What Is The Pressure (in Atm) In A 5.00 L Tank With 10.00 Grams Of Oxygen Gas At 350 K? R = 0.08206 L

What Is The Pressure (in Atm) In A 5.00 L Tank With 10.00 Grams Of Oxygen Gas At 350 K? R = 0.08206 L

Understanding the pressure of a gas within a confined space is fundamental in chemistry, physics, and engineering. When dealing with gases, the ideal gas law provides a straightforward way to calculate the pressure, given certain parameters such as volume, temperature, amount of gas, and the ideal gas constant. In this article, we will explore how to determine the pressure in atmospheres (atm) of oxygen gas contained in a 5.00-liter tank, with a mass of 10.00 grams at a temperature of 350 Kelvin, utilizing the ideal gas law. This comprehensive guide will cover the theoretical background, step-by-step calculation, and practical applications of the concept.

Understanding the Ideal Gas Law

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

\[PV = nRT \]

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

This law assumes that gases behave ideally, meaning their particles do not interact except elastic collisions, and the volume of particles themselves is negligible compared to the volume of the container.

Parameters Given in the Problem

Before proceeding with calculations, let's clearly identify the given data:

- Volume of the tank, \(V \): 5.00 L
- Mass of oxygen gas, \(m \): 10.00 grams
- Temperature, \(T \): 350 K

- Ideal gas constant, R: 0.08206 L·atm/(mol·K)

Our goal: Find the pressure P in atmospheres.

Step-by-Step Calculation Process

To determine the pressure, we need to follow a systematic approach:

1. Convert mass of oxygen to moles (n).
2. Apply the ideal gas law to solve for P.

Let's break down each step:

1. Calculating the Number of Moles of Oxygen (n)

The molar mass of oxygen gas (O_2) is approximately:

- Atomic mass of oxygen (O): 16.00 g/mol
- Molecular mass of O_2: 2 × 16.00 g/mol = 32.00 g/mol

Using the formula:

$$n = \frac{m}{M}$$

Where:
- m = mass of oxygen = 10.00 g
- M = molar mass of O_2 = 32.00 g/mol

Calculating:

$$n = \frac{10.00\, \text{g}}{32.00\, \text{g/mol}} = 0.3125\, \text{mol}$$

2. Applying the Ideal Gas Law to Find Pressure (P)

Rearranged ideal gas law:

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

Substituting the known values:

$$P = \frac{0.3125\, \text{mol} \times 0.08206\, \text{L·atm/(mol·K)} \times 350\, \text{K}}{5.00\, \text{L}}$$

Calculating numerator:

$$ 0.3125 \times 0.08206 \times 350 = 8.956 $$

Dividing by volume:

$$ P = \frac{8.956}{5.00} = 1.7912\, \text{atm} $$

Therefore, the pressure of the oxygen gas in the tank is approximately 1.79 atm.

Practical Applications of Gas Pressure Calculations

Understanding how to compute gas pressure has numerous real-world applications:

- Industrial Gas Storage: Ensuring containers can withstand the pressures exerted by stored gases.
- Chemical Reactions: Designing reactors where gas pressures influence reaction rates.
- Aerospace Engineering: Calculating cabin pressures in spacecraft and aircraft.
- Medical Applications: Managing oxygen supply systems in hospitals and emergency settings.
- Environmental Science: Modeling atmospheric gas behaviors and pollutant dispersion.

Factors Affecting Gas Pressure in Real-World Scenarios

While the ideal gas law provides a good approximation, several factors can influence actual gas pressure:

- Non-ideal behavior: At high pressures or low temperatures, gases deviate from ideality due to intermolecular forces.
- Container elasticity: Real tanks may expand or contract slightly under pressure.
- Gas purity: Impurities can affect the behavior and pressure.
- Temperature fluctuations: Changes in temperature directly impact pressure, according to Gay-Lussac’s law.

Additional Considerations for Accurate Calculations

To ensure precise calculations, consider the following:

- Verify units: Always convert measurements to compatible units.
- Use the correct gas constant: $R = 0.08206$ L·atm/(mol·K) for pressure in atm.
- Account for gas purity: If the gas isn't pure, adjust the molar amount accordingly.
- Check for ideality: At extreme conditions, use real gas equations like Van der Waals if necessary.

Summary of the Calculation

In summary, given a 5.00-liter tank containing 10.00 grams of oxygen gas at 350 K, the pressure exerted by the gas can be calculated as follows:

- Convert mass to moles: $10.00\, \text{g} / 32.00\, \text{g/mol} = 0.3125\, \text{mol}$
- Apply the ideal gas law:

$$P = \frac{nRT}{V} = \frac{0.3125 \times 0.08206 \times 350}{5.00} \approx 1.79\, \text{atm}$$

This result indicates the oxygen gas exerts a pressure of approximately 1.79 atm within the tank under the given conditions.

Conclusion

Calculating the pressure of a gas in a closed container is a fundamental skill in chemistry that combines understanding of the ideal gas law with careful unit conversion and data interpretation. By knowing the mass of gas, temperature, and volume, you can accurately determine the pressure exerted by gases in various contexts. This knowledge is not only academically valuable but also practically essential in industrial processes, environmental science, and safety engineering. Always remember to consider real-world factors that may cause deviations from ideal behavior, and apply appropriate corrections or advanced models when necessary.

References:

- Atkins, P., & de Paula, J. (2010). Physical Chemistry (9th ed.). Oxford University Press.
- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Lyman, J. (2018). Gases and Gas Laws. Chemguide.

Keywords: gas pressure calculation, ideal gas law, oxygen gas, molar mass, chemistry calculations, pressure in atm, volume and temperature, gas laws, scientific computation

Frequently Asked Questions

What is the pressure in atmospheres of 10.00 grams of oxygen gas in a 5.00 L tank at 350 K?

Using the ideal gas law PV = nRT, first calculate moles of oxygen: n = 10.00 g / 32.00 g/mol = 0.3125 mol. Then, P = (nRT) / V = (0.3125 mol × 0.08206 L·atm/(mol·K) × 350 K) / 5.00 L ≈ 1.79 atm.

How do you determine the number of moles of oxygen gas in the tank?

Divide the mass of oxygen by its molar mass: 10.00 g / 32.00 g/mol = 0.3125 mol.

Which gas law is used to find the pressure in this problem?

The ideal gas law, PV = nRT, is used to calculate the pressure.

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

The value of R used is 0.08206 L·atm/(mol·K), which is the commonly used ideal gas constant in these units.

How does temperature affect the pressure of the gas

in the tank?

According to the ideal gas law, increasing temperature at constant volume and moles increases pressure, while decreasing temperature lowers the pressure.

What assumptions are made when applying the ideal gas law to this problem?

It is assumed that oxygen behaves as an ideal gas, interactions between molecules are negligible, and the gas is at low pressure and high temperature for ideality to hold true.

If the volume of the tank was doubled, how would that affect the pressure?

Doubling the volume would halve the pressure, assuming temperature and moles remain constant, due to Boyle's law ($P \propto 1/V$).

Can real gases deviate from the ideal gas law under these conditions?

Yes, at high pressures or low temperatures, real gases deviate from ideal behavior due to intermolecular forces and finite molecular volume.

What is the significance of using 0.08206 as the gas constant R in this calculation?

It ensures the units of pressure are in atmospheres, volume in liters, temperature in Kelvin, and moles are consistent, making the calculation accurate and straightforward.

Additional Resources

What Is The Pressure (in Atm) In A 5.00 L Tank With 10.00 Grams Of Oxygen Gas At 350 K? R = 0.08206 L

Understanding the behavior of gases under different conditions is fundamental in fields ranging from chemistry and engineering to environmental science. One common question involves calculating the pressure exerted by a given amount of gas within a specified volume at a certain temperature. In this article, we will explore how to determine the pressure in atmospheres (atm) of oxygen gas contained in a 5.00-liter tank, given the mass of oxygen, the temperature, and the gas constant.

Fundamental Principles: The Ideal Gas Law

To accurately compute the pressure, we rely on the ideal gas law, which states:

$$ PV = nRT $$

Where:
- P = pressure in atmospheres (atm)
- V = volume in liters (L)
- n = number of moles of gas (mol)
- R = ideal gas constant (0.08206 L·atm/(mol·K))
- T = temperature in Kelvin (K)

This equation assumes that the gas particles do not interact and occupy negligible volume, which is a good approximation under many conditions, including the scenario at hand.

Breaking Down the Problem: Given Data and What’s Needed

Let's first identify the given parameters:

- Volume (V) = 5.00 L
- Mass of oxygen (m) = 10.00 g
- Temperature (T) = 350 K
- Gas constant (R) = 0.08206 L·atm/(mol·K)

The goal is to find the pressure P.

To do so, we need to determine the number of moles of oxygen gas, n, since the ideal gas law relates pressure to moles, not mass directly.

Calculating the Number of Moles of Oxygen (n)

Oxygen (O_2) has a molar mass of approximately 32.00 g/mol. Using this, we can find the moles of oxygen:

$$ n = \frac{m}{M} $$

Where:
- m = 10.00 g
- M = 32.00 g/mol

Calculation:

$$ n = \frac{10.00 \text{ g}}{32.00 \text{ g/mol}} = 0.3125 \text{ mol} $$

This is the amount of oxygen in the tank.

Applying the Ideal Gas Law to Find Pressure

With the number of moles known, we substitute all known values into the ideal gas law:

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

Plugging in the numbers:

$$ P = \frac{0.3125 \text{ mol} \times 0.08206 \text{ L·atm/(mol·K)} \times 350 \text{ K}}{5.00 \text{ L}} $$

Calculating numerator:

$$ 0.3125 \times 0.08206 \times 350 \approx 8.957 $$

Then, dividing by volume:

$$ P = \frac{8.957}{5.00} \approx 1.79 \text{ atm} $$

Therefore, the pressure exerted by the oxygen gas in the tank is approximately 1.79 atmospheres.

Understanding the Significance of the Result

This calculation illustrates several important concepts:

- Relationship between mass and pressure: Increasing the mass of oxygen (or any gas) in a fixed volume at constant temperature increases the number of moles, thereby increasing pressure.
- Temperature’s role: Higher temperatures increase molecular kinetic energy, leading to higher pressure if the amount of gas remains constant.
- Volume considerations: A larger volume at the same temperature and molar amount results in lower pressure, highlighting the inverse relationship between pressure and volume.

In practical terms, such calculations are vital in designing pressurized vessels, understanding gas storage, and predicting behaviors in various industrial processes.

Limitations and Real-World Considerations

While the ideal gas law provides a solid approximation, real gases can deviate from ideal behavior, especially at high pressures or low temperatures where intermolecular forces and molecular sizes become significant. For oxygen at 350 K and 1.79 atm, the ideal approximation remains quite valid, but in more extreme conditions, corrections might be necessary using equations of state like Van der Waals.

Furthermore, ensuring the gas behaves ideally requires that the gas particles are sufficiently far apart, which is generally true at the given conditions.

Summary and Practical Applications

To recap:

- The calculation involved converting mass to moles using molar mass.
- The ideal gas law was employed to determine the pressure.
- The resulting pressure for 10 g of oxygen in a 5.00 L tank at 350 K is approximately 1.79 atm.

This process exemplifies fundamental principles that underpin much of chemical engineering, atmospheric science, and laboratory chemistry, where precise measurements of gas behaviors are essential.

Practical applications include:

- Designing gas storage containers.
- Calculating pressures in scuba tanks.
- Understanding atmospheric pressure variations.
- Engineering processes involving gas reactions.

Understanding such calculations enhances our capacity to manage and utilize gases safely and effectively in various technological and scientific contexts.

In conclusion, determining the pressure of oxygen in a contained environment involves a straightforward application of the ideal gas law, provided accurate data on mass, temperature, and volume. This example underscores the importance of basic chemistry principles in real-world scenarios, bridging theoretical understanding with practical utility.

What Is The Pressure In Atm In A 5 00 L Tank With 10 00 Grams Of Oxygen Gas At 350 K R 0 08206 L

What Is The Pressure In Atm In A 5 00 L Tank With 10 00 Grams Of Oxygen Gas At 350 K R 0 08206 L

Related Articles

- What Does Granholm Use To End Her "Remembering Rosa Parks" Speech?O A. A SaluteB. A PoemC. A SongO D.
- 1 Point3. Trout Is Sold At Kroger In Four Different Quantities, Each With Differentprices. What Is The
- Using What You've Learned So Far, Is The Air Quality Forecast Likely To Bebetter In Urban Areas Or In

Back to Home