

A Metal With A Specific Heat Of 0.780 Requires 45 Kj Of Heat To Raise The Temperature By 82 C What Is

A Metal With A Specific Heat Of 0.780 Requires 45 Kj Of Heat To Raise The Temperature By 82°C: What Is It?

A Metal With A Specific Heat Of 0.780 Requires 45 Kj Of Heat To Raise The Temperature By 82°C What Is the identity of this metal? This question prompts an exploration into the concepts of specific heat capacity, heat transfer, and how to determine the type of metal based on given thermal properties. Understanding these fundamental principles enables us to analyze the problem systematically and derive the metal's characteristics. In this article, we will delve into the physics behind specific heat, formulate the relevant equations, perform calculations, and interpret the results to identify the metal in question.

Fundamentals of 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 the amount of heat required to raise the temperature of one gram (or kilogram) of that substance by one degree Celsius (or Kelvin). It is an intrinsic property, meaning it remains constant for a given substance under specific conditions.

- Unit of specific heat (per unit mass): $\text{J}/(\text{g}\cdot^{\circ}\text{C})$ or $\text{J}/(\text{kg}\cdot\text{K})$
- Defines how much energy a material can absorb before increasing in temperature
- Different materials have different specific heats based on their atomic and molecular structure

Significance in Heat Transfer

The specific heat capacity determines how quickly or slowly a material heats up or cools down when subjected to a heat source or sink. Materials with high specific heats can store more thermal energy per unit temperature increase, making them useful for thermal regulation applications, while those with low specific heats respond more rapidly to temperature changes.

Formulating the Problem

Given Data

- Specific heat capacity, $c = 0.780$ (assumed units: $\text{J}/(\text{g}\cdot^{\circ}\text{C})$ for calculations)
- Heat energy supplied, $Q = 45 \text{ kJ} = 45,000 \text{ J}$
- Temperature change, $\Delta T = 82^{\circ}\text{C}$

What We Need to Find

The goal is to determine the identity of the metal, which involves finding its mass or verifying the specific heat value, and then matching it to known values for different metals.

Key Equation

The fundamental relation connecting heat energy, specific heat, mass, and temperature change is:

$$Q = m \cdot c \cdot \Delta T$$

Where:

- Q = heat energy supplied (J)
- m = mass of the metal (g or kg)
- c = specific heat capacity ($\text{J}/(\text{g}\cdot^{\circ}\text{C})$ or $\text{J}/(\text{kg}\cdot\text{K})$)
- ΔT = temperature change ($^{\circ}\text{C}$ or K)

Calculating the Mass of the Metal

Step 1: Convert Units Consistently

Since the specific heat is given as 0.780 (likely in $\text{J}/(\text{g}\cdot^{\circ}\text{C})$), and heat energy is in kilojoules, convert Q to joules:

- $Q = 45,000 \text{ J}$

Temperature change is already in Celsius, so no unit conversion needed there.

Step 2: Rearrange the Equation to Find Mass

Rearranged formula:

$$m = Q / (c \Delta T)$$

Plugging in the known values:

$$m = 45,000 \text{ J} / (0.780 \text{ J}/(\text{g}\cdot^{\circ}\text{C}) \cdot 82^{\circ}\text{C})$$

Step 3: Perform the Calculation

$$m = 45,000 / (0.780 \cdot 82)$$

$$m = 45,000 / 63.96$$

$$m \approx 703.0 \text{ g}$$

Interpreting the Results

Mass of the Metal

The calculated mass of the metal is approximately 703 grams. This is a substantial quantity that allows us to compare the specific heat capacity to known values of various metals.

Matching the Specific Heat Capacity

The key property provided is the specific heat capacity: $0.780 \text{ J}/(\text{g}\cdot^{\circ}\text{C})$. To identify the metal, we need to compare this value to standard specific heats of common metals:

Known Specific Heat Values of Common Metals

- Aluminum: $\sim 0.900 \text{ J/(g}\cdot^{\circ}\text{C)}$
- Copper: $\sim 0.385 \text{ J/(g}\cdot^{\circ}\text{C)}$
- Iron: $\sim 0.450 \text{ J/(g}\cdot^{\circ}\text{C)}$
- Gold: $\sim 0.129 \text{ J/(g}\cdot^{\circ}\text{C)}$
- Silver: $\sim 0.235 \text{ J/(g}\cdot^{\circ}\text{C)}$
- Lead: $\sim 0.128 \text{ J/(g}\cdot^{\circ}\text{C)}$

The calculated specific heat ($0.780 \text{ J/(g}\cdot^{\circ}\text{C)}$) is closest to that of aluminum, which is approximately $0.900 \text{ J/(g}\cdot^{\circ}\text{C)}$. While not an exact match, it is within a reasonable range considering experimental uncertainties, purity of the sample, and measurement conditions. Therefore, the metal is most likely aluminum or a similar material with comparable specific heat capacity.

Additional Considerations

Factors Affecting Accuracy

- Measurement errors in heat energy or temperature change
- Purity and alloy composition of the metal
- Heat losses to surroundings during heating
- Assumption of uniform temperature distribution

Refining the Identification

To confidently identify the metal, additional tests could be performed:

1. Measuring thermal conductivity
2. Examining melting point
3. Using spectroscopic analysis

However, based on the available data and typical specific heat capacities, aluminum is the most plausible candidate.

Conclusion

In conclusion, by using the basic principles of heat transfer and specific heat capacity, we calculated that approximately 703 grams of a metal with a specific heat of $0.780 \text{ J/(g}\cdot^{\circ}\text{C)}$ require 45 kJ of energy to increase in temperature by 82°C . Comparing the specific heat value to known data suggests that the metal is most likely aluminum or a similar alloy. This analysis underscores how fundamental thermodynamic equations can help identify materials and understand their thermal properties.

Frequently Asked Questions

What is the name of the metal if it requires 45 kJ of heat to raise its temperature by 82°C with a specific heat of $0.780 \text{ J/g}^{\circ}\text{C}$?

The specific metal cannot be identified solely based on the given data without its mass. Additional information such as the mass of the metal is needed.

How do you calculate the mass of a metal given its specific heat, heat energy, and temperature change?

Use the formula: $\text{mass} = \text{heat energy} / (\text{specific heat} \times \text{temperature change})$.

What is the formula to determine heat energy required to change the temperature of a metal?

$Q = m \times c \times \Delta T$, where Q is heat energy, m is mass, c is specific heat, and ΔT is temperature change.

If a metal has a specific heat of $0.780 \text{ J/g}^{\circ}\text{C}$ and needs 45 kJ to increase its temperature by 82°C , what is the mass of the metal?

First, convert 45 kJ to joules: 45,000 J. Then, $m = 45,000 \text{ J} / (0.780 \text{ J/g}^{\circ}\text{C} \times 82^{\circ}\text{C}) \approx 703.66 \text{ grams}$.

What is the significance of specific heat capacity in heating and cooling processes?

Specific heat capacity indicates how much heat energy is required to change the temperature of a material, affecting how quickly it heats or cools.

How can the given data be used to compare different metals' thermal properties?

By calculating the mass or heat capacity, you can compare how different metals respond to heat, based on their specific heat capacities and energy requirements.

What units are typically used for specific heat capacity and heat energy in these calculations?

Specific heat capacity is usually in $\text{J/g}^\circ\text{C}$ or $\text{J/kg}^\circ\text{C}$, while heat energy is in joules (J) or kilojoules (kJ).

Additional Resources

Specific Heat Capacity: Unlocking the Secrets of Heat Transfer in Metals

In the world of materials science and thermal physics, understanding how different substances absorb and transfer heat is fundamental. Whether you're an engineer designing cooling systems, a scientist conducting experiments, or a student exploring thermodynamics, grasping the concept of specific heat capacity is essential. Today, we delve into a fascinating case study involving a metal with a specific heat of $0.780 \text{ J/g}^\circ\text{C}$, which requires 45 kJ of heat to raise its temperature by 82°C . This exploration will not only shed light on the properties of this particular metal but also serve as an enlightening review of how specific heat impacts real-world applications.

Understanding Specific Heat Capacity: The Foundation of Thermal Physics

What Is Specific Heat Capacity?

Specific heat capacity, often simply called specific heat, is a physical property that indicates how much energy (heat) is needed to raise the temperature of a unit mass of a substance by one degree Celsius (or Kelvin).

It is expressed mathematically as:

$$c = \frac{Q}{m \times \Delta T}$$

Where:

- Q is the heat energy supplied (in Joules)
- m is the mass of the substance (in grams or kilograms)
- ΔT is the temperature change (in $^{\circ}\text{C}$ or K)

In simpler terms, the higher the specific heat, the more heat a material can absorb without a significant increase in temperature. Conversely, materials with low specific heats heat up quickly and cool down rapidly.

The Significance of Specific Heat in Practical Applications

Understanding specific heat is crucial across various fields:

- Engineering: Designing thermal management systems for electronics and engines
- Environmental Science: Modeling climate systems and heat exchange in oceans
- Material Selection: Choosing appropriate materials for cookware, insulation, or heat exchangers
- Science Education: Explaining fundamental principles of heat transfer and thermodynamics

Deciphering the Given Data: The Metal's Heat Capacity and Mass

The problem statement provides:

- Specific heat capacity, $c = 0.780 \text{ J/g}^{\circ}\text{C}$
- Heat energy supplied, $Q = 45 \text{ kJ}$
- Temperature increase, $\Delta T = 82^{\circ}\text{C}$

The goal is to determine the mass of the metal involved, or more generally, to understand how these parameters interrelate.

Converting Units for Consistency

Before calculations, ensure all units are compatible:

- Convert the heat energy (Q) from kilojoules to joules:

$$[45, \text{kJ} = 45,000, \text{J}]$$

- Recognize that the specific heat capacity is given in $\text{J/g}^\circ\text{C}$, and temperature change in $^\circ\text{C}$, so units align.

Calculating the Metal's Mass: Step-by-Step

Using the relation:

$$[Q = m \times c \times \Delta T]$$

Rearranged to solve for mass:

$$[m = \frac{Q}{c \times \Delta T}]$$

Substituting the known values:

$$[m = \frac{45,000, \text{J}}{0.780, \text{J/g}^\circ\text{C} \times 82^\circ\text{C}}]$$

Calculating denominator:

$$[0.780 \times 82 = 63.96]$$

Now, compute the mass:

$$[m = \frac{45,000}{63.96} \approx 702.7, \text{g}]$$

Result: The mass of the metal is approximately 703 grams.

Implications of the Calculation

This calculation highlights how specific heat capacity directly influences the amount of heat needed to change a material's temperature. A metal requiring 45 kJ to increase its temperature by 82°C has a relatively moderate specific heat, as evidenced by the value $0.780 \text{ J/g}^\circ\text{C}$. For context, water's specific heat is about $4.18 \text{ J/g}^\circ\text{C}$, which is significantly higher, explaining water's ability to store and transfer heat efficiently.

Exploring the Metal's Identity: What Could It Be?

Knowing the specific heat capacity and the mass involved, can we speculate on the metal's identity? The specific heat capacity is a characteristic property that varies across metals.

Common Metals and Their Specific Heats

Metal	Specific Heat Capacity (J/g°C)	Notes
Aluminum	~0.900	Lightweight, good conductor
Copper	~0.385	Excellent thermal and electrical conductor
Iron	~0.450	Common structural metal
Steel	~0.490	Alloy of iron, varies with composition
Gold	~0.129	High density, soft
Silver	~0.240	Best thermal conductor

The given value, 0.780 J/g°C, is closest to that of Aluminum, though slightly lower, or perhaps some alloy or composite material.

- Possible candidates include:
- Aluminum or aluminum alloys: Typical specific heat around 0.900, but slight variations or impurities could lower it.
 - Certain metals or alloys with specific heat capacities near 0.780 J/g°C

Is the Metal Pure or an Alloy?

- Real-world materials often differ from textbook values due to:
- Alloying elements
 - Impurities
 - Manufacturing processes

Thus, while the specific heat suggests aluminum or a similar light metal, it could also be a specialized alloy with tailored thermal properties.

Real-World Applications and Significance

Understanding the specific heat capacity of this metal informs various practical uses:

1. Thermal Management

- Metals with moderate specific heats like this one are suitable for applications requiring controlled heating or cooling.
- For example, in heat exchangers, a balance between heat capacity and thermal conductivity is essential.

2. Engineering Design

- Selecting materials for cookware, heat sinks, or thermal barriers depends on precise knowledge of their heat capacity.
- This metal's capacity to absorb heat without rapid temperature change could make it ideal for certain applications.

3. Material Selection for Energy Efficiency

- Knowing how much energy is needed to change the temperature helps optimize energy consumption in industrial processes.

4. Educational Demonstrations

- The calculations serve as excellent teaching tools for illustrating the principles of heat transfer and thermodynamics.

Further Investigations: What Else Can Be Explored?

While this analysis provides a solid understanding, further questions naturally emerge:

- What is the exact identity of the metal? Laboratory techniques such as spectroscopy or density measurements can provide definitive answers.
- How does the metal's thermal conductivity relate to its specific heat? Combining these properties offers a fuller picture of its heat transfer capabilities.
- What about the metal's melting point and phase change behaviors? These are vital for high-temperature applications.
- How does alloy composition influence the specific heat? This is critical when designing materials for specific thermal environments.

Conclusion: The Interplay of Heat, Material, and Application

This deep dive into a metal with a specific heat of $0.780 \text{ J/g}^\circ\text{C}$ exemplifies the importance of fundamental physical properties in practical contexts. By calculating the mass based on supplied heat and temperature change, we've demonstrated how specific heat capacity directly influences energy requirements for thermal processes. The likely identity points toward lightweight metals like aluminum or its alloys, which are prized for their balance of thermal capacity and conductivity.

Understanding these properties empowers engineers, scientists, and students to make informed decisions in design, research, and education. As materials science advances, tailoring properties like specific heat will remain central to innovation—whether in developing more efficient heat exchangers, creating better insulating materials, or exploring new alloys with customized thermal behaviors.

In essence, the specific heat capacity isn't just a number; it's a window into a material's behavior, potential, and suitability for countless applications in our thermally-driven world.

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