Gas Laws

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January 7, 2020

1 Aim

The aim is to find the effect of change of quantity of a gas on the pressure of the gas when other variables are constant.

2 Apparatus

See lab sheet.

3 Procedure

See lab sheet.

4 Data Collection

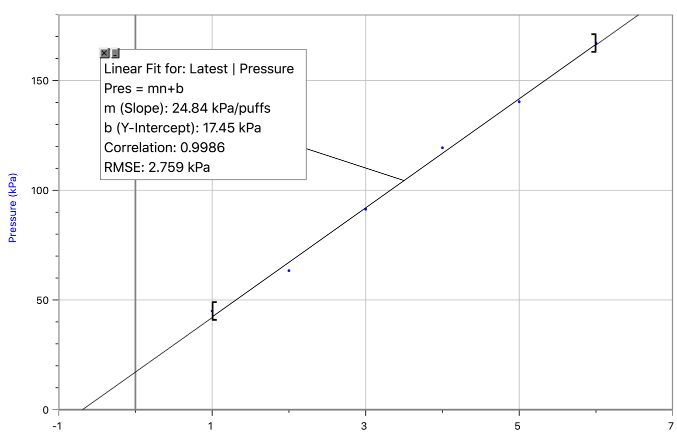

Figure 1: n vs. P

Table 1: Data

n (puffs)	P (kPa)
1	44.97
2	63.34
3	91.30
4	119.33
5	140.29
6	167.04

5 Data Analysis

As observed in the graph, the relationship between n and P is linear, which means that n is having a *linear correlation* with P.

The reason that P should increase as n increases is that when n increases, the number of moles of air will be increased, thus there's more air particles hitting the sensor per a unit time than before, thus increasing the P.

5.1 Calculate Air Molecules in 1 Puff

From the definition of 1 puff we know that 1 puff = 3mL = 3cm^3. Also, by volume, the largest two constituents of air are 78%N_2 and 21%O_2 [1], and the density of air under ISA (International Standard Atmosphere; P = 1013.25hPa, T = 15°C) the air density is approximately 1.225kg m^{-3}. By using those data we can then calculate the mass for each of those gas constituents:

$$\mathrm{N_2} = 78\% \times 1.225\mathrm{kg\,m^{-3}} = 0.9555\mathrm{kg\,m^{-3}}$$
$$\mathrm{O_2} = 21\% \times 1.225\mathrm{kg\,m^{-3}} = 0.2573\mathrm{kg\,m^{-3}}$$

which then we can calculate the number of moles of those gas constituents in 1m^3 by using the molecular masses of N_2 (28.0134g mol^{-1}) and O_2 (31.9988g mol^{-1}) using:

$$\mathrm{N_2} = \frac{955.5\mathrm{g\,m^{-3}}}{28.0134\mathrm{g\,mol^{-1}}} = 34.11\mathrm{mol\,m^{-3}}$$
$$\mathrm{O_2} = \frac{257.3\mathrm{g\,m^{-3}}}{31.9988\mathrm{g\,mol^{-1}}} = 8.041\mathrm{mol\,m^{-3}}$$

which at last we can then calculate the number of moles of particles in 1 puff by using:

$$\mathrm{N_2} : \frac{34.11\mathrm{mol}}{1\mathrm{m^3}} = \frac{x\mathrm{mol}}{3\mathrm{cm^3}}$$
$$n_{\mathrm{N_2}} = 1.0233 \times 10^{-4}\mathrm{mol}$$

$$\mathrm{O_2} : \frac{8.041\mathrm{mol}}{1\mathrm{m^3}} = \frac{x\mathrm{mol}}{3\mathrm{cm^3}}$$
$$n_{\mathrm{O_2}} = 2.4123 \times 10^{-5}\mathrm{mol}$$

therefore the combined number of moles of gas particles is

$$\begin{aligned} n &= 1.0233 \times 10^{-4}\text{mol} + 2.4123 \times 10^{-5}\text{mol} \\ &= 1.2645 \times 10^{-4}\text{mol} \end{aligned}$$

which at last, gives us that there's

$$1.2645 \times 10^{-4}\text{mol} \times 6.023 \times 10^{23}\text{mol}^{-1} = 7.6161 \times 10^{19}$$

particles in exactly '1 puff'.

Error Analysis

The air between the syringe and the sensor inside the Gas-Pressure sensor will let the n field of our data been lower than the actual value. This is a systematic error, where there's a design or execution flaw in our experiment.

The error can be corrected by observing a n reading when $P = 0$, which we can get such reading by solving the linear fit equation, whereas we can set $P = 0$ which gives $0 = 24.84n + 17.45$. By solving n we get $n = -0.70$, which indicates that there's 0.70puffs of air existing between the syringe and the sensor during the whole period of measurement.

The error can also be reduced by improving the environment design, which includes:

- reducing the length of tube between the syringe and the sensor
- reducing the diameter of tube between the syringe and the sensor
- use a smaller syringe

5.2 Findings with other groups

The proportionality between P and n has been found by our experiment. Specifically, we found a *linear relationship* between P and n, with the increase of n lets P increases linearly. From other groups we get to know that they also find the following rules:

- *Linear Correlation* between P and T
- ***Inverse*** *Linear Correlation* between P and V

which states that $P \cdot V \propto n \cdot T$, and by putting a constant we at last will got the gas law equation

$$PV = nRT$$

6 Conclusion

In the gas law equation, $PV = nRT$, one will be able to find the n only by given the P parameter, because we have an assumption of $T = 15°\text{C}$ and we also know the consentration of gas particle in the atmosphere, as well as their molecular masses. Given by those variables we can easily calculate the n given that we don't know V and R, which shows the robustness of the gas law formula.

References

[1] Allen, C. W., and Arthur N. Cox. Allen's Astrophysical Quantities. New York: AIP Press Springer, 2000. Print.