	1
6. Measurement errors are minimized by appropriate procedures or apparatus.	**1**	1	1
7. The methods are clear enough to be followed by other students.	**1**	1	1
8. No invalid assumptions are made.	**1**	1	1
9. Reagents that need accurate measurement are identified.	**1**	1	1
10. Lab trials are stated.	**1**	1	1
11. Repeats are stated.	**1**	1	1
12. Chemistry vocabulary is used correctly.	**1**	1	1
13. Limitations of the experimental design are described.	**1**	1	1
TOTAL:	**13**	13	13

12....Experiment 1