

A Cylindrical Tube Has A Length Of 14.4cm And A Radius Of 1.5cm And Is Filled With A Colorless Gas. If

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If you are exploring the fascinating world of cylindrical measurements, gas laws, and related calculations, this comprehensive guide aims to provide clarity, detailed explanations, and practical insights. Whether you are a student, educator, or science enthusiast, understanding the dimensions and properties of cylindrical containers filled with gases is fundamental in various scientific and industrial applications. Let's delve into the details, starting from the basic measurements to advanced concepts like gas behavior, volume calculations, and their real-world implications.

Understanding the Basic Dimensions of the Cylindrical Tube

1. Dimensions of the Cylinder

The initial data given indicates:

- Length (Height) of the cylinder (h): 14.4 cm
- Radius of the base (r): 1.5 cm

These measurements are crucial for calculating the volume, surface area, and understanding the physical properties of the cylinder.

2. Significance of the Dimensions

Knowing the length and radius allows for:

- Precise volume calculations
- Understanding the capacity of the container
- Determining surface interactions (e.g., gas diffusion)
- Designing experiments or industrial processes involving gases

Calculating the Volume of the Cylindrical Tube

1. Volume Formula

The volume (V) of a cylinder is given by the formula:

$$V = \pi r^2 h$$

where:

- (r) is the radius
- (h) is the height (or length)
- (π) is approximately 3.1416

2. Step-by-Step Calculation

Given:

$$- \text{ } (r = 1.5 \text{ cm})$$

$$- \text{ } (h = 14.4 \text{ cm})$$

Calculations:

$$V = \pi \times (1.5)^2 \times 14.4$$

$$V = 3.1416 \times 2.25 \times 14.4$$

$$V = 3.1416 \times 32.4$$

$$V \approx 101.8 \text{ cm}^3$$

Thus, the volume of the cylindrical tube is approximately 101.8 cubic centimeters.

3. Importance of Volume in Gas Laws

The volume directly affects:

- Gas pressure inside the cylinder
- Gas density
- Molar quantity of the gas (if amount is known)

Understanding the Gas Inside the Cylinder

1. Nature of the Gas

The gas is described as colorless, which could refer to:

- Gases like oxygen, nitrogen, carbon dioxide, or noble gases
- No visible color or odor

Understanding the type of gas influences calculations related to:

- Gas behavior under different conditions
- Molar mass considerations
- Gas laws applicable

2. Assumptions for Gas Behavior

In most calculations involving gases in a sealed container, the following assumptions are made based on the ideal gas law:

- The gas behaves ideally
- The temperature remains constant
- The gas molecules do not interact with each other significantly
- The volume of individual molecules is negligible

Applying the Ideal Gas Law

1. The Ideal Gas Law Equation

$$PV = nRT$$

Where:

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

2. Converting Volume Units

Since the volume is in cubic centimeters, convert to liters:

$$V = 101.8 \text{ cm}^3 \times \frac{1 \text{ L}}{1000 \text{ cm}^3} \approx 0.1018 \text{ L}$$

3. Practical Gas Law Calculations

Suppose you want to determine:

- The pressure inside the cylinder at a given temperature
- The number of moles of gas present
- The effects of temperature changes on pressure or volume

For example, if the temperature is 25°C (298 K), and the gas behaves ideally, and you know the number of moles, you can calculate the pressure using the ideal gas law.

Real-World Applications of the Cylindrical Gas Container

1. Industrial Gas Storage

Cylindrical tubes are commonly used for storing gases in:

- Medical applications (e.g., oxygen tanks)
- Laboratory experiments
- Industrial processes (e.g., welding gases)

Understanding the dimensions helps in designing appropriate storage systems.

2. Gas Flow and Diffusion Studies

The shape and size influence:

- Gas flow rates
- Diffusion rates
- Reaction kinetics if gases are involved in reactions

3. Safety Considerations

Knowing the precise volume and pressure is vital for:

- Preventing overpressure incidents
- Ensuring safe handling
- Properly ventilating gases

Additional Calculations Related to the Cylinder

1. Surface Area of the Cylinder

Total surface area (A) :

\[

$$A = 2\pi r^2 + 2\pi r h$$

\]

Calculations:

\[

$$A = 2 \times 3.1416 \times (1.5)^2 + 2 \times 3.1416 \times 1.5 \times 14.4$$

\]

\[

$$A = 2 \times 3.1416 \times 2.25 + 2 \times 3.1416 \times 1.5 \times 14.4$$

\]

\[

$$A \approx 14.137 + 135.7 \approx 149.84 \text{ cm}^2$$

\]

This information is useful for understanding heat transfer and surface reactions.

2. Surface Area to Volume Ratio

\[

$$\frac{A}{V} = \frac{149.84}{101.8} \approx 1.472$$

\]

A higher ratio indicates more surface area relative to volume, which affects processes like gas exchange.

Impact of Changing Conditions on the Gas in the Cylinder

1. Effect of Temperature Changes

- Increasing temperature generally increases pressure if volume remains constant.
- Decreasing temperature reduces pressure.

2. Effect of Volume Changes

- Compressing the cylinder reduces volume, increasing pressure.
- Expanding the volume decreases pressure.

3. Boyle's and Charles's Laws

- Boyle's Law: $(P_1 V_1 = P_2 V_2)$ (at constant temperature)
- Charles's Law: $(V_1 / T_1 = V_2 / T_2)$ (at constant pressure)

These laws help predict how gases behave under different environmental conditions.

Conclusion

Understanding the measurements and properties of a cylindrical tube filled with a colorless gas involves a range of calculations and concepts rooted in geometry and thermodynamics. From

calculating volume and surface area to applying the ideal gas law, these principles are fundamental in scientific and industrial contexts. Accurate comprehension of how dimensions influence gas behavior enables better design, safety, and efficiency in applications involving gases stored in cylindrical containers.

Whether you're analyzing laboratory setups, industrial storage, or scientific experiments, mastering these calculations ensures precise control and understanding of gaseous systems. Remember, always consider the assumptions behind ideal gas law applications and adjust for real-world deviations when necessary.

Frequently Asked Questions

How do you calculate the volume of a cylindrical tube with a length of 14.4 cm and a radius of 1.5 cm?

The volume V of a cylinder is given by $V = \pi \times r^2 \times h$. Substituting $r = 1.5$ cm and $h = 14.4$ cm, $V = \pi \times (1.5)^2 \times 14.4 \approx 3.1416 \times 2.25 \times 14.4 \approx 102.1$ cubic centimeters.

What is the significance of knowing the volume of the gas-filled cylindrical tube?

Knowing the volume allows us to determine the amount of gas present, apply gas laws such as ideal gas law for calculations involving pressure, temperature, or moles of gas, and assess the tube's capacity.

If the gas inside the tube is colorless, what precautions should be taken when handling or analyzing it?

Since the gas is colorless, it may be difficult to detect visually. Proper ventilation, use of detection instruments, and safety protocols are essential to prevent inhalation hazards or leaks, especially if the

gas is toxic or flammable.

How would increasing the length of the cylindrical tube affect the volume of the contained gas?

Increasing the length of the tube proportionally increases its volume, assuming the radius remains constant. The volume is directly proportional to the height (length) of the cylinder.

What is the importance of knowing the radius of the cylindrical tube in gas-related calculations?

The radius determines the cross-sectional area of the cylinder, which is crucial for calculating the volume, flow rates, and pressure-related properties of the gas within the tube.

Additional Resources

A Cylindrical Tube Has A Length Of 14.4cm And A Radius Of 1.5cm And Is Filled With A Colorless Gas – this phrase encapsulates a fundamental concept in physics and chemistry, particularly in the study of gases and their behaviors within confined spaces. Such a simple description opens the door to a broad spectrum of scientific analysis, from calculating the volume of the contained gas to understanding the principles of gas laws, pressure, and temperature relationships. In this comprehensive review, we will explore the various aspects of this cylindrical tube, its properties, and the scientific principles that can be derived from such a configuration.

Understanding the Geometry of the Cylindrical Tube

The first step in analyzing this problem involves understanding the geometric parameters of the

cylindrical tube. The given dimensions are a length (height) of 14.4 cm and a radius of 1.5 cm.

Calculating the Volume of the Cylinder

The volume (V) of a cylinder is given by the formula:

$$V = \pi r^2 h$$

Where:

- (r) is the radius,
- (h) is the height (or length),
- (π) is Pi, approximately 3.1416.

Plugging in the values:

$$V = 3.1416 \times (1.5, \text{cm})^2 \times 14.4, \text{cm}$$

$$V = 3.1416 \times 2.25, \text{cm}^2 \times 14.4, \text{cm}$$

$$V \approx 3.1416 \times 2.25 \times 14.4$$

Calculating step-by-step:

$$\begin{aligned} & \sqrt[3]{3.1416 \times 2.25} \approx 7.0686 \\ & \end{aligned}$$

$$\begin{aligned} & \sqrt[3]{7.0686 \times 14.4} \approx 101.85 \text{ cm}^3 \\ & \end{aligned}$$

Therefore, the volume of the gas-filled cylinder is approximately 101.85 cubic centimeters.

Properties of the Gas Inside the Cylinder

The cylinder is filled with a colorless gas, which could be any number of gases such as nitrogen, oxygen, argon, or even a gas mixture. The key characteristics of these gases are crucial in understanding their behavior under different conditions.

Common Attributes of Colorless Gases

- Transparency: They are invisible to the naked eye, which is why the gas appears colorless.
- Compressibility: Gases are highly compressible, meaning their volume can change significantly under pressure.
- Diffusivity: Gases tend to diffuse and mix rapidly with other gases.
- Pressure and Temperature Dependence: Their pressure, volume, and temperature are interconnected through gas laws.

Application of Gas Laws to the Cylinder

Given the physical setup, various gas laws can be applied to analyze the behavior of the gas within the cylinder.

Boyle's Law (Pressure–Volume Relationship)

Boyle's law states that at constant temperature:

$$P_1 V_1 = P_2 V_2$$

Where:

- P is pressure,
- V is volume.

If the gas is compressed or expanded within the cylinder, the change in pressure can be calculated accordingly.

Charles's Law (Temperature–Volume Relationship)

Charles's law states that at constant pressure:

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

Where:

- T is temperature in Kelvin.

This law indicates that heating or cooling the gas results in volume expansion or contraction.

Gay-Lussac's Law (Pressure-Temperature Relationship)

This law states that at constant volume:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Understanding these laws helps in designing experiments or devices that rely on the behavior of gases in confined spaces.

Pressure and Temperature Considerations

In practical scenarios, the pressure and temperature of the gas inside the cylinder are vital parameters.

Estimating Gas Pressure

- If the gas is at room temperature ($\sim 25^\circ\text{C}$ or 298K) and atmospheric pressure ($\sim 1\text{ atm}$), the initial conditions are straightforward.
- Changes in temperature or external pressure will affect the gas's behavior, leading to expansion or

compression.

Ideal Gas Law Application

The ideal gas law combines the individual laws:

$$PV = nRT$$

Where:

- P is the pressure,
- V is the volume (~101.85 cm³ or 0.10185 liters),
- n is the number of moles of gas,
- R is the universal gas constant (8.314 J/mol·K),
- T is temperature in Kelvin.

Knowing the number of moles and temperature allows precise calculation of pressure, or vice versa.

Practical Applications and Significance

Understanding the behavior of gases in such a cylindrical container has applications in multiple fields:

Scientific Experiments

- Measuring gas properties under controlled conditions.
- Studying gas diffusion and mixing.
- Conducting pressure-volume-temperature (PVT) experiments.

Industrial Uses

- Storage of gases in cylinders for medical, industrial, or laboratory use.
- Designing pressure vessels and safety mechanisms.
- Gas chromatography equipment.

Educational Demonstrations

- Demonstrating gas laws in classroom settings.
- Visualizing the effects of temperature and pressure changes.

Advantages and Limitations of the Cylindrical Gas Container

Understanding the features of the cylindrical tube helps in evaluating its suitability for various applications.

Features

- Uniform Cross-Section: The shape facilitates consistent pressure distribution.
- Ease of Calculation: Simple geometry makes volume calculations straightforward.

- Material Flexibility: Can be made from glass, metal, or plastic depending on pressure and chemical compatibility.

Pros

- Easy to analyze thermodynamic properties.
- Suitable for small-scale experiments.
- Compact and portable.

Cons

- Limited volume capacity; not ideal for large quantities.
- Structural integrity depends on material strength.
- Cannot sustain very high pressures without reinforcement.

Safety Considerations When Handling Gas-Filled Cylinders

Handling pressurized gas cylinders, even small ones like this, requires strict safety protocols.

- Avoid Mechanical Damage: Cracks or dents can lead to sudden failure.
- Proper Storage: Keep away from heat sources.
- Use Appropriate Valves and Regulators: To control pressure and prevent leaks.
- Regular Inspections: Check for leaks or corrosion.

Conclusion

The analysis of a cylindrical tube with a length of 14.4 cm and a radius of 1.5 cm filled with a colorless gas offers rich insights into fundamental physics and chemistry principles. From calculating the precise volume to understanding how gases behave under different temperature and pressure conditions, such a setup exemplifies core scientific concepts. Its applications span scientific research, industrial processes, and educational demonstrations, making it a versatile and valuable tool. While it boasts features like ease of analysis and portability, considerations regarding safety and structural integrity are paramount. Ultimately, this simple cylinder encapsulates complex behaviors that are central to our understanding of gases and their properties, highlighting the importance of precise measurements and adherence to safety protocols in practical applications.

Features and Summary:

- Accurate volume calculation based on geometric parameters.
- Application of fundamental gas laws (Boyle's, Charles's, Gay-Lussac's, ideal gas law).
- Practical relevance in scientific and industrial contexts.
- Considerations for safety, structural design, and material choice.

This comprehensive review underscores the significance of understanding basic physical dimensions and their implications in real-world scenarios involving gases within cylindrical containers.

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