# Three Cubes Of Equal Mass Are Composed Of Gold (density = 19.32 G/cm3 ), Platinum (density = 21.45 G/cm3

**Three Cubes Of Equal Mass Are Composed Of Gold (density = 19.32 G/cm3 ), Platinum (density = 21.45 G/cm3**. This intriguing scenario presents an excellent opportunity to explore the concepts of density, volume, and material properties in depth. When three cubes of identical mass are made from different materials, their physical characteristics such as volume and density become crucial in understanding their behavior and differences. In this article, we will analyze the properties of these cubes, derive important formulas, and investigate the implications of their compositions.

## Understanding Density and Its Significance

### What Is Density?

Density is a fundamental physical property defined as the mass of a substance per unit volume. It is expressed mathematically as:

- **Density (ρ) = Mass (m) / Volume (V)**

The SI unit for density is kilograms per cubic meter (kg/m3), but in the context of this problem, where densities are given in grams per cubic centimeter (g/cm3), it is more convenient to work within these units for consistency.

### Significance of Density in Material Identification

Density helps in identifying materials and understanding their physical behaviors. For example:

- Materials with higher density are generally heavier for the same volume.
- Material selection in engineering often depends on density for weight optimization.
- Density influences buoyancy, which is essential in fluid mechanics.

## Given Data and Assumptions

## Material Densities

- Gold: 19.32 $g/cm^3$
- Platinum: 21.45 $g/cm^3$

## Equal Mass of Three Cubes

- Let the common mass of each cube be denoted as $m$ grams.
- The masses are identical, but their volumes will differ based on the material.

## Objective

- Determine the individual volumes of each cube.
- Explore how the densities influence their sizes.
- Analyze the physical implications of the differences.

# Deriving the Volumes of the Cubes

## Volume Formula Revisited

Given the mass $m$ and density $\rho$:

$$
V = \frac{m}{\rho}
$$

The volume of each cube can be computed directly if the mass is specified. Since the mass is not specified numerically, we will express the volumes in terms of $m$.

## Calculating Individual Volumes

- For the gold cube:

$$
V_{gold} = \frac{m}{19.32}
$$

- For the platinum cube:

$$
V_{plat} = \frac{m}{21.45}
$$

These expressions show that, for the same mass, the volume of gold is larger than that of platinum due to its lower density.

# Determining the Side Lengths of the Cubes

## Cube Volume and Side Length Relationship

Since all the shapes are cubes, their volumes relate to their side lengths $a$:

$$
V = a^3
$$

Therefore:

$$
a = \sqrt[3]{V}
$$

- Side length of gold cube:

$$
a_{gold} = \sqrt[3]{\frac{m}{19.32}}
$$

- Side length of platinum cube:

$$
a_{plat} = \sqrt[3]{\frac{m}{21.45}}
$$

Because the densities differ, the side lengths will differ as well, with the gold cube being larger for the same mass.

## Relative Sizes of the Cubes

To compare the sizes:

$$
\frac{a_{gold}}{a_{plat}} = \left( \frac{\frac{m}{19.32}}{\frac{m}{21.45}} \right)^{1/3} = \left( \frac{21.45}{19.32} \right)^{1/3}
$$

Calculating:

$$
\frac{a_{gold}}{a_{plat}} = \left( 1.11 \right)^{1/3} \approx 1.035
$$

This indicates that the gold cube's side length is approximately 3.5% larger than that of the platinum cube, which is a subtle but meaningful difference.

# Implications of Material Properties and

# Physical Behavior

## Weight and Density Effects

- Since all cubes have the same mass, the one made of platinum is smaller but denser, hence heavier per unit volume.
- The gold cube appears larger but is lighter per unit volume.

## Buoyancy and Displacement

- When submerged in a fluid, the displacement depends on the volume, not the mass.
- The gold cube displaces more fluid due to its larger volume.
- This property is critical in applications such as buoyancy calculations and designing objects for specific fluid interactions.

## Practical Applications and Material Selection

- Engineers and designers choose materials based on density for weight and size constraints.
- For example, in jewelry, gold's lower density means larger pieces for the same weight compared to platinum.
- In industrial uses, the higher density of platinum makes it suitable for applications requiring compactness and durability.

# Exploring the Effects of Changing Mass

## Scaling Up or Down

- If the mass $m$ is increased or decreased, the volume and side length scale proportionally.
- The ratios between the sizes of the cubes remain constant because they depend on the cube root of the density ratio.

## Example Calculation with a Specific Mass

Suppose each cube has a mass of 100 grams:

- Gold cube volume:

$$
V_{gold} = \frac{100}{19.32} \approx 5.18\, \text{cm}^3
$$

- Platinum cube volume:

$$
V_{plat} = \frac{100}{21.45} \approx 4.66\, \text{cm}^3
$$

Calculating side lengths:

- Gold cube:

$$
a_{gold} = \sqrt[3]{5.18} \approx 1.73\, \text{cm}
$$

- Platinum cube:

$$
a_{plat} = \sqrt[3]{4.66} \approx 1.67\, \text{cm}
$$

These calculations reinforce that even with a specific mass, the size differences are modest but measurable.

# Summary and Conclusions

- When three cubes of equal mass are made from materials with different densities, their volumes and sizes vary inversely with density.
- The cube made of gold (lower density) is larger than the platinum cube for the same mass.
- The side length difference is approximately 3.5%, illustrating how subtle density differences influence physical dimensions.
- Understanding these relationships is vital in fields like material science, engineering, jewelry making, and fluid mechanics.

## Final Remarks

This analysis demonstrates how fundamental principles of density and volume interrelate, providing insight into the physical properties of materials. Whether designing lightweight structures, crafting jewelry, or studying buoyancy, grasping the relationship between mass, volume, and density is essential. The example of three cubes of equal mass made of gold and platinum highlights the importance of material properties in determining size and weight, emphasizing the nuanced differences that arise from varying densities.

# Frequently Asked Questions

## What is the density of gold and platinum used in the problem?

The density of gold is 19.32 $g/cm^3$, and the density of platinum is 21.45 $g/cm^3$.

## If three cubes of equal mass are made of gold and platinum, how do their volumes compare?

Since they have the same mass but different densities, the cube made of gold will have a larger volume than the platinum cube, as volume is inversely proportional to density for equal mass.

## How do you calculate the volume of each cube given their mass and density?

The volume can be calculated using the formula $V = m / \rho$, where $m$ is the mass of the cube and $\rho$ is its density.

## Which cube will be larger in size—the gold or the platinum cube—if their masses are equal?

The gold cube will be larger because gold has a lower density, resulting in a greater volume for the same mass.

## How can this problem be used to compare the physical properties of different metals?

It demonstrates how different densities affect the volume and size of objects with the same mass, highlighting the importance of density in material properties.

## If the mass of each cube is 100 grams, what are their respective volumes?

For gold: $V = 100\ g / 19.32\ g/cm^3 \approx 5.18\ cm^3$; for platinum: $V = 100\ g / 21.45\ g/cm^3 \approx 4.66\ cm^3$.

## Why is understanding density important when working with different materials like gold and platinum?

Understanding density helps determine the size, weight, and material properties, which are essential for applications in jewelry, manufacturing, and scientific research.

## Can the density values help identify an unknown metal if the mass and volume are known?

Yes, measuring the mass and volume to find the density can help identify the metal by comparing it to known density values.

# Additional Resources

Gold and Platinum: A Comparative Analysis of Three Equal-Mass Cubes

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## Introduction

When exploring the fascinating world of precious metals, few comparisons are as intriguing as examining objects of identical mass but different densities. Gold and platinum, two of the most coveted and valuable metals, exemplify this contrast beautifully. Imagine three cubes, each with the same mass, crafted from gold and platinum respectively. What insights can we derive about their physical characteristics, volume, and practical implications? This detailed review delves into the properties of these metals, the geometry of the cubes, and the scientific principles that underpin their differences.

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## Understanding Density and Its Implications

Density is a fundamental property that influences the size, weight, and even the applications of materials. It is defined as mass per unit volume:

$$
\text{Density} (\rho) = \frac{\text{Mass} (m)}{\text{Volume} (V)}
$$

In our context:

- Gold has a density of 19.32 g/cm³
- Platinum has a density of 21.45 g/cm³

Given a fixed mass for each cube, the density directly affects the volume, and consequently, the size of each cube. Higher density materials occupy less volume for the same mass, resulting in smaller cubes, while lower density materials occupy more volume, leading to larger cubes.

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## Calculating the Volume of Each Cube

Suppose each cube has a mass $m$. For the purposes of this analysis, let's assume a standard mass of 100 grams for both cubes to facilitate comparison.

### Volume of Gold Cube

$$
V_{\text{Gold}} = \frac{m}{\rho_{\text{Gold}}} = \frac{100\, \text{g}}{19.32\, \text{g/cm}^3} \approx 5.18\, \text{cm}^3
$$

### Volume of Platinum Cube

$$
V_{\text{Platinum}} = \frac{m}{\rho_{\text{Platinum}}} = \frac{100\, \text{g}}{21.45\, \text{g/cm}^3} \approx 4.66\, \text{cm}^3
$$

Observation: The gold cube, being less dense, is larger in volume than the platinum cube for the same mass.

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Determining the Cube Dimensions

Since each cube is geometrically regular, the side length $a$ of each cube can be derived from its volume:

$$
a = \sqrt[3]{V}
$$

Side Length of Gold Cube

$$
a_{\text{Gold}} = \sqrt[3]{5.18\, \text{cm}^3} \approx 1.72\, \text{cm}
$$

Side Length of Platinum Cube

$$
a_{\text{Platinum}} = \sqrt[3]{4.66\, \text{cm}^3} \approx 1.66\, \text{cm}
$$

Insight: The gold cube is approximately 0.06 cm larger on each side than the platinum cube, reflecting the difference in density.

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Visualizing the Comparison

| Property | Gold Cube | Platinum Cube |
| --- | --- | --- |
| Density | 19.32 g/cm³ | 21.45 g/cm³ |
| Volume (for 100 g) | 5.18 cm³ | 4.66 cm³ |
| Side Length | ~1.72 cm | ~1.66 cm |

This comparison underscores the impact of density on physical size: a higher-density metal results in a smaller object for the same mass.

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Practical Implications

1. Handling and Storage

- Size Difference: The size disparity, although small, can influence handling. For instance, a slightly larger gold cube might be easier to grip or examine visually, which can be relevant in jewelry or display applications.
- Weight: Since mass is constant, the weight is identical, but the size difference could affect packaging or storage considerations where volume is a factor.

2. Manufacturing and Design

- Precision Cutting: When manufacturing precision components or jewelry, understanding these size differences is crucial for fitting and aesthetic consistency.
- Material Selection: The density plays a role in choosing materials based on weight constraints or space limitations.

3. Scientific and Educational Contexts

- These cubes serve as excellent teaching tools to demonstrate the principles of density, volume, and mass.
- They also exemplify how different materials, despite being similar in shape and mass, differ significantly in size and physical properties.

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Additional Considerations

Density Variance in Real-World Samples

- Impurities and Alloys: Actual gold and platinum used in jewelry or industrial applications often contain impurities or alloyed elements, slightly altering their densities.
- Temperature Effects: Density can vary with temperature; however, for most practical purposes at room temperature, these values are stable.

Economic and Market Factors

- The higher density of platinum correlates with its higher market value per unit mass, influencing pricing strategies and investment decisions.

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Exploring Different Masses

Let's briefly consider what happens if we increase the mass to 1000 grams:

- Gold Volume: $\approx 51.8\, \text{cm}^3$
- Gold Side Length: $\approx 3.72\, \text{cm}$

- Platinum Volume: $\approx 46.6\, \text{cm}^3$
- Platinum Side Length: $\approx 3.58\, \text{cm}$

The proportional differences remain consistent, reinforcing the fundamental relationship between density and size at any scale.

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Conclusion

The comparative analysis of three cubes of equal mass composed of gold and platinum reveals the profound influence of density on physical characteristics. Gold, with its lower density, manifests as a larger cube, offering tangible proof of how material properties shape their real-world applications. Whether for jewelry, industrial use, or educational demonstrations, understanding these differences aids in making informed decisions about material selection, design, and handling.

In a broader sense, this exploration underscores the elegance of physics and chemistry in explaining observable phenomena and underscores the importance of material properties in practical contexts. For collectors, jewelers, engineers, or students, recognizing the nuances between gold and platinum — especially through the lens of simple geometric objects like cubes — deepens appreciation for these precious metals and their unique qualities.

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In essence: For the same mass, gold's lower density results in a larger cube, emphasizing how fundamental properties like density directly influence the physical dimensions and potential applications of these treasured elements.

## Three Cubes Of Equal Mass Are Composed Of Gold Density 19 32 G Cm3 Platinum Density 21 45 G Cm3

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