A Piece Of Aluminum Has Density 2.70 G/cm3 And Mass 775 G. The Aluminum Is Submerged In A Container Of

A Piece Of Aluminum Has Density 2.70 G/cm3 And Mass 775 G. The Aluminum Is Submerged In A Container Of water, and this simple scenario opens the door to exploring fundamental concepts in physics and chemistry, such as density, volume, buoyancy, and displacement. Whether you're a student, educator, or someone interested in understanding the properties of materials, this article will delve into the details surrounding this piece of aluminum, providing insights into how its physical characteristics interact with the environment around it.

Understanding the Properties of the Aluminum Piece

Density and Mass

Density is a measure of how much mass is contained within a given volume. In this case, the aluminum has a density of 2.70 grams per cubic centimeter (g/cm^3) and a total mass of 775 grams. These properties are crucial because they determine how the aluminum behaves when submerged in a fluid, especially in terms of buoyancy.

Calculating the Volume of Aluminum

Knowing the density and mass allows us to calculate the volume of the aluminum piece:

- Volume (V) = Mass / Density
- $V = 775\ g / 2.70\ g/cm^3 \approx 286.96\ cm^3$

This volume indicates how much space the aluminum occupies, which is essential when considering displacement and buoyant force.

Displacement and Buoyancy Principles

Archimedes' Principle

Archimedes' principle states that an object submerged in a fluid experiences an upward buoyant force equal to the weight of the displaced fluid. When the aluminum is submerged in water, understanding this principle helps determine whether it will sink or float.

Calculating the Buoyant Force

The buoyant force (F_b) can be calculated as:

- $F_b = \rho_{fluid} \times g \times V_{displaced}$

where:

- ρ_{fluid} = density of water (approximately 1.00 g/cm^3 or 1000 kg/m^3)
- g = acceleration due to gravity (9.81 m/s^2)
- $V_{displaced}$ = volume of fluid displaced (equals the volume of the aluminum when fully submerged)

Given the volume of the aluminum (approximately 286.96 cm^3), the weight of the displaced water is:

- Weight = $\rho_{water} \times V \times g$
- = $1.00\ g/cm^3 \times 286.96\ cm^3 \times 9.81\ m/s^2$

Converting units appropriately, you can determine whether the aluminum will float or sink based on its weight relative to the displaced water.

Scenario: Submerging Aluminum in Water

Will the Aluminum Float or Sink?

Using the previous calculations:

- Mass of aluminum = 775 g

- Weight of aluminum = 775 g × 9.81 m/s^2 ≈ 7593.75 dynes (or 7.59375 N)
- Weight of displaced water = 286.96 cm^3 × 1 g/cm^3 × 9.81 m/s^2 ≈ 2.814 N

Since the weight of the aluminum (7.59 N) exceeds the buoyant force (approximately 2.81 N), the aluminum will sink in water.

Implications and Observations

This analysis confirms that a solid aluminum piece with these properties will sink in water. However, if the aluminum were shaped differently, such as a hollow object, its overall density could be reduced, potentially allowing it to float.

Additional Factors Affecting Buoyancy and Behavior

Shape and Surface Area

The shape of the aluminum piece impacts how it interacts with water:

- More streamlined shapes experience less drag.
- Hollow or porous shapes can increase volume without significantly increasing mass, promoting buoyancy.

Temperature Effects

Temperature can influence the density of water and aluminum:

- Heating water decreases its density, slightly reducing buoyant force.
- Aluminum's density remains relatively stable across typical temperature ranges.

Material Purity and Alloy Composition

While pure aluminum has a density of 2.70 g/cm^3, alloyed or impure aluminum may have slightly different densities, affecting buoyancy and weight calculations.

Practical Applications and Experiments

Measuring Volume via Water Displacement

One common experiment involves submerging the aluminum in water to measure the displaced volume:

1. Fill a container with water and record the initial level.
2. Submerge the aluminum carefully without spilling.
3. Record the new water level.
4. The difference indicates the volume of the aluminum (about 286.96 cm^3).

Determining Density Through Displacement

By measuring the volume via displacement and knowing the mass, students can verify the density:

- Density = Mass / Volume ≈ 775 g / 286.96 cm^3 ≈ 2.70 g/cm^3

This reinforces understanding of how physical properties are interconnected.

Summary and Key Takeaways

- The aluminum piece weighs 775 grams and has a density of 2.70 g/cm^3, corresponding to a volume of approximately 287 cm^3.
- When submerged in water, the aluminum sinks because its weight exceeds the buoyant force exerted by displaced water.
- Understanding the principles of density, displacement, and buoyancy enables accurate predictions about how objects interact with fluids.
- Practical experiments, such as water displacement, help verify theoretical calculations and deepen

comprehension of material properties.

- Factors like shape, temperature, and material composition influence buoyancy and should be considered in real-world applications.

Conclusion

The exploration of this aluminum piece's properties illustrates fundamental physics principles with practical implications. Whether in designing ships, submarines, or simple experiments, understanding how density and displacement work together is essential. Recognizing that a solid aluminum object with the given mass and density will sink in water provides a foundation for further study and application in various scientific and engineering fields.

This detailed analysis underscores the importance of precise measurements and calculations in understanding material behavior, paving the way for innovations and educational insights alike.

Frequently Asked Questions

What is the volume of the aluminum piece with a mass of 775 g and density of 2.70 g/cm^3?

The volume is calculated by dividing the mass by the density: Volume = 775 g ÷ 2.70 g/cm^3 ≈ 287.04 cm^3.

How does the density of aluminum affect its buoyancy when submerged in water?

Since the density of aluminum (2.70 g/cm^3) is greater than water (1.00 g/cm^3), the aluminum will sink when submerged.

What is the weight of the aluminum in newtons?

Weight = mass × acceleration due to gravity = 775 g × 9.81 m/s^2 = 7.60 N (since 775 g = 0.775 kg).

How can Archimedes' principle be applied to determine if the aluminum will float or sink?

Archimedes' principle states that an object sinks if its density is greater than the fluid's density. Since aluminum's density (2.70 g/cm^3) exceeds water's, it will sink.

What would be the volume of the displaced water when the aluminum is submerged?

The volume of displaced water equals the volume of aluminum, which is approximately 287.04 cm^3.

If the aluminum is submerged in a container of oil with a density of 0.85 g/cm^3, will it float or sink?

Since aluminum's density (2.70 g/cm^3) is greater than the oil's density (0.85 g/cm^3), the aluminum will sink in the oil.

Additional Resources

Aluminum: An In-Depth Exploration of Its Density, Mass, and Behaviors When Submerged

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Introduction: The Versatile Metal at a Glance

Aluminum, a lightweight and abundant metal, has become an essential component in industries ranging from aerospace to packaging. Its unique combination of properties—lightweight, corrosion-resistant, and highly malleable—make it a material of choice for countless applications. In this article, we delve into a specific scenario involving aluminum with a known density and mass, exploring its properties, calculations, and behaviors when submerged in a liquid. Whether you're a student, an engineer, or simply a curious reader, this comprehensive guide aims to illuminate the nuances of aluminum's physical characteristics and practical implications.

Understanding the Fundamental Properties of Aluminum

Density of Aluminum: 2.70 G/cm^3

Density is a measure of how much mass is contained within a given volume—a crucial property in materials science. For aluminum, the density is approximately 2.70 grams per cubic centimeter (G/cm^3). This value indicates that every cubic centimeter of aluminum weighs about 2.70 grams.

Implications of Aluminum’s Density:
- Lightweight Nature: Compared to other metals like iron (~7.87 g/cm^3) or copper (~8.96 g/cm^3), aluminum's lower density makes it ideal for applications where weight savings are critical.
- Buoyancy and Submersion: Aluminum's density relative to liquids determines whether it floats or sinks,

an essential factor in applications like shipbuilding or buoyancy devices.

Mass of the Aluminum Sample: 775 Grams

The mass of the aluminum piece is given as 775 grams. Using this, we can determine the volume it occupies and explore its behavior in various environments.

Calculating the Volume of the Aluminum Piece

Knowing the mass and density allows us to determine the volume of the aluminum sample with the formula:

$$
\text{Volume} = \frac{\text{Mass}}{\text{Density}}
$$

Calculation:

$$
\text{Volume} = \frac{775 \text{ g}}{2.70 \text{ g/cm}^3} \approx 287.04 \text{ cm}^3
$$

Interpretation:

- The aluminum piece occupies approximately 287.04 cubic centimeters.
- This volume is a critical factor in understanding how the object interacts with its environment, especially in fluid mechanics.

Behavior of Aluminum When Submerged

The real intrigue often lies in how an object behaves when placed in a fluid. This involves principles of buoyancy, displacement, and fluid dynamics. To explore this, we consider the scenario of submerging this aluminum piece into a container filled with a liquid.

Key Factors to Consider:
- Type of liquid: The density of the liquid significantly influences whether the aluminum floats or sinks.
- Object's density vs. liquid's density: Determines buoyant force and equilibrium.
- Shape and orientation of the object: Affect the volume displaced and stability when floating.

Submersion Dynamics: Buoyancy and Archimedes' Principle

Archimedes' Principle Explained

Archimedes' principle states:

> An object submerged in a fluid experiences an upward buoyant force equal to the weight of the fluid displaced by the object.

Mathematically:

$$
F_b = \rho_{fluid} \times g \times V_{displaced}
$$

Where:
- F_b = buoyant force
- ρ_{fluid} = density of the fluid
- g = acceleration due to gravity (~9.81 m/s^2)
- $V_{displaced}$ = volume of fluid displaced (equal to the volume of the submerged part of the object)

Determining Whether the Aluminum Sinks or Floats

Case 1: Submerging in Water

- Density of water: approximately 1.00 g/cm^3
- Density of aluminum: 2.70 g/cm^3

Since the aluminum's density exceeds that of water, it will sink when placed in water.

Calculation of object's weight:

$$
W_{object} = \text{Mass} \times g = 775 \text{ g} \times 9.81 \text{ m/s}^2 \approx 7.6 \text{ N}
$$

Buoyant force in water:

\[

F_b = \rho_{water} \times g \times V_{displaced}
\]

To balance the weight, the displaced volume must satisfy:

\[
F_b = W_{object}
\]

\[
\rho_{water} \times g \times V_{displaced} = 7.6 \text{ N}
\]

Expressed in terms of volume:

\[
V_{displaced} = \frac{7.6 \text{ N}}{\rho_{water} \times g}
\]

Given:

\[
\rho_{water} = 1.00 \text{ g/cm}^3 = 1000 \text{ kg/m}^3
\]

Convert mass and volume units appropriately:

\[
V_{displaced} = \frac{7.6 \text{ N}}{(1000 \text{ kg/m}^3) \times 9.81 \text{ m/s}^2} \approx 0.000775 \text{ m}^3
\]

which is 775 cm^3. Since the total volume of the aluminum is approximately 287.04 cm^3, it cannot displace enough water to balance its weight—confirming that the aluminum will sink.

Case 2: Submerging in a Denser Liquid

If the liquid's density exceeds 2.70 g/cm^3, the aluminum could float partially, depending on the density. For instance:

- If submerged in mercury (~13.5 g/cm^3): Aluminum would float, as the buoyant force exceeds its weight when partially submerged.
- In saline or other dense solutions: Similar behavior can be observed, depending on the exact density.

Practical Applications and Implications

Understanding these principles is crucial for various practical applications:

1. Designing Buoyancy Devices

Knowing the volume and density helps in designing objects that float or sink as needed—for instance, submarines, ballast systems, or flotation aids.

2. Material Selection for Engineering

Engineers select aluminum for lightweight structures but must account for its sinking behavior in water, ensuring proper design for stability and safety.

3. Material Testing and Quality Control

By measuring mass and volume, one can verify the purity and consistency of aluminum samples, ensuring they meet specifications.

Additional Factors in Real-World Scenarios

While calculations provide a foundational understanding, real-world behaviors involve additional considerations:

- Surface Tension Effects: Particularly in small-scale applications.
- Corrosion and Surface Conditions: Aluminum forms an oxide layer that can influence buoyancy and interaction with liquids.
- Shape and Surface Area: A flat sheet behaves differently than a spherical or irregular piece.

Summary: Key Takeaways

- The aluminum piece with a mass of 775 grams and density 2.70 g/cm^3 occupies approximately 287.04 cm^3.
- In pure water, due to its higher density, the aluminum will sink.
- Displacement calculations confirm that the object cannot displace enough water to counteract its weight, reinforcing its sinking behavior.
- In liquids with densities exceeding 2.70 g/cm^3, the aluminum could float partially or completely, depending on the volume displaced.

- Understanding these properties is vital in designing systems involving buoyancy, material selection, and fluid interaction.

Final Thoughts: The Significance of Material Properties

This exploration underscores the importance of fundamental material properties—density, mass, volume—in predicting and controlling the behavior of materials in various environments. Aluminum's unique characteristics make it a versatile and widely used metal, but also necessitate careful consideration when designing objects meant to float, sink, or withstand specific conditions.

By mastering these principles, engineers, scientists, and enthusiasts can better harness aluminum's potential, ensuring safety, efficiency, and innovation across a broad spectrum of applications.

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