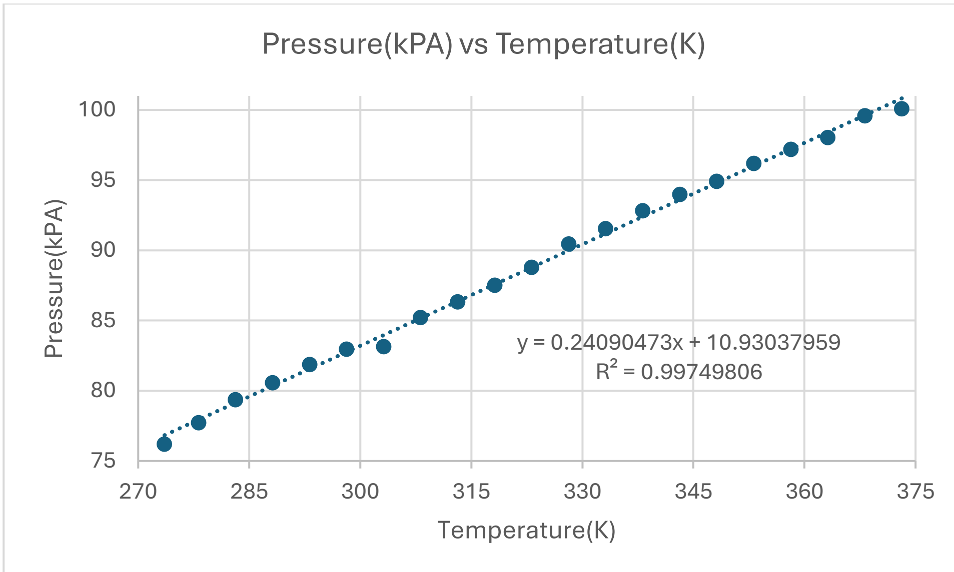
Pressure and Temperature

1. Insert a table of your pressure and temperature data. This table should include pressure, 1/pressure, temperature in Celsius, temperature in Kelvin, and 1/temperature in Kelvin.

Table 1. Pressure(kPa), 1/Pressure(1/kPa), Temperature(C), Temperature(K), 1/Temperature(K)

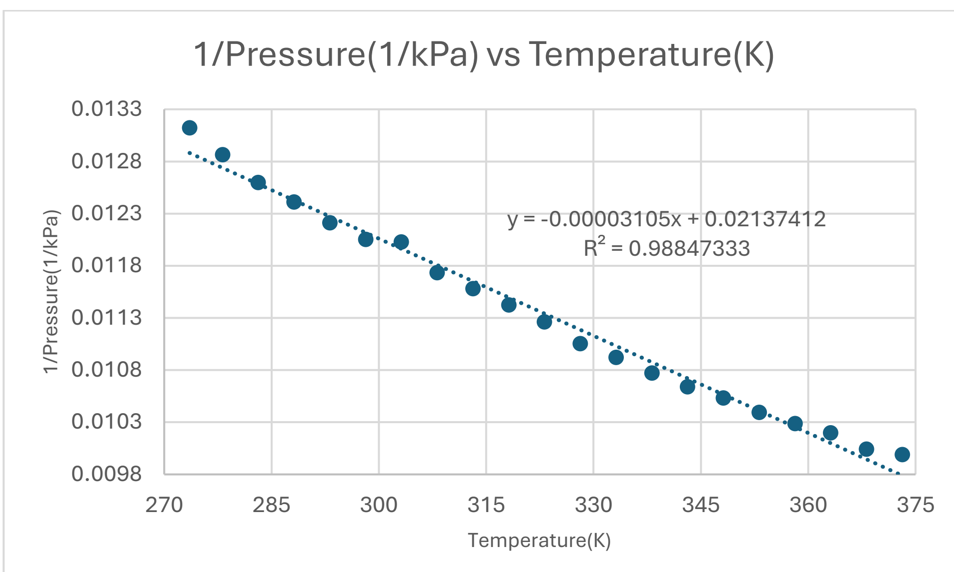
Pressure(kPa)	1/Pressure(1/kPa)	Temperature(C)	Temperature(K)	1/ Temperature(1/K)
100.08	0.009992066	100.0	373.15	0.002679
99.57	0.010042182	95.0	368.15	0.002715
98.04	0.010200	90.0	363.15	0.002754
97.20	0.010288	85.0	358.15	0.002792
96.19	0.010396	80.0	353.15	0.002832
94.92	0.010535	75.0	348.15	0.002872
93.98	0.010641	70.0	343.15	0.002915
92.82	0.010774	65.0	338.15	0.002957
91.55	0.010923	60.0	333.15	0.003003
90.45	0.011056	55.0	328.15	0.003047
88.78	0.011264	50.0	323.15	0.003096
87.51	0.011427	45.0	318.15	0.003142
86.34	0.011582	40.0	313.15	0.003194
85.21	0.011736	35.0	308.15	0.003246
83.13	0.012029	30.0	303.15	0.003299
82.95	0.012055	25.0	298.15	0.003355
81.87	0.012214	20.0	293.15	0.003411
80.57	0.012412	15.0	288.15	0.003471
79.36	0.012601	10.0	283.15	0.003532
77.73	0.012865	5.0	278.15	0.003596
76.20	0.013123	0.4	273.55	0.003656

2. Insert a graph of pressure vs temperature (in K).



Graph 1. Pressure vs Temperature(K)

3. Insert a graph of 1/pressure vs temperature in K.



Graph 2. 1/Pressure(1/kPa) vs Temperature(K)

4. Using your data, explain whether pressure and temperature are directly or inversely proportional.

Pressure and Temperature are directly proportional because the graph of Pressure vs Temperature shows a linear line, while inverse graph of 1/Pressure vs Temperature shows a linear relationship, but negatively. This is shown as one variable increases, so does the other.

5. Using the plot that best describes the relationship between pressure and temperature, predict what the pressure (in kPa) of the system would be if the temperature of your system was 200 °C. Show all your work for full credit.

Y = 0.24090473X + 10.93037959

X = (Temp(c) + 273.15)

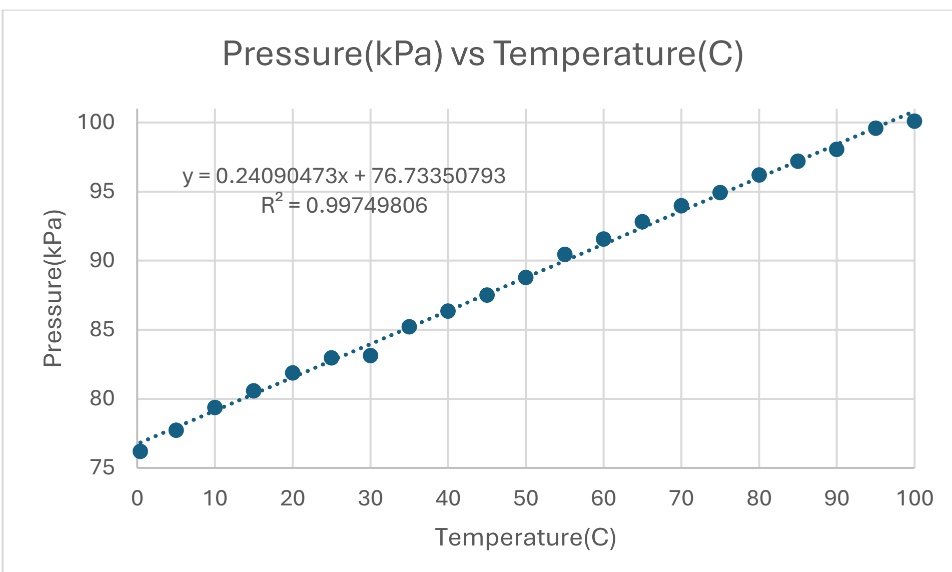
X = 473.15

Y = 0.24090473(473.15) + 10.93037959

Y = 124.91445259

So the pressure would be 124.91445259 kPA.

6. Insert a graph of pressure vs temperature in Celsius.



Graph 3. Pressure(kPa) vs Temperature(C)

7. Calculate the value of absolute zero (in Celsius) based on your data. Show all work for full credit.

$y = 0.24090473x + 76.73350793$

$0 = 0.24090473(temp_{abs\_zero}) + 76.73350793$

$-76.73350793 / 0.24090473 = temp_{abs\_zero}$

$temp_{abs\_zero} = -318.51$ C

8. Is your value in agreement with the known value of absolute zero? What are some factors of this experiment that could cause a deviation?

My value of -318.51 C is less than the known value of absolute zero, -273.15 C or 0 K. Some factors that may have caused this deviation is that the air that we used was not exactly ideal and the machine error that may have occurred. So the air that we used, wasn't exactly pure oxygen, as it was a blend of O_2 and CO_2 and isn't in any way an ideal gas. But we assumed the air was ideal (PV= nRT), so we're not going to get a very exactly precise absolute zero temperature. Other factors being that our pipes may leak over time, our sensors aren't giving us precise, accurate readings. These issues can shift the line of best fit up so that our x intercept becomes more negative. This makes sense in our instance, as -318.51 is more negative than true absolute zero. The temperature sensor not reading exactly the true temperature, and either the temperature of the beaker, or the ice at contact may also have caused the obtained values to not be precise.

9. Explain the pressure-temperature relationship using the concepts of molecular velocity and molecular collisions.

   Molecular velocity is directly proportional to temperature. If a substance becomes hotter and increases in temperature, the individual molecules' velocities are higher, and this means the faster particles are striking the walls of the container faster and with more force, this leads to an increase in pressure, due to the equation for Pressure being $P = \frac{F}{A}$

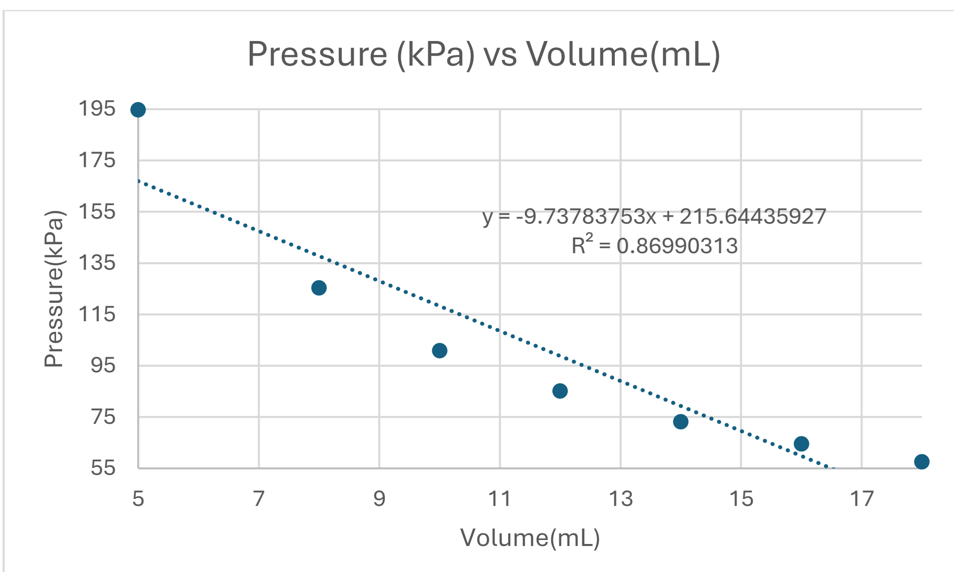
Pressure and Volume

10. Insert a table of your pressure and volume data. This table should include pressure, 1/pressure, and volume in mL.

Table 2. Pressure(kPa), 1/Pressure(kPa), Volume(mL)

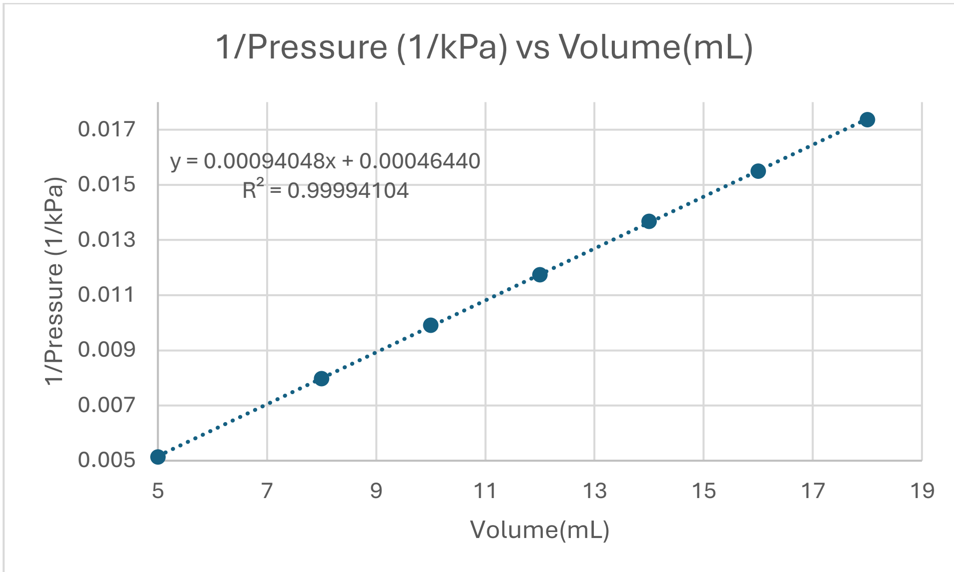
Pressure(kPa)	1/Pressure(1/kPa)	Volume(mL)
194.7	0.0051361	5
125.33	0.0079789	8
100.87	0.0099138	10
85.13	0.011747	12
73.11	0.013678	14
64.53	0.015496	16
57.6	0.017361	18

11. Insert a graph of pressure vs volume.



Graph 4. Pressure(kPa) vs Volume(mL)

12. Insert a graph of 1/pressure vs volume.



Graph 5. 1/Pressure (1/kPa) vs Volume(mL)

13. Using your data, explain whether pressure and volume are directly or inversely proportional.

Pressure vs Volume, we can see that it's an inverse relationship, because the graph of P/V shows a downwards trend. When compared to the 1/P vs V graph, we see that the inverse has basically linearized the data, and has a much better linear fit, given the almost 1 R^2 value.

14. Using the plot that best describes the relationship between pressure and volume, predict what volume (in mL) would result in a pressure of 10.0 kPa. Show all your work for full credit.

y = 0.00094048x + 0.00046440

1/10.0 = 0.00094048x + 0.00046440

.1 – 0.00046440 = 0.00094048x

X = (.1 – 0.00046440) / 0.00094048

X = 105.85 mL

15. Explain the pressure-volume relationship using the concepts of molecular velocity and molecular collisions.

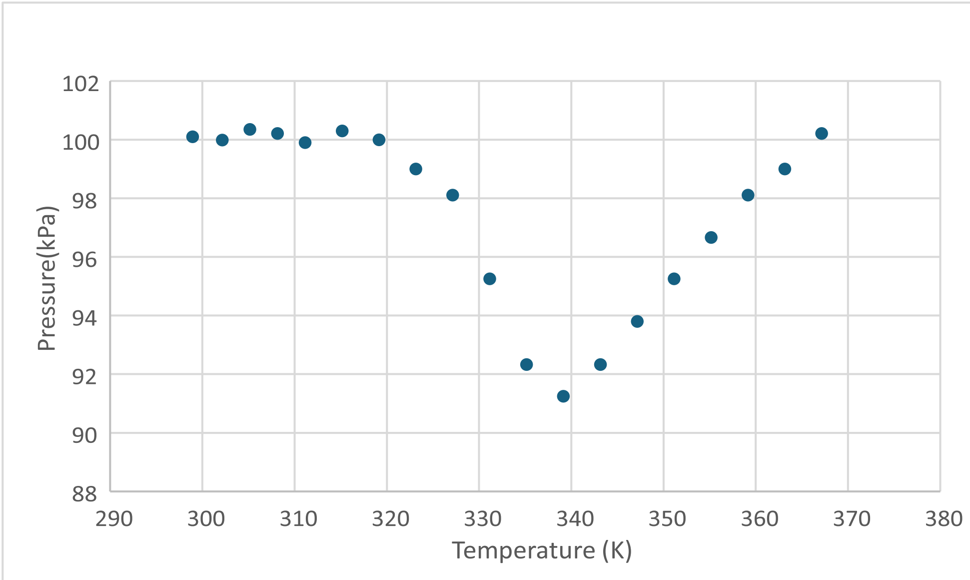
If we already stated and understand that Pressure is caused by molecules hitting the walls of a container, reducing the volume and size of the container effectively reduces the area that the molecules can strike, meaning more molecules are likely to cover the smaller area more often, as they have to travel less, and reach smaller distances. But if we expanded the volume, keeping n,T constant, than the molecules have to travel farther, and cover more surface area, meaning that they hit the container walls much less, meaning that Pressure is decreasing. So as volume increases, pressure decreases, indicating a inverse relationship.

Conceptual Understanding

16. You performed this experiment using air, which we know is a mixture of several gases. Would the results of this experiment be improved if we used a sample of pure nitrogen? Why or why not?

N_2 Gas is much more of a truly idea gas, as compared to air. The air we use in our experiments is a solution of many gases, and is in no way ideal. However, if we used an ideal gas like N_2, we'd be able to get much more accurate experiment results, as ideal gases follow the law of $PV = nRT$ much better than regular gases, meaning that we would have gotten better sample data, and most likely more accurate calculations, especially for the absolute zero calculation.

17. A student plots their data after performing this experiment and has the following graph. They checked that the pressure and temperature probe were properly calibrated and functioning properly. What happened during the experiment to cause this? Explain in great detail (think molecular level) what is happening at the beginning, middle, and end of the experiment. Use your knowledge of Kinetic molecular theory.



Pressure (kPa) vs Temperature (K)

Figure 1. Empirical relationship between pressure and temperature. But the end looks a little funky.

The beginning of the experiment starts at approximately 370 kelvin, and the student started to put in ice, to cool down the water, and slow down the molecules as temperature decreased, leading to pressure decreasing. We see a direct, linear proportion until 340K. But using our equation PV=nRT, the cork or the pipes or the stopper or something must have loosened, letting our enclosed vial of air escape, and even though the student kept putting in ice to cool down the beaker, the pressure slowly came back to atmospheric pressure.

Lab Notebook Pages

Attach **ALL** lab notebook pages for this experiment.

10/24/2024

Manas Purandhami

Gas Laws Lab

Purpose: Observe the relation between pressure, volume, temperature

Safety / Waste:

Use tongs to maneuver hot glassware

* pay attention to hot surface warning lights

- Wear safety goggles
- Water and ice disposed in sink

Chemicals:
ice
deionized water

Equipment:
- Vernier Pressure Sensor - 20mL syringe - stirplate / hot plate
- temp. probe - stir bar - 600mL beaker - plastic-tubing
- three way valve rubber stopper - 125mL Erlen. Flask
- clamps - ring stand - large pipet - beaker tongs

Procedure:

Part 1: $P \propto T$
- Place E. Flask with air sample in water bath of varying temps
- Pressure is monitored by pressure sensor, temp with temp probe
- Volume of gas sample & n of molecules are constant
- Collect (P,T) pairs, find absolute zero for F & C scales
- available temps: $0 < t < 100°C$
- Fill 600mL beaker 2/3 way, add stir bar, heat bath with stir bar moderate speed: set to 300°C initially: 5-6 mode

- Plug pressure sensor into Channel 1 of LoggerPro, temp sensor into Channel 2
- take piece of plastic-tubing from rubber stopper assembly, attach connector to open stem of pressure sensor with clockwise turn
- Leave two-way valve on rubber stopper open (parallel to valve stem)
- Insert assembly into dry 125mL E. flask (twist stopper into neck)

- Lab Files -> Chem 117 - Temperature
- y-axis = pressure (kPA), x-axis - Temp. (C°)
- Leak test: take 20mL syringe, adjust plunger to 0mL
- Attach syringe to two-way valve, open valve
- Remove air by moving syringe to 20mL
- Close two-way valve, monitor pressure for 30 seconds
- If pressure increases to atmospheric, leak present

- Click collect
- Place E. flask into water bath (2 way valve is open), raise temp to boiling
- use clamp to hold flask into water bath (all wires & tubing away from hot plate)
- Place t-probe into bath, shouldn't touch bottom
- When boiling, close two-way valve
- When pressure stabilize, keep (Data Point 1)
- turn off hot, let bath cool slowly, collect data points every 5°C, until 0°C
- will add ice after room temp, but allow equilibration before getting data point
- Stop, record room temp, atmospheric pressure in kPA
- Record all data points

Part B: P & V relationships:

- Plug P-sensor into Channel 1
- Before connecting syringe to pressure sensor, move syringe so inside black ring is at 10.0mL mark
- Attach 20mL syringe to white stem with gentle half-turn
- Open -> Chem 117 - Volume
- y-axis - pressure (kPA), x-axis - ~~[illegible]~~ volume (mL)
- Collect
- move plunger to 5.0mL, keep after stabilize
- 6 more data points 5.0 < V < 20.0 mL volume, below 5.0 bad!
- record all points & values

8
10
12
14
16
18

~~Part A:~~

Boiling

~~Pressure~~ ~~Temperature~~

Part A: Room temp: 21.3°C
Atm Pressure: 100.08

Temp	Pressure
100	100.08
95	99.57
90	98.04
85	97.20
80	96.19
75	94.92
70	93.98
65	92.82
60	91.55
55	90.45
50	88.78
45	87.51
40	86.34
35	85.21
30	84.13
25	82.95
20	81.87
15	80.57
10	79.36
5	77.73
0.4	76.20

Part B:

Volume	Pressure
5.0mL	194.7
8.0mL	125.33
10.0mL	100.87
12.0mL	85.13
14.0mL	73.11
16.0mL	64.53
18.0mL	57.60

X [illegible]