If 10.5 G Of Iron, At 25C, Absorbs 128 J Of Heat, What Will Be The Final Temperature Of Metal? (The Specific

If 10.5 G Of Iron, At 25C, Absorbs 128 J Of Heat, What Will Be The Final Temperature Of Metal? (The Specific

Understanding how heat affects metals is fundamental in physics and chemistry, especially when dealing with thermal properties like specific heat capacity. When a metal such as iron absorbs heat, its temperature rises depending on its mass, the amount of heat absorbed, and its specific heat capacity. This article delves into the detailed calculation of the final temperature of iron after absorbing a specific amount of heat, illustrating the concepts with clear explanations, formulas, and practical applications.

Introduction to Heat Transfer and Specific Heat Capacity

Heat transfer is a process where thermal energy moves from one body or system to another due to temperature differences. When a metal absorbs heat, its internal energy increases, leading to a rise in temperature. The amount of heat required to change the temperature of a substance depends on its specific heat capacity, a material-specific property indicating how much heat is needed to raise the temperature of 1 gram of the substance by 1°C.

Key Definitions:

- Heat (Q): The energy transferred from one system to another, measured in Joules (J).
- Mass (m): The amount of substance, measured in grams (g) or kilograms (kg).
- Specific Heat Capacity (c): The amount of heat required to raise 1 gram of a substance by 1°C, measured in J/(g·°C).
- Temperature Change (ΔT): The difference in temperature before and after heat absorption, measured in °C or K.

Given Data and Problem Statement

Let’s restate the problem with the given data:

- Mass of Iron (m): 10.5 grams
- Initial Temperature (Tinitial): 25°C
- Heat Absorbed (Q): 128 Joules
- Specific Heat Capacity of Iron (c): Approximately 0.449 J/(g·°C)

Our goal is to find the final temperature (Tfinal) of the iron after it absorbs the heat.

Understanding Specific Heat Capacity of Iron

The specific heat capacity of iron is a well-established physical property. It indicates how much energy is needed to raise the temperature of a unit mass of iron by 1°C.

Properties of Iron:

- Specific heat capacity (c): ~0.449 J/(g·°C)
- Density: Approximately 7.87 g/cm^3 (useful for volume calculations but not needed here)
- Melting point: About 1538°C (not relevant unless reaching phase change)

Calculating the Final Temperature of Iron

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

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

Where:

- Q is the heat absorbed,
- m is the mass,
- c is the specific heat capacity,
- $\Delta T = T_{final} - T_{initial}$.

Rearranged to solve for T_{final}:

$$ T_{final} = T_{initial} + \frac{Q}{m \times c} $$

Step-by-step Calculation:

1. Insert the known values:

$$ T_{final} = 25°C + \frac{128\, \text{J}}{10.5\, \text{g} \times 0.449\, \text{J/(g·°C)}} $$

2. Calculate the denominator:

$$ 10.5\, \text{g} \times 0.449\, \text{J/(g·°C)} = 4.7145\, \text{J/°C} $$

3. Compute the temperature change (ΔT):

$$ \frac{128\, \text{J}}{4.7145\, \text{J/°C}} \approx 27.15\, \text{°C} $$

4. Determine the final temperature:

$$ T_{final} = 25°C + 27.15°C \approx 52.15°C $$

Therefore, the final temperature of the iron after absorbing 128 J of heat is approximately 52.15°C.

Implications and Practical Applications

Understanding how to calculate temperature changes due to heat absorption has numerous practical applications:

- Material Processing: In metal forging and heat treatment, precise control of temperature is crucial for achieving desired mechanical properties.
- Engineering Design: Thermal management systems in electronics and machinery depend on accurate calculations of heat transfer.
- Scientific Experiments: Estimating temperature changes in calorimetry experiments involves similar calculations.

Factors Affecting Temperature Change

While the calculation above assumes ideal conditions, real-world scenarios may involve additional factors:

- **Heat Loss:** Heat may dissipate to surroundings, reducing the actual temperature rise.
- **Material Purity:** Impurities can slightly alter specific heat capacities.
- **Phase Changes:** If the temperature approaches melting point, latent heat must be considered.

For the scope of this problem, we assume no heat loss and that the temperature remains well below the melting point.

Enhancing Accuracy in Calculations

To improve the accuracy of such calculations:

- Use precise specific heat capacity values for the specific grade of iron.
- Consider environmental heat exchange if conducting real experiments.
- Account for phase changes if the temperature approaches melting or boiling points.

Additional Related Concepts

Understanding this problem also introduces related concepts such as:

- Specific Heat Capacity of Different Materials: Metals like copper, aluminum, and steel have different values, impacting heat absorption and temperature change.
- Heat Capacity (C): Total heat required to change the temperature of an object, calculated as $C = m \times c$.
- Calorimetry: The science of measuring heat transfer in physical and chemical processes.

Conclusion

In summary, when 10.5 grams of iron at 25°C absorbs 128 Joules of heat, its temperature increases to approximately 52.15°C. This calculation hinges on understanding the relationship between heat energy, mass, specific heat capacity, and temperature change. Such calculations are fundamental in engineering, materials science, and physics, enabling precise control and understanding of thermal processes.

Key Takeaways:

- The specific heat capacity of iron is approximately 0.449 J/(g·°C).
- The formula $T_{final} = T_{initial} + \frac{Q}{m \times c}$ allows calculation of temperature change.
- Accurate calculations require considering material properties and environmental conditions.

Understanding these principles enables engineers and scientists to predict how materials respond to heat, optimize processes, and develop new applications across various fields.

Frequently Asked Questions

What is the specific heat capacity of iron used in calculating the final temperature after heat absorption?

The specific heat capacity of iron is approximately 0.45 J/g°C.

How do you calculate the change in temperature of iron when given the heat absorbed?

Use the formula $\Delta T = Q / (\text{mass} \times \text{specific heat capacity})$.

Given 10.5 g of iron absorbs 128 J of heat, what is the

final temperature if the initial temperature is 25°C?

First, calculate $\Delta T = 128 \text{ J} / (10.5 \text{ g} \times 0.45 \text{ J/g°C}) \approx 26.99°C$. Final temperature = 25°C + 26.99°C ≈ 52°C.

What assumptions are typically made when calculating temperature change in this kind of heat transfer problem?

Assumptions include no heat loss to surroundings, the specific heat capacity remains constant over the temperature range, and the material is uniform.

If the mass of iron increases, how does that affect the final temperature after absorbing the same amount of heat?

The final temperature decreases because a larger mass requires more heat to achieve the same temperature change.

Additional Resources

Iron heat absorption and temperature change: a comprehensive analysis

Understanding the thermal behavior of metals like iron is fundamental in fields ranging from materials science to engineering thermodynamics. When a specific mass of iron absorbs heat, its temperature rises based on its specific heat capacity—a property that indicates how much energy is needed to change its temperature. In this detailed review, we analyze the scenario where 10.5 grams of iron, at 25°C, absorbs 128 joules of heat. The goal is to determine the final temperature of the metal after this energy transfer, exploring the underlying principles, calculations, and implications involved.

Fundamentals of Heat Transfer and Specific Heat Capacity

Before delving into the calculation, it’s vital to understand the core concepts that govern the problem:

What is Specific Heat Capacity?

Specific heat capacity (usually denoted as c) is a physical property that indicates the amount of heat required to raise the temperature of one gram of a substance by one degree Celsius (or Kelvin). For iron, this value is approximately 0.45 J/g°C, although it can vary slightly depending on purity and temperature.

Key features of specific heat capacity:
- Material-specific: Different materials have different c values.
- Temperature dependence: c can vary with temperature, but for small temperature ranges, it is often considered constant.
- Units: Typically expressed as J/g°C or J/kg·K.

Heat Transfer Equation

The fundamental relationship governing heat absorption is:

$$ Q = mc\Delta T $$

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

This equation indicates that the heat energy supplied to an object results in a change in its temperature proportional to its mass and specific heat capacity.

Calculating the Final Temperature of Iron

Given data:
- Mass of iron, $m = 10.5\, \text{g}$
- Initial temperature, $T_i = 25^\circ \text{C}$
- Heat absorbed, $Q = 128\, \text{J}$
- Specific heat capacity of iron, $c \approx 0.45\, \text{J/g}^\circ \text{C}$

Using the heat transfer equation:

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

Plugging in the values:

$$ \Delta T = \frac{128\, \text{J}}{10.5\, \text{g} \times 0.45\, \text{J/g}^\circ \text{C}} $$

Calculating the denominator:

$$ 10.5 \times 0.45 = 4.725\, \text{J/}^\circ \text{C} $$

Therefore:

$$\Delta T = \frac{128}{4.725} \approx 27.07^\circ \text{C}$$

The final temperature:

$$T_{final} = T_i + \Delta T = 25^\circ \text{C} + 27.07^\circ \text{C} \approx 52.07^\circ \text{C}$$

Hence, the final temperature of the iron after absorbing 128 J of heat is approximately 52.07°C.

Discussion and Implications of the Calculation

This straightforward calculation hinges on the assumption that the specific heat capacity remains constant over the temperature range involved. It also presumes no heat loss to the surroundings, which is an idealization but acceptable for theoretical analysis.

Practical Applications

Understanding such heat transfer scenarios is crucial in various real-world situations, such as:
- Metalworking and forging: Controlling the temperature of iron during heating processes.
- Thermal management in engineering: Designing systems where precise temperature control of metals is required.
- Material testing: Determining how materials respond to heat absorption.

Limitations and Assumptions

While the calculation is straightforward, several assumptions limit its precision:
- Constant Specific Heat: In reality, c varies slightly with temperature, especially over larger temperature ranges.
- No Heat Loss: Heat transfer to surroundings, radiation, or conduction to other materials is neglected.
- Uniform Heating: Assumes the entire mass of iron heats uniformly, which might not be the case in practice.

Features and Pros/Cons of the Calculation Method

Features:
- Simplicity: Uses basic principles of thermodynamics with minimal complexity.
- Applicability: Useful for quick estimations in controlled environments.
- Educational Value: Demonstrates fundamental physics concepts clearly.

Pros:
- Straightforward calculation with readily available data.
- Effective for small-scale, idealized problems.
- Reinforces understanding of heat transfer and material properties.

Cons:
- Ignores heat losses and environmental factors.
- Assumes constant specific heat capacity.
- Not suitable for high-precision engineering applications without adjustments.

Additional Considerations and Extensions

While the basic calculation provides a good estimate, more complex scenarios might involve:

- Variable specific heat capacity: Incorporating temperature-dependent c values.
- Heat losses: Applying heat transfer models (conduction, convection, radiation).
- Phase changes: If heating approaches melting points, latent heat must be considered.
- Mass variations: For larger quantities, more detailed thermodynamic models may be needed.

Conclusion

The calculation of the final temperature of iron after absorbing a specified amount of heat exemplifies fundamental thermodynamic principles. By applying the heat transfer equation \(Q = mc\Delta T\), we find that 10.5 grams of iron initially at 25°C, upon absorbing 128 joules of heat, will reach approximately 52.07°C. This example underscores the importance of specific heat capacity in thermal analysis and highlights the assumptions involved in idealized calculations. Such understanding is essential for practical applications across various scientific and engineering disciplines, emphasizing the need to consider real-world factors like heat loss and material property variations for precise thermal management.

In summary:
- The problem involves basic thermodynamics principles.
- The calculation demonstrates how energy transfer affects temperature.
- Understanding the limitations helps refine real-world applications.
- This analysis can serve as a foundation for more advanced thermal studies.

By mastering these concepts, engineers and scientists can better predict and control thermal behaviors in materials, leading to safer, more efficient, and more innovative designs and processes.

If 10 5 G Of Iron At 25c Absorbs 128 J Of Heat What Will Be The Final Temperature Of Metal The Specific

If 10 5 G Of Iron At 25c Absorbs 128 J Of Heat What Will Be The Final Temperature Of Metal The Specific

Related Articles

- In 1.0 Second, A Battery Charger Moves 0.54 CC Of Charge From The Negative Terminal To The Positive Terminal
- Olivia Owns A Convenience Store And Has Invested A Lot Ofmoney In Gambling Machines For The Store. Recently,
- Give The Correct Tense Or Form Of The Verbs In Brackets.1. Nam (never / Eat) _____________ Pizza Before.2.

Back to Home