A Student Has A Sample Of 1.58 Moles Of Fluorine Gas That Is Contained In A 25.3 L Container At 274 K.

A Student Has A Sample Of 1.58 Moles Of Fluorine Gas That Is Contained In A 25.3 L Container At 274 K. This scenario offers an excellent opportunity to explore various fundamental concepts in chemistry, including gas laws, molar calculations, and the properties of fluorine gas. Understanding how to analyze such a problem involves applying the ideal gas law, calculating molar volume, and interpreting the physical conditions of the gas sample. Whether you're a student studying chemistry or an enthusiast interested in the behavior of gases, this comprehensive guide will walk you through the essential principles and calculations related to the sample of fluorine gas described.

Understanding the Key Components of the Problem

1. The Given Data

- Number of moles of fluorine gas (n): 1.58 mol
- Volume of the container (V): 25.3 liters
- Temperature (T): 274 Kelvin
- Type of gas: Fluorine gas (F_2)

2. The Objectives of the Problem

- Calculate the pressure exerted by the fluorine gas inside the container.
- Determine the molar volume of fluorine gas under the given conditions.
- Analyze whether the gas behaves ideally under these conditions.
- Explore the physical properties and safety considerations of fluorine gas.

Applying the Ideal Gas Law

1. The Ideal Gas Law Equation

The ideal gas law provides a mathematical relationship between pressure (P), volume (V), temperature (T), and amount of substance (n):

$$
PV = nRT
$$

Where:
- P = pressure in atmospheres (atm)
- V = volume in liters (L)
- n = number of moles (mol)
- R = ideal gas constant (0.0821 L·atm/(mol·K))
- T = temperature in Kelvin (K)

2. Calculating the Pressure of Fluorine Gas

Given:
- n = 1.58 mol
- V = 25.3 L
- T = 274 K
- R = 0.0821 L·atm/(mol·K)

Plugging the values into the ideal gas law:

$$
P = \frac{nRT}{V} = \frac{(1.58)(0.0821)(274)}{25.3}
$$

Calculating step-by-step:

- $0.0821 \times 274 = 22.4814$
- $1.58 \times 22.4814 = 35.545$
- $P = \frac{35.545}{25.3} \approx 1.406\, \text{atm}$

Result: The pressure exerted by the fluorine gas is approximately 1.41 atm.

Molar Volume of Fluorine Gas Under Given Conditions

1. Definition of Molar Volume

Molar volume refers to the volume occupied by one mole of a gas at specific temperature and pressure conditions.

$$
\text{Molar Volume} (V_m) = \frac{V}{n}
$$

2. Calculating Molar Volume

Using the provided data:

$$
V_m = \frac{25.3\, \text{L}}{1.58\, \text{mol}} \approx 16.01\, \text{L/mol}
$$

Implication: Under the given conditions (T=274 K, P≈1.41 atm), one mole of fluorine gas occupies approximately 16.01 liters.

3. Comparison with Ideal Gas Molar Volume

At standard temperature and pressure (STP: 273.15 K, 1 atm), the molar volume of an ideal gas is approximately 22.4 L/mol.

- The calculated molar volume (16.01 L/mol) is less than the ideal molar volume at STP, indicating that fluorine gas under these conditions is somewhat compressed relative to ideal behavior. This is expected because real gases deviate from ideal behavior at different temperatures and pressures.

Physical and Chemical Properties of Fluorine Gas

1. Characteristics of Fluorine Gas

- Color and Odor: Pale yellow, pungent odor
- Physical State: Highly reactive, toxic, and corrosive gas
- Molecular Composition: Diatomic molecule (F_2)

2. Reactivity and Safety Considerations

- Fluorine is the most electronegative element, making it extremely reactive.
- It reacts with almost all organic and inorganic substances, often releasing energy.
- Due to its high reactivity, fluorine gas must be handled with specialized equipment and safety protocols.

3. Industrial and Laboratory Uses

- Used in the production of uranium hexafluoride for nuclear fuel processing.
- Employed in manufacturing fluorocarbons and pharmaceuticals.
- Utilized in etching and cleaning processes in electronics manufacturing.

Gas Laws and Real-World Implications

1. Deviations from Ideal Behavior

While the ideal gas law provides a good approximation, real gases exhibit deviations, especially at high pressures and low temperatures. Factors influencing these deviations include:
- Molecular size
- Intermolecular forces

For fluorine gas, the high reactivity and small molecular size mean deviations are relatively minimal at moderate conditions but become more significant under extreme conditions.

2. Calculating the Compressibility Factor (Z)

The compressibility factor Z helps quantify deviations:

$$
Z = \frac{PV}{nRT}
$$

Using the calculated P and V:

$$
Z = \frac{(1.41\, \text{atm})(25.3\, \text{L})}{(1.58\, \text{mol})(0.0821)(274\, \text{K})}
$$

Calculations:

- Numerator: $1.41 \times 25.3 = 35.673$
- Denominator: $1.58 \times 0.0821 \times 274 = 35.545$

$$
Z \approx \frac{35.673}{35.545} \approx 1.00
$$

Conclusion: The Z-factor is approximately 1, indicating that fluorine behaves nearly ideally under these conditions.

Conclusion and Summary

- A sample of 1.58 moles of fluorine gas in a 25.3-liter container at 274 K exerts a pressure of approximately 1.41 atm.
- The molar volume of fluorine gas under these conditions is about 16.01 L/mol, which is less than the molar volume at STP, reflecting slight compression.

- Fluorine’s properties make it highly reactive and hazardous, requiring careful handling.
- Under the specified conditions, fluorine gas exhibits near-ideal behavior, as indicated by the compressibility factor close to 1.
- Understanding these principles is essential for chemists working with gases, especially reactive gases like fluorine.

Additional Considerations for Students and Professionals

- Always consider safety protocols when handling fluorine gas due to its toxicity and reactivity.
- Use accurate measurements and calibrated equipment for precise calculations.
- Recognize the limitations of the ideal gas law and know when to apply real gas corrections.
- Explore further applications of gas laws in industrial processes, environmental science, and research.

Optimizing for SEO Keywords:

- Fluorine gas properties
- Ideal gas law calculations
- Molar volume of fluorine
- Gas law applications
- Fluorine reactivity and safety
- Real gas behavior
- Gas pressure and temperature relationship
- Handling reactive gases

By understanding the behavior of fluorine gas within the framework of fundamental gas laws, students and professionals can better grasp the nuances of gas chemistry and its practical applications.

Frequently Asked Questions

What is the molar amount of fluorine gas in the sample?

The sample contains 1.58 moles of fluorine gas.

What is the volume of the container holding the fluorine gas?

The fluorine gas is contained in a 25.3 L container.

What is the temperature of the fluorine gas sample?

The temperature of the sample is 274 K.

How can we determine the pressure of the fluorine gas using the ideal gas law?

Using the ideal gas law $PV = nRT$, where P is pressure, V is volume, n is moles, R is the gas constant, and T is temperature, we can calculate the pressure.

What is the value of the ideal gas constant R used in calculations?

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

Calculate the pressure of the fluorine gas in the container.

Using $PV = nRT$: $P = (nRT)/V = (1.58 \text{ mol})(0.0821 \text{ L·atm/(mol·K)})(274 \text{ K})/25.3 \text{ L} \approx 2.83 \text{ atm}$.

Why is understanding the ideal gas law important in this context?

It allows students to predict and analyze the behavior of gases under different conditions, such as calculating pressure, which is crucial in chemical experiments and industrial applications involving fluorine gas.

Additional Resources

A Student Has A Sample Of 1.58 Moles Of Fluorine Gas That Is Contained In A 25.3 L Container At 274 K

In the world of chemistry, understanding the behavior of gases under different conditions is fundamental. Recently, a student conducted an experiment involving fluorine gas—an element known for its high reactivity and significance in various industrial applications. The student’s sample consisted of 1.58 moles of fluorine gas confined within a 25.3-liter container at a temperature of 274 Kelvin. This scenario offers a fascinating opportunity to explore the core principles governing gases, particularly through the lens of the Ideal Gas Law, and to examine how these principles translate into real-world laboratory conditions.

In this article, we will delve into the details of this case, breaking down the underlying chemistry, calculations, and implications. From understanding the basic properties of fluorine gas to applying the ideal gas law for practical calculations, this discussion aims to be both technical and accessible, illuminating the significance of such experiments in scientific learning and industrial applications.

Understanding Fluorine Gas: Properties and Significance

What is Fluorine Gas?

Fluorine gas (F_2) is a diatomic molecule composed of two fluorine atoms bonded together. It is the most reactive and electronegative element on the periodic table, making it highly corrosive and toxic. Due to its reactivity, fluorine gas readily forms compounds with almost all other elements, including those that are typically inert.

Physical Properties

- Molecular weight: Approximately 38.00 g/mol
- State at room temperature: Gas
- Color and odor: Pale yellow gas with a pungent odor
- Reactivity: Extremely reactive, capable of forming fluorides with metals and nonmetals

Industrial and Scientific Importance

Fluorine’s unique properties make it invaluable in manufacturing:

- Production of uranium hexafluoride in nuclear fuel cycles
- Synthesis of pharmaceuticals and agrochemicals
- Manufacturing of Teflon and other fluoropolymers
- Treatment of water to prevent tooth decay

Given its hazardous nature, controlled laboratory experiments and precise calculations are essential to safely handle fluorine gas and understand its behavior.

The Scenario: Analyzing the Fluorine Gas Sample

The core of the scenario involves a sample with the following parameters:

- Number of moles (n): 1.58 mol
- Volume (V): 25.3 liters
- Temperature (T): 274 Kelvin
- Ideal Gas Law: PV = nRT

By analyzing these parameters, scientists and students can determine various properties such as pressure and density, which are crucial for understanding how fluorine behaves under specific conditions.

Applying the Ideal Gas Law: Foundations and Calculations

The Ideal Gas Law Equation

The ideal gas law is expressed as:

$$PV = nRT$$

Where:

- P: Pressure (atm)
- V: Volume (liters)
- n: Number of moles (mol)
- R: Ideal gas constant (0.0821 L·atm/(mol·K))
- T: Temperature (Kelvin)

This law assumes that gas particles do not interact and occupy no volume—an approximation that holds well at moderate conditions for many gases, including fluorine.

Calculating the Pressure

Given the known parameters, we can calculate the pressure exerted by the fluorine gas:

$P = (nRT) / V$

Plugging in the values:

$P = (1.58 \text{ mol} \times 0.0821 \text{ L·atm/(mol·K)} \times 274 \text{ K}) / 25.3 \text{ L}$

Calculating step-by-step:

- $R \times T = 0.0821 \times 274 \approx 22.49$
- $n \times (R \times T) = 1.58 \times 22.49 \approx 35.58$
- $P = 35.58 / 25.3 \approx 1.41$ atm

Result: The pressure of fluorine gas in the container is approximately 1.41 atmospheres.

Significance of the Pressure Calculation

Understanding the pressure helps in:

- Ensuring safe handling conditions
- Designing appropriate containment systems
- Predicting how the gas will behave under different conditions

In industrial settings, maintaining pressures within safe limits is critical, especially with reactive gases like fluorine.

Exploring Gas Density and Molar Volume

Gas Density

Density (d) refers to the mass per unit volume:

$d = \text{mass} / \text{volume}$

Since mass = moles × molar mass:

- Mass = 1.58 mol × 38.00 g/mol ≈ 60.04 grams

Therefore:

$$d = 60.04\ g / 25.3\ L \approx 2.37\ g/L$$

This density value informs us about how much fluorine gas weighs per liter at the given conditions, which is vital for storage and transportation considerations.

Molar Volume

The molar volume at the given temperature and pressure can be calculated as:

$$V_m = V / n = 25.3\ L / 1.58\ mol \approx 16.01\ L/mol$$

This is close to the molar volume of an ideal gas at standard temperature and pressure (22.4 L/mol), indicating slight deviations due to the actual conditions.

Real-World Implications and Safety Considerations

Safety Precautions

Handling fluorine gas requires strict safety protocols owing to its:

- High reactivity
- Toxicity
- Corrosiveness
- Potential to cause severe chemical burns

Laboratories employ specialized equipment, such as corrosion-resistant containers and proper ventilation, to contain and manage fluorine safely.

Industrial Relevance

Accurate calculations of pressure, density, and molar volume influence the design of:

- Storage tanks
- Reactors
- Gas delivery systems

Understanding these properties ensures that industrial processes involving fluorine are efficient, safe, and compliant with regulations.

Broader Applications of Gas Calculations

The principles illustrated in this scenario are foundational for:

- Predicting gas behavior in chemical reactions
- Designing industrial processes
- Developing safety standards
- Conducting environmental impact assessments

For students and professionals alike, mastering the ideal gas law and related calculations is essential for advancing in fields like chemical engineering, environmental science, and materials science.

Conclusion: Bridging Theory and Practice

The case of a student with 1.58 moles of fluorine gas in a 25.3-liter container at 274 Kelvin exemplifies how fundamental principles of chemistry translate into practical understanding. By applying the ideal gas law, we can determine key properties such as pressure and density, which inform safety protocols and industrial applications. Fluorine's reactive nature underscores the importance of precise calculations and careful handling.

This scenario highlights the intersection of theoretical knowledge and real-world application, demonstrating that even a single gas sample can serve as a gateway to deeper scientific insights. Whether in academic laboratories or industrial plants, mastering these concepts ensures safe, efficient, and innovative use of gases like fluorine in advancing technology and industry.

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