A Container Of Gas At 29 Psi Is Compressed Toone Seventh Its Original Volume. What Is Thenew Pressure

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Understanding the relationship between pressure, volume, and temperature of gases is fundamental in physics and engineering. When a gas is compressed or expanded, its pressure changes accordingly, following principles outlined by the Ideal Gas Law. This law states that for a given amount of gas at constant temperature, the pressure and volume are inversely proportional. In this article, we will explore a practical problem involving gas compression: "A container of gas initially at 29 Psi is compressed to one seventh of its original volume. What is the new pressure?" We will delve into the concepts, calculations, and real-world applications to provide a comprehensive understanding of this scenario.

Understanding the Basic Principles: The Ideal Gas Law

What is the Ideal Gas Law?

The Ideal Gas Law combines several gas laws into a single equation:

\[PV = nRT \]

Where:
- P = pressure of the gas
- V = volume of the gas
- n = number of moles of gas
- R = universal gas constant
- T = temperature in Kelvin

For the purposes of this problem, we assume that the temperature remains constant (isothermal process), and the amount of gas does not change. Under these conditions, the law simplifies to:

\[P_1 V_1 = P_2 V_2 \]

This relationship states that the product of pressure and volume remains constant during an isothermal process.

Analyzing the Problem: Initial Conditions

Let's define the initial and final states:

- Initial pressure: $P_1 = 29 \text{ Psi}$
- Initial volume: $V_1 = V$ (unknown, but we will see it cancels out)
- Final volume: $V_2 = \frac{V_1}{7}$

Our goal: find the new pressure P_2.

Applying Boyle's Law: The Inverse Relationship

Since the temperature is constant, Boyle's Law applies:

$$P_1 V_1 = P_2 V_2$$

Rearranged to solve for P_2:

$$P_2 = P_1 \times \frac{V_1}{V_2}$$

Substituting the known values:

$$P_2 = 29 \text{ Psi} \times \frac{V}{V/7}$$

Simplifies to:

$$P_2 = 29 \text{ Psi} \times 7$$

Calculating:

$$P_2 = 203 \text{ Psi}$$

Therefore, the final pressure after compression is 203 Psi.

Understanding the Result and Real-World Implications

Significance of the Pressure Increase

The calculation shows that compressing the gas to one seventh of its original volume results in a sevenfold increase in pressure, assuming constant temperature:

- Original pressure: 29 Psi
- Compressed pressure: 203 Psi

This illustrates a key principle: pressure and volume are inversely proportional for gases under isothermal conditions.

Practical Applications of Gas Compression

Understanding how pressure changes with volume is crucial in various industries:

- Compressed Gas Cylinders: Used in welding, medical applications, and industrial processes.
- Aerospace Engineering: Managing fuel and oxidizer pressures.
- HVAC Systems: Compressors increase refrigerant pressure for heat exchange.
- Automotive Engines: Pistons compress air-fuel mixtures, increasing pressure before ignition.

Additional Considerations in Gas Compression

While the ideal calculations provide a good estimate, real-world situations may involve other factors:

Temperature Changes

- If the compression is adiabatic (no heat exchange), temperature increases, affecting pressure beyond simple Boyle's Law predictions.
- Adiabatic compression involves the relation:

$$ P V^\gamma = \text{constant} $$

where γ is the heat capacity ratio.

Material Strength and Safety

- Containers must withstand high pressures; safety standards are critical.
- Over-pressurization can lead to failure or explosions.

Summary of Key Points

- When a gas is compressed at constant temperature, pressure increases proportionally to the inverse of volume change.
- Compressing a gas to one seventh of its original volume increases its pressure by a factor of seven.
- The initial pressure of 29 Psi becomes approximately 203 Psi after compression.
- Real-world applications must account for temperature changes and material constraints.

Step-by-Step Calculation Recap

To summarize, here's a quick guide to solving similar problems:

1. Identify initial conditions: P_1, V_1.
2. Determine final volume: V_2.
3. Use Boyle's Law:

$$P_2 = P_1 \times \frac{V_1}{V_2}$$

4. Plug in values and compute.

Example:

Parameter	Value
P_1	29 Psi
V_2	$\frac{V_1}{7}$

$$
P_2 = 29 \times 7 = 203 \text{ Psi}
$$

Final Answer:

The new pressure after compressing the gas to one seventh of its original volume is approximately 203 Psi.

Conclusion

Understanding the relationship between pressure and volume in gases is essential for designing safe and efficient systems across various industries. The simple yet powerful principle demonstrated here showcases how fundamental physics principles can predict real-world behavior, ensuring safety and effectiveness in applications involving gas compression. Whether in industrial settings, engineering design, or scientific research, mastering these concepts enables professionals to optimize processes and maintain safety standards.

Interested in learning more about gas laws and their applications? Stay tuned for our upcoming articles on adiabatic processes, temperature effects, and advanced thermodynamics!

Frequently Asked Questions

What is the initial pressure of the gas in the container?

The initial pressure is 29 psi.

To what fraction is the gas compressed in volume?

The gas is compressed to one seventh of its original volume.

Which law relates the initial and final pressure and volume of the gas?

Boyle's Law relates initial and final pressure and volume for a gas at constant temperature.

How do you calculate the new pressure after compression?

Using Boyle's Law: $P1 \times V1 = P2 \times V2$, so $P2 = P1 \times (V1 / V2)$.

What is the formula to find the new pressure based on the initial pressure and change in volume?

$P2 = P1 \times (V1 / V2)$, where V2 is the compressed volume.

What is the new pressure of the gas after compression?

The new pressure is 29 psi × 7 = 203 psi.

Why does the pressure increase when the volume decreases?

Because gas particles collide more frequently with container walls as volume decreases, increasing pressure, per Boyle's Law.

Additional Resources

A Container Of Gas At 29 Psi Is Compressed To One Seventh Its Original Volume. What Is Thenew Pressure?

Understanding how gases behave under compression is fundamental in fields ranging from engineering and physics to everyday applications like scuba diving, automotive systems, and industrial processes. The problem of determining the new pressure of a gas after compression involves applying the principles of gas laws, primarily Boyle’s Law, which relates pressure and volume at constant temperature. This scenario presents a classic example of how pressure and volume interact, and analyzing it offers insight into the practical applications of these scientific principles.

Introduction to Gas Laws and the Context of the Problem

Before delving into the specific solution, it’s essential to understand the foundational concepts involved. Gases are highly compressible, and their behavior under changing conditions is described mathematically by the ideal gas law:

$$PV = nRT$$

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

In many practical problems, especially those involving constant temperature conditions (isothermal processes), Boyle’s Law becomes highly relevant:

$$P_1 V_1 = P_2 V_2$$

This law states that the product of the initial pressure and volume equals the product of the final pressure and volume when temperature remains constant.

In our scenario, a gas initially at a pressure of 29 psi is compressed to one seventh of its original volume. Our goal is to determine what the new pressure will be after this compression, assuming the temperature remains unchanged.

Analyzing the Problem Step-by-Step

Initial Conditions

- Initial pressure, $P_1 = 29$ psi
- Initial volume, V_1 (unknown but considered as the original volume)
- Final volume, $V_2 = \frac{1}{7} V_1$

Since the problem involves ratios, the actual numerical value of V_1 is not necessary; the ratio suffices for calculations.

Applying Boyle’s Law

Given the assumptions:
- Temperature is constant.
- Gas behaves ideally.
- No leaks or other energy exchanges.

The relationship becomes:

$$ P_1 V_1 = P_2 V_2 $$

Rearranged to solve for the new pressure:

$$ P_2 = P_1 \times \frac{V_1}{V_2} $$

Substitute $V_2 = \frac{1}{7} V_1$:

$$ P_2 = 29 \times \frac{V_1}{\frac{1}{7} V_1} = 29 \times 7 = 203 \text{ psi} $$

Thus, the new pressure after compression is 203 psi.

Understanding the Implications of the Result

The calculation reveals that compressing a gas to one-seventh of its original volume results in a sevenfold increase in pressure, assuming temperature remains constant. This is a direct consequence of Boyle's Law, illustrating the inverse relationship between volume and pressure.

This insight is practically significant. For example, in scuba diving, the pressure of air in tanks must be carefully monitored to avoid over-pressurization, which can be dangerous. Similarly, in industrial applications involving compressed gases, understanding how volume reductions affect pressure is vital for safety and efficiency.

Real-World Applications and Significance

Industrial Gas Storage

Industries store gases like oxygen, nitrogen, or propane under high pressure. Understanding the relationship between compression and pressure ensures the tanks are designed to withstand the resulting forces, preventing leaks or explosions.

Features:
- High-pressure tanks are designed with safety margins considering Boyle's Law.
- Compression ratios inform safety protocols and regulatory standards.

Pros:
- Efficient storage of large quantities in small volumes.
- Facilitates transportation and handling.

Cons:
- Risk of catastrophic failure if pressure exceeds design limits.
- Requires precise calculations and safety measures.

Engine and Mechanical Systems

Internal combustion engines rely on the compression of air-fuel mixtures, and understanding pressure-volume relationships is essential for optimizing efficiency and performance.

Features:
- Compression ratios impact power output and fuel efficiency.
- Engineers use Boyle’s Law to design combustion chambers.

Pros:
- Enhanced engine performance.
- Better fuel economy.

Cons:
- Higher compression ratios can lead to knocking.
- Material limitations to withstand increased pressures.

Scientific and Educational Significance

Understanding gas laws through such problems enhances comprehension of thermodynamics principles which are fundamental in physics and chemistry education.

Features:
- Provides practical examples of theoretical concepts.
- Encourages analytical thinking.

Pros:
- Strengthens problem-solving skills.
- Bridges theory and practice.

Cons:
- Simplified models may not account for real-world deviations.
- Assumptions like ideal behavior may not always hold.

Limitations and Assumptions in the Calculation

While the calculation provides a clear answer under idealized conditions, real-world scenarios might involve additional factors:

- Temperature Changes: The assumption of constant temperature may not hold during rapid compression, leading to temperature increases (adiabatic compression), which would affect pressure differently.
- Non-Ideal Gas Behavior: At high pressures, gases deviate from ideal behavior, requiring correction factors.
- Material Constraints: Physical constraints of the container may limit the extent of compression or influence safety considerations.

Understanding these limitations emphasizes the importance of considering real-world complexities beyond theoretical calculations.

Conclusion: Summarizing the Key Takeaways

In conclusion, the problem of determining the new pressure after compressing a gas from an initial pressure of 29 psi to one seventh of its original volume illustrates the fundamental principles of Boyle's Law. The straightforward calculation shows that the pressure increases proportionally, reaching a value of 203 psi under ideal conditions at constant temperature. This example highlights the significance of understanding gas laws in practical applications, from industrial storage and engineering design to scientific education. While the theoretical framework provides essential insights, engineers and scientists must also account for real-world factors such as temperature variations, material limitations, and non-ideal gas behavior to ensure safety and efficiency in practical scenarios.

This problem underscores the importance of mastering basic gas laws, which serve as the foundation for more complex thermodynamic analyses, and demonstrates the pivotal role they play across various technological and scientific domains.

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