Gas Laws: Combined Gas Law

Video Workbook with Dr. B.

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If we combine Boyle's, Charles, and Gay-Lussac's laws we get the Combined Gas Law.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

You use the Combined Gas Law when you have **initial** and **final** conditions.

While Celsius often works with the Combined Gas Law, it is recommended to **always work in Kelvin**.

When a question says "**held constant**" it means we can ignore the variable (it didn't change).

The Combined Gas Law

Gas Laws Playlist

When to Use the Combined Gas Law

Example 1

A gas occupies 2.3 liters at a pressure of 1.3 atm. What is the volume when the pressure is increased to 4.7 atm? The temperature remains constant.

Video of worked solution.

Example 1 Solution

Here we can ignore temperature since it does not change (stays constant). That means we use $P_1V_1=P_2V_2$.

$$(1.3\text{atm})(2.3\text{L}) = (4.7\text{atm})V_2$$

Solving for V_2, the new volume will be 0.64 L.

Example 2

3.22 L of a gas is collected at 23.0 °C. What will be its volume after it cools to 15.0 °C if pressure remains constant?

Video of worked solution.

Example 2 Solution

We can ignore P as the pressure remains constant. We use:

$$V_1/T_1 = V_2/T_2$$

$$3.22\text{L}/296.15\text{K} = V_2/288.15\text{K}$$

Solving for V_2 the new volume is 3.13 L.

Note, you would get the same answer using °C but this doesn't always work.

Example 3	*Example 3 Solution*
For a gas in a closed container the pressure is increased from 11.0 atmospheres to 12.2 atmospheres. If the original temperature was 25.0 °C, what is the final temperature of the gas? Video of worked solution.	Since volume is not stated in the problem we assume it is held constant and we can ignore it. $P_1/T_1 = P_2/T_2$ $(11.0atm)(298.15K) = (27.0atm)/T_2$ Solving for T_2 we get 330 K .

Example 4	*Example 4 Solution*
A gas initially at 2.00 atm, 1.20 L, and 273 K has its pressure reduced to 0.90 atm, and the volume is increased to 3.1 L. Determine the final temperature. Video of worked solution.	In this problem we have P, V, and T so we use: $P_1V_1/T_1 = P_2T_2/V_2$ $\frac{(2.0atm)(1.2L)}{273K} = \frac{(0.9atm)(3.1L)}{T_2}$ Solving for T_2 we get 317 K.

Example 5	*Example 5 Solution*
A balloon has a volume of 3.5 L at STP. What will the new volume be if the balloon is taken outside on a day where the new temperature is -17.15 °C? Assume the pressure inside and outside is the same (1.0 atm). Video of worked solution.	The key to this problem is recognizing that STP is Standard Temperature and Pressure (1 atm and 273.15K). $\frac{(1.0atm)(3.5L)}{273.15K} = \frac{(1.0\ atm)(V2)}{255.95K}$ Solving for V_2 we get 3.3 L.

Example 6	
A sample of 2.0 moles of gas has a pressure of 1.33 atm, a volume of 5.24 L, and temperature of 35.5 °C. If you cool it to a final temperature of 10.0 °C, decrease the volume to 2.32 L, and add an additional 3.0 moles of gas (for a final of 5.0 moles), what will the pressure be? $\frac{P_1 \cdot V_1}{T_1 \cdot n_1} = \frac{P_2 \cdot V_2}{T_2 \cdot n_2}$	We can extend the Combined Gas Law to include moles (n). $\frac{P_1 \cdot V_1}{T_1 \cdot n_1} = \frac{P_2 \cdot V_2}{T_2 \cdot n_2}$ $\frac{(1.33atm)(5.24L)}{(308.65K)(2.0mol)} = \frac{P_2(2.32L)}{(283.15K)(5.0mol)}$ Note, for T_2 we add the initial moles (2.0) and the amount we added (3.0) to get the final number of moles (5.0 moles). Solving for P_2 we get 6.8 atm.

Example 7 Solution

A sample of gas has a volume of 15.0L at a pressure of 1.0 atm and a temperature of 27.2 degrees Celsius. What is the new volume if the pressure is raised to 1580 mmHg and the temperature is raised to 356.2K degrees Celsius?

Note: 1atm = 760 mmHg

Video of worked solution.

Example 7 Solution

The challenge here is that the units for the initial and final don't match for pressure or temperature.

Divide 1580 mmHg by 760 mmHg/atm to get P in atm.

$$\frac{(1.0atm)(15.0L)}{300.35K} = \frac{(2.08atm)(V_2)}{356.2K}$$

Solving for P_2 we get 8.6 L.

Guides

KMT and the Gas Laws

Combined Gas Law (this guide)

Ideal Gas Law

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