

using the combined gas law aleks

Using the combined gas law is essential for understanding the relationships among temperature, pressure, and volume of gases in various scientific fields, including chemistry and physics. This law is a critical tool in both academic studies and practical applications, allowing scientists and engineers to predict how a gas will behave under different conditions. This article will explore the combined gas law, its derivation, applications, and practical examples to enhance your understanding of this fundamental principle.

Understanding the Combined Gas Law

The combined gas law is a mathematical relationship that combines three individual gas laws: Boyle's Law, Charles's Law, and Gay-Lussac's Law. Each of these laws describes how gases behave under specific conditions:

- Boyle's Law states that the pressure of a gas is inversely proportional to its volume when the temperature is held constant. This can be expressed as:

$$\begin{aligned} & \backslash[\\ P_1V_1 &= P_2V_2 \\ & \backslash] \end{aligned}$$

- Charles's Law states that the volume of a gas is directly proportional to its temperature (in Kelvin) when the pressure is held constant:

$$\begin{aligned} & \backslash[\\ \frac{V_1}{T_1} &= \frac{V_2}{T_2} \\ & \backslash] \end{aligned}$$

- Gay-Lussac's Law states that the pressure of a gas is directly proportional to its temperature (in Kelvin) when the volume is held constant:

$$\begin{aligned} & \backslash[\\ \frac{P_1}{T_1} &= \frac{P_2}{T_2} \\ & \backslash] \end{aligned}$$

The combined gas law integrates these three relationships into a single equation, which is useful for solving problems where more than one variable changes:

$$\begin{aligned} & \backslash[\\ \frac{P_1V_1}{T_1} &= \frac{P_2V_2}{T_2} \\ & \backslash] \end{aligned}$$

\]

Deriving the Combined Gas Law

To derive the combined gas law, we start with the three individual laws mentioned above.

1. From Boyle's Law, we can express temperature as a constant:

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$$P \propto \frac{1}{V} \quad (T \text{ constant})$$

\]

2. From Charles's Law, we express pressure as a constant:

\[

$$V \propto T \quad (P \text{ constant})$$

\]

3. From Gay-Lussac's Law, we express volume as a constant:

\[

$$P \propto T \quad (V \text{ constant})$$

\]

By combining these relationships, we find that:

\[

$$PV \propto T$$

\]

This leads us to the combined gas law, which holds true when the amount of gas remains constant. It's important to remember that all temperatures must be in Kelvin for these formulas to work correctly.

Applications of the Combined Gas Law

The combined gas law has numerous practical applications across various fields. Here are some of the most common uses:

- **Laboratory Experiments:** Scientists use the combined gas law to predict how gases will respond to changes in pressure, volume, and temperature during experiments.
- **Engineering:** Engineers apply the combined gas law in the design of equipment that involves gas

storage and usage, such as compressors and gas tanks.

- **Aerospace:** The law is essential in the aerospace industry for calculating how gases behave at high altitudes where pressure and temperature differ significantly from sea level.
- **Environmental Science:** It helps in understanding how gases in the atmosphere behave, which is crucial for studying air pollution and climate change.

Example Problems Using the Combined Gas Law

To further illustrate the use of the combined gas law, let's solve a couple of example problems.

Example 1: Pressure Change

Problem: A gas has a volume of 5.0 L at a pressure of 1.0 atm and a temperature of 300 K. If the volume changes to 10.0 L, what is the new pressure at the same temperature?

Solution:

Using the combined gas law:

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

Since the temperature is constant ($T_1 = T_2$), we can simplify to:

$$P_1 V_1 = P_2 V_2$$

Plugging in the known values:

$$(1.0 \text{ atm})(5.0 \text{ L}) = P_2(10.0 \text{ L})$$

Solving for (P_2) :

$$P_2 = \frac{(1.0 \text{ atm})(5.0 \text{ L})}{10.0 \text{ L}} = 0.5 \text{ atm}$$

The new pressure is 0.5 atm.

Example 2: Volume Change with Temperature

Problem: A gas occupies a volume of 2.0 L at a pressure of 3.0 atm and a temperature of 273 K. If the temperature is raised to 546 K and the pressure is reduced to 1.5 atm, what is the new volume?

Solution:

Using the combined gas law:

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

Substituting the known values:

$$\frac{(3.0 \text{ atm})(2.0 \text{ L})}{273 \text{ K}} = \frac{(1.5 \text{ atm})V_2}{546 \text{ K}}$$

Cross-multiplying gives:

$$(3.0)(2.0)(546) = (1.5)V_2(273)$$

Calculating the left side:

$$3.0 \times 2.0 \times 546 = 3276$$

Now, calculating the right side:

$$1.5 \times 273 = 409.5$$

So:

$$3276 = 409.5V_2$$

Now solve for (V_2) :

$$V_2 = \frac{3276}{409.5} \approx 8.0 \text{ L}$$

\]

The new volume is approximately 8.0 L.

Conclusion

Using the combined gas law is essential for anyone studying gases, whether in an academic setting or a professional field. By understanding the relationships between pressure, volume, and temperature, you can make accurate predictions about gas behavior under varying conditions. This knowledge is not only fundamental in theoretical physics and chemistry but also has real-world applications in industries ranging from engineering to environmental science. As you continue to explore the sciences, mastering the combined gas law will enhance your problem-solving skills and deepen your understanding of the gaseous state of matter.

Frequently Asked Questions

What is the combined gas law and how is it used in ALEKS?

The combined gas law is an equation that relates pressure, volume, and temperature of a gas. In ALEKS, it is used to solve problems involving changes in these properties, allowing students to calculate one variable when the others are known.

How do you rearrange the combined gas law equation in ALEKS?

To rearrange the combined gas law equation ($PV/T = \text{constant}$), you can isolate any variable by multiplying or dividing through by the other variables. For example, to solve for volume (V), you would rearrange it to $V = nRT/P$.

Can you provide an example problem using the combined gas law in ALEKS?

Sure! If a gas has a pressure of 2 atm, a volume of 5 L, and a temperature of 300 K, and you want to find the new volume when the pressure is changed to 1 atm and the temperature to 400 K, you would use the combined gas law to solve for the new volume.

What common mistakes should be avoided when using the combined gas

law in ALEKS?

Common mistakes include forgetting to convert units (e.g., temperature must be in Kelvin), not maintaining consistent units for pressure and volume, and incorrectly rearranging the formula, which can lead to wrong answers.

How does ALEKS help in understanding the combined gas law?

ALEKS provides interactive tutorials and practice problems that guide students through the application of the combined gas law, offering immediate feedback and step-by-step solutions to reinforce understanding.

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