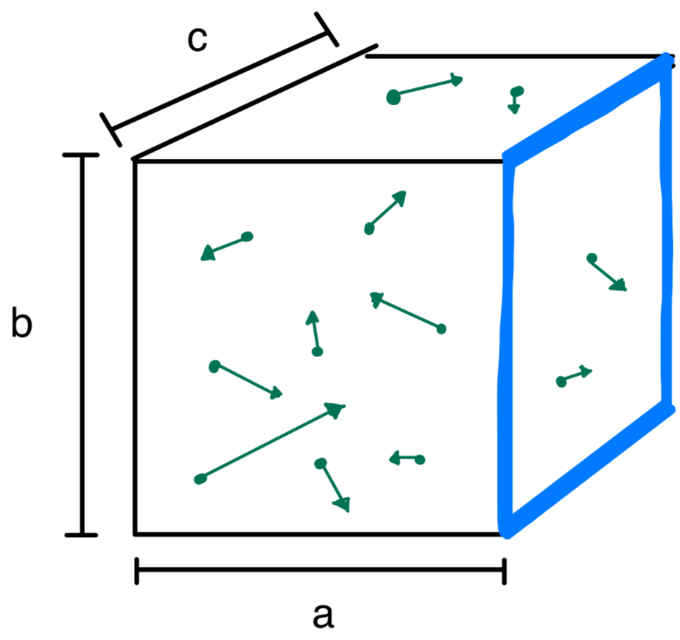
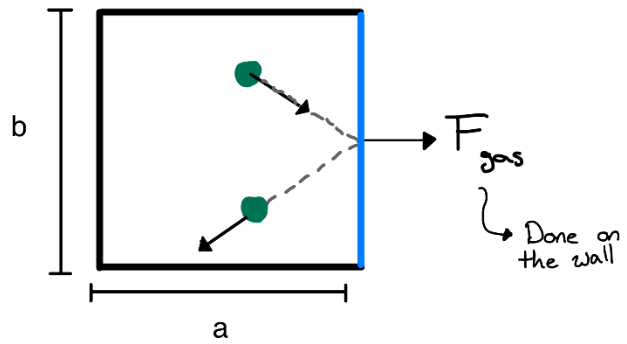
Ideal Gases

A very simple way of thinking of gases is to picture them as individual molecules floating around the empty space with a random velocity. The average speed of our gas molecules is directly proportional to the temperature at which the gas is. That is, if our gas is at a higher temperature its particles will move faster than a gas at a lower temperature.



Ideal Gases

The collisions of the gas molecules with the walls of the box, will produce a force on it. Since this force is distributed over the whole area of the different sides of the box, we can say that the gas has a definite pressure.



An increase in volume would be accompanied to a decrease in pressure (think about what happens to the collisions with the walls of the box). A decrease in the volume would be accompanied by an increase in the pressure of the gas. These observations lead us to claim that:

$$\text{Pressure} \times \text{Volume} = \text{Constant}$$

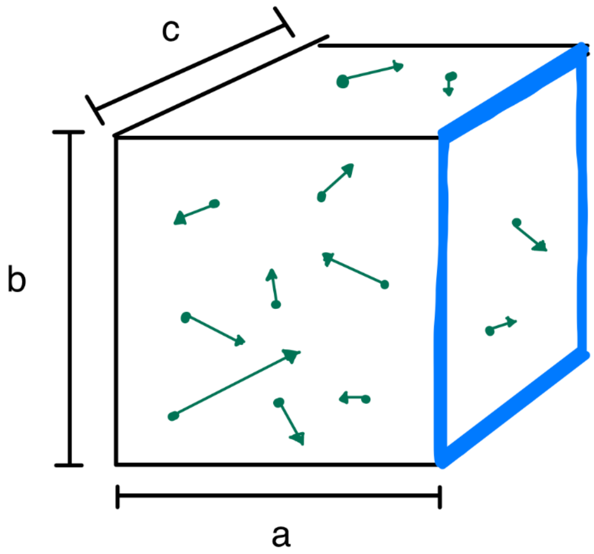
Later, we will see that this constant depends on the temperature and number of molecules of the gas

Ideal Gases

The value of the constant in the previous equation depends on the specific details of each gas that you are studying. However, once it is determined, it won't change if you change the volume or the pressure of the gas.

Example: Suppose that you have a gas with initial volume of V_i=5m^3 and initial pressure of P_i=3,000 Pa. In this case,

$$V_i \times P_i = 15,000 \text{ m}^3 \text{ Pa}$$



If we now change the volume of the gas, or we change the pressure so that the new volume and pressure of the gas are V_f and P_f , then we know that

$$V_f \times P_f = 15,000 \text{ m}^3 \text{ Pa}$$

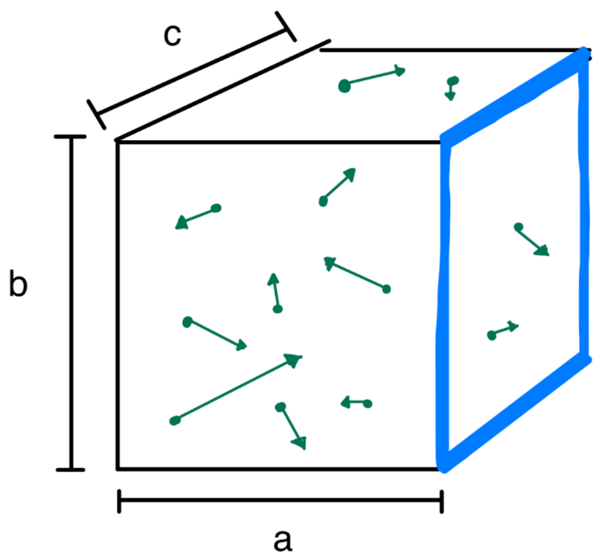
We can use this information to determine either V_f or P_f.

Ideal Gases

Another way to think about this is as follows. If we know that for this particular gas, the product between pressure and volume will remain constant, then for any initial and final conditions we will have the following relations:

$$V_i \times P_i = C$$
$$V_f \times P_f = C$$

Since they are both equal to the same constant, then they must be equal to each other.



In other words, we will have

$$V_i \times P_i = V_f \times P_f$$

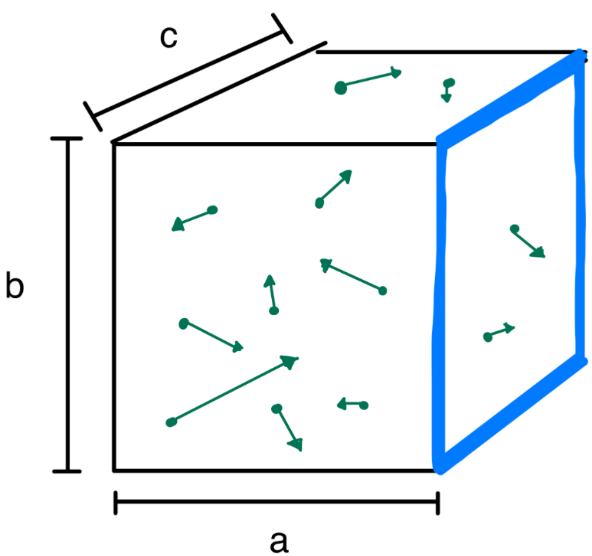
From this equation, we can always solve for the variable we are interested as long as we know the value of the other three.

Ideal Gases

As with the volume and the pressure of a gas, we can also think of what happens if we change the **Temperature** of the gas. From our previous discussions, we saw that the temperature is associated with the kinetic energy of the molecules. In other words, it tells us how much the molecules of the gas are moving. It is easier to see then that the temperature will also be directly related to the pressure and volume of the gas. It turns out that:

$$\frac{\text{Pressure} \times \text{Volume}}{\text{Temperature}} = \text{Constant}$$

NOTE: The temperature should be in Kelvin for this to work!



Following the same logic as before, we will have

$$\frac{V_i \times P_i}{T_i} = \frac{V_f \times P_f}{T_f}$$

In this case, we need to make an assumption of one of the three variables. After that, we can solve for the relation between the remaining two.

Homework

Problem 1. Imagine that we submerge the giraffe balloon into a bath of liquid nitrogen, so that its temperature decreases tremendously. Using the equation:

$$\frac{V_i \times P_i}{T_i} = \frac{V_f \times P_f}{T_f}$$

argue what will happen to the pressure and the volume of the giraffe.

Problem 2. Explain in your own words, what would happen if a body is able to reach 0K? What is the advantage of using the Kelvin scale compared to the Fahrenheit or Celsius?