

1.8.5: Combined Gas Law

The modern refrigerator takes advantage of the gas laws to remove heat from a system. Compressed gas in the coils is allowed to expand. This expansion lowers the temperature of the gas and transfers heat energy from the material in the refrigerator to the gas. As the gas is pumped through the coils, the pressure on the gas compresses it and raises the gas temperature. This heat is then dissipated through the coils into the outside air. As the compressed gas is pumped through the system again, the process repeats itself.

Combined Gas Law

To this point, we have examined the relationships between any two of the variables of P , V , and T , while the third variable is held constant. However, situations do arise where all three variables change. The **combined gas law** expresses the relationship between the pressure, volume, and absolute temperature of a fixed amount of gas. For a combined gas law problem, only the amount of gas is held constant.

$$\frac{P \times V}{T} = k \quad \text{and} \quad \frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

Example 1.8.5.1

2.00 L of a gas at 35°C and 0.833 atm is brought to standard temperature and pressure (STP). What will be the new gas volume?

Solution

Step 1: List the known quantities and plan the problem.

Known

- $P_1 = 0.833 \text{ atm}$
- $V_1 = 2.00 \text{ L}$
- $T_1 = 35^\circ\text{C} = 308 \text{ K}$
- $P_2 = 1.00 \text{ atm}$
- $T_2 = 0^\circ\text{C} = 273 \text{ K}$

Unknown

Use the combined gas law to solve for the unknown volume (V_2). STP is 273 K and 1 atm. The temperatures have been converted to Kelvin.

Step 2: Solve.

First, rearrange the equation algebraically to solve for V_2 .

$$V_2 = \frac{P_1 \times V_1 \times T_2}{P_2 \times T_1}$$

Now substitute the known quantities into the equation and solve.

$$V_2 = \frac{0.833 \text{ atm} \times 2.00 \text{ L} \times 273 \text{ K}}{1.00 \text{ atm} \times 308 \text{ K}} = 1.48 \text{ L}$$

Step 3: Think about your result.

Both the increase in pressure and the decrease in temperature cause the volume of the gas sample to decrease. Since both changes are relatively small, the volume does not decrease dramatically.

It may seem challenging to remember all the different gas laws introduced so far. Fortunately, Boyle's, Charles's, and Gay-Lussac's laws can all be easily derived from the combined gas law. For example, consider a situation where a change occurs in the volume and pressure of a gas while the temperature is being held constant. In that case, it can be said that $T_1 = T_2$. Look at the combined gas law and cancel the T variable out from both sides of the equation. What is left over is Boyle's Law: $P_1 \times V_1 = P_2 \times V_2$. Likewise, if the pressure is constant, then $P_1 = P_2$ and cancelling P out of the equation leaves Charles's Law. If the volume is constant, then $V_1 = V_2$ and cancelling V out of the equation leaves Gay-Lussac's Law.

Summary

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

1.8.5: Combined Gas Law is shared under a [CC BY-NC](#) license and was authored, remixed, and/or curated by LibreTexts.

- **14.6: Combined Gas Law** by [CK-12 Foundation](#) is licensed [CK-12](#). Original source: <https://flexbooks.ck12.org/cbook/ck-12-chemistry-flexbook-2.0/>.