If I Have 5.0 Moles Of Bromine Gas That Is Kept At 46.7 OC In A 1.4 L Container, What Is The Pressure

If I Have 5.0 Moles Of Bromine Gas That Is Kept At 46.7 OC In A 1.4 L Container, What Is The Pressure provides a compelling question that combines fundamental principles of chemistry, specifically gases behavior, the ideal gas law, and thermodynamics. Whether you're a student preparing for exams or a science enthusiast exploring the properties of gases, understanding how to calculate the pressure of a gas sample given the amount, temperature, and volume is essential. This article offers a comprehensive guide to solving this problem, delving into the underlying concepts, formulas, and step-by-step calculations to help you grasp the topic thoroughly.

Understanding the Components of the Problem

Before jumping into calculations, it’s crucial to understand the information provided and the physical principles involved.

Given Data

- Number of moles of bromine gas (n): 5.0 mol
- Temperature (T): 46.7°C
- Container volume (V): 1.4 L

What Is Being Asked?

- To find the pressure (P) exerted by the bromine gas inside the container.

Fundamental Concepts in Gas Laws

The problem revolves around the ideal gas law, which relates pressure, volume, temperature, and amount of gas.

The Ideal Gas Law

The ideal gas law is expressed as:

$$PV = nRT$$

Where:
- P: Pressure (atm, Pa, or other units)
- V: Volume (liters or cubic meters)
- n: Number of moles (mol)
- R: Ideal gas constant
- T: Temperature (Kelvin)

Converting Data to Appropriate Units

To perform the calculation correctly, all variables must be in compatible units.

1. Temperature Conversion

Convert Celsius to Kelvin:

$$T(K) = T(°C) + 273.15$$

For T = 46.7°C:

$$T = 46.7 + 273.15 = 319.85\, \text{K}$$

2. Gas Constant (R)

The value of R depends on the units used for pressure and volume.

Common choices include:
- 0.082057 L·atm/(mol·K) (if pressure in atm)
- 8.314 J/(mol·K) (if pressure in Pascals, volume in m^3)

For this calculation, we'll use R = 0.082057 L·atm/(mol·K) because the volume is given in liters and it simplifies the pressure calculation in atm.

Calculating the Pressure of Bromine Gas

Now, with all data in appropriate units, apply the ideal gas law.

Step 1: Write the Ideal Gas Law

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P = (nRT) / V
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Step 2: Plug in the Known Values

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P = (5.0 mol) × (0.082057 L·atm/(mol·K)) × (319.85 K) / 1.4 L
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Step 3: Perform the Calculation

Calculate numerator:

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5.0 × 0.082057 × 319.85 ≈ 5.0 × 26.246 ≈ 131.23
```

Divide by volume:

```
P ≈ 131.23 / 1.4 ≈ 93.73 atm
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Therefore, the pressure of bromine gas is approximately 93.73 atm.

Understanding the Significance of the Result

A pressure of nearly 94 atm indicates a highly pressurized environment, which is significant in various chemical and industrial processes involving bromine gas. Such high pressures imply the importance of safety measures and appropriate container design when dealing with gases under these conditions.

Additional Considerations and Real-World Factors

While the ideal gas law provides a good approximation, real gases deviate from ideal behavior under certain conditions. Here are some factors to consider:

- **Gas Deviations:** Bromine gas is a diatomic molecule with polarizability, which might cause deviations from ideal behavior at high pressures or low temperatures.

- **Van der Waals Equation:** For more accurate calculations, especially at high pressures, the Van der Waals equation accounts for molecular size and intermolecular forces.

- **Temperature Effects:** The temperature of 46.7°C is moderate, but as temperature increases, gases tend to behave more ideally.

Practical Applications and Context

Understanding how to calculate the pressure of a gas sample has numerous applications:

Industrial Chemistry

- Managing storage conditions for hazardous gases like bromine.
- Designing reactors and containers that withstand specific pressures.

Laboratory Experiments

- Predicting gas behavior under different temperature and volume conditions.
- Conducting safety assessments for experiments involving bromine.

Environmental Monitoring

- Modeling the dispersion and pressure of gases in the atmosphere.

Summary and Key Takeaways

- The ideal gas law is a fundamental equation used to relate pressure, volume, temperature, and moles of a gas.
- Always convert temperature to Kelvin for calculations.
- Use the appropriate value of the gas constant R based on the units of pressure and volume.
- The calculated pressure for 5.0 mol of bromine gas at 46.7°C in a 1.4 L container is approximately 93.73 atm.
- Real gases may deviate from ideal behavior under certain conditions; more advanced equations can improve accuracy.

Final Thoughts

The ability to determine the pressure of a gas sample accurately is vital across multiple fields, from academic research to industrial applications. This example illustrates how fundamental principles like the ideal gas law provide practical solutions to real-world problems. Whether you're calculating pressures for laboratory experiments or designing industrial processes, mastering these calculations enhances your understanding of gas behavior and thermodynamics.

Remember: Always consider the context of your calculations, and use the appropriate constants and units to ensure accuracy. For complex situations involving high pressures or low temperatures, explore beyond the ideal gas law to more comprehensive models like the Van der Waals equation.

Frequently Asked Questions

How do I calculate the pressure of bromine gas given the moles, temperature, and volume?

You can use the Ideal Gas Law: P = (nRT)/V, where n is moles, R is the gas constant, T is temperature in Kelvin, and V is volume.

What is the value of the gas constant R used in the calculation?

The gas constant R is 0.0821 L·atm/(mol·K) when calculating pressure in atmospheres.

How do I convert the temperature from Celsius to Kelvin?

Add 273.15 to the Celsius temperature: 46.7°C + 273.15 = 319.85 K.

What is the step-by-step calculation to find the pressure of bromine gas?

First, convert temperature to Kelvin (319.85 K). Then, apply the ideal gas law: P = (nRT)/V = (5.0 mol 0.0821 L·atm/(mol·K) 319.85 K) / 1.4 L ≈ 93.4 atm.

What assumptions are made when applying the ideal gas law in this scenario?

The assumptions include that the gas behaves ideally, interactions between molecules are negligible, and the gas particles occupy no volume compared to the container.

How would the pressure change if the temperature increased?

According to the ideal gas law, increasing the temperature (in Kelvin) would proportionally increase the pressure, assuming volume and moles remain constant.

Can real gas deviations affect the calculation for bromine gas under these conditions?

Yes, at high pressures or low temperatures, real gases deviate from ideal behavior. For most conditions like this, the ideal gas law provides a good approximation.

What are common units used for pressure in such calculations, and which should I use?

Common units include atmospheres (atm), pascals (Pa), and torr. For the ideal gas law, atm is typically used, but ensure consistency throughout the calculation.

Additional Resources

If I Have 5.0 Moles Of Bromine Gas That Is Kept At 46.7°C In A 1.4 L Container, What Is The Pressure?

This question encapsulates fundamental principles of chemistry, specifically the application of the ideal gas law to determine the pressure exerted by a given amount of bromine gas at a specified temperature and volume. Understanding how to manipulate and interpret the ideal gas law is essential for students and professionals working in chemical laboratories, industrial processes, and environmental science. This article will provide a comprehensive analysis of the problem, break down the relevant concepts, and walk through the calculations systematically, ensuring clarity for readers with varying levels of familiarity with the subject.

Understanding the Basics: The Ideal Gas Law

The ideal gas law is a pivotal equation in chemistry that relates the pressure, volume, temperature, and amount of gas in moles. It is expressed as:

$$PV = nRT$$

Where:
- P = pressure (atm, Pa, or other units)
- V = volume (L, m^3, etc.)
- n = number of moles (mol)
- R = ideal gas constant
- T = temperature (Kelvin)

This law assumes gases behave ideally, meaning particles do not interact and occupy negligible volume. While real gases deviate at high pressures or low temperatures, for most practical purposes and moderate conditions, the ideal gas law provides a reliable approximation.

Converting Temperature to Kelvin

Given temperature in Celsius (°C), it must be converted to Kelvin (K) since the ideal gas law requires absolute temperature:

$$T(K) = T(°C) + 273.15$$

For our problem:
$$T = 46.7 + 273.15 = 319.85\,K$$

This conversion ensures accurate calculations, as Kelvin scale starts at absolute zero, the theoretical point where particles have minimum possible energy.

Choosing the Appropriate Gas Constant R

The gas constant R can be expressed in various units; the most common for calculations involving pressure in atmospheres and volume in liters is:

$$R = 0.082057\, \text{L·atm·mol}^{-1}\text{·K}^{-1}$$

Using this value simplifies the calculation directly in atmospheres, which is a convenient pressure unit for many applications.

Calculating the Pressure

Given data:
- $n = 5.0\, \text{mol}$
- $V = 1.4\, \text{L}$
- $T = 319.85\,K$
- $R = 0.082057\, \text{L·atm·mol}^{-1}\text{·K}^{-1}$

Applying the ideal gas law:

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

Substituting the known values:

$$ P = \frac{5.0 \times 0.082057 \times 319.85}{1.4} $$

Performing the calculation step-by-step:

1. Calculate numerator:
$$ 5.0 \times 0.082057 = 0.410285 $$
$$ 0.410285 \times 319.85 \approx 131.218 $$

2. Divide by volume:
$$ P = \frac{131.218}{1.4} \approx 93.73\, \text{atm} $$

Thus, the pressure exerted by the bromine gas is approximately 93.73 atm.

Interpreting the Result: Significance and Practical Considerations

The calculated pressure of nearly 94 atmospheres indicates a highly pressurized environment, which is significant in various industrial and laboratory settings. Bromine, being a dense and reactive halogen, requires careful handling, especially under high-pressure conditions. Such pressure levels are typical in specialized chemical processes, such as bromination reactions or storage in high-pressure vessels.

Key features and considerations include:

- Safety: High-pressure gases pose risks of container rupture; appropriate safety protocols and pressure-rated equipment are essential.
- Accuracy of assumptions: The ideal gas law assumes ideal behavior; real gases deviate, especially at high pressures. Bromine’s molar volume and interactions could cause slight deviations.
- Temperature effects: Slight variations in temperature can significantly influence pressure, emphasizing the importance of precise temperature control.

Features and Limitations of the Ideal Gas Law in This Context

Features:

- Simplifies calculations involving gases under many conditions.
- Provides quick estimates useful in laboratory and industrial settings.
- Allows students to develop intuition about how variables relate.

Limitations:

- Assumes gases behave ideally, which is not always accurate.
- Deviations are more pronounced at high pressures or low temperatures.
- Bromine’s actual behavior can involve intermolecular forces and non-negligible molecular volume.

Practical tip: For more accurate predictions, especially at extreme conditions, equations of state like Van der Waals are preferred.

Alternative Approaches and Additional Considerations

While the ideal gas law provides a near-accurate estimate, real-world scenarios sometimes necessitate more sophisticated models. For example:

- Van der Waals Equation: Adjusts for intermolecular forces and finite molecular sizes, giving a more precise pressure estimate.
- Use of empirical data: For bromine, consulting published P-V-T data can inform whether deviations are significant.

Another consideration is the purity of the gas. Impurities or moisture can affect the overall pressure and behavior. Ensuring the gas is pure and accurately measured is crucial for experimental precision.

Summary and Final Thoughts

Calculating the pressure of bromine gas under specified conditions exemplifies the practical application of the ideal gas law. With 5.0 moles of bromine at 46.7°C in a 1.4 L container, the pressure is approximately 93.73 atm, a value that underscores the importance of proper safety measures and the limitations of idealized models.

Understanding the underlying principles enables chemists and engineers to design experiments, operate equipment safely, and interpret data accurately. While the ideal gas law serves as an excellent starting point, always consider real gas behavior and potential deviations for high-precision work.

In conclusion:

- The ideal gas law is a powerful tool for quick calculations.
- Temperature conversion to Kelvin is essential.
- High pressures indicate the need for careful handling and possibly more complex models.
- Always consider the context and limitations of the assumptions involved.

By mastering these concepts, you can confidently approach various problems involving gases and their behaviors in different conditions, paving the way for successful scientific and industrial applications.

If I Have 5 0 Moles Of Bromine Gas That Is Kept At 46 7 Oc In A 1 4 L Container What Is The Pressure

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