

# If The Temperature Of 85.0 G Of Copper Changes From 28.0C To 99.0C, How Much Heat Was Absorbed? The Specific

If The Temperature Of 85.0 G Of Copper Changes From 28.0°C To 99.0°C, How Much Heat Was Absorbed? The Specific

Understanding how much heat is absorbed by a substance during a temperature change is fundamental in thermodynamics and material science. In this article, we will analyze the specific case of copper—one of the most common metals used in electrical wiring, plumbing, and various industrial applications—focusing on calculating the heat absorbed when 85.0 grams of copper increases in temperature from 28.0°C to 99.0°C. We will explore the principles behind heat transfer, the relevant formulas, and the steps needed to arrive at an accurate answer.

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## Fundamental Concepts in Heat Transfer and Specific Heat Capacity

### What Is Heat and How Is It Quantified?

Heat is a form of energy transfer between systems or objects due to a temperature difference. When an object absorbs or releases heat, its internal energy changes, often resulting in a change in temperature. In thermodynamics, the amount of heat transferred ( $Q$ ) is typically measured in joules (J).

### Specific Heat Capacity: The Key to Quantifying Heat Transfer

Specific heat capacity (often denoted as  $c$ ) is a property that indicates how much heat energy is required to raise the temperature of a unit mass of a substance by one degree Celsius (or Kelvin). It is expressed in units of  $\text{J}/(\text{g} \cdot ^\circ\text{C})$  or  $\text{J}/(\text{kg} \cdot \text{K})$ .

Mathematically:

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

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where:

- $Q$  = heat absorbed or released (J)
- $m$  = mass of the substance (g or kg)
- $c$  = specific heat capacity ( $\text{J}/(\text{g}\cdot^{\circ}\text{C})$ )
- $\Delta T$  = change in temperature ( $^{\circ}\text{C}$ )

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## Properties of Copper Relevant to Heat Calculation

### Specific Heat Capacity of Copper

Copper has a well-characterized specific heat capacity:

- $c_{\text{Cu}} \approx 0.385$ ,  $\text{J}/(\text{g}\cdot^{\circ}\text{C})$

This value means that to raise 1 gram of copper by  $1^{\circ}\text{C}$ , approximately 0.385 joules of energy are needed.

### Physical Data for Our Calculation

Given data:

- Mass of copper,  $m = 85.0$ ,  $\text{g}$
- Initial temperature,  $T_{\text{initial}} = 28.0^{\circ}\text{C}$
- Final temperature,  $T_{\text{final}} = 99.0^{\circ}\text{C}$

Change in temperature:

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$$\Delta T = T_{\text{final}} - T_{\text{initial}} = 99.0^{\circ}\text{C} - 28.0^{\circ}\text{C} = 71.0^{\circ}\text{C}$$

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## Calculating the Heat Absorbed by Copper

### Step-by-Step Calculation

To determine the heat absorbed, we apply the formula:

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

Substituting the known values:

$$Q = 85.0 \text{ g} \times 0.385 \text{ J/(g}\cdot\text{°C)} \times 71.0^\circ \text{C}$$

Perform the multiplication step-by-step:

1. Multiply the specific heat capacity by the temperature change:

$$0.385 \text{ J/(g}\cdot\text{°C)} \times 71.0^\circ \text{C} = 27.335 \text{ J/g}$$

2. Then multiply by the mass:

$$85.0 \text{ g} \times 27.335 \text{ J/g} = 2324.475 \text{ J}$$

Rounding to an appropriate number of significant figures (three significant figures, as in the given data):

$$Q \approx \boxed{2324 \text{ J}}$$

Therefore, approximately 2324 joules of heat were absorbed by the copper during the temperature increase.

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## Discussion of Factors and Assumptions

### Assumptions in the Calculation

- The specific heat capacity of copper remains constant over the temperature range. In reality,  $c$  can vary slightly with temperature, but for most practical purposes, using a constant value provides a good approximation.
- Heat loss to surroundings is negligible during the process.
- The system is perfectly insulated, ensuring all heat energy goes into raising the temperature of copper only.

### Implications of the Calculation

Understanding how much heat a material absorbs during a temperature change is vital in many applications:

- Designing cooling or heating systems
- Calculating energy requirements for industrial processes
- Understanding thermal properties of materials for safety and efficiency

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## **Additional Considerations and Variations**

### **Effect of Changing Specific Heat Capacity with Temperature**

While for many calculations the specific heat capacity is assumed constant, in some cases, especially over large temperature ranges,  $c$  can vary. More precise calculations might involve integrating  $c(T)$  over the temperature interval.

### **Heat Transfer in Real Systems**

In practical scenarios, factors such as:

- Heat losses to the environment
- Conductive and convective heat transfer mechanisms
- Material imperfections

can affect the actual heat transfer, making the ideal calculation a baseline for real-world measurements.

### **Other Forms of Energy Transfer**

While this calculation considers only sensible heat (change in temperature), in some processes, other forms of energy transfer, such as latent heat during phase changes, may occur. For copper, which remains in the solid state over the temperature range, latent heat is not relevant here.

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## **Summary and Final Remarks**

To summarize:

- The amount of heat absorbed by 85.0 grams of copper as its temperature increases from 28.0°C to 99.0°C is approximately 2324 joules.
- The calculation hinges on the fundamental thermodynamic principle  $(Q = m \times c \times \Delta T)$ .
- Accurate knowledge of the material's specific heat capacity is essential for precise calculations.
- While simplified models assume constant  $c$ , real-world applications may require considering temperature-dependent variations and heat losses.

Understanding these principles allows engineers, scientists, and students to predict energy requirements, design thermal systems, and interpret experimental data accurately. Mastery of heat transfer calculations such as this underpins much of thermodynamics and materials science, highlighting the importance of quantitative reasoning in science and engineering.

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## Frequently Asked Questions

### How do you calculate the heat absorbed by copper when its temperature changes?

You use the formula  $Q = mc\Delta T$ , where  $Q$  is the heat absorbed,  $m$  is the mass,  $c$  is the specific heat capacity, and  $\Delta T$  is the temperature change.

### What is the specific heat capacity of copper?

The specific heat capacity of copper is approximately 0.385 J/g°C.

### How much heat is absorbed by 85.0 g of copper when it heats from 28.0°C to 99.0°C?

Using  $Q = mc\Delta T$ ,  $Q = 85.0 \text{ g} \times 0.385 \text{ J/g}^\circ\text{C} \times (99.0^\circ\text{C} - 28.0^\circ\text{C}) = 85.0 \times 0.385 \times 71.0 \approx 2318.5 \text{ Joules}$ .

### Why is it important to know the specific heat

## **capacity when calculating heat transfer?**

Because the specific heat capacity indicates how much energy is needed to raise the temperature of a substance, allowing accurate calculation of heat transfer during temperature changes.

## **Can the heat absorbed by copper be used to determine phase changes?**

No, the calculation for heat absorbed during temperature change assumes no phase change occurs; phase changes involve latent heat which requires different calculations.

## **What are common applications of knowing the heat absorption of copper?**

Applications include thermal management in electronics, designing heat exchangers, and understanding heat transfer in industrial processes involving copper.

## **How does the temperature change affect the amount of heat absorbed in a metal like copper?**

The greater the temperature change ( $\Delta T$ ), the more heat is absorbed or released, as heat transfer is directly proportional to  $\Delta T$  in the formula  $Q = mc\Delta T$ .

## **Additional Resources**

Heat Transfer in Copper: A Comprehensive Analysis of Energy Absorption During Temperature Change

Understanding the principles of heat transfer is fundamental in fields ranging from materials science to engineering and thermodynamics. Copper, renowned for its excellent thermal conductivity and widespread industrial applications, offers an ideal case study for exploring how energy interacts with matter during temperature variations. This article delves into the question: If 85.0 grams of copper experiences a temperature increase from 28.0°C to 99.0°C, how much heat is absorbed? We will explore the underlying physics, the calculation process, and the factors influencing the heat transfer, providing a detailed, expert-level understanding of this classic problem.

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# Fundamentals of Heat Transfer and Specific Heat Capacity

Before embarking on the calculation, it is essential to understand the core concepts involved: heat transfer, specific heat capacity, and their roles in energy exchange.

## What Is Heat Transfer?

Heat transfer refers to the movement of thermal energy from one body or system to another due to a temperature difference. The three primary modes are conduction, convection, and radiation. In the context of heating a solid object like copper, conduction is typically the dominant mode, where heat flows through the material's particles.

## Specific Heat Capacity: The Key to Quantifying Heat Absorption

The specific heat capacity (often just called specific heat) of a substance is a physical property that indicates how much heat energy is required to raise the temperature of a unit mass of the substance by one degree Celsius (or Kelvin). For copper, this value remains relatively constant over typical temperature ranges, making calculations straightforward.

The specific heat capacity of copper is approximately:

- Specific heat (c): 0.385 J/g°C

This means that to increase the temperature of 1 gram of copper by 1°C, 0.385 joules of energy are needed.

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## Calculating the Heat Absorbed: Step-by-Step Approach

The problem at hand involves determining the quantity of heat (Q) absorbed by the copper when its temperature changes from 28.0°C to 99.0°C. The general formula used for such calculations is:

$$Q = mc\Delta T$$

Where:

- $Q$  = heat absorbed (in Joules)
- $m$  = mass of the substance (in grams)

- $c$  = specific heat capacity (J/g°C)
- $\Delta T$  = change in temperature (in °C)

Let's proceed systematically.

## Step 1: Identify Known Values

- Mass of copper (m): 85.0 g
- Initial temperature ( $T_1$ ): 28.0°C
- Final temperature ( $T_2$ ): 99.0°C
- Specific heat capacity of copper (c): 0.385 J/g°C

## Step 2: Calculate Temperature Change ( $\Delta T$ )

$$\Delta T = T_2 - T_1 = 99.0^\circ\text{C} - 28.0^\circ\text{C} = 71.0^\circ\text{C}$$

This change signifies how much the copper's temperature has increased.

## Step 3: Plug Values into the Formula

$$Q = mc\Delta T$$

$$Q = 85.0\text{ g} \times 0.385\text{ J/g}^\circ\text{C} \times 71.0\text{ }^\circ\text{C}$$

## Step 4: Perform the Calculation

First, multiply the specific heat by the temperature change:

$$0.385\text{ J/g}^\circ\text{C} \times 71.0\text{ }^\circ\text{C} = 27.335\text{ J/g}$$

Next, multiply by the mass:

$$Q = 85.0\text{ g} \times 27.335\text{ J/g} = 2324.0\text{ J}$$

Therefore, approximately 2324 Joules of heat are absorbed by the copper during this temperature increase.

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# Analyzing the Results and Practical Implications

Understanding the magnitude of heat involved in such a process offers valuable insights into thermal management and energy efficiency in practical applications.

## Significance of the Calculated Heat

- Industrial Processes: When heating copper components, knowing the energy requirements helps in designing appropriate heating systems, such as furnaces or induction heaters.
- Material Testing: Precise heat calculations are crucial for experiments involving thermal properties, ensuring controlled and accurate outcomes.
- Energy Conservation: Quantifying heat absorption supports energy auditing and optimization, reducing waste and improving sustainability.

## Factors Affecting Heat Transfer in Real-World Scenarios

While the calculation assumes ideal conditions where all the heat goes into raising the copper's temperature, several factors can influence actual heat transfer:

- Heat Losses: Conduction to surroundings, radiation, and convection can dissipate heat, requiring more energy input.
- Material Purity: Impurities in copper can slightly alter its specific heat capacity.
- Temperature Range: Although specific heat is relatively constant over moderate ranges, extreme temperatures may cause deviations.
- Measurement Accuracy: Precision in temperature readings and mass measurements impacts the fidelity of calculations.

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## Additional Considerations and Advanced Topics

For those interested in expanding their understanding, several advanced topics are relevant.

## Specific Heat Capacity Variations

While the value of  $0.385 \text{ J/g}^\circ\text{C}$  is typical for copper, at very high temperatures or under specific conditions, specific heat may vary slightly.

Such variations can be modeled using polynomial fits or experimental data.

## Heat Capacity and Molar Specific Heat

Instead of mass-based calculations, molar specific heat considers the amount of heat per mole of substance. For copper:

- Molar mass: approximately 63.55 g/mol
- Molar specific heat:  $c_{\text{molar}} = c \times M \approx 0.385 \times 63.55 \approx 24.5 \text{ J/mol}^\circ\text{C}$

This perspective is useful in atomic-scale thermodynamics and materials science.

## Energy Efficiency and Thermal Conductivity

Copper's high thermal conductivity (~400 W/m·K) means it can rapidly distribute heat throughout its structure, affecting how quickly it reaches the desired temperature and how much energy is required overall.

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## Conclusion: Quantitative Insights into Copper's Thermal Behavior

In summary, when 85.0 grams of copper undergoes a temperature increase from 28.0°C to 99.0°C, it absorbs approximately 2324 Joules of heat energy. This calculation, rooted in fundamental thermodynamic principles, illustrates the straightforward yet powerful relationship between mass, temperature change, and specific heat capacity.

Understanding these principles is vital for designing efficient heating systems, conducting precise scientific experiments, and optimizing energy use across various industries. Copper's well-characterized thermal properties make it an ideal candidate for such analyses, reinforcing its status as a cornerstone material in thermal management and engineering.

Final note: Always consider real-world factors such as heat losses and material imperfections when applying theoretical calculations to practical situations. Accurate data and careful measurement are key to translating these insights into effective applications.

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- Cengel, Y. A., & Boles, M. A. (2015). Thermodynamics: An Engineering Approach. McGraw-Hill Education.

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