A 4.1 G Sample Of Gold (specific Heat Capacity = 0.130 J/g C) Is Heated Using 52.2 J Of Energy. If The

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Understanding the thermal properties of gold and calculating how much its temperature increases when heated is an essential aspect of thermodynamics, especially in fields such as materials science, metallurgy, and engineering. In this article, we will explore the specific heat capacity of gold, how energy transfer affects temperature, and walk through the calculations involved in determining the temperature change of a gold sample subjected to a known amount of energy.

Introduction to Specific Heat Capacity

What Is Specific Heat Capacity?

Specific heat capacity, often simply called specific heat, is a physical property of a material that indicates how much heat energy is required to raise the temperature of one gram of the substance by one degree Celsius (or Kelvin). It is expressed in units of joules per gram per degree Celsius (J/g°C).

Mathematically, the relationship between heat energy, mass, specific heat, and temperature change is given by:

$$ Q = mc\Delta T $$

Where:
- Q = heat energy added (J)
- m = mass of the substance (g)
- c = specific heat capacity (J/g°C)
- ΔT = change in temperature (°C)

Properties of Gold

Gold is a highly valued precious metal known for its excellent thermal and electrical conductivity. Its specific heat capacity is relatively low compared to many other metals, meaning it heats up and cools down quickly. The specific heat capacity of gold is approximately 0.130 J/g°C, which signifies that each gram of gold requires 0.130 joules of energy to increase its temperature by 1°C.

Calculating Temperature Change of Gold Sample

Given:
- Mass of gold (m) = 4.1 grams

- Specific heat capacity (c) = 0.130 J/g°C
- Energy supplied (Q) = 52.2 joules

We want to find the temperature change (ΔT) after heating the gold sample with 52.2 J of energy.

Applying the Heat Equation

Using the basic heat transfer formula:

$$\Delta T = \frac{Q}{mc}$$

Plugging in the known values:

$$\Delta T = \frac{52.2\, \text{J}}{4.1\, \text{g} \times 0.130\, \text{J/g°C}}$$

Carrying out the calculation:

$$\Delta T = \frac{52.2}{4.1 \times 0.130}$$
$$\Delta T = \frac{52.2}{0.533}$$
$$\Delta T \approx 97.9\, \text{°C}$$

Thus, the temperature of the gold sample increases by approximately 97.9°C.

Implications of the Temperature Increase

Understanding the Result

The calculated temperature rise indicates that when 52.2 joules of energy is supplied to a 4.1 g gold sample, its temperature increases by nearly 98°C. This is a significant temperature change, emphasizing gold's relatively low specific heat capacity compared to other materials.

Practical Applications

Such calculations are crucial in several practical contexts:
- Metallurgy and Gold Refining: Knowing how much energy is needed to heat gold to a specific temperature helps in designing efficient heating processes.
- Thermal Management: In electronic applications, understanding how gold heats up can influence cooling strategies.
- Scientific Experiments: Accurate calculations of temperature change enable precise control and measurement in laboratory settings.

Factors Affecting the Heating Process

Heat Losses

In real-world scenarios, heat loss to surrounding environment (via conduction, convection, and radiation) can affect the actual temperature change, making it lower than the theoretical calculation suggests.

Material Purity and Structure

Impurities or alloying elements in gold can alter its specific heat capacity slightly, influencing the amount of energy required to change its temperature.

Heating Method

The way energy is supplied (e.g., direct heating, induction, or resistive heating) impacts the efficiency and uniformity of heating.

Additional Considerations in Thermodynamics

Latent Heat

While not relevant in this specific calculation, when heating materials, phase changes such as melting or vaporization involve latent heat, which must be considered in more complex thermal analyses.

Temperature Limits

Gold has a melting point of approximately 1064°C. Calculations involving heating beyond this point require considerations of phase change and latent heat.

Conclusion

Understanding how to calculate the temperature change of a gold sample based on supplied energy is fundamental in thermodynamics. The straightforward application of the heat equation reveals that supplying 52.2 J to a 4.1 g gold sample with a specific heat capacity of 0.130 J/g°C results in a temperature increase of approximately 98°C. This calculation underscores the importance of specific heat capacity in predicting thermal responses and designing processes involving heat transfer.

Whether in scientific research, industrial applications, or educational contexts, mastering these calculations enhances our ability to manipulate and control thermal processes effectively. Gold's unique properties, combined with fundamental thermodynamic principles, make it a fascinating subject of study with broad practical significance.

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Note: The data and calculations presented are based on standard properties of gold and idealized assumptions, neglecting heat losses or other real-world factors.

Frequently Asked Questions

How much does the temperature of the 4.1 g gold sample increase when 52.2 J of energy is supplied?

The temperature increase can be calculated using $Q = mc\Delta T$. Rearranged, $\Delta T = Q / (mc) = 52.2\ J / (4.1\ g \times 0.130\ J/g°C) \approx 52.2 / 0.533 \approx 97.9°C$.

What is the specific heat capacity of the gold sample in this problem?

The specific heat capacity provided is 0.130 J/g°C.

If the initial temperature of the gold sample is 25°C, what is its final temperature after heating?

Assuming initial temperature is 25°C, the final temperature will be approximately $25°C + 97.9°C \approx 122.9°C$.

What assumptions are made in calculating the temperature change of the gold sample?

It is assumed that all the supplied energy is used solely to heat the gold sample without any heat loss to the surroundings and that the specific heat capacity remains constant over the temperature change.

How would the temperature change if the energy supplied was doubled to 104.4 J?

If 104.4 J is supplied, the temperature increase would be approximately $2 \times 97.9°C \approx 195.8°C$, assuming the same conditions.

Why is it important to know the specific heat capacity of the material when calculating temperature changes?

The specific heat capacity indicates how much energy is needed to raise the temperature of a unit mass of the material by 1°C, which is essential in determining the temperature change resulting from a given amount of heat energy.

Additional Resources

A 4.1 G Sample Of Gold (specific Heat Capacity = 0.130 J/g°C) Is Heated Using 52.2 J Of Energy. If The—this intriguing scenario invites us to explore fundamental concepts of thermodynamics, specifically how energy transfer influences temperature changes in materials like gold. Whether you're a student, educator, or enthusiast, understanding the detailed process behind such a problem deepens your grasp of heat transfer principles and their practical applications. In this comprehensive guide, we'll walk through the steps needed to analyze this problem, interpret the results, and understand the underlying physics at play.

Understanding the Scenario

Let's restate the problem in detail:

- Sample Material: Gold
- Mass of Gold: 4.1 grams
- Specific Heat Capacity of Gold: 0.130 J/g°C
- Energy Supplied: 52.2 Joules

The question implies that we are to analyze the effect of this energy input—how much the temperature of the gold sample increases after absorbing 52.2 J of heat.

Foundational Concepts

Before diving into calculations, it's essential to understand the core principles involved:

1. Specific Heat Capacity (c)

- The amount of heat energy required to raise the temperature of 1 gram of a substance by 1°C.
- For gold, c = 0.130 J/g°C.

2. Heat Energy (Q)

- The total energy transferred to or from a substance, measured in Joules (J).
- When heat is added to a substance, it causes a temperature increase, assuming no phase change occurs.

3. Temperature Change (ΔT)

- The difference between the final and initial temperatures of the sample.

The relationship between heat energy, mass, specific heat, and temperature change is given by:

$$ Q = mc\Delta T $$

Where:

- Q = heat energy input (J)
- m = mass (g)
- c = specific heat capacity (J/g°C)
- ΔT = change in temperature (°C)

Step-by-Step Solution Approach

To determine the temperature change of the gold sample after absorbing 52.2 J of energy, follow these steps:

Step 1: Identify Known Values

Parameter	Value
Mass (m)	4.1 g
Specific heat capacity (c)	0.130 J/g°C
Heat energy (Q)	52.2 J

Step 2: Write the Heat Equation

$$
Q = mc\Delta T
$$

Rearranged to solve for ΔT:

$$
\Delta T = \frac{Q}{mc}
$$

Step 3: Plug in the Values

$$
\Delta T = \frac{52.2 \text{ J}}{4.1 \text{ g} \times 0.130 \text{ J/g°C}}
$$

Calculating the denominator:

$$
4.1 \times 0.130 = 0.533 \text{ J/°C}
$$

Thus,

$$
\Delta T = \frac{52.2}{0.533} \approx 97.9°C
$$

Interpretation of Results

The calculation indicates that the temperature of the gold sample increases by approximately 97.9°C after absorbing 52.2 Joules of energy.

Implication:
If, for example, the initial temperature was room temperature (~25°C), the final temperature would be roughly:

$$
25°C + 97.9°C \approx 122.9°C
$$

This significant temperature rise underscores how small amounts of heat energy can cause substantial temperature increases in low-mass, high-specific-heat-capacity materials like gold.

Additional Considerations

While the core calculation is straightforward, several factors could influence the real-world outcome or the interpretation of this problem:

1. Initial Temperature of the Sample

- The problem does not specify the initial temperature. Assuming room temperature is typical unless otherwise stated.

2. Phase Changes or Melting

- Gold melts at approximately 1064°C, so in this scenario, the temperature increase remains well below melting point, and phase change isn't an issue.

3. Heat Losses

- The calculation assumes perfect insulation with no heat lost to surroundings. Real-world experiments may see deviations due to heat exchange.

4. Measurement Accuracy

- The precision of the mass measurement and heat energy supplied can affect final temperature calculations.

Broader Context and Applications

Understanding the relationship between heat energy and temperature change in materials like gold has many practical implications:

- Material Processing: Precise thermal control in goldsmithing or electronic component fabrication.
- Thermal Conductivity Studies: Gold's high thermal conductivity makes it suitable for heat transfer applications.
- Calibration Devices: Gold's stable properties make it ideal for calibration in thermometry.

Summary and Takeaways

- The fundamental formula $Q=mc\Delta T$ allows us to determine temperature changes resulting from heat input.
- In this problem, 52.2 J of energy causes a nearly 98°C increase in a 4.1 g gold sample.
- Key insights:
- Small mass and low specific heat capacity lead to significant temperature increases with modest energy input.
- Accurate calculations require awareness of initial conditions and assumptions about heat losses.

Final Thoughts

Exploring scenarios like "A 4.1 G Sample Of Gold Is Heated Using 52.2 J Of Energy" provides valuable insight into thermodynamics principles. Whether you're designing heating systems, conducting experiments, or simply curious about how heat affects materials, mastering these calculations enhances your understanding of energy transfer phenomena. Remember, always consider real-world factors like heat loss and phase changes, but for theoretical purposes, the equations and methods outlined here serve as a robust foundation for analyzing thermal processes involving metals like gold.

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