Lab 2 - Investigation of the Relationship between Volume and Temperature

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1 Pre-Lab

1.1 Purpose

1. Identify the relationship between volume and temperature.
2. Investigate some properties of a gas (air).
3. Use a Bunsen burner.
4. Convert pressure and temperature values of different units.

1.2 Definitions

Volume - The three-dimensional space occupied by a solid, liquid, or gas.

Temperature - Property of matter that is a measure of the kinetic energy of its particles; measure of heat or cold.

Pressure - Measure of force per unit area.

Gas - A state of matter characterized by having neither a defined shape nor defined volume.

Direct Relationship - When one variable increases, so does the other.

Indirect Relationship - When one variable increases, the other decreases.

1.3 Equations

Charles' Law states:

1. V and T are directly proportional when n and P are constant.
2. Must convert temperatures to Kelvin

$$Charles'Law = \frac{Volume}{Temperature} = Constant \tag{1}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \tag{2}$$

$$\frac{x}{y} = \frac{V_2}{T_2} \tag{3}$$

Conversion to torr: 1 mm of Hg = 1 torr

Pressure of the "assigned system," dry air = barometric pressure (torr) - vapor pressure of water at the measured temperature of the system's water bath (torr)

Volume of the "assigned system," wet air = volume of hot dry air - volume of water in flask.

Volume of the "assigned system," dry air (to adjust for the vapor pressure) = (volume of "system", wet air) * ($\frac{\text{pressure of "system", dry air}}{\text{barometric pressure}}$)

Will need table of vapor pressure of water at different temperature conditions. (Found on page A-20 of appendix in the 6th edition of text book.)

$$\text{Best fit line} = \frac{Y_2 - Y_1}{X_2 - X_1} \tag{4}$$

2 Flowcharts

Please see the following page for flowchart.

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PART ONE

3 Waste Collection

Dispose of solution down the sink.

4 Declaration of Academic Integrity

I certify that this is my own work and I understand that if I am found to be in violation of the honor code, I will be subject to the highest penalty.

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3 Calculations

3.1 Trial 1

Pressure of the "assigned system," dry air = barometric pressure (torr) - vapor pressure of water at the measured temperature of the system's water bath (torr)

Barometric pressure = 764.5 torr

Vapor pressure (0°C) = 4.6 torr

764.5 torr - 4.6 torr = 759.9 torr

Pressure of cold, dry air = 759.9 torr

Volume of the "assigned system," wet air = volume of hot dry air - volume of water in flask.

Volume of hot dry air = 152.5 mL

Volume of water in flask = 51 mL

152.5 mL - 51 mL = 101.5 mL

Volume of cold, wet air = 101.5 mL

Volume of the "assigned system," dry air (to adjust for the vapor pressure) = (volume of "system", wet air) * $\left(\frac{\text{pressure of "system", dry air}}{\text{barometric pressure}}\right)$

Volume of cold, wet air = 101.5 mL

Pressure of cold, dry air = 759.9 torr

Barometric pressure = 764.5 torr

$$101.5 \text{ mL} * \frac{759.9 \text{ torr}}{764.5 \text{ torr}} = 100.89 \text{ mL}$$

Volume of cold, dry air = 100.89 mL

3.2 Trial 2

Pressure of the "assigned system," dry air = barometric pressure (torr) - vapor pressure of water at the measured temperature of the system's water bath (torr)

$$\text{Barometric pressure} = 764.5 \text{ torr}$$

$$\text{Vapor pressure } (0°C) = 4.6 \text{ torr}$$

$$764.5 \text{ torr} - 4.6 \text{ torr} = 759.9 \text{ torr}$$

$$\text{Pressure of cold, dry air} = 759.9 \text{ torr}$$

Volume of the "assigned system," wet air = volume of hot dry air - volume of water in flask.

$$\text{Volume of hot dry air} = 152.5 \text{ mL}$$

$$\text{Volume of water in flask} = 110 \text{ mL}$$

$$152.5 \text{ mL} - 110 \text{ mL} = 42.5 \text{ mL}$$

$$\text{Volume of cold, wet air} = 42.5 \text{ mL}$$

Volume of the "assigned system," dry air (to adjust for the vapor pressure) = (volume of "system", wet air) * $\left(\frac{\text{pressure of "system", dry air}}{\text{barometric pressure}}\right)$

$$\text{Volume of cold, wet air} = 42.5 \text{ mL}$$

$$\text{Pressure of cold, dry air} = 759.9 \text{ torr}$$

$$\text{Barometric pressure} = 764.5 \text{ torr}$$

$$42.5 \text{ mL} * \frac{759.9 \text{ torr}}{764.5 \text{ torr}} = 42.24 \text{ mL}$$

$$\text{Volume of cold, dry air} = 42.24 \text{ mL}$$

3.3 Averages

$$\text{Average volume of hot, dry air} = \frac{152.5 \text{ mL} + 152.5 \text{ mL}}{2} = 152.5 \text{ mL}$$

$$\text{Average volume of cold, dry air} = \frac{100.89 \text{ mL} + 42.24 \text{ mL}}{2} = 71.57 \text{ mL}$$

G. C. 2-2: LABORATORY REPORT

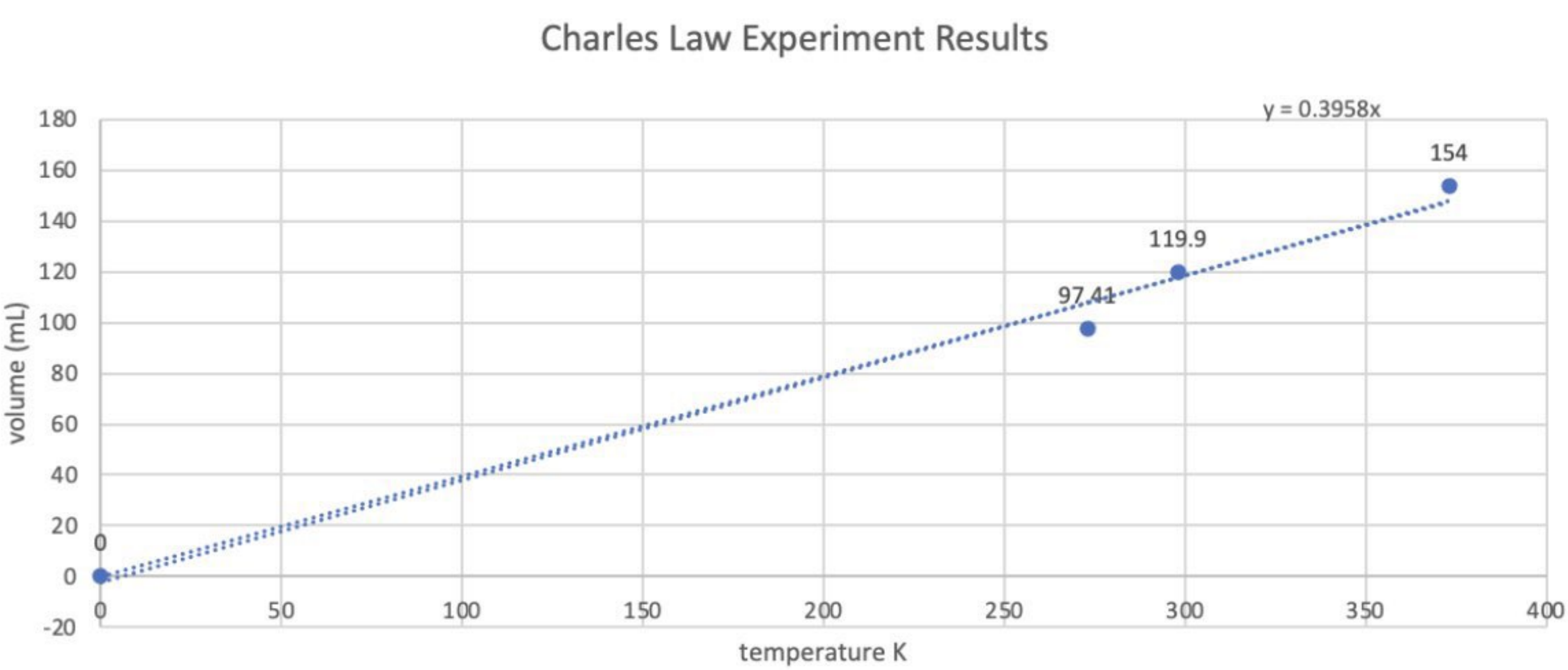
Name: Morgan Benavidez

Lab partner: Felicia Pisacano Assigned system Cold

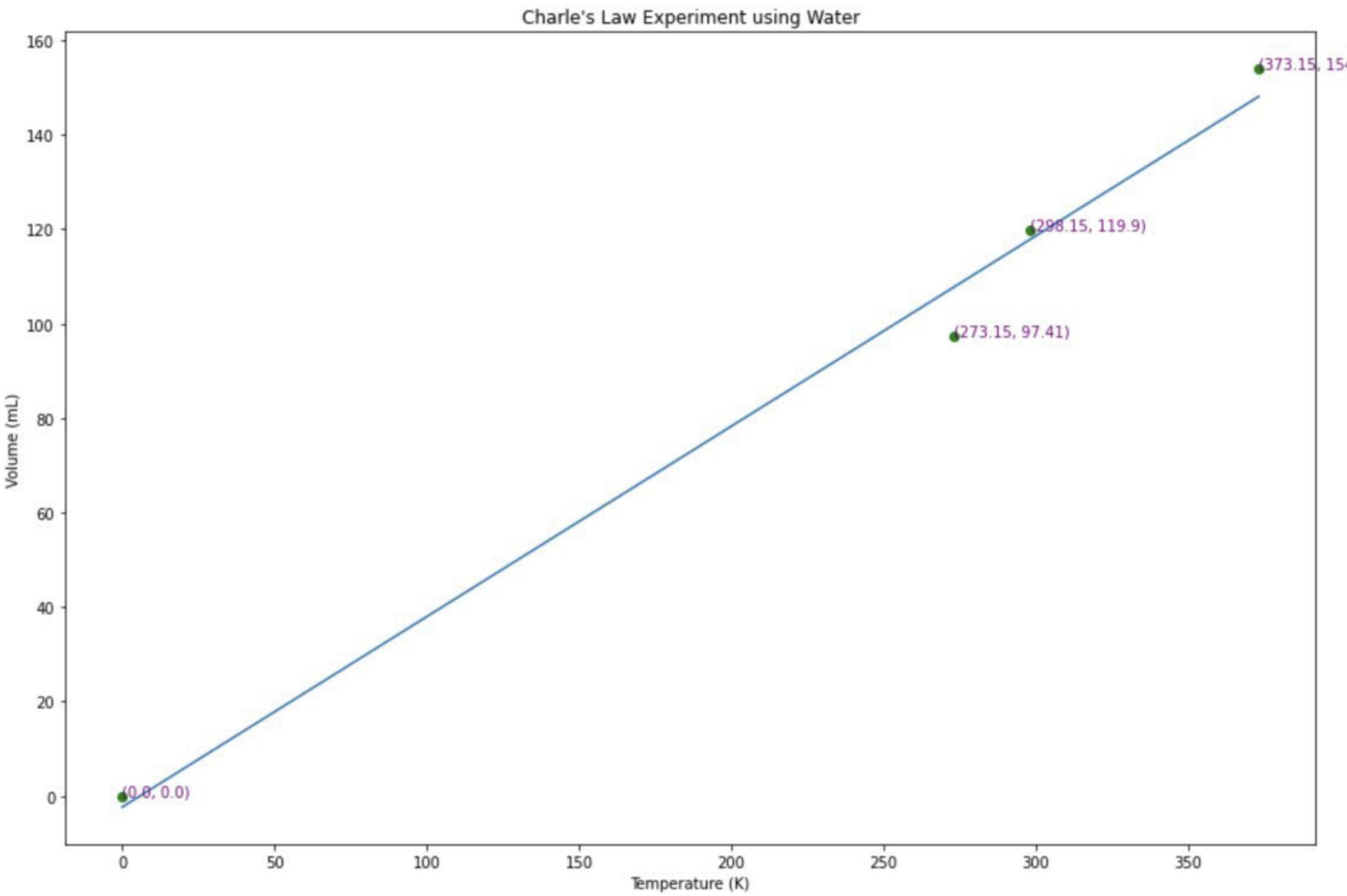
YOU MUST SHOW ALL YOUR CALCULATIONS TO RECEIVE CREDIT FOR THEM!

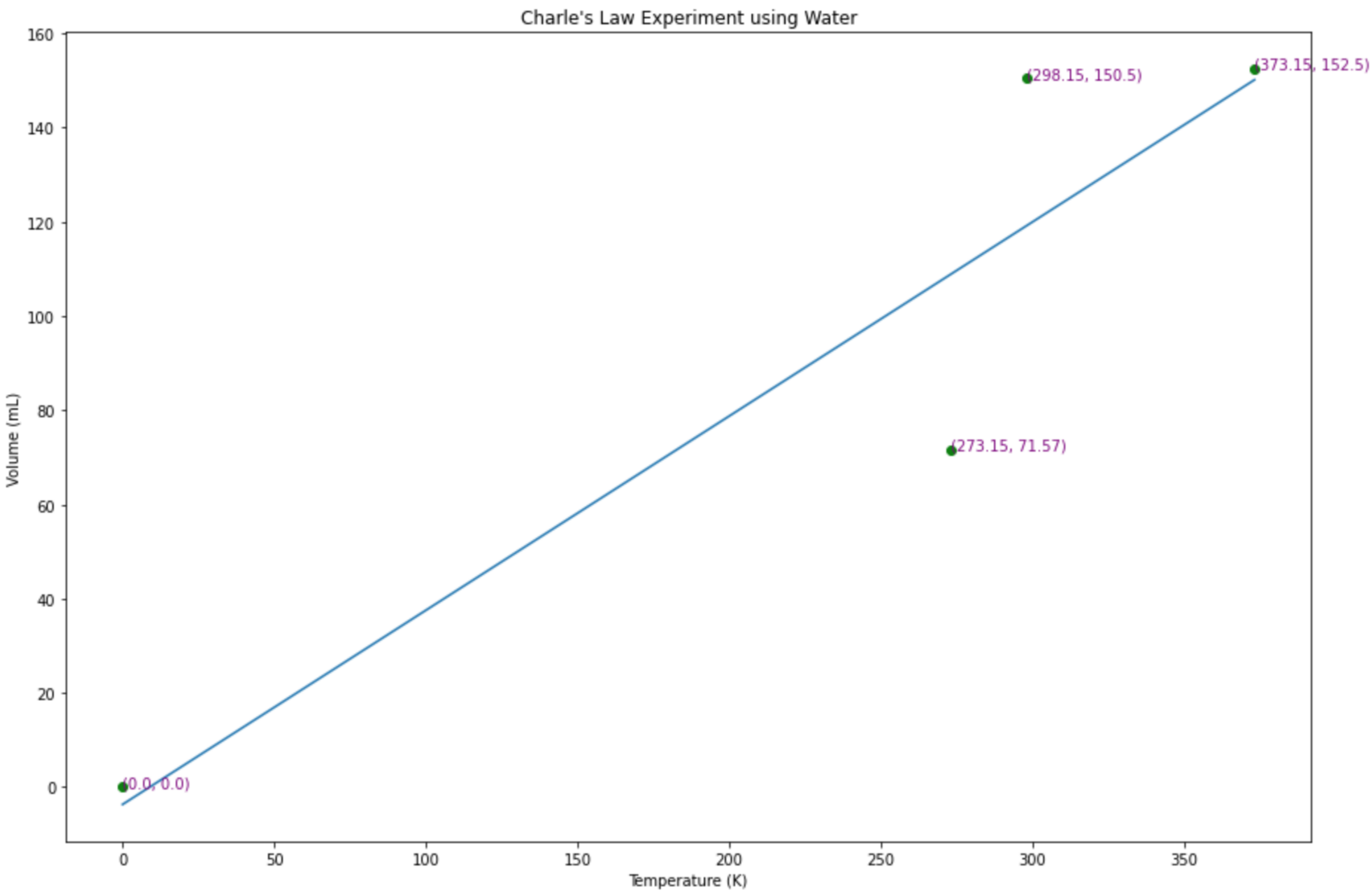
Proper use of significant figures and units is part of the grading.

Measurements	Trial No. 1	Trial No. 2
Temperature of Cold water bath, °C Room Temp/Cold*	0° C	0° C
Temperature of Cold water bath, K	273 K	273 K
Volume of water in the flask	51 mL	110 mL
Temperature of hot water bath, °C	98.5 °C	101 °C
Temperature of hot water bath, K	371.5 K	374 K
Volume of hot dry air	152.5 mL	152.5 mL
Average volume of hot dry air	152.5 mL	
Barometric pressure, mm of Hg (From TA)	764.5 mmHg	764.5 mmHg
Barometric pressure; torr	764.5 torr	764.5 torr
Pressure of cold dry air, torr	759.9 torr	759.9 torr
Volume of cold, wet air	101.5 mL	42.5 mL
Volume of cold, dry air	100.89	42.24
Average volume of Cold, dry air	71.57	
Temperature of Room water bath, **from lab partner**	26°C	
Average volume of Room dry air, **from lab partner**	150.5 mL	
Circle your system: Room Temp (RT) Cold		

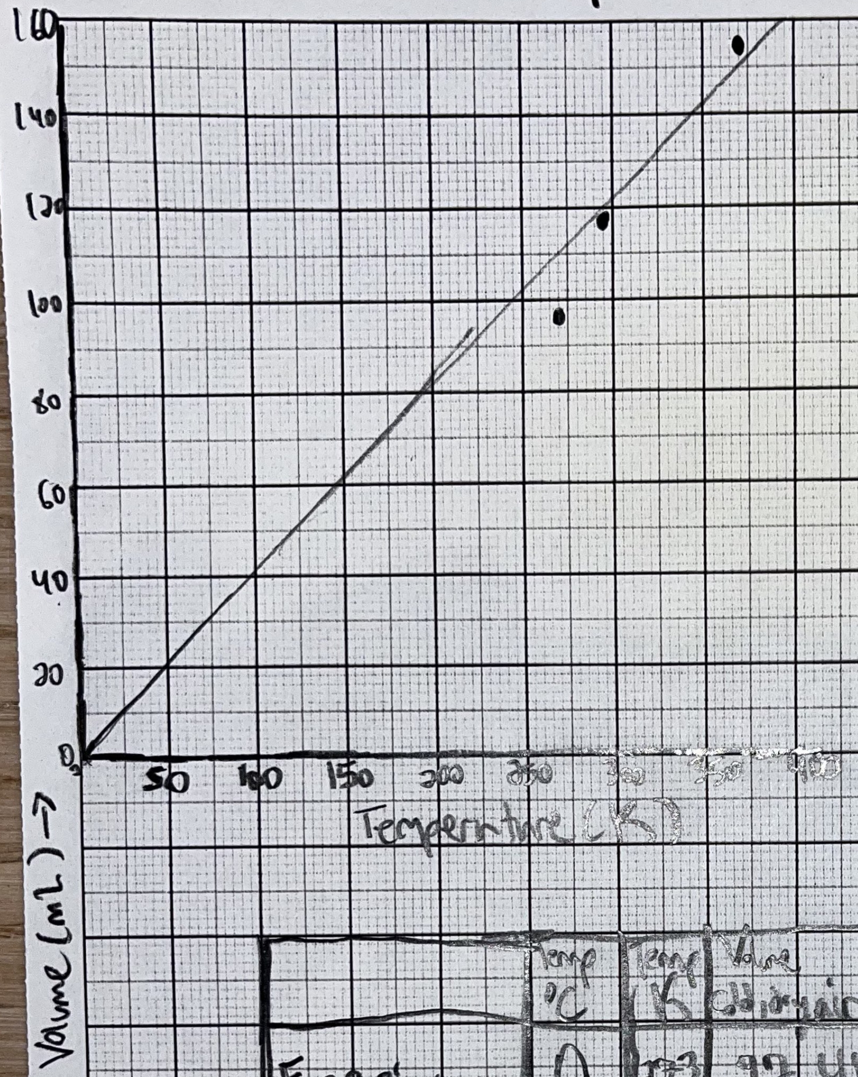


Charles Law Experiment Results
y = 0.3958x
154
119.9
97.41
0
volume (mL)
temperature K
180
160
140
120
100
80
60
40
20
0
-20
0
50
100
150
200
250
300
350
400


Charle's Law Experiment using Water
Volume (mL)
Temperature (K)
0
20
40
60
80
100
120
140
160
50
150
200
250
300
350
(0.0, 0.0)
(273.15, 97.41)
(298.15, 119.9)
(373.15, 154.0)


Charle's Law Experiment using Water
Volume (mL)
Temperature (K)
(0.0, 0.0)
(273.15, 71.57)
(298.15, 150.5)
(373.15, 152.5)
0
20
40
60
80
100
120
140
160
0
50
100
150
200
250
300
350

Charles Law Experiment with Water



	Temp °C	Temp K	Volume (mL) of air
Freezing	0	273	97.41
Room	25	298	119.9
Boiling	100	373	159

Vapor Pressure of Water at Various Temperatures

Table 15 Vapor Pressure of Water at Various Temperatures

Temperature (°C)	Vapor Pressure (torr)	Temperature (°C)	Vapor Pressure (torr)	Temperature (°C)	Vapor Pressure (torr)	Temperature (°C)	Vapor Pressure (torr)
−10	2.1	21	18.7	51	97.2	81	369.7
−9	2.3	22	19.8	52	102.1	82	384.9
−8	2.5	23	21.1	53	107.2	83	400.6
−7	2.7	24	22.4	54	112.5	84	416.8
−6	2.9	25	23.8	55	118.0	85	433.6
−5	3.2	26	25.2	56	123.8	86	450.9
−4	3.4	27	26.7	57	129.8	87	468.7
−3	3.7	28	28.3	58	136.1	88	487.1
−2	4.0	29	30.0	59	142.6	89	506.1
−1	4.3	30	31.8	60	149.4	90	525.8
0	4.6	31	33.7	61	156.4	91	546.1
1	4.9	32	35.7	62	163.8	92	567.0
2	5.3	33	37.7	63	171.4	93	588.6
3	5.7	34	39.9	64	179.3	94	610.9
4	6.1	35	42.2	65	187.5	95	633.9
5	6.5	36	44.6	66	196.1	96	657.6
6	7.0	37	47.1	67	205.0	97	682.1
7	7.5	38	49.7	68	214.2	98	707.3
8	8.0	39	52.4	69	223.7	99	733.2
9	8.6	40	55.3	70	233.7	100	760.0
10	9.2	41	58.3	71	243.9	101	787.6
11	9.8	42	61.5	72	254.6	102	815.9
12	10.5	43	64.8	73	265.7	103	845.1
13	11.2	44	68.3	74	277.2	104	875.1
14	12.0	45	71.9	75	289.1	105	906.1
15	12.8	46	75.7	76	301.4	106	937.9
16	13.6	47	79.6	77	314.1	107	970.6
17	14.5	48	83.7	78	327.3	108	1004.4
18	15.5	49	88.0	79	341.0	109	1038.9
19	16.5	50	92.5	80	355.1	110	1074.6
20	17.5						

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Discussion and Conclusion

The major concepts covered in this experiment was investigating Charles's Law and the relationship between volume and temperature of a gas at constant pressure. The experimental relationship I found between volume and gas was a direct relationship. You can see this in the graphs I generated using both Excel and Python. As temperature increases, so does the volume. You can also look at it as if volume increases, so does temperature.

The direct relationship that I determined does in fact hold true with Charles's discoveries. Charles Law states "that if a given quantity of gas is held at a constant pressure, its volume is directly proportional to the Kelvin temperature." (Kotz, Treichel)

I had to calculate volume of dry, cold air to consider the differing pressures of the system at different temperatures. I then used the average volume cold, dry air along with the cold, dry air figures from the other two systems to plot. I created two graphs, one using the data I just mentioned and another with the volumes given by the TA for what the volumes should have been.

When the temperature is increased, the kinetic energy of the gas particles is increased. When the temperature is decreased, the kinetic energy of the gas particles decreases. After a certain point of cooling, the gas will become a liquid.