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Understanding the concept of partial pressure in gas mixtures is fundamental in chemistry, especially when analyzing the behavior of gases under various conditions. In this article, we will explore how to determine the partial pressure of each gas in a mixture, using the given data: 10.0 grams of neon (Ne), 10 grams of argon (Ar), and a total pressure of 1.6 atm. We will walk through the calculations step-by-step, providing insights into the underlying principles and relevant formulas.

Introduction to Partial Pressure and Dalton's Law

Before delving into the calculations, it is essential to understand what partial pressure means and how it relates to the total pressure in a mixture of gases.

What Is Partial Pressure?

Partial pressure refers to the pressure exerted by a single component of a gas mixture as if it alone occupied the entire volume at the same temperature. It is proportional to the mole fraction of that gas in the mixture and the total pressure.

Dalton's Law of Partial Pressures

Dalton's Law states that in a mixture of non-reacting gases, the total pressure (P_{total}) is the sum of the partial pressures of individual gases:

$$P_{\text{total}} = P_{\text{Ne}} + P_{\text{Ar}}$$

Furthermore, the partial pressure of each gas can be calculated as:

$$P_{\text{gas}} = X_{\text{gas}} \times P_{\text{total}}$$

Where:

- X_{gas} is the mole fraction of the gas in the mixture.
- P_{total} is the total pressure of the mixture.

Step 1: Calculating Moles of Each Gas

The first step involves converting the given masses of neon and argon into moles, which is necessary because partial pressures depend on mole quantities.

Atomic Masses of Neon and Argon

- Neon (Ne): approximately 20.18 g/mol
- Argon (Ar): approximately 39.95 g/mol

Calculating Moles

Using the formula:

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

we get:

- Moles of Neon:

$$n_{\text{Ne}} = \frac{10.0\text{ g}}{20.18\text{ g/mol}} \approx 0.496\text{ mol}$$

- Moles of Argon:

$$n_{\text{Ar}} = \frac{10\text{ g}}{39.95\text{ g/mol}} \approx 0.250\text{ mol}$$

Step 2: Calculating Mole Fractions

The mole fraction of each gas is the ratio of moles of that gas to the total moles in the mixture.

Total moles:

$$n_{\text{total}} = n_{\text{Ne}} + n_{\text{Ar}} \approx 0.496 + 0.250 = 0.746\text{ mol}$$

Mole fraction of Neon:

$$X_{\text{Ne}} = \frac{n_{\text{Ne}}}{n_{\text{total}}} \approx \frac{0.496}{0.746} \approx 0.664$$

Mole fraction of Argon:

$$X_{\text{Ar}} = \frac{n_{\text{Ar}}}{n_{\text{total}}} \approx \frac{0.250}{0.746} \approx 0.335$$

Note: Mole fractions sum to 1:

$$X_{\text{Ne}} + X_{\text{Ar}} \approx 0.664 + 0.335 = 0.999$$

Small rounding differences are expected.

Step 3: Calculating Partial Pressures

Applying Dalton's Law:

$$P_{\text{Ne}} = X_{\text{Ne}} \times P_{\text{total}}$$

$$P_{\text{Ar}} = X_{\text{Ar}} \times P_{\text{total}}$$

Given total pressure:

$$P_{\text{total}} = 1.6 \text{ atm}$$

Calculate each:

- Neon:

$$P_{\text{Ne}} = 0.664 \times 1.6 \text{ atm} \approx 1.062 \text{ atm}$$

- Argon:

$$P_{\text{Ar}} = 0.335 \times 1.6 \text{ atm} \approx 0.536 \text{ atm}$$

Final Results and Interpretation

The partial pressures of neon and argon in the mixture are approximately:

- Neon: 1.062 atm

- Argon: 0.536 atm

These values satisfy Dalton's Law, confirming that the sum of the partial pressures equals the total pressure:

$$1.062 \text{ atm} + 0.536 \text{ atm} \approx 1.598 \text{ atm}$$

which aligns with the given total pressure of 1.6 atm, considering minor rounding errors.

Additional Insights

Understanding the partial pressures of gases in mixtures is crucial in various scientific and industrial applications, such as:

- Gas chromatography: for analyzing mixtures of gases.
- Chemical reactions: where partial pressures influence reaction rates and equilibria.
- Industrial processes: such as the production of pure gases or mixtures.

Furthermore, the principles illustrated here can be extended to more complex mixtures involving multiple gases, each with different molar masses and mole fractions.

Practical Applications and Importance

Knowing the partial pressures helps in:

- Estimating the behavior of gases under different conditions.
- Predicting how gases will behave in reactions or in confined spaces.
- Designing equipment like tanks or reactors that handle gas mixtures safely.

- Ensuring proper conditions in processes like gas separation or purification.

Summary

In summary, given the mass of neon and argon in a mixture and the total pressure, we can determine each gas's partial pressure through these steps:

1. Convert the masses into moles using molar masses.
2. Calculate mole fractions based on the total moles.
3. Multiply mole fractions by the total pressure to find partial pressures.

For the specific case discussed:

- Neon's partial pressure is approximately 1.062 atm.
- Argon's partial pressure is approximately 0.536 atm.

These calculations demonstrate the practical application of Dalton's Law and mole fraction concepts in real-world chemistry problems.

Conclusion

Understanding how to calculate partial pressures is an essential skill in chemistry, enabling scientists and engineers to analyze and manipulate gas mixtures effectively. The example provided illustrates the step-by-step approach to solving such problems, reinforcing the importance of molar conversions, mole fractions, and Dalton's Law. Whether working in laboratories, industrial settings, or academia, mastering these principles ensures accurate predictions and optimal process designs involving gases.

Keywords: partial pressure, Dalton's Law, mole fraction, gas mixture, neon, argon, total pressure, molar mass, gas calculations, chemistry

Frequently Asked Questions

What is the partial pressure of neon in the mixture?

The partial pressure of neon (Ne) is approximately 0.80 atm.

How do you calculate the partial pressure of a gas in a mixture?

The partial pressure is calculated using Dalton's Law: $P_{\text{gas}} = (\text{moles of gas} / \text{total moles}) \times \text{total pressure}$.

What is the significance of the molar masses of Ne and Ar in this calculation?

The molar masses (Ne $\approx$ 20.18 g/mol, Ar $\approx$ 39.95 g/mol) are used to determine the number of moles of each gas for calculating their partial pressures.

How do you find the total moles of gases in the mixture?

Calculate moles of each gas by dividing mass by molar mass, then sum these to find total moles.

What assumptions are made in this calculation?

Assumes ideal gas behavior and that the gases do not interact with each other.

If the total pressure is 1.6 atm, what is the partial pressure of argon?

The partial pressure of argon (Ar) is approximately 0.80 atm.

Can Dalton's Law be used directly to find each gas's partial pressure in this problem?

Yes, after calculating the mole fractions of each gas, Dalton's Law allows direct calculation of their partial pressures.

Additional Resources

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Introduction

The behavior of gases in mixtures is a fundamental concept in chemistry, particularly within the realm of gaseous laws and their applications. Understanding how individual gases contribute to the total pressure in a mixture not only deepens our grasp of thermodynamics but also has practical implications in industries ranging from chemical manufacturing to environmental science. The question at hand involves a mixture of neon (Ne) and argon (Ar) gases, with given masses, and a total pressure observed in the container. The central challenge is to determine the partial pressure of each component, specifically neon and argon, based on the provided data.

This article aims to provide a comprehensive, detailed analysis of this problem, exploring the principles behind gas mixtures, the calculations involved in deriving partial pressures, and the broader significance of these concepts.

Fundamental Principles of Gas Mixtures

Dalton's Law of Partial Pressures

At the core of understanding gas mixtures is Dalton's Law, which states:

> In a mixture of non-reacting gases, the total pressure exerted is equal to the sum of the partial pressures of individual gases.

Mathematically, this is expressed as:

$$P_{\text{total}} = P_{\text{Ne}} + P_{\text{Ar}}$$

where P_{Ne} and P_{Ar} are the partial pressures of neon and argon, respectively.

The partial pressure of each gas can be understood as the pressure the gas would exert if it alone occupied the entire volume at the same temperature.

The Mole Fraction Concept

A critical aspect of partial pressures is the mole fraction (X_i), which indicates the proportion of a particular gas within the mixture:

$$X_i = \frac{n_i}{n_{\text{total}}}$$

where:

- n_i is the number of moles of gas i ,
- n_{total} is the total number of moles in the mixture.

The partial pressure of each component can then be calculated as:

$$P_i = X_i \times P_{\text{total}}$$

This relation underscores the importance of knowing the mole quantities of each gas.

Step-by-Step Analytical Approach

1. Calculating Moles of Each Gas

Given the masses of neon and argon, the first step is to convert these to moles using their molar masses:

- Neon (Ne): Atomic mass $\approx 20.18 \text{ g/mol}$

- Argon (Ar): Atomic mass $\approx 39.95 \text{ g/mol}$

Calculations:

$$n_{\text{Ne}} = \frac{10.0 \text{ g}}{20.18 \text{ g/mol}} \approx 0.496 \text{ mol}$$

$$n_{\text{Ar}} = \frac{10 \text{ g}}{39.95 \text{ g/mol}} \approx 0.250 \text{ mol}$$

2. Determining Total Moles

Total moles in the mixture:

$$n_{\text{total}} = n_{\text{Ne}} + n_{\text{Ar}} \approx 0.496 + 0.250 = 0.746 \text{ mol}$$

3. Calculating Mole Fractions

Mole fractions are:

$$X_{\text{Ne}} = \frac{0.496}{0.746} \approx 0.664$$

$$X_{\text{Ar}} = \frac{0.250}{0.746} \approx 0.336$$

4. Applying Dalton's Law

Given the total pressure:

$$P_{\text{total}} = 1.6 \text{ atm}$$

The partial pressures are:

$$P_{\text{Ne}} = X_{\text{Ne}} \times P_{\text{total}} \approx 0.664 \times 1.6 \text{ atm} \approx 1.062 \text{ atm}$$

$$P_{\text{Ar}} = X_{\text{Ar}} \times P_{\text{total}} \approx 0.336 \times 1.6 \text{ atm} \approx 0.537 \text{ atm}$$

Broader Context and Significance

Practical Applications of Partial Pressure Calculations

Understanding partial pressures is crucial in various scientific and industrial processes:

- Gas Storage and Transportation: Ensuring safety and stability by predicting pressure contributions of each component.
- Chemical Reactions: Many reactions depend on partial pressures, especially in equilibrium calculations (Le Châtelier's principle).
- Environmental Monitoring: Tracking gas compositions in atmospheres, pollution analysis, and climate modeling.

Implications for Gas Behavior

The calculations demonstrate that even with equal masses, different gases contribute differently to the overall pressure due to their distinct molar masses and mole fractions. Neon, being lighter, has a higher mole fraction and thus a higher partial pressure than argon in this specific mixture.

Potential Sources of Error and Assumptions

While the calculations above are straightforward, certain assumptions are inherent:

- Ideal Gas Behavior: The gases are assumed to behave ideally, meaning interactions between molecules are negligible, and volume occupied by molecules themselves is insignificant.
- Constant Temperature: The entire system is maintained at a constant temperature, ensuring the validity of the ideal gas law.
- Uniform Mixing: The gases are evenly mixed, with no phase separation or stratification.

Real-world deviations from these assumptions can lead to slight differences in actual partial pressures, especially at high pressures or low temperatures.

Advanced Considerations

Non-Ideal Gas Effects

At higher pressures or lower temperatures, gases exhibit non-ideal behavior, requiring corrections such as those provided by the Van der Waals equation. In this scenario, the partial pressure calculations might need adjustment to account for these effects.

Partial Pressures in Mixture Calculations for Complex Systems

In more complex systems, such as those involving multiple gases or reactive species, partial pressure calculations become more intricate, often requiring iterative or computational methods.

Conclusion

The exercise of determining the partial pressure of neon and argon in a mixture exemplifies fundamental principles of gas behavior, notably Dalton's Law and mole fraction calculations. By converting masses to moles, computing mole fractions, and applying the total pressure, we find that neon exerts a partial pressure of approximately 1.062 atm, while argon contributes about 0.537 atm to the total 1.6 atm pressure.

Such calculations are not only academic exercises but are also vital in real-world applications where precise gas compositions influence safety, efficiency, and environmental impact. Mastery of these concepts enables scientists and engineers to design better systems, predict behaviors under various

conditions, and interpret observational data accurately.

In essence, understanding partial pressures in gas mixtures provides a window into the microscopic world of molecules, revealing how individual components shape the macroscopic properties of gases that surround us daily.

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