Assuming Ideal Behavior, Which Of These Gas Samples Has The Greatest Volume At Stp? 1g Of Kr, 1g Of Ne,

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Understanding the behavior of gases under different conditions is fundamental in chemistry, particularly when comparing the properties of various gases such as krypton (Kr) and neon (Ne). When considering which gas sample will occupy the greatest volume at standard temperature and pressure (STP), it is essential to analyze their molar masses, the principles of the ideal gas law, and how these factors influence gas volumes. This comprehensive guide explores these concepts in detail, providing clarity on why one gas might have a larger volume than the other under identical conditions.

Fundamentals of the Ideal Gas Law

Understanding the Ideal Gas Law

The ideal gas law is a fundamental equation in chemistry that describes the behavior of gases:

$$ PV = nRT $$

Where:
- $ P $ = pressure
- $ V $ = volume
- $ n $ = number of moles
- $ R $ = universal gas constant (8.314 J/(mol·K))
- $ T $ = temperature in Kelvin

At standard temperature and pressure (STP), which is defined as 0°C (273.15 K) and 1 atm pressure, the volume occupied by a gas depends primarily on the number of moles present. This principle is crucial in comparing different gases with the same mass.

Implication for Gas Volumes at STP

According to the ideal gas law, at constant $ P $ and $ T $, the volume of a gas is directly proportional to the number of moles, $ n $. Therefore, to determine which gas occupies the greatest volume given the same mass, we need to analyze their molar quantities.

Calculating Moles of Krypton and Neon

Understanding Molar Mass

The molar mass is the mass of one mole of a substance, typically expressed in grams per mole (g/mol). For the gases in question:

- Krypton (Kr): Molar mass ≈ 83.80 g/mol
- Neon (Ne): Molar mass ≈ 20.18 g/mol

These values are critical because they allow us to convert the given mass of each gas into moles.

Number of Moles in Each Sample

Given that each sample weighs 1 gram:

1. Moles of Krypton (Kr):
$$ n_{Kr} = \frac{\text{mass}}{\text{molar mass}} = \frac{1\,g}{83.80\,g/mol} \approx 0.01194\, \text{mol} $$

2. Moles of Neon (Ne):
$$ n_{Ne} = \frac{\text{mass}}{\text{molar mass}} = \frac{1\,g}{20.18\,g/mol} \approx 0.04956\, \text{mol} $$

Since the number of moles directly influences the volume at constant P and T, the gas with more moles will occupy a larger volume at STP.

Comparing Volumes of the Gas Samples at STP

Volume per Mole at STP

At STP, one mole of any ideal gas occupies approximately 22.4 liters. This is a standard molar volume used as a benchmark in calculations.

Calculating the Volume of Each Gas Sample

Using the number of moles calculated:

- Krypton (Kr):
$$ V_{Kr} = n_{Kr} \times 22.4\,L/mol \approx 0.01194 \times 22.4\,L \approx 0.268\,L $$

- Neon (Ne):

$$ V_{Ne} = n_{Ne} \times 22.4\,L/mol \approx 0.04956 \times 22.4\,L \approx 1.11\,L $$

Result:
The neon gas sample occupies a significantly larger volume (approximately 1.11 liters) compared to krypton (approximately 0.268 liters), given equal masses of 1 gram each.

Conclusion: Which Gas Has the Greatest Volume?

In an ideal behavior scenario at STP, 1 gram of neon occupies a much larger volume than 1 gram of krypton. This outcome is primarily due to the difference in molar masses:

- Neon has a much lower molar mass (20.18 g/mol) than krypton (83.80 g/mol).
- Consequently, 1 gram of neon corresponds to more moles than 1 gram of krypton.
- More moles translate into a larger total volume at the same temperature and pressure.

Therefore, the gas sample of neon has the greatest volume at STP when compared to krypton, assuming ideal behavior.

Additional Considerations and Real-World Factors

While the theoretical calculations assume ideal gas behavior, real gases may deviate slightly due to intermolecular forces and actual molar volumes. However, for most practical purposes, especially under standard conditions, these deviations are minimal.

Key points to consider:

- Ideal Gas Assumption: The calculations rely on the gases behaving ideally, which is a valid approximation at STP for noble gases like neon and krypton.
- Temperature and Pressure: The comparison holds strictly at STP; altering these conditions would affect the volumes proportionally.
- Mass vs. Moles: When comparing gases by mass, the molar mass significantly influences the total number of molecules and thus the total volume.

Summary of Key Points

- The ideal gas law states that at constant pressure and temperature, the volume of a gas is proportional to the number of moles.
- Neon has a much lower molar mass than krypton, leading to a higher number of moles in a 1-gram

sample.
- As a result, 1 gram of neon occupies a larger volume at STP than 1 gram of krypton.
- The calculations demonstrate the importance of molar mass in determining gas volumes under ideal conditions.

Practical Implications and Applications

Understanding which gases occupy larger volumes at a given mass is essential in various fields, including:

- Industrial Gas Storage: Planning for storage capacities based on molar masses and gas behaviors.
- Chemical Reactions: Calculating reactant volumes to optimize reactions involving noble gases.
- Environmental Science: Estimating gas concentrations and volumes in atmospheric studies.

Final Thoughts

In conclusion, assuming ideal behavior, the 1-gram sample of neon will occupy a considerably larger volume at STP compared to 1 gram of krypton. This outcome underscores the crucial role of molar mass in gas volume calculations and highlights the importance of fundamental principles like the ideal gas law in solving practical chemistry problems.

Remember: Always consider the context and assumptions behind these calculations, and recognize that real-world deviations may occur, especially at extreme pressures or temperatures. However, for most standard conditions, the ideal gas law provides a reliable and straightforward method to compare gas volumes based on mass and molar properties.

Frequently Asked Questions

Which gas sample has the greatest volume at STP when assuming ideal behavior: 1g of krypton (Kr) or 1g of neon (Ne)?

The 1g of neon (Ne) will have the greater volume at STP because neon has a lower molar mass than krypton, resulting in more moles of neon for the same mass, and thus a larger volume under ideal gas conditions.

Why does neon occupy a larger volume than krypton at STP

when equal masses are compared?

Because neon has a lower molar mass (20.18 g/mol) compared to krypton (83.80 g/mol), more moles of neon are present in 1g, leading to a larger volume according to the ideal gas law.

What is the key factor determining which gas sample has the greatest volume at STP?

The key factor is the number of moles present, which depends on the molar mass; the gas with the lower molar mass will have more moles and thus a larger volume at STP.

How do you calculate the number of moles for each gas sample in this comparison?

Use the formula: moles = mass / molar mass. For 1g of each gas, divide 1 gram by its respective molar mass to find the number of moles.

What are the molar masses of krypton and neon, and how do they influence the volume at STP?

Krypton has a molar mass of approximately 83.80 g/mol, and neon has about 20.18 g/mol. Since volume at STP is proportional to the number of moles, neon's lower molar mass results in more moles and a larger volume.

If both gases are at the same temperature and pressure, which one will occupy a larger volume: 1g of Kr or 1g of Ne?

1g of neon will occupy a larger volume because it contains more moles than 1g of krypton due to its lower molar mass.

Does assuming ideal behavior significantly affect which gas has the greater volume in this scenario?

Assuming ideal behavior simplifies calculations and confirms that the gas with more moles—in this case, neon—will have the greater volume at STP.

How would the answer change if the masses of krypton and neon were different?

If the masses differ, the gas with the larger number of moles (considering both mass and molar mass) will have the greater volume; the comparison must then account for the specific masses used.

Can this reasoning be applied to other gases to determine which has the greatest volume at STP?

Yes, for any gases, the one with the lower molar mass at the same mass will have more moles and

thus a larger volume at STP, assuming ideal behavior.

Additional Resources

Assuming Ideal Behavior, Which Of These Gas Samples Has The Greatest Volume At STP? 1g Of Kr, 1g Of Ne

Understanding the behavior of gases under standard conditions is fundamental in chemistry, especially when comparing different gases based on their quantities and properties. When asked which gas sample—either 1 gram of Krypton (Kr) or 1 gram of Neon (Ne)—occupies the greatest volume at Standard Temperature and Pressure (STP), it's essential to analyze the problem systematically, applying the principles of the ideal gas law and molar concepts. This detailed review will explore the theoretical basis, calculations, and implications of assuming ideal gas behavior, culminating in a reasoned conclusion.

Fundamentals of Gas Behavior and the Ideal Gas Law

Before delving into specific calculations, it is crucial to understand the foundational principles governing gases:

1. The Ideal Gas Law

The ideal gas law provides a mathematical model to describe the behavior of gases under certain conditions:

$$
PV = nRT
$$

Where:
- P = pressure (atm)
- V = volume (liters)
- n = number of moles
- R = universal gas constant ($0.0821\, \text{L·atm·mol}^{-1}\text{·K}^{-1}$)
- T = temperature (Kelvin)

At STP, by definition:
- Pressure P = 1 atm
- Temperature T = 273.15 K

Given these conditions, the volume of a gas depends directly on the number of moles n.

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2. Molar Mass and Moles Calculation

The key to comparing different gases of the same mass lies in calculating the number of moles each sample contains:

$$
n = \frac{\text{mass}}{\text{molar mass}}
$$

Thus, the molar mass of Krypton and Neon is crucial.

Gas	Atomic Number	Molar Mass (g/mol)
Krypton (Kr)	36	83.80 g/mol
Neon (Ne)	10	20.18 g/mol

Calculating Moles of Each Gas Sample

Given 1 gram of each gas, the number of moles can be calculated:

1. Moles of Krypton (Kr)

$$
n_{Kr} = \frac{1\, \text{g}}{83.80\, \text{g/mol}} \approx 0.01193\, \text{mol}
$$

2. Moles of Neon (Ne)

$$
n_{Ne} = \frac{1\, \text{g}}{20.18\, \text{g/mol}} \approx 0.04956\, \text{mol}
$$

Observation: Neon has approximately four times more moles than Krypton in a 1-gram sample because of its significantly lower molar mass.

Volume Calculation at STP

Using the ideal gas law and the number of moles, the volume for each gas at STP can be calculated

with:

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

At STP, $P = 1\, \text{atm}$, $T = 273.15\, \text{K}$, and $R = 0.0821\, \text{L·atm·mol}^{-1}\text{·K}^{-1}$.

1. **Krypton (Kr):**

   $$
   V_{Kr} = n_{Kr} \times R \times T / P = 0.01193\, \text{mol} \times 0.0821\, \text{L·atm·mol}^{-1}\text{·K}^{-1} \times 273.15\, \text{K}
   $$
   $$
   V_{Kr} \approx 0.01193 \times 0.0821 \times 273.15 \approx 0.268\, \text{L}
   $$

2. **Neon (Ne):**

   $$
   V_{Ne} = 0.04956\, \text{mol} \times 0.0821 \times 273.15
   $$
   $$
   V_{Ne} \approx 0.04956 \times 0.0821 \times 273.15 \approx 1.11\, \text{L}
   $$

Comparison and Interpretation

From the calculations:
- Volume of 1g Krypton at STP: approximately 0.268 liters
- Volume of 1g Neon at STP: approximately 1.11 liters

Conclusion: Under ideal conditions, 1 gram of Neon occupies a significantly larger volume than 1 gram of Krypton at STP.

Deeper Insights and Implications

While the calculations seem straightforward, understanding the implications and underlying reasons enriches our perspective:

1. Role of Molar Mass in Gas Volume

- The molar mass determines the number of moles present in a given mass.
- Lower molar mass gases yield more moles for the same mass, resulting in larger volumes at the same temperature and pressure.

2. Ideal Gas Assumption

- The calculations assume gases behave ideally, meaning no intermolecular forces and particles occupy no volume.
- Real gases deviate from ideal behavior at high pressures or low temperatures but are close to ideal at STP for noble gases like Krypton and Neon.

3. Noble Gases and their Ideal Behavior

- Noble gases are monatomic and have minimal intermolecular interactions, making them excellent candidates for ideal gas approximations.
- The differences observed are primarily due to molar mass differences, not complex intermolecular effects.

Additional Factors and Considerations

While the ideal gas law provides a solid foundation, real-world applications often require more nuanced understanding. Here are some additional aspects:

1. Variability at Different Conditions

- Deviations from ideal behavior increase at high pressures and low temperatures.
- For gases like Krypton and Neon, at standard conditions, deviations are minimal, but this should be kept in mind for other contexts.

2. Practical Applications

- Knowledge of molar volume differences informs the storage and transport of noble gases.
- Neon, being lighter and occupying more volume per unit mass, is preferred in applications requiring large volumes of gas, such as neon lighting.

3. Isotopic Variations

- While not relevant here, isotopic differences can slightly alter molar masses and, consequently, volume calculations.

Summary and Final Perspective

Based on the ideal gas law and the calculations above, the gas sample with the greatest volume at STP for 1 gram of each is Neon. The key points are:

- Neon has a molar mass of approximately 20.18 g/mol, resulting in about 0.04956 mol in 1 g.
- Krypton's molar mass of about 83.80 g/mol yields only about 0.01193 mol in 1 g.
- Since volume at STP is directly proportional to the number of moles, Neon's volume is roughly four times that of Krypton's.

In essence, assuming ideal behavior, the lighter noble gas (Neon) will always occupy a greater volume than the heavier noble gas (Krypton) when equal masses are compared at STP.

Final Remarks

This analysis underscores the importance of understanding molar mass and the ideal gas law when comparing gaseous samples. It's a testament to how fundamental principles in chemistry can yield clear, quantitative insights. For students and professionals alike, mastering these concepts enhances predictive capabilities and informs experimental design, storage considerations, and application development involving gases.

In conclusion, assuming ideal behavior, 1 gram of Neon occupies a significantly larger volume at STP than 1 gram of Krypton, primarily due to Neon's lower molar mass and higher molar quantity per unit mass.

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