A Gas Has A Volume Of 460ml At 500 MmHg. What Will Be The Volume At 1.2 Atm?

A Gas Has A Volume Of 460ml At 500 MmHg. What Will Be The Volume At 1.2 Atm?

Understanding how gases behave under different pressure conditions is fundamental in chemistry and physics. When dealing with gases, the relationship between pressure and volume is described by Boyle's Law, which states that at constant temperature, the pressure of a gas varies inversely with its volume. This principle allows us to predict how a gas's volume will change when subjected to different pressures—a concept particularly useful in various scientific and industrial applications. In this article, we will explore how to determine the new volume of a gas when its pressure changes from 500 mmHg to 1.2 atm, using Boyle's Law, and delve into the underlying concepts, calculations, and practical implications.

Understanding Boyle's Law and Its Significance

Boyle's Law is one of the fundamental gas laws, formulated by Robert Boyle in the 17th century. It states:

At constant temperature, the pressure of a given mass of gas is inversely proportional to its volume.

Mathematically, Boyle's Law is expressed as:

$$P_1V_1 = P_2V_2$$

Where:
- P_1 = initial pressure
- V_1 = initial volume
- P_2 = final pressure
- V_2 = final volume

This relationship implies that if the pressure increases, the volume decreases proportionally, provided the temperature remains unchanged. Conversely, decreasing pressure results in an increase in volume.

Key points about Boyle's Law:
- Applies only at constant temperature (isothermal conditions).
- Assumes the gas behaves ideally.
- Useful in calculations involving compression or expansion of gases.

Converting Units: From mmHg to atm

Before applying Boyle's Law, it's essential to ensure that the pressure units are consistent. The initial pressure is given as 500 mmHg, and the target pressure is 1.2 atm.

Conversion factors:
- 1 atm = 760 mmHg
- Therefore:
- To convert mmHg to atm: divide by 760.

Calculations:

- Initial pressure (P_1):

  - P_1 = 500 mmHg
  - P_1 in atm = 500 / 760 ≈ 0.6579 atm

- Final pressure (P_2):

  - P_2 = 1.2 atm (already in atm, no conversion needed)

This conversion ensures that the pressure values are in compatible units for the calculations.

Applying Boyle's Law to Find the New Volume

Given:
- Initial volume, V_1 = 460 ml
- Initial pressure, P_1 ≈ 0.6579 atm
- Final pressure, P_2 = 1.2 atm

We want to find the final volume, V_2.

Using Boyle's Law:

$$P_1V_1 = P_2V_2$$

Rearranged as:

$$V_2 = (P_1V_1) / P_2$$

Calculations:

- Substitute the known values:

- $V_2 = (0.6579 \text{ atm} \times 460 \text{ ml}) / 1.2 \text{ atm}$

- Compute numerator:

$0.6579 \times 460 \approx 302.634$ ml·atm

- Divide by P_2:

$V_2 \approx 302.634 / 1.2 \approx 252.2$ ml

Result:

The volume of the gas at 1.2 atm pressure is approximately 252.2 ml.

Implications and Practical Applications

Understanding how gas volume changes with pressure is critical in many fields:

- Medical Applications: In respiratory therapy, understanding lung compression and expansion involves Boyle's Law principles.
- Industrial Processes: Gas compression in pipelines, chemical reactors, and storage tanks relies on precise volume and pressure calculations.

- Aviation and Scuba Diving: Knowledge of gas laws helps in managing cabin pressure and preventing conditions like decompression sickness.
- Laboratory Experiments: Accurate predictions of gas behavior are essential for calibration and experimental design.

Factors Affecting Gas Behavior Beyond Boyle's Law

While Boyle's Law provides a good approximation under ideal conditions, real gases may deviate due to:

- Temperature Changes: Boyle's Law assumes constant temperature; any variation affects the relationship.
- Gas Interactions: At high pressures or low temperatures, gas molecules interact, deviating from ideal behavior.
- Volume Constraints: Physical boundaries or container shapes can influence the behavior.

In such cases, the combined gas law or more advanced models like the Van der Waals equation are used for more accurate predictions.

Summary of Calculation Process

To summarize, here are the steps to determine the volume of a gas when pressure changes:

1. Convert all pressure units to a common standard (preferably atm).
2. Use Boyle's Law ($P_1V_1 = P_2V_2$) to set up the equation.
3. Solve for V_2:

   - $V_2 = (P_1 \times V_1) / P_2$

4. Perform the calculations to find the new volume.

Applying these steps ensures accurate and reliable results for gas volume predictions under varying pressure conditions.

Additional Tips for Gas Law Calculations

- Always verify unit consistency before calculations.
- Remember that Boyle's Law applies only at constant temperature.
- Use precise conversion factors to minimize errors.
- Consider real-world deviations when working with high pressures or non-ideal gases.

Conclusion

In conclusion, when a gas initially occupying 460 ml at 500 mmHg is subjected to a pressure of 1.2 atm, its volume decreases to approximately 252.2 ml, assuming temperature remains constant and the gas behaves ideally. This calculation highlights the inverse relationship between pressure and volume described by Boyle's Law, a fundamental principle in understanding gas behavior. Whether in scientific research, medical applications, or industrial processes, mastering the application of Boyle's Law enables accurate predictions and efficient management of gas systems.

References and Further Reading

- Atkinson, H. (2012). Principles of Chemistry. Oxford University Press.
- Atkins, P., & de Paula, J. (2014). Physical Chemistry. Oxford University Press.
- Boyle, R. (1662). New Experiments Physico-Mechanical, touching the Spring of the Air, and its Effects.
- Khan Academy. (n.d.). Boyle's Law and Gas Pressure-Volume Relationship. Retrieved from https://www.khanacademy.org/science/physics/thermodynamics

---

Note: Always ensure safety and proper calibration when working with gases in laboratory or industrial environments.

Frequently Asked Questions

What is the initial pressure of the gas in atm, given its pressure in mmHg?

The initial pressure is 500 mmHg, which converts to 0.658 atm (since 1 atm = 760 mmHg).

What is the temperature assumption in this problem? Is it constant?

The problem assumes constant temperature, applying Boyle's Law, which states that volume and pressure are inversely proportional at constant temperature.

How do you convert the final pressure from atm to mmHg for calculation purposes?

The final pressure is 1.2 atm, which converts to 912 mmHg (1.2 atm × 760 mmHg/atm).

What is the formula used to find the new volume of the gas?

The formula used is Boyle's Law: $P_1V_1 = P_2V_2$, where P_1 and V_1 are initial pressure and volume, and P_2 and V_2 are final pressure and volume.

What is the calculated volume of the gas at 1.2 atm?

Using Boyle's Law: $V_2 = (P_1 \times V_1) / P_2 = (0.658 \text{ atm} \times 460 \text{ mL}) / 1.2 \text{ atm} \approx 251.8 \text{ mL}$.

Additional Resources

Gas Behavior Under Varying Conditions: A Detailed Analysis of Volume Changes

Understanding how gases respond to changes in pressure and temperature is fundamental in fields ranging from chemistry and physics to engineering and environmental science. Today, we delve into a practical scenario: what happens to the volume of a gas when the pressure changes? Specifically, we will analyze a gas that initially occupies 460 mL at 500 mmHg and determine its new volume when the pressure is increased to 1.2 atm. This exploration provides insights into the principles of gas laws, particularly Boyle’s Law, and demonstrates their real-world application.

Fundamentals of Gas Behavior: The Basics of Gas Laws

Before tackling the problem, it's essential to understand the core principles governing gas behavior. Gases are highly compressible and expand to fill their containers, and their properties are described by a set of fundamental laws:

- Boyle's Law: At constant temperature and amount of gas, the pressure and volume are inversely proportional. Mathematically,
$$ P_1 V_1 = P_2 V_2 $$
- Charles's Law: At constant pressure, the volume of a gas is directly proportional to its temperature.
- Gay-Lussac's Law: At constant volume, the pressure of a gas is directly proportional to its temperature.
- Ideal Gas Law: Combines all three into one equation:
$$ PV = nRT $$

For this problem, Boyle's Law is most relevant because the temperature and amount of gas are assumed constant, and only pressure and volume change.

Converting Units for Consistency and Accuracy

Accurate calculations require consistent units. The initial data provided are:

- Initial Volume V_1 = 460 mL
- Initial Pressure P_1 = 500 mmHg
- Final Pressure P_2 = 1.2 atm

Step 1: Convert the initial pressure from mmHg to atm

Since 1 atm = 760 mmHg,
$$ P_1 = \frac{500\, \text{mmHg}}{760\, \text{mmHg/atm}} \approx 0.6579\, \text{atm} $$

Step 2: Confirm the final pressure in atm

Given $P_2 = 1.2\, \text{atm}$, no conversion needed.

Summary of pressures:

Parameter	Value	Units
P_1	0.6579	atm
P_2	1.2	atm

Applying Boyle’s Law to Find the Final Volume

Boyle’s Law states:

$$P_1 V_1 = P_2 V_2$$

Rearranged to find V_2:

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

Plugging in the known values:

$$V_2 = \frac{0.6579\, \text{atm} \times 460\, \text{mL}}{1.2\, \text{atm}}$$

Calculating numerator:

$$0.6579 \times 460 \approx 302.634\, \text{mL}$$

Then,

$$V_2 = \frac{302.634}{1.2} \approx 252.19\, \text{mL}$$

Result:

The volume of the gas when the pressure is increased to 1.2 atm is approximately 252.19 mL.

Interpreting the Results and Practical Implications

Key Takeaway: Increasing the pressure from 0.6579 atm to 1.2 atm causes the gas's volume to decrease from 460 mL to approximately 252 mL. This inverse relationship underscores Boyle’s Law’s significance in real-world applications, such as:

- Respiratory Mechanics: Understanding lung volume changes under varying pressures.
- Industrial Gas Storage: Designing containers that withstand pressure variations.
- Aerospace Engineering: Calculating volume adjustments in spacecraft cabins.

Exploring the Assumptions and Limitations

While Boyle's Law provides a straightforward approach, it assumes:

- Constant Temperature: No heat exchange occurs during compression or expansion.
- Ideal Gas Behavior: The gas particles do not interact, and the volume of particles is negligible.
- No Chemical Reactions: The gas remains unchanged during pressure variation.

In real scenarios, deviations might occur at high pressures or low temperatures, or with gases that do not behave ideally. For example, at very high pressures, gases tend to liquefy, invalidating Boyle's Law.

Additional Considerations for Comprehensive Analysis

Temperature Effects: If temperature changes alongside pressure, the ideal gas law (PV = nRT) must be employed, considering the initial and final temperatures.

Gas Composition: Different gases have different compressibility factors; for precise calculations, the compressibility factor \(Z \) can be incorporated.

Measurement Accuracy: Experimental data can be affected by measurement errors; hence, slight variations are expected in practical applications.

Conclusion: Mastering Gas Law Applications

This detailed examination illustrates how fundamental principles like Boyle's Law enable us to predict and understand gas behavior under varying conditions. By converting units accurately and applying the inverse proportionality between pressure and volume, we deduced that increasing the pressure from approximately 0.658 atm to 1.2 atm reduces the gas's volume from 460 mL to roughly 252 mL.

Such calculations are invaluable across scientific, medical, and industrial fields, emphasizing the importance of a solid grasp of gas laws. Whether optimizing breathing apparatus, designing pressurized containers, or conducting chemical reactions, understanding these relationships ensures safety, efficiency, and innovation.

In essence, the behavior of gases under changing pressures is not just a theoretical concept but a practical tool that, when mastered, unlocks a deeper understanding of the physical world and its myriad applications.

A Gas Has A Volume Of 460ml At 500 Mmhg What Will Be The Volume At 1 2 Atm

A Gas Has A Volume Of 460ml At 500 Mmhg What Will Be The Volume At 1 2 Atm

Related Articles

- What Do Twin Studies Tell Us About Genetics And The Ability To Read Emotions?
- Write An Article In Your School Magazine On Problems Facing In Your School
- Y"-y'-6y=0 Y(0)=1, Y'(0)=-1Using Laplace Transform To Soilve Initial Value

Back to Home