A 295-mL Flask Contains Pure Helium At A Pressure Of 757 Torr. A Second Flask With A Volume Of 465 ML

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Understanding the properties and behavior of gases is fundamental in chemistry and physics. When dealing with gases such as helium, it's essential to analyze parameters like volume, pressure, temperature, and moles to predict how they will respond under different conditions. In this article, we explore a specific scenario involving two flasks: one containing pure helium and the other with a known volume, diving into the principles and calculations that govern their behavior.

Introduction to Gas Laws and Their Significance

Gas laws describe how gases behave under varying conditions. These laws are derived from experimental observations and serve as the foundation for understanding phenomena such as pressure changes, volume expansion, temperature effects, and mole calculations.

The key gas laws include:
- Boyle's Law: $P_1 V_1 = P_2 V_2$ (at constant temperature and moles)
- Charles's Law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (at constant pressure and moles)
- Gay-Lussac's Law: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ (at constant volume and moles)
- Avogadro's Law: $V_1 / n_1 = V_2 / n_2$ (at constant temperature and pressure)
- Ideal Gas Law: $PV = nRT$

When analyzing the behavior of helium in the given scenario, the ideal gas law provides a useful framework.

Scenario Overview and Key Parameters

Let's examine the initial conditions:

- First Flask (Flask A):
- Volume (V_A): 295 mL
- Pressure (P_A): 757 Torr
- Contains: Pure helium
- Temperature (T_A): Assumed constant unless specified

- Second Flask (Flask B):
- Volume (V_B): 465 mL
- Contains: Unknown gas or helium (not specified if pure helium)
- Initial pressure and temperature are not provided in the initial statement but are crucial for calculations.

This setup suggests that the problem involves calculating the behavior of helium under different conditions, potentially involving the application of gas laws to determine unknown parameters.

Understanding the Key Variables and Units

Before diving into calculations, it's essential to understand the units and variables involved:

- Pressure: Typically measured in Torr, atm, or Pa. Conversion factors are necessary:
- 1 atm = 760 Torr
- 1 Torr ≈ 133.322 Pa

- Volume: Usually in mL or liters. Conversion:
- 1 L = 1000 mL

- Temperature: In Kelvin (K). Convert Celsius to Kelvin by adding 273.15.

- Number of moles (n): Central to calculations, often derived from the ideal gas law.

Converting Units for Consistent Calculations

Suppose we need to compare or calculate the behavior of gases in the flasks, converting units to SI units ensures consistency:

- Volume:
- Flask A: 295 mL = 0.295 L
- Flask B: 465 mL = 0.465 L

- Pressure:
- 757 Torr = 757 / 760 atm ≈ 0.996 atm

- Temperature:
- Assume room temperature: approximately 25°C = 298.15 K

Calculating the Number of Moles of Helium in Flask A

Using the ideal gas law:

$$
n = \frac{PV}{RT}
$$

Where:
- P: pressure in atm
- V: volume in liters
- R: ideal gas constant, 0.082057 L·atm/(mol·K)
- T: temperature in Kelvin

Plugging in the known values:

$$
n_A = \frac{0.996\, \text{atm} \times 0.295\, \text{L}}{0.082057\, \text{L·atm/(mol·K)} \times 298.15\, \text{K}}
$$

Calculating numerator:

$$
0.996 \times 0.295 \approx 0.294\, \text{L·atm}
$$

Calculating denominator:

$$
0.082057 \times 298.15 \approx 24.45\, \text{L·atm/mol}
$$

Thus,

$$
n_A \approx \frac{0.294}{24.45} \approx 0.01202\, \text{mol}
$$

Interpretation: Flask A contains approximately 0.012 mol of helium under the given conditions.

Analyzing the Second Flask – Possible Scenarios

Given the volume of Flask B (465 mL) but without pressure or temperature data, several scenarios can be considered:

Scenario 1: Both Flasks Contain Helium at the Same Temperature

If the gases are at the same temperature and pressure, then by Avogadro's law, the number of moles in Flask B can be calculated if its pressure is known, or vice versa.

Scenario 2: Equal Moles, Different Volumes, and Pressures

If the moles of helium are conserved and the gases are at the same temperature, Boyle's law can be used to relate the pressures and volumes:

$$
P_A V_A = P_B V_B
$$

Scenario 3: Gas Transfer or Mixing

If the flasks are connected or helium is transferred between them, the calculations involve combined gas laws, considering the total moles and the partial pressures.

Applications of Gas Laws in Real-Life Situations

Understanding the behavior of gases in containers like flasks has practical applications:

- Industrial Gas Storage: Ensuring safe storage of helium for balloons, MRI machines, and scientific experiments.
- Chemical Reactions: Controlling pressure and volume in reactions involving gases.
- Diving Medicine: Calculating gas pressures in scuba tanks.
- Meteorology: Understanding atmospheric pressure and gas behavior.

Practical Calculations and Examples

Suppose we want to determine the pressure in Flask B if it contains the same amount of helium as in Flask A, and the temperature remains constant.

Given:
- $n_A = n_B = 0.01202$ mol
- $V_B = 0.465\, \text{L}$
- $T_B = 298.15\, \text{K}$

Using ideal gas law:

\[

$$
P_B = \frac{nRT}{V}
$$

Calculate:

$$
P_B = \frac{0.01202 \times 0.082057 \times 298.15}{0.465}
$$

Numerator:

$$
0.01202 \times 24.45 \approx 0.294\, \text{L·atm}
$$

Divide:

$$
P_B \approx \frac{0.294}{0.465} \approx 0.632\, \text{atm}
$$

Convert to Torr:

$$
0.632 \times 760 \approx 480\, \text{Torr}
$$

Result: If Flask B contains the same amount of helium at the same temperature, its pressure would be approximately 480 Torr.

Conclusion: The Importance of Gas Laws in Scientific Analysis

The scenario involving a 295-mL flask containing pure helium at 757 Torr and a second flask of 465 mL showcases the fundamental principles of gas behavior. Using the ideal gas law, scientists can determine the amount of gas present, predict pressure changes under different conditions, and design experiments and storage solutions accordingly.

Key takeaways include:
- Accurate unit conversions are crucial for calculations.
- Gas laws interrelate pressure, volume, temperature, and moles.
- Real-world applications rely heavily on understanding these principles.
- Safety considerations are vital when handling gases under pressure.

Further Considerations and Advanced Topics

Beyond basic calculations, more advanced topics related to gases include:

- Real Gas Behavior: Deviations from ideality at high pressures or low temperatures, described by equations like Van der Waals.
- Gas Mixtures: Calculations involving partial pressures, mole fractions, and Dalton's Law.
- Thermodynamics: Entropy, enthalpy, and energy changes during gas processes.
- Kinetic Molecular Theory: Insights into molecular motion and collision dynamics.

References and Resources for Further Learning

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach.
- Petrucci, R. H., et al. (2017). General Chemistry: Principles & Modern Applications.
- Online resources:
- [Khan Academy Gas Laws](https://www.khanacademy.org/science/chemistry/kinetic-molecular-theory)
- [ChemCollective Gas Law Simulations](http://chemcollective.org/)

In summary, analyzing the behavior of

Frequently Asked Questions

What is the initial pressure of helium in the 295-mL flask?

The initial pressure of helium in the 295-mL flask is 757 Torr.

If the second flask has a volume of 465 mL, how does its volume compare to the first flask?

The second flask's volume (465 mL) is larger than the first flask's volume (295 mL).

What principles can be used to determine the pressure of helium if the temperature and amount of gas remain constant?

The ideal gas law (PV = nRT) can be used, especially Boyle's law for constant temperature and amount of gas, to relate pressure and volume.

If the temperature is kept constant, what happens to the pressure when helium is transferred from the 295-mL flask to the 465-mL flask?

The pressure decreases in the larger volume assuming no additional helium is added, following Boyle's law.

How can the pressure of helium in the second flask be calculated if it contains the same amount of gas at the same temperature?

Using Boyle's law: $P1V1 = P2V2$, where you can solve for P2 given the initial pressure, initial volume, and the second flask's volume.

What is the significance of knowing the initial pressure and volume in gas law problems?

They serve as the initial conditions to calculate changes in pressure, volume, or temperature of the gas under different scenarios.

Can the pressure in the second flask be directly compared to the first flask's pressure without calculations?

No, unless the volumes and other conditions are identical, calculations are necessary to determine the pressure in the second flask.

What assumptions are made when applying the ideal gas law to this problem?

Assumptions include that helium behaves as an ideal gas, and temperature and amount of gas remain constant during the transfer.

If the temperature increases, how does it affect the pressure of helium in the flask?

An increase in temperature at constant volume and amount results in an increase in pressure, according to Gay-Lussac's law.

What practical applications involve transferring gases between containers of different volumes?

Applications include gas storage, laboratory experiments, and industrial processes where controlling gas pressure and volume is essential.

Additional Resources

Helium: The Lightest Noble Gas and Its Practical Applications

In the realm of gases, helium stands out as a fascinating element renowned for its unique properties, applications, and scientific significance. Today, we delve into a detailed exploration of a specific scenario involving helium contained within two different flasks—a 295-mL flask holding pure helium at a pressure of 757 Torr, and a second flask with a volume of 465 mL. This detailed analysis will examine the properties of helium, the implications of the given measurements, and practical insights into the behavior of gases under such conditions.

Understanding the Fundamentals: Helium as a Noble Gas

What is Helium?

Helium is the second element on the periodic table, symbolized as He, and classified as a noble gas. Its atomic number is 2, and it is characterized by a complete outer electron shell, rendering it chemically inert under typical conditions. This inertness makes helium extremely stable, non-reactive, and ideal for various specialized applications.

Key Properties of Helium

- Lightweight: With a molar mass of approximately 4.00 g/mol, helium is the lightest noble gas, contributing to its low density.
- Low Boiling Point: Helium remains gaseous at temperatures near absolute zero, with a boiling point of about -268.9°C.
- High Thermal Conductivity: This property makes helium useful in cooling applications, such as in MRI machines and nuclear reactors.
- Inertness: Its lack of chemical reactivity allows it to be used safely in environments where other gases might react.

Applications of Helium

- Cooling systems: For superconducting magnets and cryogenic systems.
- Lifting gas: Due to its low density, helium is used in balloons and airships.
- Leak detection: Helium's small atomic size makes it ideal for detecting leaks in pressurized systems.
- Scientific research: As a noble gas, helium serves in various experiments exploring quantum phenomena and low-temperature physics.

Analyzing the First Flask: 295-mL of Pure Helium at 757 Torr

The Setup

The first flask contains 295 mL of pure helium at a pressure of 757 Torr. To understand the behavior and properties of the gas within, we need to analyze the given parameters using fundamental gas laws.

Converting Units for Consistency

- Volume: 295 mL = 0.295 L
- Pressure: 757 Torr

Since the ideal gas law (PV = nRT) requires pressure in atmospheres, convert Torr to atm:

$$
1 \text{ atm} = 760 \text{ Torr}
$$

$$
P = \frac{757 \text{ Torr}}{760} \approx 0.995 \text{ atm}
$$

Applying the Ideal Gas Law

Assuming temperature (T) is constant and known or standard (say 25°C = 298.15 K), we can determine the number of moles of helium in the flask.

$$
PV = nRT
$$

$$
n = \frac{PV}{RT}
$$

Using:

- $P \approx 0.995 \text{ atm}$
- $V = 0.295 \text{ L}$
- $R = 0.082057 \text{ L·atm·mol}^{-1}\text{·K}^{-1}$
- $T = 298.15 \text{ K}$

Calculating:

$$
n = \frac{0.995 \times 0.295}{0.082057 \times 298.15} \approx \frac{0.2935}{24.447} \approx 0.0120 \text{ mol}
$$

Implications

- The flask contains approximately 0.012 moles of helium.
- The density of helium in the flask can be calculated as:

$$
\text{Density} = \frac{\text{mass}}{\text{volume}}
$$

where mass:

$$
\text{mass} = n \times \text{molar mass} = 0.0120 \times 4.00 \text{ g} = 0.048 \text{ g}
$$

and volume:

$$
0.295 \text{ L} = 295 \text{ mL}
$$

Thus, the density:

$$
\frac{0.048 \text{ g}}{295 \text{ mL}} \approx 0.000163 \text{ g/mL}
$$

which is extremely low, consistent with helium's reputation as the least dense gas.

The Second Flask: 465-mL Volume—A Comparative Perspective

Volume and Potential

The second flask contains 465 mL of gas, but its pressure, temperature, and whether it contains helium are not explicitly specified. For the purpose of this analysis, assume it also contains pure helium at the same temperature as the first flask, providing a basis for comparison.

Calculating the Number of Moles in the Second Flask

Using the ideal gas law again:

$$
V = 465 \text{ mL} = 0.465 \text{ L}
$$

\[

$$
P \text{ (assumed same)} = 0.995 \text{ atm}
$$

$$
T = 298.15 \text{ K}
$$

Number of moles:

$$
n = \frac{0.995 \times 0.465}{0.082057 \times 298.15} \approx \frac{0.462}{24.447} \approx 0.0189 \text{ mol}
$$

This indicates that the second flask contains roughly 0.0189 mol of helium—more than in the first flask due to its larger volume.

Density and Practical Implications

- Mass of helium:

$$
0.0189 \times 4.00 \text{ g} = 0.0756 \text{ g}
$$

- Density:

$$
\frac{0.0756 \text{ g}}{465 \text{ mL}} \approx 0.000162 \text{ g/mL}
$$

The densities are remarkably similar, affirming helium's consistent low density across different volumes under identical conditions.

Understanding Gas Behavior: Pressure, Volume, and Moles

The Relationship Between Variables

The ideal gas law provides a fundamental relationship connecting pressure (P), volume (V), temperature (T), and moles (n):

$$
PV = nRT
$$

Key Points

- Pressure (P): The force exerted by gas molecules colliding with container walls.
- Volume (V): Space occupied by the gas; can be altered if the container is flexible or pressure changes.
- Temperature (T): Influences molecular speed; higher temperatures increase kinetic energy.
- Number of Moles (n): Quantity of molecules present.

Implications for the Two Flasks

- If both flasks are maintained at the same temperature but have different volumes, the amount of helium (in moles) scales directly with volume for a given pressure.
- Any change in pressure or temperature would influence the number of moles or the density, which is critical in applications like leak detection or gas collection.

Practical Applications and Considerations in Handling Helium

Safety and Handling

While helium is inert and non-toxic, it does pose some safety considerations:

- Asphyxiation risk: Displacing oxygen in confined spaces can lead to suffocation.
- High-pressure storage: Requires appropriate cylinders and regulators.
- Leakage: Helium's small atomic size allows it to escape through tiny leaks, making detection crucial in industrial settings.

Storage and Use

- Helium should be stored in high-pressure cylinders designed for inert gases.
- When releasing helium into a system, consider the pressure differential; proper regulation prevents accidents.
- For precise experiments, control temperature and pressure to maintain consistent conditions.

Measurement and Experimentation

- Use of manometers or pressure gauges helps monitor helium pressure.
- For experiments requiring precise molar amounts, volumetric measurements combined with temperature and pressure readings enable accurate calculations.

Conclusion: The Significance of Precise Gas

Measurements

The detailed analysis of helium in two different flask volumes underscores the importance of understanding fundamental gas laws for scientific and practical applications. Whether for research, industrial use, or educational purposes, accurately determining the amount of helium, its behavior under different conditions, and its properties is vital.

The scenario of a 295-mL flask at 757 Torr and a second flask with a volume of 465 mL exemplifies how volume and pressure directly influence the quantity of gas present, adhering closely to the ideal gas law under standard conditions. Helium's low density, inertness, and specific properties make it indispensable across various fields, from cooling systems to leak detection.

In essence, mastering the principles highlighted by this scenario enhances our ability to manipulate, measure, and utilize helium efficiently, ensuring safety, precision, and optimal application in scientific endeavors and industry.

Final thoughts: As the lightest noble gas, helium continues to intrigue scientists and engineers alike. Its behavior in controlled environments, such as the described flasks, provides crucial insights into the fundamentals of gas chemistry and physics, reinforcing the importance of precise measurement and understanding in harnessing this remarkable element

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