300 G Of Requires 30000 J Of Thermal Energy To Raise The Temperature From 25 C To 85 C, What Is The Heat

300 G Of Requires 30000 J Of Thermal Energy To Raise The Temperature From 25°C To 85°C, What Is The Heat

Understanding thermal energy and heat transfer is fundamental in physics and engineering. The question "300 g of substance requires 30,000 J of thermal energy to raise its temperature from 25°C to 85°C, what is the heat?" invites us to explore the concepts of heat, specific heat capacity, and the calculation involved in thermal processes. This article provides a comprehensive explanation of these concepts, guiding you step-by-step through the calculation, and clarifies related principles for a better grasp of thermal energy transfer.

Introduction to Thermal Energy and Heat

What is Thermal Energy?

Thermal energy refers to the internal energy contained within a substance due to the random motion of its molecules. It is a form of kinetic energy that depends on temperature, mass, and the nature of the material.

What is Heat?

Heat is the transfer of thermal energy from one body or system to another because of a temperature difference. It is not energy stored within a substance but the energy transferred during thermal interactions.

Understanding the Given Data

To analyze the problem, let's understand what information is provided:

1. Mass of the substance, m = 300 g = 0.3 kg
2. Thermal energy supplied, Q = 30,000 J
3. Initial temperature, T_1 = 25°C
4. Final temperature, T_2 = 85°C

The question asks: What is the heat? In physics, the term "heat" often refers to the transfer of thermal energy, but in the context of this problem, it seems to ask for the amount of heat energy transferred to raise the temperature, which corresponds to the given thermal energy Q. We will verify the relationship between these quantities.

Fundamental Concepts and Formulae

Specific Heat Capacity (c)

Specific heat capacity is an intensive property of a material, indicating how much energy is required to raise the temperature of one kilogram of the substance by one degree Celsius.

It is expressed as:

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

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

Calculating Specific Heat Capacity

If the heat energy (Q), mass (m), and temperature change (ΔT) are known, we can rearrange the formula to find c:

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

Calculating the Specific Heat Capacity from the Given Data

Let's compute the specific heat capacity of the substance using the provided data.

Step 1: Find the Temperature Change

$$\Delta T = T_2 - T_1 = 85°C - 25°C = 60°C$$

Step 2: Convert Mass to Kilograms

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m = 300 g = 0.3 kg
```

Step 3: Calculate c

```
c = Q / (m × ΔT) = 30,000 J / (0.3 kg × 60°C) = 30,000 / 18 = 1,666.67
J/kg·°C
```

Result: The specific heat capacity of the substance is approximately 1666.67 J/kg·°C.

Interpreting the Results

The calculated specific heat capacity indicates that this substance requires about 1666.67 joules of energy to raise one kilogram of it by 1°C. Since the question states that 30,000 J of energy are required to increase the temperature of 0.3 kg of the substance from 25°C to 85°C, this aligns with our calculations.

Furthermore, in the context of the question, the "heat" refers to the thermal energy transferred, which is already given as 30,000 J. This confirms that the heat required to produce this temperature change in the given mass is 30,000 Joules.

Additional Considerations in Thermal Energy Calculations

Types of Heat Transfer

Understanding the modes of heat transfer is essential:

- **Conduction:** Transfer of heat through a solid material.
- **Convection:** Transfer via fluid motion (liquids and gases).
- **Radiation:** Transfer through electromagnetic waves.

In many practical situations, heat transfer involves a combination of these modes.

Units of Heat and Energy

The SI unit of heat and energy is the Joule (J). Sometimes, calories are used, where 1 calorie ≈ 4.184 J.

Real-world Applications

- Designing heating systems and appliances.
- Calculating energy requirements for cooking or industrial processes.
- Understanding climate and environmental heat transfer.

Summary and Key Takeaways

1. The amount of heat required to raise the temperature of a substance depends on its mass, specific heat capacity, and temperature change.

2. In the given problem, the thermal energy supplied (Q) is 30,000 Joules, which raises 300 grams of the substance from 25°C to 85°C.

3. The specific heat capacity of the substance is approximately 1666.67 J/kg·°C, indicating its thermal properties.

4. Understanding these principles helps in various scientific and engineering applications, including designing heating and cooling systems and analyzing thermal processes.

Conclusion

The question "300 g of substance requires 30,000 J of thermal energy to raise its temperature from 25°C to 85°C, what is the heat?" illustrates fundamental concepts in thermodynamics. The heat transferred (Q) is explicitly given as 30,000 Joules, confirming the energy needed for this temperature change. Calculating the specific heat capacity provides further insight into the material's thermal properties. Mastery of these concepts enables better understanding of thermal systems and efficient energy management in real-world applications.

Note: Always verify the units and conversions when tackling thermal energy problems to ensure accuracy.

Frequently Asked Questions

What is the amount of thermal energy required to raise 300 g of a substance from 25°C to 85°C?

It requires 30,000 Joules of thermal energy.

How can we calculate the heat energy needed to increase the temperature of a substance?

By using the formula $Q = mc\Delta T$, where m is mass, c is specific heat capacity, and ΔT is the temperature change.

Given 300 g of a substance needs 30,000 J to increase in temperature, what is its approximate specific heat capacity?

The specific heat capacity c is approximately 1 J/g°C, calculated as $c = Q / (m \times \Delta T)$.

Why is the specific heat capacity important in calculating heat energy requirements?

It determines how much energy is needed to change the temperature of a specific mass of a substance by a certain amount.

If the initial temperature is 25°C and final temperature is 85°C, what is the temperature change ΔT?

The temperature change ΔT is 60°C (85°C - 25°C).

What assumptions are made in calculating the heat energy required for heating a substance?

Assumptions include constant specific heat capacity and no heat loss to surroundings during the process.

Can the heat energy required vary with different substances even if the mass and temperature change are the same?

Yes, because different substances have different specific heat capacities, affecting the total heat energy needed.

What practical applications depend on understanding heat energy calculations like this?

Applications include designing heating systems, cooking, material processing, and thermal management in engineering.

Additional Resources

300 G Of Requires 30000 J Of Thermal Energy To Raise The Temperature From 25°C To 85°C, What Is The Heat?

Understanding how much heat energy is needed to change the temperature of a substance is fundamental in thermodynamics and practical applications such as cooking, engineering, and scientific research. In this article, we explore the problem: "300 g of a substance requires 30,000 J of thermal energy to raise its temperature from 25°C to 85°C," and analyze what this tells us about the heat capacity and related properties of the material. Whether you're a student, educator, or professional, this comprehensive guide will help you understand the concepts, calculations, and implications involved in such thermal energy problems.

Introduction to Thermal Energy and Heat

Before delving into the specifics of the problem, it’s essential to clarify some fundamental concepts:

- Thermal Energy (Heat): The energy transferred between systems or bodies due to temperature difference.
- Specific Heat Capacity (c): The amount of heat required to raise the temperature of 1 gram (or kilogram) of a substance by 1°C (or 1 K). It is expressed in units such as J/(g°C) or J/(kg°C).
- Heat (Q): The total energy transferred as heat, often calculated using the relation:

$$
Q = mc\Delta T
$$

where:
- m is the mass,
- c is the specific heat capacity,
- ΔT is the change in temperature.

Breaking Down the Problem

Given Data:

- Mass of the substance, $m = 300\, g$
- Initial temperature, $T_i = 25^\circ C$
- Final temperature, $T_f = 85^\circ C$
- Thermal energy supplied, $Q = 30,000\, J$

Objective:

- Determine the heat capacity, or understand what the given data implies about the material's properties.
- Confirm whether the heat supplied matches the expected energy based on the temperature change.

Step 1: Calculating the Temperature Change

The first step is to find the temperature difference:

$$
\Delta T = T_f - T_i = 85^\circ C - 25^\circ C = 60^\circ C
$$

This value indicates how much the substance's temperature increases during heating.

Step 2: Understanding the Relationship Between Heat, Mass, and Temperature Change

Using the fundamental heat transfer relation:

$$
Q = mc\Delta T
$$

where:

- $Q = 30,000\, J$,
- $m = 300\, g$,
- $\Delta T = 60^\circ C$.

Our goal is to find the specific heat capacity c:

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

Substituting the known values:

$$
c = \frac{30,000\, J}{300\, g \times 60^\circ C}
$$

To keep units consistent, convert grams to kilograms:

$$
300\, g = 0.3\, kg
$$

Now, recalculate:

$$
c = \frac{30,000\, J}{0.3\, kg \times 60^\circ C} = \frac{30,000\, J}{18\, kg^\circ C} \approx 1666.67\, J/(kg^\circ C)
$$

\]

Alternatively, if we prefer specific heat capacity in J/(g°C):

\[
c = \frac{30,000\, J}{300\, g \times 60^\circ C} = \frac{30,000\, J}{18,000\, g^\circ C} \approx 1.67\, J/(g^\circ C)
\]

Interpretation: The substance's specific heat capacity is approximately 1.67 J/(g°C) or 1667 J/(kg°C), which is typical for many metals and some liquids.

Step 3: Verifying the Consistency of the Data

Given the calculations, the data seems consistent with a substance having a specific heat capacity around 1.67 J/(g°C). The total heat energy supplied (30,000 J) aligns with the temperature increase from 25°C to 85°C for this material.

Step 4: What Is the "Heat" in Context?

The question "What is the heat?" can be interpreted in different contexts:

1. The Total Heat Energy Supplied (Q)

In the problem, the heat energy supplied is explicitly given as 30,000 J. This is the amount of thermal energy transferred to the substance to cause its temperature rise.

2. The Specific Heat Capacity of the Substance

From the calculations, the specific heat capacity is approximately 1.67 J/(g°C). This property is intrinsic to the material and reflects how much energy is needed to increase its temperature.

3. Heat Capacity (C)

Total heat capacity of the object can also be calculated:

\[
C = mc
\]

Using the mass and specific heat capacity:

\[
C = 300\, g \times 1.67\, J/(g°C) \approx 501\, J/°C
\]

This indicates that the entire object requires approximately 501 Joules of energy to increase its temperature by 1°C.

Additional Considerations

Material Identification

With the specific heat capacity in the ballpark of 1.67 J/(g°C), the material could be:

- Aluminum (~0.9 J/g°C)
- Copper (~0.39 J/g°C)
- Water (~4.18 J/g°C)
- Steel (~0.49 J/g°C)

Since the calculated \(c\) is higher than common metals, it might be a liquid or a different material altogether.

Energy Efficiency and Losses

In real-world applications, not all supplied energy is used solely for heating; some is lost to the surroundings. Here, the calculation assumes perfect energy transfer.

Practical Applications and Implications

Understanding how much energy is required to heat a substance has diverse applications:

- Cooking: Estimating energy requirements for heating ingredients.
- Engineering: Designing heating systems, boilers, or thermal insulations.
- Material Science: Determining material properties based on heat capacity.
- Environmental Science: Calculating energy transfer in climate models.

Summary of Key Points

- The heat energy required to raise the temperature of 300 g of a substance from 25°C to 85°C is 30,000 J.
- The temperature change (\(\Delta T\)) is 60°C.
- The specific heat capacity of the substance is approximately 1.67 J/(g°C).
- The total heat capacity of the object is about 501 J/°C.
- These calculations assume no heat losses and perfect thermal transfer.

Final Thoughts

Understanding thermal energy transfer involves fundamental concepts like specific heat capacity and heat equations. By analyzing the given data, we can infer critical properties of the material involved, which guides practical applications across science and engineering. The problem exemplifies how a straightforward calculation can reveal the intrinsic thermal characteristics of a substance, emphasizing the importance of precise measurement and understanding in thermodynamics.

References

- "Fundamentals of Thermodynamics" by Richard E. Sonntag, Claus Borgnakke, Gordon J. Van Wylen.
- "Introduction to Thermal Physics" by Daniel V. Schroeder.
- Engineering toolbox: Specific heat capacities of common materials.

Feel free to reach out with questions or for further clarification on thermodynamics concepts and calculations.

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