A Hydrogen Filled Balloon Has A Bolume Of 8.3 L At 36 C And 751 Torr. How Many Moles Of Hydrogen Are

A Hydrogen Filled Balloon Has A Bolume Of 8.3 L At 36 C And 751 Torr. How Many Moles Of Hydrogen Are this question is a classic example of applying the ideal gas law to real-world scenarios. Understanding how to determine the number of moles of a gas based on its volume, temperature, and pressure is fundamental in chemistry, especially in fields like chemical engineering, environmental science, and physics. In this article, we will explore the principles behind the ideal gas law, walk through the calculations step-by-step, and discuss related concepts to deepen your understanding of gas behavior.

Understanding the Ideal Gas Law

The ideal gas law is a fundamental equation in chemistry that describes the behavior of gases under various conditions. It is expressed as:

$$ PV = nRT $$

Where:
- P = pressure of the gas
- V = volume of the gas
- n = number of moles of gas
- R = ideal gas constant
- T = temperature in Kelvin

This law assumes that gas particles do not interact with each other and occupy no volume, which is a good approximation under many conditions.

Converting Known Values to Standard Units

Before applying the ideal gas law, it’s crucial to ensure all measurements are in compatible units:

Pressure
Given: 751 Torr
Conversion: 1 atm = 760 Torr
Therefore,

$$ P = \frac{751\, \text{Torr}}{760\, \text{Torr/atm}} \approx 0.987\, \text{atm} $$

Temperature
Given: 36°C
Conversion to Kelvin:

$$ T = 36 + 273.15 = 309.15\, \text{K} $$

Volume
Given: 8.3 L (already in liters, which is compatible with the gas constant units)

Gas Constant
Use the value of R in appropriate units:

$$ R = 0.0821\, \text{L·atm/(mol·K)} $$

Step-by-Step Calculation of Moles of Hydrogen

Now that all values are in compatible units, we can proceed with the calculation.

Step 1: Write the ideal gas law formula

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

Step 2: Substitute known values

$$ n = \frac{(0.987\, \text{atm}) \times (8.3\, \text{L})}{(0.0821\, \text{L·atm/(mol·K)}) \times (309.15\, \text{K})} $$

Step 3: Perform the calculation

Numerator:

$$ 0.987 \times 8.3 \approx 8.196 $$

Denominator:

$$ 0.0821 \times 309.15 \approx 25.340 $$

Step 4: Calculate the number of moles

$$ n = \frac{8.196}{25.340} \approx 0.323 \, \text{mol} $$

Therefore, the balloon contains approximately 0.323 moles of hydrogen.

Additional Considerations and Real-World Factors

While the ideal gas law provides a good estimate, real gases exhibit deviations under certain conditions. It’s essential to understand these factors and when corrections are necessary.

1. Non-Ideal Gas Behavior

At high pressures or low temperatures, gas molecules interact more strongly, and the ideal gas law becomes less accurate. Real gases are better described by equations like the Van der Waals equation, which accounts for particle volume and intermolecular forces.

2. Accuracy of Measurements

Precision in measuring pressure, temperature, and volume affects the accuracy of the calculated moles. Using calibrated instruments and proper conversion techniques is vital.

3. Safety Precautions

Hydrogen is highly flammable; handling it requires safety measures, especially in lab or industrial settings.

Related Concepts and Applications

Understanding the calculation of moles from gas measurements has broad applications:

- Gas Law Problems: Such as determining gas quantities in chemical reactions.
- Gas Storage and Transportation: Calculating how much gas is stored under certain conditions.
- Environmental Science: Estimating pollutant or greenhouse gas concentrations.
- Engineering: Designing systems involving pressurized gases.

Practice Problems for Better Understanding

To reinforce your knowledge, try solving these related problems:

1. Calculate the moles of oxygen in a 10 L container at 25°C and 1 atm.
2. A balloon contains 2 mol of helium at 20°C and 2 atm. What is its volume?
3. If a gas sample has a volume of 5 L at 50°C and 600 Torr, how many moles does it contain?

Conclusion

Determining the number of moles of a gas from its volume, temperature, and pressure is a fundamental skill in chemistry. Using the ideal gas law, with proper unit conversions and careful calculations, allows scientists and engineers to understand and manipulate gases effectively. In our example, the hydrogen-filled balloon contains approximately 0.323 moles of hydrogen, illustrating how theoretical concepts translate into real-world insights.

By mastering these calculations, you not only enhance your problem-solving skills but also gain a deeper appreciation for the behavior of gases in various scientific and industrial contexts.

Frequently Asked Questions

What is the ideal gas law formula used to determine the number of moles of hydrogen in the balloon?

The ideal gas law formula is $PV = nRT$, where P is pressure, V is volume, n is moles, R is the gas constant, and T is temperature in Kelvin.

How do you convert the given temperature from Celsius to Kelvin for the calculation?

Add 273.15 to the Celsius temperature: 36°C + 273.15 = 309.15 K.

What is the value of the gas constant R in appropriate units for this calculation?

Using liters, atmospheres, and Kelvin, R = 0.0821 L·atm/(mol·K).

How do you convert the pressure from Torr to Atmospheres?

Divide the pressure in Torr by 760: 751 Torr / 760 ≈ 0.987 atm.

What is the step-by-step calculation to find the number of moles of hydrogen in the balloon?

Using $PV = nRT$: $n = PV / RT = (0.987\ \text{atm})(8.3\ \text{L}) / (0.0821\ \text{L·atm/(mol·K)})(309.15\ \text{K}) \approx 0.326$ mol.

What is the approximate number of moles of hydrogen gas in the balloon?

Approximately 0.326 moles of hydrogen gas.

Why is it important to ensure unit consistency when calculating the number of moles?

Ensuring units are consistent (e.g., pressure in atm, volume in L, temperature in K) is crucial for accurate calculation using the ideal gas law.

Additional Resources

A Hydrogen Filled Balloon Has A Volume of 8.3 L at 36°C and 751 Torr: How Many Moles of Hydrogen Are Present?

Understanding the precise quantity of hydrogen within a balloon involves applying fundamental principles of gas laws, particularly the ideal gas law. This investigation explores the detailed methodology for calculating the number of moles of hydrogen gas contained in a balloon given specific conditions—volume, temperature, and pressure—and examines the broader implications of such calculations in scientific and practical contexts.

Introduction

Hydrogen, the simplest and most abundant element in the universe, plays a vital role in various scientific, industrial, and environmental applications. Its properties, especially when confined within a vessel such as a balloon, are governed by the fundamental principles of gas behavior. Precise quantification of the amount of hydrogen, often expressed in moles, is crucial for applications ranging from chemical reactions to energy storage.

In this article, we analyze a scenario where a balloon filled with hydrogen has a known volume of 8.3 liters at a temperature of 36°C and a pressure of 751 Torr. Our goal is to determine the number of moles of hydrogen gas present within it, using classical gas law equations.

Understanding the Parameters

Before delving into calculations, it is essential to understand the given parameters:

- Volume (V): 8.3 liters
- Temperature (T): 36°C
- Pressure (P): 751 Torr

These parameters are typical of laboratory or environmental conditions, and each plays a critical role in deriving the amount of gas.

Converting Units for Consistency

Accurate calculations require consistent units:

- Temperature: Convert Celsius to Kelvin
- Pressure: Convert Torr to atmospheres (atm)
- Volume: Already in liters, compatible with common gas law units

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Temperature Conversion

Temperature in Kelvin (K) is obtained by adding 273.15 to Celsius temperature:

$T(K) = 36°C + 273.15 = 309.15\ K$

Pressure Conversion

Standard pressure units are atmospheres (atm):

1 atm = 760 Torr

Therefore,

$P(atm) = 751\ Torr \div 760\ Torr/atm \approx 0.9878\ atm$

Application of the Ideal Gas Law

The ideal gas law provides a foundation for calculating the number of moles:

$PV = nRT$

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

Rearranged for n:

$n = PV / (RT)$

This formula allows us to compute the moles of hydrogen gas present under the given conditions.

Calculating the Number of Moles

Plugging in the values:

$n = (0.9878 \text{ atm}) \times (8.3 \text{ L}) / (0.082057 \text{ L·atm/(mol·K)} \times 309.15 \text{ K})$

Calculating numerator:

$0.9878 \times 8.3 \approx 8.202$

Calculating denominator:

$0.082057 \times 309.15 \approx 25.319$

Therefore,

$n \approx 8.202 / 25.319 \approx 0.324$ mol

Result: The balloon contains approximately 0.324 moles of hydrogen.

Implications of the Calculation

The derived amount of hydrogen—roughly one-third of a mole—might seem modest, but it underscores the importance of precise measurement and calculation in scientific contexts.

Practical Significance

- Energy Storage: Knowing the moles of hydrogen helps estimate energy content, since 1 mole of H_2 yields approximately 120 MJ of energy upon combustion.
- Safety Considerations: Hydrogen's flammability necessitates precise quantification for safety protocols during storage and transport.
- Material Science: Understanding gas quantities informs the design of materials resistant to hydrogen embrittlement.

Significance in Scientific Research

Accurate molar calculations aid in:

- Reaction Stoichiometry: Determining reactant and product quantities in chemical reactions involving hydrogen.
- Environmental Monitoring: Estimating hydrogen emissions in ecological studies.
- Fuel Cell Development: Quantifying hydrogen for performance assessments.

Factors Affecting Accuracy and Assumptions

While the ideal gas law offers a straightforward calculation, several factors influence accuracy:

- Non-ideal Behavior: Hydrogen, at high pressures or low temperatures, deviates slightly from ideality.
- Temperature Fluctuations: Variations in temperature impact gas volume and density.
- Measurement Precision: Slight errors in pressure or volume measurements can significantly alter the molar estimate.

In practical applications, corrections using real gas equations (e.g., Van der Waals equation) may be necessary for high-precision work.

Broader Context and Future Perspectives

Understanding the molar quantity of hydrogen in confined spaces is fundamental for advancing technologies such as:

- Hydrogen Fuel Cells: Accurate quantification supports efficiency calculations.
- Hydrogen Economy: Facilitates scalable storage and transport solutions.
- Environmental Impact Assessments: Helps model hydrogen emissions and their ecological effects.

Emerging research focuses on improving measurement techniques, including spectroscopic methods and advanced sensor technologies, to enhance the accuracy of gas quantification in various settings.

Conclusion

Through meticulous application of the ideal gas law, we have determined that a hydrogen-filled balloon with a volume of 8.3 liters at 36°C and 751 Torr contains approximately 0.324 moles of hydrogen gas. This calculation exemplifies the fundamental importance of unit conversions, understanding gas laws, and considering real-world factors influencing gas behavior.

Such quantitative insights are vital across scientific disciplines and industrial applications, from energy storage and safety protocols to environmental monitoring and material science. As technology advances, integrating more sophisticated models and measurement techniques will further refine our understanding of gas quantities in diverse contexts, ultimately contributing to safer, more efficient utilization of hydrogen as a clean energy resource.

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