A Sample Of Neon Gas (Ne, Molar Mass M = 20.2 G/mol) At A Temperature Of 13.0C Is Put Into A Steel Container

A Sample Of Neon Gas (Ne, Molar Mass M = 20.2 G/mol) At A Temperature Of 13.0C Is Put Into A Steel Container This scenario provides an excellent opportunity to explore the fundamental principles of gas behavior, thermodynamics, and the practical considerations involved in handling noble gases like neon. Neon, known for its distinctive reddish-orange glow in neon signs, is a noble gas with unique physical and chemical properties that make it both fascinating and useful in various applications. Understanding how neon behaves under different conditions within a sealed steel container involves delving into the ideal gas law, real gas deviations, and the implications of temperature and pressure changes.

Understanding Neon Gas and Its Properties

Atomic and Molecular Characteristics of Neon

Neon is a monoatomic noble gas with the chemical symbol Ne. Its atomic number is 10, and it belongs to Group 18 of the periodic table. As a noble gas, neon has a complete outer electron shell, making it chemically inert under most conditions. Its molar mass, M = 20.2 g/mol, reflects its atomic weight, which influences its physical behavior, especially in gaseous form.

Physical Properties Relevant to Gas Behavior

- Density: Neon's density at standard temperature and pressure (STP) is approximately 0.9 g/L.
- Boiling Point: Around -246.05°C, meaning neon remains gaseous at typical laboratory and industrial temperatures.
- Color and Glow: When electrified, neon emits a characteristic bright reddish-orange glow, a property exploited in lighting.

Applying the Ideal Gas Law to Neon in a Steel Container

The Ideal Gas Law Fundamentals

The behavior of neon gas inside the container can be described using the ideal gas law:

$$ PV = nRT $$

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

This equation assumes that neon molecules do not interact and occupy negligible volume, which is a good approximation under typical conditions.

Converting Temperature to Kelvin

Given temperature: 13.0°C

$$
T = 13.0°C + 273.15 = 286.15\,K
$$

This temperature influences the pressure exerted by the neon gas if the volume and amount of gas are held constant.

Calculating the Number of Moles of Neon

Suppose a certain amount of neon is introduced into a known volume (say, 1 liter). The mass of neon can be calculated from the molar mass:

$$
\text{Mass} = n \times M
$$

For example, if 20.2 grams of neon are placed into the container:

$$
n = \frac{\text{Mass}}{M} = \frac{20.2\,g}{20.2\,g/mol} = 1\,mol
$$

Using this, the initial pressure inside the container can be calculated.

Behavior of Neon Gas in a Sealed Steel Container

Pressure at 13.0°C

Assuming the volume of the steel container is known, the pressure exerted by the neon gas can be calculated:

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

Suppose the volume V is 1 liter (which is 0.001 m^3):

$$
P = \frac{(1\,mol)(8.314\,J/(mol·K))(286.15\,K)}{0.001\,m^3} \approx 2,378\,kPa
$$

This pressure exceeds atmospheric pressure (~101.3 kPa), indicating that the neon gas is under significant pressure inside the container.

Implications of Temperature and Pressure Changes

- Temperature Increase: Heating the container would increase the pressure proportionally, potentially risking container failure if pressure exceeds design limits.
- Temperature Decrease: Cooling would reduce pressure, possibly leading to condensation if cooled sufficiently, though neon’s high boiling point makes this unlikely at typical temperatures.
- Volume Changes: If the steel container is flexible, volume changes could also influence pressure, but in rigid containers, pressure varies with temperature and amount of gas.

Real Gas Deviations and Corrections

Limitations of the Ideal Gas Law

While the ideal gas law provides a good approximation at moderate conditions, real gases like neon exhibit deviations due to intermolecular forces and finite molecular volume, especially at high pressures or low temperatures.

Van der Waals Equation

To account for these factors, the Van der Waals equation modifies the ideal gas law:

$$
\left(P + a \frac{n^2}{V^2} \right) (V - nb) = nRT
$$

where:
- a accounts for attractive forces
- b accounts for the finite size of molecules

For neon:
- $a \approx 0.209\, \text{L}^2\,\text{atm}/\text{mol}^2$
- $b \approx 0.0171\, \text{L}/\text{mol}$

Applying these corrections provides a more accurate estimation of the pressure and behavior under non-ideal conditions.

Practical Considerations in Handling Neon Gas

Container Material and Safety

Steel is commonly used for gas storage due to its strength and inertness. When handling neon:
- Ensure the container is rated for the expected pressure.
- Regularly inspect for leaks or corrosion.
- Use appropriate pressure relief devices.

Applications of Neon Gas

- Lighting: Neon’s ability to emit bright colors is exploited in signage and decorative lighting.
- Lasers: Neon lasers are used in scientific applications.
- Cryogenics and Scientific Research: Neon’s inertness and physical properties make it useful in specialized scientific experiments.

Environmental and Cost Considerations

Neon is a rare gas harvested from the atmosphere, making it relatively expensive. Efficient storage and recycling are important to minimize costs and environmental impact.

Summary and Key Takeaways

- Neon is a noble, monoatomic gas with a molar mass of 20.2 g/mol, used extensively in lighting and scientific applications.
- At 13.0°C, neon behaves approximately as an ideal gas, with pressure depending on the amount of gas, volume, and temperature.
- Understanding gas laws and deviations from ideality is crucial when designing systems that contain neon.
- Proper handling, storage, and safety protocols are essential due to high pressures involved in sealed containers.
- Real gas corrections, like Van der Waals, provide more accurate predictions under non-ideal conditions, especially at high pressures.

Final Thoughts

The study of neon gas in a confined environment exemplifies the broader principles of physical chemistry and thermodynamics. From its atomic structure to its practical applications, neon's behavior in a steel container underscores the importance of fundamental scientific understanding in engineering, safety, and innovation. Whether used in vibrant signage or cutting-edge scientific equipment, neon continues to be a fascinating and vital element in modern technology.

Keywords for SEO Optimization:
- Neon gas properties
- Ideal gas law neon
- Neon in steel container
- Neon molar mass
- Gas behavior at 13°C
- Real gas corrections neon
- Neon storage safety
- Applications of neon gas
- Van der Waals equation neon
- Noble gases in industry

Frequently Asked Questions

What is the molar mass of neon gas used in the sample?

The molar mass of neon gas (Ne) is 20.2 g/mol.

What temperature in Kelvin is the neon gas sample at if

the temperature is 13.0°C?

The temperature in Kelvin is 13.0°C + 273.15 = 286.15 K.

How does the ideal gas law relate to calculating the pressure of neon gas in the container?

The ideal gas law ($PV = nRT$) allows us to determine the pressure if the number of moles, temperature, and volume are known.

If the container's volume is fixed, how does increasing temperature affect the pressure of neon gas?

Increasing temperature increases the kinetic energy of the gas molecules, which results in higher pressure at constant volume.

How can you calculate the number of moles of neon gas in the sample if you know its mass?

Number of moles n = mass of neon / molar mass (20.2 g/mol).

What assumptions are made when applying the ideal gas law to neon gas in this scenario?

Assumptions include that neon behaves as an ideal gas, with negligible interactions between molecules and point-like particles.

Why is neon considered a noble gas and how does this affect its chemical reactivity?

Neon is a noble gas with a full outer electron shell, making it chemically inert and unlikely to react with other substances.

What impact does increasing the temperature have on the molar volume of neon gas at constant pressure?

At constant pressure, increasing temperature increases the molar volume according to Charles's law.

How would the pressure of neon gas change if the temperature is increased from 13.0°C to 27.0°C at constant volume and moles?

The pressure would increase proportionally with temperature in Kelvin, following the ideal gas law: $P \propto T$.

Additional Resources

A Sample Of Neon Gas (Ne, Molar Mass M = 20.2 G/mol) At A Temperature Of 13.0°C Is Put Into A Steel Container—this scenario provides an intriguing window into the fundamental principles of gas behavior, thermodynamics, and the application of the ideal gas law. Understanding how neon gas interacts with its environment, especially within a confined steel container, allows scientists and engineers to predict properties such as pressure, volume, and temperature changes, as well as analyze real-world applications where neon's unique properties are utilized. This guide aims to walk you through the scientific considerations, calculations, and implications of placing neon gas at a specific temperature into a steel container, offering clarity for students, professionals, or enthusiasts interested in physical chemistry and thermodynamics.

Introduction to Neon and Its Properties

Neon (Ne) is a noble gas characterized by its inertness and distinctive bright reddish-orange glow when electrified, making it popular in neon signage. With a molar mass of 20.2 grams per mole, neon is the second-lightest noble gas after helium. Its atomic number is 10, and it exists in gaseous form under standard conditions.

Key Properties of Neon:
- Atomic number: 10
- Molar mass (M): 20.2 g/mol
- Density at STP: approximately 0.900 g/L
- Boiling point: -246.05°C
- Color: Colorless, odorless, inert gas

Understanding neon's physical properties is essential for predicting how it behaves when confined within a container at specific temperatures and pressures.

Setting the Scenario

In our case, we have a sample of neon gas (Ne, M = 20.2 g/mol) placed inside a steel container. The initial temperature of the neon is given as 13.0°C (which is 286.15 K in Kelvin). To analyze this scenario, several questions arise:

- What is the initial pressure of the neon gas inside the container?
- How does the temperature influence the pressure and volume?
- What are the implications of using steel as the container material?

To address these questions, we will utilize the ideal gas law, assumptions about the container, and relevant thermodynamic principles.

Fundamental Principles: The Ideal Gas Law

The core equation used in analyzing gases under many conditions is the ideal gas law:

$PV = nRT$

Where:
- P = Pressure (atm or Pa)
- V = Volume (liters or m^3)
- n = Number of moles
- R = Universal gas constant (8.314 J/(mol·K))
- T = Temperature (Kelvin)

This law assumes gas particles are point masses with no interactions, which holds true for neon under typical conditions due to its inertness and low reactivity.

Step-by-Step Analysis

1. Determine the Quantity of Neon Gas (Number of Moles)

Suppose the mass of neon added to the container is known or specified. If not specified, assume a certain mass for the purpose of demonstration.

Example assumption:
Let’s assume 10 grams of neon are placed into the container.

Number of moles:

n = mass / molar mass = 10 g / 20.2 g/mol ≈ 0.495 mol

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2. Convert Temperature to Kelvin

Given temperature: 13.0°C

$T = 13.0 + 273.15 = 286.15$ K

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3. Determine the Container Volume

Suppose the steel container has a fixed volume, say 10 liters.

$V = 10$ L

---

4. Calculate the Initial Pressure

Using the ideal gas law:

$P = (nRT) / V$

Where:

- $n = 0.495$ mol
- $R = 0.082057$ L·atm/(mol·K) (for convenience in liters and atmospheres)
- $T = 286.15$ K
- $V = 10$ L

Calculating:

$P = (0.495 \text{ mol} \times 0.082057 \text{ L·atm/(mol·K)} \times 286.15 \text{ K}) / 10 \text{ L}$

$P \approx (0.495 \times 0.082057 \times 286.15) / 10$

First, compute numerator:

$0.495 \times 0.082057 \approx 0.04055$

$0.04055 \times 286.15 \approx 11.6$

Then, divide by 10:

$P \approx 1.16$ atm

Result: The initial pressure of neon in the container at 13.0°C is approximately 1.16 atmospheres.

Thermodynamic Implications and Real-World Considerations

1. Container Material (Steel) and Its Impact

Steel is a common choice for gas containers due to its strength, durability, and inertness. Its properties influence the system:

- Thermal Conductivity: Steel conducts heat efficiently, so temperature changes in the environment can impact the gas temperature.
- Pressure Resistance: Steel containers are designed to withstand high pressures, but understanding the maximum allowable pressure is crucial to prevent failure.
- Impermeability: Steel prevents neon from escaping, maintaining the integrity of the sample over time.

2. Behavior Under Temperature Changes

If the container is thermally isolated, then:

- Heating or Cooling: Changes in external temperature will affect the internal pressure according to Gay-Lussac’s law (P/T constant at constant V).
- Expansion or Contraction: The physical dimensions of the steel container may expand or

contract slightly with temperature, but this effect is often negligible for small temperature ranges.

3. Ideal Gas Approximation Validity

Neon's behavior closely matches that of an ideal gas at moderate pressures and temperatures, but at very high pressures or low temperatures, deviations occur:

- Real Gas Effects: Intermolecular forces become significant, leading to deviations from ideal behavior.
- Van der Waals Equation: For high-precision calculations, corrections can be made using the Van der Waals equation.

Advanced Calculations and Considerations

1. Calculating the Density of Neon in the Container

Density (ρ) = mass / volume

$\rho = 10\ g / 10\ L = 1\ g/L$

Compare this to the standard density at STP (~0.9 g/L). The density is slightly higher because the pressure is slightly above 1 atm, consistent with the earlier calculation.

2. Estimating the Internal Energy

For a monatomic ideal gas:

$U = (3/2)\ nRT$

$U = (3/2) \times 0.495\ mol \times 8.314\ J/(mol \cdot K) \times 286.15\ K$

$U \approx 1.5 \times 0.495 \times 8.314 \times 286.15$

Calculating:

$0.495 \times 8.314 \approx 4.116$

$4.116 \times 286.15 \approx 1177\ J$

$U \approx 1.5 \times 1177 \approx 1765\ J$

This energy represents the total internal energy of the neon sample at the given state.

Practical Applications and Insights

Understanding the behavior of neon gas in a steel container is crucial in several fields:

- Lighting Industry: Neon’s excitation produces characteristic glow. Managing pressure and temperature is vital in signage manufacturing.
- Cryogenics: Neon is used in cryogenic applications; understanding its thermodynamic properties aids in designing efficient systems.
- Scientific Research: Precise control of neon’s state variables is essential in experiments involving inert gases.

Summary and Key Takeaways

- When a sample of neon gas (Ne, M = 20.2 g/mol) at 13.0°C is placed into a steel container, the initial pressure can be estimated using the ideal gas law based on the amount of neon and the container volume.
- Assuming 10 grams of neon in a 10-liter container yields an initial pressure of approximately 1.16 atm.
- The temperature directly influences the pressure; as temperature increases, so does pressure, assuming volume remains constant.
- Steel containers are well-suited for storing neon due to their strength and inertness, but thermal management and pressure limits must be considered.
- Neon’s behavior under these conditions aligns well with ideal gas assumptions, but real-world deviations may need correction in high-pressure or low-temperature scenarios.

Final Thoughts

This exploration of neon gas in a confined environment exemplifies fundamental thermodynamic principles, illustrating how temperature, pressure, and volume interrelate through the ideal gas law. Such analyses are essential in designing safe, efficient systems in lighting, scientific research, and industrial applications, ensuring the inert and stable nature of neon is harnessed effectively.

Understanding these principles not only deepens your grasp of physical chemistry but also prepares you to tackle complex real-world problems involving gases and their behaviors within engineered systems.

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