The Temperature Of An Example Of CH4 Gas (10.34g) In A 50.0L Vessel At 1.33atm Is___A. 984B. -195C. 195D.

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Understanding the Problem: Determining the Temperature of CH_4 Gas

In this article, we will explore how to determine the temperature of a sample of methane (CH_4) gas, given specific parameters. The problem states that 10.34 grams of CH_4 are contained within a 50.0-liter vessel at a pressure of 1.33 atmospheres. The goal is to find the temperature of this gas, choosing from the options: 984°C, -195°C, 195°C, or another value.

This kind of problem is typical in chemistry, especially in the context of the ideal gas law, which relates pressure, volume, temperature, and amount of gas. Understanding how to apply the ideal gas law allows us to solve for the unknown, which in this case is the temperature.

The Significance of the Ideal Gas Law

The ideal gas law is a fundamental equation in chemistry that describes the behavior of gases under various conditions:

\[PV = nRT \]

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

By rearranging the ideal gas law, we can solve for the temperature:

\[T = \frac{PV}{nR} \]

Applying this law to our problem requires calculating the number of moles of CH_4, then substituting all known values to find T.

Step-by-Step Solution to Find the Temperature of CH_4

1. Calculating the Moles of CH_4

Given mass of CH_4:

\[\text{Mass} = 10.34\,g \]

The molar mass of methane (CH_4):

- Carbon (C): 12.01 g/mol

- Hydrogen (H): 1.008 g/mol

$$ \text{Molar mass of CH}_4 = 12.01 + (4 \times 1.008) = 12.01 + 4.032 = 16.042\,g/mol $$

Number of moles:

$$ n = \frac{\text{Mass}}{\text{Molar mass}} = \frac{10.34\,g}{16.042\,g/mol} \approx 0.6448\,mol $$

2. Applying the Ideal Gas Law

Now, using the known values:

- $P = 1.33$ atm
- $V = 50.0$ L
- $n \approx 0.6448$ mol
- $R = 0.0821$ L·atm/(mol·K)

Calculate T:

$$ T = \frac{PV}{nR} = \frac{(1.33\,atm)(50.0\,L)}{(0.6448\,mol)(0.0821\,L·atm/(mol·K))} $$

Numerator:

$$ 1.33 \times 50.0 = 66.5 $$

Denominator:

$$ 0.6448 \times 0.0821 \approx 0.05294 $$

Therefore,

$$ T \approx \frac{66.5}{0.05294} \approx 1256\,K $$

3. Converting Kelvin to Celsius

To express the temperature in Celsius:

$$ T_{°C} = T_{K} - 273.15 $$

$$ T_{°C} \approx 1256 - 273.15 \approx 983\,°C $$

Interpreting the Results and Matching with Multiple Choice Options

The calculated temperature is approximately 983°C, which closely matches option A: 984°C. This makes sense considering rounding during calculations and the typical approach in chemistry problems.

Therefore, the correct answer is A: 984°C.

Additional Context: Understanding Gas Behavior at Extreme Temperatures

The temperature of a gas has significant implications on its physical properties and behavior:

- High temperatures (like ~984°C) cause gas particles to move rapidly, increasing pressure if volume is constant.
- Extremely low temperatures (like -195°C) are close to the liquefaction point of many gases, including

methane, which liquefies at around -161.5°C under atmospheric pressure.

In this problem, the high calculated temperature (~984°C) indicates that the gas, if heated to this temperature, would be in a highly energetic state, well above the liquefaction point, and would remain in the gaseous phase.

Practical Applications of Such Calculations

Understanding the temperature of gases under specific conditions is crucial in various fields:

- Industrial processes: controlling the temperature of methane in reactors or pipelines.
- Environmental science: modeling methane emissions and their behavior in the atmosphere.
- Energy production: optimizing processes like natural gas liquefaction and storage.

Summary of Key Steps to Solve Similar Gas Law Problems

1. Identify known variables: pressure, volume, mass of gas.
2. Calculate moles of gas: using molar mass.
3. Apply the ideal gas law: $PV = nRT$.
4. Solve for temperature: $T = \frac{PV}{nR}$.
5. Convert units appropriately: Kelvin to Celsius or Fahrenheit.
6. Compare the calculated temperature with multiple-choice options.

Final Remarks

This problem exemplifies the importance of the ideal gas law in chemistry, especially when dealing with real-world scenarios involving gases like methane. By carefully calculating the number of moles and applying the law, we determined that the temperature of 10.34g of CH_4 in a 50.0L vessel at 1.33atm is approximately 984°C, confirming option A as the correct answer.

Understanding these concepts enhances your ability to analyze various chemical and physical systems, making you better equipped for academic exams, laboratory work, and industry applications.

Keywords for SEO Optimization

- Ideal gas law calculation
- Methane (CH_4) gas temperature
- Gas law problems solving
- Moles of methane calculation
- Gas behavior at high temperature
- Chemistry problem examples
- Gas properties at different temperatures
- Thermodynamics of gases
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- Gas law equations and applications

By mastering these concepts and calculation techniques, students and professionals can confidently approach problems involving gases and their thermodynamic properties.

Frequently Asked Questions

What is the approximate temperature of 10.34 g of CH4 gas in a 50.0 L vessel at 1.33 atm?

The temperature is approximately -195°C (Option B).

Which gas law is used to determine the temperature of CH4 in this scenario?

The Ideal Gas Law (PV = nRT) is used to calculate the temperature.

How do you calculate the moles of CH4 given its mass?

Divide the mass of CH4 (10.34 g) by its molar mass (16.04 g/mol), resulting in approximately 0.644 mol.

What is the value of the ideal gas constant R in appropriate units for this calculation?

R = 0.0821 L·atm/(mol·K).

What is the formula to find the temperature T in Kelvin for this problem?

T = (PV) / (nR).

What is the significance of the temperature value being negative Celsius in this context?

Negative Celsius indicates a temperature below freezing point, which is consistent with the calculated value of approximately -195°C.

Why is the answer option B (-195°C) considered correct for this problem?

Because the calculations based on ideal gas law yield a temperature close to -195°C, matching option B as the correct choice.

Additional Resources

Methane (CH_4) Temperature Analysis in a Controlled Environment: An Expert Review

Understanding the behavior of gases under specific conditions is fundamental to chemistry, environmental science, and engineering applications. Among the simplest hydrocarbon gases, methane (CH_4) serves as a key component in natural gas, a significant energy source. This article explores the temperature of a sample of methane gas—specifically 10.34 grams—in a 50.0-liter vessel at a pressure of 1.33 atmospheres. We will analyze the problem using the ideal gas law, discuss the implications of the calculations, and provide a comprehensive understanding of gas behavior under these conditions.

Introduction to the Problem

The core question revolves around determining the temperature of a methane gas sample when provided with specific parameters:

- Mass of CH_4: 10.34 g
- Volume of the vessel: 50.0 L
- Pressure: 1.33 atm

The options for the temperature are given as:

A. 984 K
B. -195°C
C. 195 K
D. (unspecified or missing in the prompt)

Given that the options include a negative Celsius temperature and a high Kelvin temperature, the problem's goal is to identify the correct temperature based on the data.

Fundamental Principles and Tools

The Ideal Gas Law

The ideal gas law is the primary equation used to relate the physical state variables of a gas:

$$ PV = nRT $$

Where:

- P = pressure (atm)
- V = volume (L)
- n = number of moles (mol)
- R = ideal gas constant = 0.082057 L·atm/(mol·K)
- T = temperature (K)

This law assumes gases behave ideally, which is typically valid at moderate pressures and temperatures not approaching absolute zero.

Calculating Moles of Methane

To find the temperature, we first need to determine the number of moles of methane in the sample:

$$
n = \frac{\text{mass}}{\text{molar mass of } CH_4}
$$

The molar mass of methane (CH_4):

$$
\text{C} = 12.01\, \text{g/mol} \\
$$

$$
\text{H} = 1.008\, \text{g/mol} \\
\text{Total} = 12.01 + (4 \times 1.008) = 12.01 + 4.032 = 16.042\, \text{g/mol}
$$

Calculating n:

$$
n = \frac{10.34\, \text{g}}{16.042\, \text{g/mol}} \approx 0.644\, \text{mol}
$$

Step-by-Step Calculation of Temperature

Applying the Ideal Gas Law

Rearranged for temperature:

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

Plugging in known values:

$$
T = \frac{(1.33\, \text{atm}) \times (50.0\, \text{L})}{0.644\, \text{mol} \times 0.082057\, \text{L·atm/(mol·K)}}
$$

Calculating numerator:

$$
1.33 \times 50.0 = 66.5\, \text{L·atm}
$$

Calculating denominator:

$$
0.644 \times 0.082057 \approx 0.05288\, \text{L·atm/(mol·K)}
$$

Finally:

$$
T = \frac{66.5}{0.05288} \approx 1257\, \text{K}
$$

Interpreting the Results

The calculated temperature is approximately 1257 Kelvin, which is significantly higher than any of the options provided. This discrepancy suggests several considerations:

- Potential errors in the problem statement or options
- The possibility that the options are meant to test understanding of temperature conversions
- A different interpretation, perhaps involving the gas's temperature in Celsius or Fahrenheit

Given the options:

- A. 984 K
- B. -195°C
- C. 195 K
- D. (unspecified)

Our calculated temperature (1257 K) does not match exactly but is closer than the options suggest.

Converting and Comparing Temperatures

Let's convert the calculated Kelvin temperature into Celsius and Fahrenheit:

- Celsius:

$$
T(°C) = T(K) - 273.15 = 1257 - 273.15 \approx 983.85°C
$$

- Fahrenheit:

$$
T(°F) = (T(°C) \times 1.8) + 32 \approx (983.85 \times 1.8) + 32 \approx 1771.93 + 32 \approx 1803.93°F
$$

This confirms an extremely high temperature, consistent with the high Kelvin value.

Analyzing the Options in Context

Since the options include:

- A. 984 K: Very close to our calculated 1257 K, but still notably lower.
- B. -195°C: Corresponds to the boiling point of methane at atmospheric pressure, but negative Celsius is inconsistent with our high-temperature calculation.
- C. 195 K: Significantly lower than our calculation.
- D.: Not specified, but perhaps intended as a distractor or an incomplete option.

Given the calculations:

- The temperature is definitely above room temperature (~298 K).
- It's nowhere near -195°C (which is roughly -319°F), the boiling point of methane.
- The most plausible answer among the options, considering the approximate calculations, is A. 984 K.

Implications and Real-World Applications

Understanding Gas Temperatures in Practical Contexts

The temperature of gases like methane under controlled conditions informs various applications:

- Energy Production: Accurate temperature calculations are vital for combustion efficiency and safety.
- Environmental Monitoring: Methane's role as a greenhouse gas depends on its state and temperature in natural reservoirs.
- Industrial Storage: Ensuring the integrity of storage vessels requires knowledge of gas behavior at different temperatures and pressures.

Limitations of the Ideal Gas Law

While the ideal gas law provides valuable estimations, real gases exhibit deviations, especially at high pressures or low temperatures. Methane, being a small, non-polar molecule, behaves approximately ideally in many conditions, but corrections may be necessary for precise calculations.

Conclusion

Based on the detailed calculations and analyses, the temperature of 10.34 g of methane within a 50.0 L vessel at 1.33 atm pressure is approximately 1257 K. Converting this to Celsius yields about 984°C, aligning closely with option A (984 K). While the options presented might seem inconsistent at first glance, the most accurate choice based on the calculations is A. 984 K.

Final thoughts:
This exercise underscores the importance of understanding fundamental principles like the ideal gas law, molar mass calculations, and temperature conversions. It also highlights the necessity of critically evaluating multiple-choice options and performing thorough calculations to arrive at the most logical conclusion.

Disclaimer:
Always consider real-world deviations from ideal behavior, especially in high-pressure or low-temperature scenarios. For precise applications, consult detailed thermodynamic data and models.

End of Article

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