Verification of gas laws

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September 26 2018

Introduction:

Gases

A gas is a state if matter consisting of particles that have no fixed shape nor volume. The particles are separated from each other and are always in constant random motion and collide with one another (1).

Ideal Gas

Since gases are so complicated and do not behave as expected, the ideal gas, a hypothetical gas, was composed to help model and predict the behaviour of real gasses (2). Ideal gases obey the two gas law. The first is that since the particles are so small and far apart, they have no volume. The second is that the gas molecules do not attract or repel each other as there is no force acting among them (2). The ideal gas law is modeled by the equation,

$$PV=nRT$$

The variables are pressure (P), volume (V), number of moles (n), gas constant (R), and temperature (T). The pressure is measured in pascals (Pa)(also expressed as N/m^2), volume in meters cubed (m^3), moles in moles (calculated by mass/molar mass), temperature in Kelvin (K) and gas constant (8.314) measured in J / mol.

The ideal gas law is a combination of Boyle's Law, Charles' Law and Avogadro's Law. Knowing these simple gas laws will help to better understand the ideal gas law.

Charles' Law

Charles's Law describes how the volume of the gas changes with the temperature when the pressure is held constant. This theory was first suggested by Jacques Alexandre Charles and was later further explored and developed by John Dalton and Joseph Louis Gay-Lussac (4). Charles's law helps to describes how gases tend to expand when heated and contract when cooled. In other words, volume (V) is directly proportional temperature in Kelvin (K) when the pressure is constant (3). This relationship is expressed in the following equation where k is the constant:

$$V/T=k$$

Boyle's Law

Boyle's Law states that at a constant temperature, the pressure (P) of a given volume of gas varies inversely with its volume (V) (5). This relationship is expressed in the following equation where k is the constant:

$$PV=k$$

Procedure:

Verification of Charles' Law

As described in the lab manual (6).

Verification Boyle's law

1) Connect Gas Pressure Sensor to LabQuest 2.
2) Move the 20 mL syringe to 12 mL initial volume
3) Set up LabQuest 2 data-collection mode
4) Start data collection, measuring the pressure (KPa) in the syringe at (12,10,8,7,9,11,13,15,12) mL
5) Decided which measurement at the original volume (12 ml) to keep
6) Analyze the graph of your variables to determine the mathematical relationship

Materials:

Charles' Law	Boyle's Law
125 mL Erlenmeyer flask 1L or 600mL Beaker Stopper with hole Thermometer Ice bath Extension clamp Hot plate Graduated cylinder	LabQuest 2 Vernier Gas Pressure Sensor 20 mL gas syringe USB key

Data and Observations:

Qualitative Observations:

Charles' Law	Boyle's Law
Water began to bubble around 86.0℃ Water reached a full boil at 99.0℃ Condensate/steam around erlimyer flask	As the volume of air in 20 mL syringe gets smaller-there is more force pushing against my hand As the volume of the air in 20 mL syringe gets bigger-there is less force pushing against my hand

Quantitative Observations:

Charles' Law

Temperature of boiling water after 6 minutes = T_1
Temperature of ice bath = T_2
Volume of water that is in Erlenmeyer flask = Vcw
Total volume of Erlenmeyer flask = V_1
Volume occupied by the gas at T_2 = V_2

Test #1
T_1=99.0℃
T_2=4.0℃
Vcw=13 mL
V_1=159 mL

A mistake was made in our data collection of Vcw, a lot of water was spilt when pouring water from the erlenmeyer flask to the graduated cylinder-leading to inaccurate results.

Test #2
T_1=101.0℃
T_2=2.0℃
Vcw=29 mL

V_1=155.4 mL

<u>Test #3</u>
T_1=101.0℃
T_2=3.5℃
Vcw=31 mL
V_1=160.8 mL

Calculations:

Solve for	Trail #2	Trial #3
V_2	V_2=V_1- Vcw =(155.4 mL) - (29 mL) =126.4 mL	V_2=V_1- Vcw =(160.8 mL) - (31 mL) =129.8 mL
K (kelvin)	T_1: 101.0℃ 101.0℃ + 273.15=374.15 K T_2: 2.0℃ 2.0℃ + 273.15= 275.15 K	T_1=101.0℃ 101.0℃ + 273.15 = 374.15 T_2: 3.5℃ 3.5 + 273.15=276.65 K
V/T=***k***	<u>Gas and heat:</u> T_1: 374.15 K V_1=155.4 mL V/T=k k = (155.4 mL) / (374.15 K) = 0.41534144 = 0.4153 <u>Gas and cold:</u> T_2:275.15 K V_2:126.4 mL	<u>Gas and heat:</u> T_1= 374.15 K V_1=160.8 mL V/T=k k = (160.8 mL) / (374.15 K) = 0.42977415 = 0.4298 <u>Gas and cold:</u> T_2:276.65 K V_2:129.8 mL

	V/T=k k = (126.4 mL) / (275.15 K) = 0.45938579 = 0.4594	V/T=k k = (129.8 mL) / (276.65 K) = 0.46918489 = 0.4692

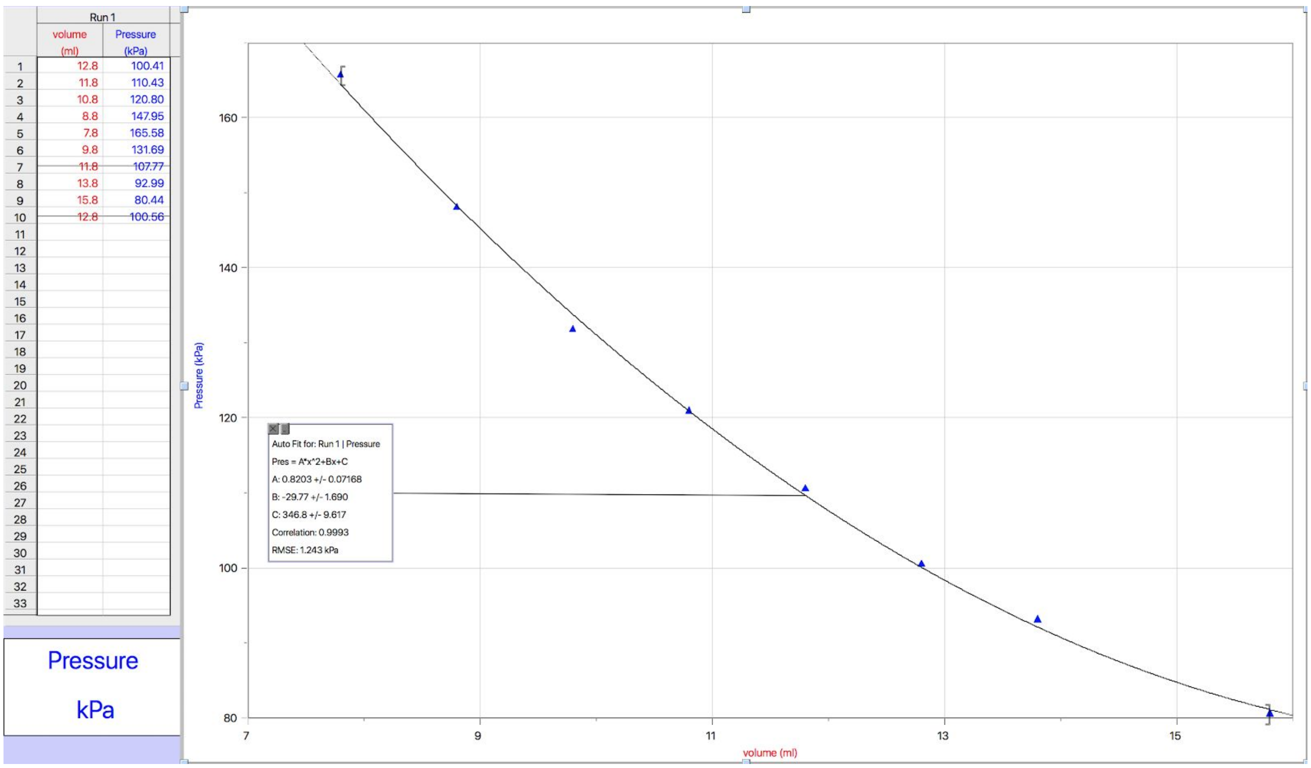
Boyle's Law

Volume (mL)	Pressure (KPa)
12.8	100.50
10.8	120.57
8.8	146.70
7.8	165.65
9.8	131.35
11.8	110.26
13.8	92.93
15.8	80.45
12.8	100.47

Calculations:

PV= k
(100.41 KPa)(12.8 mL) =1285.248
(110.43 KPa)(11.8 mL) =1303.074
(120.80 KPa)(10.8 mL) =1304.64
(147.95 KPa)(8.8 mL) =1301.96

(165.58 KPa)(7.8 mL) =1291.524
(131.69 KPa)(9.8 mL) =1290.562
(92.99 KPa)(13.8 mL) =1283.262
(80.44 KPa)(15.8 mL) =1270.952



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(3) Verification Of Gas Laws, T.S.Eliot, Experiment 1, Page 2-5
(4) https://www.britannica.com/science/Charless-law, The Editors of Encyclopaedia Britannica, Encyclopaedia Britannica
(5)https://www.britannica.com/science/Boyles-law, The Editors of Encyclopaedia Britannica, Encyclopaedia Britannica
(6)Verification Of Gas Laws, T.S.Eliot, Experiment 1, Page 7-8