Charle's LawAt 27.00 C A Gas Has A Volume Of 6.00 L. What Will The Volume Be At 150.00 C?Given:Unknown:Formula:Solution:Final

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Understanding Charle's Law and Its Significance

Charle's Law is a fundamental principle in thermodynamics that describes how gases behave when subjected to temperature changes, assuming constant pressure and amount of gas. It establishes a direct relationship between the temperature and volume of a gas, making it essential for various scientific and engineering applications.

In the scenario provided, we are asked to determine the new volume of a gas when its temperature increases from 27.00°C to 150.00°C, with the initial volume known. Grasping the core concepts behind Charle's Law will help us accurately solve this problem.

Fundamental Concepts of Charle's Law

Definition

Charle's Law states that at constant pressure and amount of gas, the volume of a fixed amount of gas is directly proportional to its absolute temperature (measured in Kelvin).

Mathematically, it can be expressed as:

$$ \frac{V_1}{T_1} = \frac{V_2}{T_2} $$

where:
- V_1 and V_2 are the initial and final volumes,
- T_1 and T_2 are the initial and final absolute temperatures in Kelvin.

Key Assumptions

- The pressure remains constant throughout the process.
- The amount of gas (number of moles) does not change.
- The temperature is expressed in Kelvin to ensure linear proportionality.
- The gas behaves ideally within the temperature and pressure ranges considered.

Understanding Absolute Temperature

Since Charle's Law operates on absolute temperature, convert Celsius to Kelvin:

$$ T(K) = T(°C) + 273.15 $$

This conversion is crucial for accurate calculations.

Applying Charle's Law to the Given Problem

Given Data

- Initial temperature, $T_1 = 27.00°C$
- Initial volume, $V_1 = 6.00\, \text{L}$
- Final temperature, $T_2 = 150.00°C$
- Final volume, $V_2 = ?$ (unknown)

Step 1: Convert Temperatures to Kelvin

$$
T_1 = 27.00 + 273.15 = 300.15\, \text{K}
$$
$$
T_2 = 150.00 + 273.15 = 423.15\, \text{K}
$$

Step 2: Set Up the Equation

Using Charle's Law:

$$
\frac{V_1}{T_1} = \frac{V_2}{T_2}
$$

Rearranged to solve for V_2:

$$
V_2 = V_1 \times \frac{T_2}{T_1}
$$

Step-by-Step Calculation

Step 3: Plug in Known Values

$$
V_2 = 6.00\, \text{L} \times \frac{423.15\, \text{K}}{300.15\, \text{K}}
$$

Step 4: Perform the Calculation

$$
V_2 = 6.00\, \text{L} \times 1.409
$$

$$
V_2 \approx 8.454\, \text{L}
$$

Therefore, the volume of the gas at 150.00°C will be approximately 8.45 liters.

Understanding the Implications of the Result

The increase in temperature from 27.00°C to 150.00°C causes the gas to expand, reflected in the larger volume. The proportional relationship dictated by Charle's Law confirms that as temperature increases, so does the volume, provided pressure remains constant.

This calculation demonstrates the predictable nature of gases under thermal changes and emphasizes the importance of converting temperatures to Kelvin for accuracy.

Additional Considerations and Real-World Applications

Limitations of Charle's Law

While Charle's Law provides a useful approximation, it works best under ideal conditions. Real gases may deviate at high pressures or low temperatures where interactions between molecules become significant.

Practical Applications

- Hot Air Balloons: Understanding how air volume changes with temperature helps in controlling flight.
- Gas Storage: Designing containers that accommodate volume expansion due to temperature changes.
- Chemical Reactions: Managing temperature to influence reaction rates and gas behavior.

Related Gas Laws

Charle's Law is part of the ideal gas law, which combines multiple laws:

$$PV = nRT$$

where:
- P = pressure,
- V = volume,
- n = number of moles,
- R = universal gas constant,
- T = absolute temperature.

Summary and Final Calculation

To summarize, the problem involves calculating the new volume of a gas when its temperature increases at constant pressure. Using the principles of Charle's Law, the process involves:

1. Converting Celsius temperatures to Kelvin.
2. Applying the proportionality equation.
3. Calculating the new volume.

Final answer:
The volume of the gas at 150.00°C will be approximately 8.45 liters.

This example underscores the significance of understanding gas laws in scientific analysis and engineering design, providing predictable insights into gas behavior under thermal variations.

Keywords for SEO Optimization

- Charle's Law
- Gas Law Calculations
- Temperature and Volume Relationship
- Ideal Gas Law
- Thermodynamics Principles
- Gas Expansion at High Temperatures
- Physics and Chemistry Tutorials
- Gas Volume Change Calculation
- Scientific Problem Solving
- Engineering Applications of Gas Laws

Conclusion

Understanding Charle's Law is essential for anyone studying thermodynamics, physics, or chemistry. The ability to predict how gases expand or contract with temperature changes not only aids in academic pursuits but also in practical engineering and scientific applications. Remember to always convert temperatures to Kelvin, apply the proportionality correctly, and consider the limitations of ideal gas assumptions when working with real gases.

By mastering these concepts, you can confidently solve related problems and appreciate the elegant simplicity of the physical laws governing our universe.

Frequently Asked Questions

What is Charles's Law and how does it relate temperature and volume of a gas?

Charles's Law states that the volume of a gas is directly proportional to its temperature (measured in Kelvin) at constant pressure. As temperature increases, volume increases; as temperature decreases, volume decreases.

Given a gas at 27.00°C with a volume of 6.00 L, what will its volume be at 150.00°C?

Using Charles's Law, the volume at 150.00°C will be approximately 7.52 L.

What is the temperature in Kelvin when calculating gas laws involving Celsius temperatures?

To convert Celsius to Kelvin, add 273.15. For example, 27.00°C equals 300.15 K.

What is the formula for Charles's Law?

$V1/T1 = V2/T2$, where V1 and T1 are the initial volume and temperature, and V2 and T2 are the final volume and temperature (in Kelvin).

How do you solve for the final volume in Charles's Law?

Rearranged as $V2 = V1 (T2 / T1)$. Plug in known values for V1, T1, and T2 to find V2.

What are the key assumptions when applying Charles's Law?

The gas must be at constant pressure, and the amount of gas should remain unchanged. The law is valid for ideal gases under these conditions.

Why do we need to convert Celsius temperatures to Kelvin in gas law calculations?

Kelvin is an absolute temperature scale, ensuring proportionality in gas law equations. Celsius temperatures are not suitable because they do not start at absolute zero.

What is the significance of the initial and final temperatures in the calculation?

They determine how the volume changes according to Charles's Law. The ratio of the temperatures in Kelvin directly affects the final volume.

Can Charles's Law be used for real gases at high pressures or low temperatures?

Charles's Law is most accurate for ideal gases under low pressure and high temperature. Deviations can occur for real gases under extreme conditions.

Additional Resources

Charle's Law: Exploring the Relationship Between Temperature and Volume in Gases

Charle's LawAt 27.00 C A Gas Has A Volume Of 6.00 L. What Will The Volume Be At 150.00 C?Given:Unknown:Formula:Solution:Final

Imagine a balloon on a hot summer day expanding as the temperature rises, or a tire slightly bulging after a long drive under the sun. These everyday observations are direct manifestations of a fundamental principle in chemistry and physics known as Charles's Law. This law describes how, under constant pressure, the volume of a gas is directly proportional to its temperature.

In this article, we'll delve into a detailed exploration of Charles's Law, understand its theoretical foundation, walk through a real-world example, and outline the mathematical process to determine the unknown volume of a gas at a different temperature. Whether you're a student preparing for an exam or a curious reader interested in the science behind gases, this comprehensive guide aims to clarify the concept in a reader-friendly manner.

Understanding Charles's Law: The Foundation of Gas Behavior

What is Charles's Law?

Charles's Law states that, for a fixed amount of gas at constant pressure, the volume of the gas is directly proportional to its absolute temperature (measured in Kelvin). Mathematically, it can be expressed as:

$$ V \propto T \quad \text{or} \quad \frac{V}{T} = \text{constant} $$

This means if you increase the temperature of a gas, its volume will increase proportionally, provided the pressure remains unchanged. Conversely, cooling the gas causes its volume to decrease.

Historical Context

This law is named after Jacques Charles, a French scientist who first formulated the relationship in the late 18th century. His experiments laid the groundwork for understanding the thermal behavior of gases, which later contributed to the development of the ideal gas law.

Theoretical Underpinning: From Observation to Equation

The Concept of Absolute Temperature

An essential aspect of Charles's Law is the use of Kelvin as the temperature scale. Unlike Celsius or Fahrenheit, Kelvin starts at absolute zero, the theoretical point where particle motion ceases. The conversion from Celsius to Kelvin is:

$$ T(K) = T(°C) + 273.15 $$

Using Kelvin ensures the proportionality remains valid because negative or zero Celsius temperatures would otherwise lead to nonsensical results.

The Mathematical Expression

From the proportionality, we derive the combined form:

\[

$$
\frac{V_1}{T_1} = \frac{V_2}{T_2}
$$

where:

- V_1 and T_1 are the initial volume and temperature,
- V_2 and T_2 are the final volume and temperature.

This equation allows us to calculate unknown variables when the other quantities are known.

Practical Example: Calculating the Final Volume

Let's apply this understanding to a real-world scenario. Suppose we have a gas with the following initial conditions:

- Initial temperature: 27.00°C
- Initial volume: 6.00 L
- Final temperature: 150.00°C
- Final volume: to be determined

The question posed is: What will the volume of the gas be at 150.00°C?

Step 1: Convert Temperatures to Kelvin

To use Charles's Law correctly, convert Celsius to Kelvin:

$$
T_1 = 27.00 + 273.15 = 300.15\, \text{K}
$$

$$
T_2 = 150.00 + 273.15 = 423.15\, \text{K}
$$

Step 2: Identify Known and Unknown Variables

- Known:
- $V_1 = 6.00\, \text{L}$
- $T_1 = 300.15\, \text{K}$
- $T_2 = 423.15\, \text{K}$
- Unknown:
- $V_2 = ?$

Step 3: Use the Charles's Law Equation

$$
\frac{V_1}{T_1} = \frac{V_2}{T_2}
$$

Rearranged to solve for V_2:

$$
V_2 = V_1 \times \frac{T_2}{T_1}
$$

Step 4: Perform the Calculation

$$
V_2 = 6.00\, \text{L} \times \frac{423.15\, \text{K}}{300.15\, \text{K}}
$$

$$
V_2 \approx 6.00 \times 1.409
$$

$$
V_2 \approx 8.45\, \text{L}
$$

Result: At 150.00°C, the gas will occupy approximately 8.45 liters.

Broader Implications of Charles's Law

Applications in Real-World Scenarios

- Hot Air Balloons: The increasing temperature causes the air inside the balloon to expand, decreasing its density and allowing it to rise.
- Weather and Climate: Understanding how gases expand or contract with temperature changes helps meteorologists predict weather patterns.
- Industrial Processes: Managing gas temperatures and volumes is vital in chemical manufacturing, refrigeration, and aeronautics.

Limitations and Considerations

While Charles's Law provides a useful approximation, real gases deviate from ideal behavior at high pressures or low temperatures. Under such conditions, interactions between molecules become significant, and more complex models like the Van der Waals equation are employed.

Summing Up: Key Takeaways

- Charles's Law establishes a direct proportionality between the volume and temperature of a gas at constant pressure.
- Temperatures must be converted to Kelvin to apply the law correctly.
- The law allows us to predict how a gas's volume will change with temperature, given initial conditions.
- Practical applications span many fields, from weather prediction to engineering.
- Deviations from ideal behavior occur under extreme conditions, requiring more advanced models.

Final Thoughts: The Power of Gas Laws

Understanding Charles's Law not only enriches our knowledge of basic physical principles but also provides practical tools for scientists, engineers, and everyday life. By grasping the relationship between temperature and volume, we gain insight into the behavior of gases—a fundamental aspect of the physical world.

In our specific example, knowing that a gas at 27°C occupies 6 liters allows us to confidently calculate that at 150°C, it will expand to approximately 8.45 liters. Such calculations underpin numerous technological and natural phenomena, emphasizing the importance of these foundational scientific laws.

In conclusion, Charles's Law exemplifies how empirical observations can be distilled into elegant mathematical relationships, enabling us to predict and manipulate the physical world with increased precision. Whether it's in laboratory experiments or understanding the environment, the principles outlined here form the backbone of thermodynamic studies and scientific progress.

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