0.50 Moles Of Gas Take Up 10.5 Lof Space Under Constant Pressureand Temperature Conditions.What Volume

0.50 Moles Of Gas Take Up 10.5 Lof Space Under Constant Pressureand Temperature Conditions. What Volume?

Understanding how gases behave under different conditions is fundamental in chemistry, physics, and various engineering applications. When dealing with gases, the relationship between the amount of gas, its volume, pressure, and temperature is described by the ideal gas law. In this article, we will analyze the scenario where 0.50 moles of gas occupy 10.5 liters at constant pressure and temperature, and explore how to determine the volume of the gas under these conditions. We will also discuss the key concepts, calculations, and practical implications associated with this situation.

Introduction to Gas Laws and Their Significance

Gases are unique among the states of matter because they are highly compressible and expand to fill their containers. Their behavior can be described mathematically using various gas laws, which relate pressure (P), volume (V), temperature (T), and amount of gas (n). These relationships are essential for predicting and controlling gas behavior in laboratory and industrial settings.

Key Gas Laws:
- Boyle's Law: $P_1V_1 = P_2V_2$ (constant T and n)
- Charles's Law: $V_1/T_1 = V_2/T_2$ (constant P and n)
- Gay-Lussac's Law: $P_1/T_1 = P_2/T_2$ (constant V and n)
- Avogadro's Law: $V_1/n_1 = V_2/n_2$ (constant P and T)

The Ideal Gas Law:
$$ PV = nRT $$
Where:
- P = pressure (atm)
- V = volume (L)
- n = number of moles (mol)
- R = ideal gas constant (0.0821 L·atm/mol·K)
- T = temperature (Kelvin)

This law combines all the above relationships and is applicable under many conditions, especially for ideal gases.

Scenario Overview: Gas Volume at Constant Pressure and Temperature

Given:
- Moles of gas, n = 0.50 mol
- Volume of gas, V = 10.5 L
- Conditions: constant pressure and temperature

Question: What is the volume of the gas under the given conditions?

At first glance, the question may seem straightforward—if the gas already occupies 10.5 liters at given conditions, then that is its volume. However, the real question often revolves around understanding the relationship between the amount of gas and its volume, especially if the initial conditions are different or if we are asked to determine the volume for a different amount of gas under the same conditions.

Calculating the Volume of Gas Using the Ideal Gas Law

Assuming the initial data reflects a specific set of conditions, we can verify the relationship between moles and volume, and then determine the volume for a different amount of gas if needed.

Step 1: Identify the conditions (pressure and temperature) used in the initial measurement.

Suppose the conditions are:
- Pressure, P = 1 atm
- Temperature, T = 273 K (standard temperature)

Using the ideal gas law:
\[V = \frac{nRT}{P} \]

Plugging in the known values:
\[V = \frac{0.50 \times 0.0821 \times 273}{1} \]
\[V \approx 0.50 \times 22.4143 \]
\[V \approx 11.21\, \text{L} \]

This calculation suggests that 0.50 mol of an ideal gas at STP (Standard Temperature and Pressure) occupies approximately 11.21 liters.

Note: The initial problem states the gas takes up 10.5 liters, which indicates that either:
- The pressure is higher than 1 atm
- The temperature is lower than 273 K
- Or the gas is not ideal under these conditions

Step 2: Determine the actual pressure and temperature conditions, or confirm the assumptions.

If the volume is given as 10.5 L for 0.50 mol, then using the ideal gas law:
$$ P = \frac{nRT}{V} $$
$$ P = \frac{0.50 \times 0.0821 \times T}{10.5} $$

Without temperature, we cannot specify pressure precisely, but we understand the proportionality.

Understanding the Relationship: Moles and Volume

The key takeaway is that, under constant pressure and temperature, the volume of a gas is directly proportional to the number of moles, as per Avogadro's Law.

Avogadro's Law:
$$ V \propto n $$

Implication:
- Doubling the moles doubles the volume
- Halving the moles halves the volume

Given the initial data:
- 0.50 mol of gas occupies 10.5 L
- Therefore, for any other amount of gas, the volume V_2 can be calculated as:
$$ V_2 = V_1 \times \frac{n_2}{n_1} $$

Example Calculation:
If we want to find the volume of 1 mol of gas under the same conditions:
$$ V_2 = 10.5\, \text{L} \times \frac{1\, \text{mol}}{0.50\, \text{mol}} = 21\, \text{L} $$

Similarly, for 0.25 mol:
$$ V_2 = 10.5\, \text{L} \times \frac{0.25}{0.50} = 5.25\, \text{L} $$

Practical Applications of Gas Volume Calculations

Understanding the relationship between moles and volume under constant pressure and temperature has many real-world applications:

1. Gas Collection and Storage:
- Determining the volume of gases needed or produced in chemical reactions
- Designing storage tanks based on expected gas quantities

2. Chemical Reaction Stoichiometry:
- Calculating the amount of gas produced or consumed
- Ensuring safety by knowing the volume of gases involved

3. Industrial Processes:
- Gas pipelines and flow calculations
- Designing reactors and separators

4. Environmental Monitoring:
- Estimating emissions based on mole measurements

Key Factors Affecting Gas Volume

While the ideal gas law provides a good approximation, real gases can behave differently under certain conditions. Factors influencing gas volume include:

- Pressure: Increasing pressure compresses gases, reducing volume
- Temperature: Raising temperature causes expansion, increasing volume
- Gas Nature: Deviations from ideal behavior occur at high pressures or low temperatures
- Intermolecular Forces: Real gases experience attractions and repulsions, affecting volume

---

Summary and Conclusion

In summary, when 0.50 moles of gas occupy 10.5 liters under constant pressure and temperature, the volume is directly proportional to the amount of gas, as described by Avogadro's Law. If the initial conditions align with ideal gas behavior at standard conditions, then the volume for 0.50 mol is approximately 11.21 liters, slightly more than the given 10.5 liters, indicating possible real-gas deviations or different conditions.

To determine the volume of any amount of gas under constant P and T:
- Use the proportionality: \(V \propto n \)
- Apply the formula: \(V_2 = V_1 \times \frac{n_2}{n_1} \)

This understanding is critical in chemistry calculations, industrial applications, and environmental science, providing a foundation for predicting and controlling gas behavior in various contexts.

Final Remarks

Mastering gas law calculations enhances proficiency in scientific problem-solving and practical applications. Remember, always consider the conditions and assumptions underlying the ideal gas law, and adjust calculations accordingly for real-world scenarios. Whether designing chemical processes or understanding natural phenomena, these principles serve as essential tools in science and engineering.

Frequently Asked Questions

What is the volume occupied by 0.50 moles of gas under constant pressure and temperature conditions?

The volume is 10.5 liters.

Which law relates the volume and amount of gas at constant temperature and pressure?

The Ideal Gas Law (PV = nRT) applies.

Given 0.50 moles of gas occupy 10.5 L, how can you find the molar volume of the gas?

Molar volume = total volume / number of moles = 10.5 L / 0.50 mol = 21 L/mol.

If the amount of gas increases to 1 mole at the same conditions, what would be its volume?

The volume would double to 21 L, following Avogadro's law.

What assumptions are made when using the ideal gas law in this calculation?

Assumptions include the gas behaves ideally, with no interactions between particles and negligible volume of particles.

How does temperature affect the volume of the gas at constant pressure?

According to Charles's Law, increasing temperature increases volume; decreasing temperature decreases volume.

Can these calculations be applied to real gases exactly? Why or why not?

No, real gases deviate slightly from ideal behavior, especially at high pressures or low temperatures, but the ideal gas law provides a good approximation under many conditions.

Additional Resources

Understanding Gas Volume Changes: Calculating the Volume of 0.50 Moles of Gas Under Specific Conditions

---

Introduction

In the realm of chemistry, gases exhibit fascinating behaviors governed by fundamental principles and laws. One such principle is the relationship between the amount of gas, its volume, pressure, and temperature. When examining the volume occupied by a specific amount of gas under controlled conditions, it becomes essential to understand how these variables interact.

This detailed discussion aims to analyze a scenario where 0.50 moles of gas take up 10.5 liters of space under constant pressure and temperature. The key question is: What volume would a different amount of gas occupy under the same conditions? To address this, we will explore the foundational concepts of the Ideal Gas Law, examine the data provided, and perform relevant calculations. Along the way, we will delve into related concepts such as molar volume, gas laws, and real-world applications.

Fundamental Concepts in Gas Behavior

1. The Ideal Gas Law

The Ideal Gas Law is the cornerstone for understanding how gases behave under various conditions. It is expressed as:

$$PV = nRT$$

Where:
- P = Pressure (atm)
- V = Volume (L)
- n = Moles of gas (mol)
- R = Universal gas constant ($0.08206 \, \mathrm{L \cdot atm \, mol^{-1} \, K^{-1}}$)
- T = Temperature (Kelvin, K)

This law states that, at constant pressure and temperature, the volume of a gas is directly proportional to the number of moles present.

2. Molar Volume of a Gas

At standard temperature and pressure (STP: 0°C or 273.15 K and 1 atm), one mole of an ideal gas occupies approximately 22.4 liters. This is called the molar volume (V_m) at STP.

Data Analysis: The Scenario Presented

The problem states:

- Number of Moles (n): 0.50 mol
- Volume (V): 10.5 L
- Conditions: Constant pressure and temperature

The goal is to find the volume occupied by a different amount of gas under the same conditions, or to interpret the data in context.

Step-by-Step Breakdown

1. Verify the Consistency of Data

Using the ideal gas law, we can verify the conditions under which 0.50 mol occupies 10.5 L:

$$
PV = nRT
$$

Suppose the temperature T and pressure P are known or given; however, since they are held constant, we can analyze volume proportionality based on moles.

Given:
- $n_1 = 0.50 \, \text{mol}$
- $V_1 = 10.5\, \text{L}$

If the pressure and temperature remain constant, then according to the ideal gas law:

$$
\frac{V_1}{n_1} = \frac{V_2}{n_2}
$$

Where V_2 and n_2 are the volume and moles of the second scenario.

Calculations and Applications

2. Determining the Molar Volume from the Data

Since 0.50 mol occupies 10.5 L:

$$
V_m = \frac{V}{n} = \frac{10.5\, \text{L}}{0.50\, \text{mol}} = 21.0\, \text{L/mol}
$$

Implication: The molar volume in this scenario is 21.0 L/mol, which is slightly higher than the standard molar volume (22.4 L/mol at STP). This indicates that the conditions may not be exactly STP, or the gas behaves slightly differently from an ideal gas.

3. Calculating the Volume for Different Moles

Suppose we want to determine the volume occupied by another amount of gas, say, 1.0 mol, under the same conditions:

$$
V_2 = n_2 \times V_m = 1.0\, \text{mol} \times 21.0\, \text{L/mol} = 21.0\, \text{L}
$$

Similarly, for 0.25 mol:

$$
V_3 = 0.25\, \text{mol} \times 21.0\, \text{L/mol} = 5.25\, \text{L}
$$

This proportional relationship emphasizes the core principle: under constant pressure and temperature, the volume of a gas is directly proportional to the number of moles.

Practical Applications and Further Insights

4. Real-World Implications

Understanding the proportionality between moles and volume is critical in various practical contexts:

- Chemical reactions involving gases: Knowing how much volume a certain amount of gas occupies aids in designing reactors and storage systems.
- Gas collection experiments: When collecting gases over water or other mediums, volume measurements help determine the amount of gas evolved.
- Industrial processes: Gas volume calculations are essential for optimizing processes like ammonia synthesis, natural gas processing, and more.

5. Deviations from Ideal Behavior

While the ideal gas law provides a robust approximation, real gases exhibit deviations, especially at high pressures or low temperatures. These deviations are addressed by:

- Van der Waals Equation: Adjusts for molecular size and intermolecular forces.
- Real Gas Behavior: Measured via compressibility factors, Z, which indicate how much a real gas deviates from ideal behavior.

In our scenario, the slight difference between the calculated molar volume (21.0 L/mol) and the standard 22.4 L/mol at STP suggests that the gas may be at a different temperature or pressure, or marginally non-ideal.

Additional Considerations

6. Temperature and Pressure Conditions

While the problem states that pressure and temperature are constant, it’s insightful to consider their potential values:

- If the gas is at STP, 0.50 mol would occupy approximately 11.2 L (using 22.4 L/mol), but the data shows 10.5 L. This suggests conditions slightly different from STP, possibly at higher pressure or lower temperature.
- To find the exact conditions, one could rearrange the ideal gas law:

$$
T = \frac{PV}{nR}
$$

or

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

and plug in known values if P and T are specified.

7. Molar Volume Under Different Conditions

The molar volume of gases varies with temperature and pressure:

Condition	Molar Volume (V_m)	Remarks
STP	22.4 L/mol	Standard conditions
Higher T / Lower P	> 22.4 L/mol	Gas expands
Lower T / Higher P	< 22.4 L/mol	Gas compresses

Understanding these variations is essential when dealing with real gases in laboratory and industrial environments.

Summary and Key Takeaways

- Gas volume is directly proportional to the number of moles when pressure and temperature are held constant.
- In the given scenario, 0.50 mol of gas occupies 10.5 liters, implying a molar volume of 21.0 L/mol, slightly below the standard 22.4 L/mol at STP, indicating conditions are close but not exactly at STP.
- To find the volume of any amount of gas under the same conditions, multiply the moles by the molar volume:

$$
V = n \times V_m
$$

- Real gases may deviate from ideal behavior, especially at extreme conditions, but the ideal gas law provides a solid approximation for most practical purposes.
- Precise knowledge of pressure and temperature allows for exact calculations and better

understanding of gas behavior.

Final Thoughts

Understanding the relationship between the amount of gas and the volume it occupies is fundamental in chemistry and engineering. Whether designing chemical reactors, analyzing reaction stoichiometry, or conducting laboratory experiments, grasping how gases behave under various conditions empowers scientists and engineers to predict outcomes accurately. The principle that volume scales with moles under constant pressure and temperature forms the backbone of many practical and theoretical applications in gas chemistry.

In conclusion, given the data, the volume that 0.50 moles of gas occupy under the specified conditions is 10.5 liters. Any change in the amount of gas, with pressure and temperature held constant, results in a proportional change in volume, a direct consequence of the ideal gas law. A thorough understanding of these principles facilitates precise calculations and effective application in scientific and industrial contexts.

0 50 Moles Of Gas Take Up 10 5 Lof Space Under Constant Pressureand Temperature Conditions What Volume

0 50 Moles Of Gas Take Up 10 5 Lof Space Under Constant Pressureand Temperature Conditions What Volume

Related Articles

- Which Answer Choice Correctly Represents The Relationship Between 2/3 / (1/8)and 2 /3 * 8/ 1 ?A 2 3 /
- When Considering The Operating Effectiveness Of A Control, Which Of The Following Sampling Approaches
- 1.How Do Voluntary Export Restraints Differ From Other Protective Barriers?Voluntary Export Restraints

Back to Home