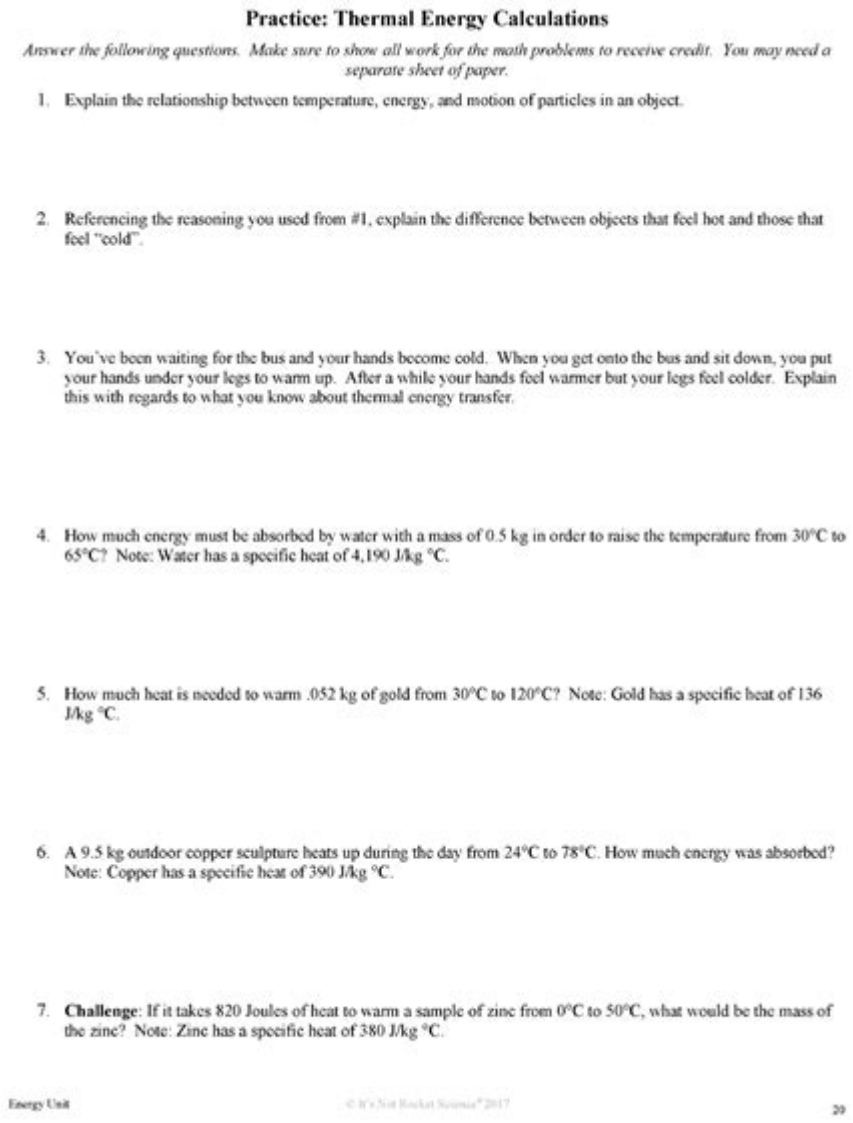
Practice Thermal Energy Calculations Answer Key



Practice: Thermal Energy Calculations

Answer the following questions. Make sure to show all work for the math problems to receive credit. You may need a separate sheet of paper.

1. Explain the relationship between temperature, energy, and motion of particles in an object.

2. Referencing the reasoning you used from #1, explain the difference between objects that feel hot and those that feel "cold".

3. You've been waiting for the bus and your hands become cold. When you get onto the bus and sit down, you put your hands under your legs to warm up. After a while your hands feel warmer but your legs feel colder. Explain this with regards to what you know about thermal energy transfer.

4. How much energy must be absorbed by water with a mass of 0.5 kg in order to raise the temperature from 30°C to 65°C? Note: Water has a specific heat of 4,190 J/kg °C.

5. How much heat is needed to warm .052 kg of gold from 30°C to 120°C? Note: Gold has a specific heat of 136 J/kg °C.

6. A 9.5 kg outdoor copper sculpture heats up during the day from 24°C to 78°C. How much energy was absorbed? Note: Copper has a specific heat of 390 J/kg °C.

7. **Challenge**: If it takes 820 Joules of heat to warm a sample of zinc from 0°C to 50°C, what would be the mass of the zinc? Note: Zinc has a specific heat of 380 J/kg °C.

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Practice thermal energy calculations answer key are essential tools for students and professionals in the fields of physics, engineering, and environmental science. Understanding thermal energy calculations is crucial for analyzing heat transfer, energy conservation, and the efficiency of thermal systems. This article will provide a comprehensive overview of thermal energy calculations, including fundamental concepts, formulas, examples, and an answer key for practice problems.

Understanding Thermal Energy

Thermal energy refers to the internal energy present in a system due to the random motions of its molecules. The total thermal energy of an object is influenced by its mass, temperature, and the specific heat capacity of the material.

Key Concepts

1. Temperature: A measure of the average kinetic energy of the particles in a substance. It is measured in degrees Celsius (°C), Kelvin (K), or Fahrenheit (°F).

2. Specific Heat Capacity (c): The amount of heat required to change the temperature of a unit mass of a substance by one degree Celsius. It varies for different materials and is usually expressed in units of J/(kg·°C).

3. Heat (Q): The energy transferred between a system and its surroundings due to a temperature difference. It is measured in joules (J).

4. Mass (m): The quantity of matter in an object, typically measured in kilograms (kg).

Thermal Energy Calculation Formulas

The fundamental equation for calculating thermal energy is given by the formula:

$$
Q = mc\Delta T
$$

Where:
- Q = heat energy (J)
- m = mass (kg)
- c = specific heat capacity (J/(kg·°C))
- ΔT = change in temperature (°C), calculated as $T_{final} - T_{initial}$

Calculating Change in Temperature

To calculate the change in temperature, use the formula:

$$
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$$
\Delta T = T_{final} - T_{initial}
$$

This formula allows you to determine how much the temperature of a substance changes when it absorbs or releases heat.

Heat Transfer in Different Scenarios

Heat transfer can occur in various scenarios, including:

- Heating a substance: When energy is added to increase its temperature.
- Cooling a substance: When energy is removed, leading to a decrease in temperature.
- Phase changes: Such as melting, boiling, or sublimation, where additional energy is required.

For phase changes, use the formula:

$$
Q = mL
$$

Where:
- L = latent heat (J/kg), which is the heat required for phase transitions without changing temperature.

Example Problems and Solutions

To solidify the understanding of thermal energy calculations, here are several example problems followed by their solutions.

Example 1: Heating Water

Problem: Calculate the amount of heat required to raise the temperature of 500 grams of water from 20°C to 100°C. The specific heat capacity of water is 4,186 J/(kg·°C).

Solution:
1. Convert mass to kilograms:
$m = 500 \, \text{g} = 0.5 \, \text{kg}$

2. Calculate the change in temperature:
$\Delta T = 100°C - 20°C = 80°C$

3. Substitute values into the formula:

$$
Q = mc\Delta T = (0.5 \, \text{kg})(4,186 \, \text{J/(kg·°C)})(80°C)
$$

4. Calculate Q:
$$
Q = 0.5 \times 4,186 \times 80 = 167,440 \, \text{J}
$$

Answer: The heat required is 167,440 J.

Example 2: Cooling Oil

Problem: A 2 kg block of oil cools from 150°C to 100°C. If the specific heat capacity of oil is 2,000 J/(kg·°C), how much heat is released?

Solution:
1. Calculate the change in temperature:
$\Delta T = 100°C - 150°C = -50°C$

2. Substitute values into the formula:
$$
Q = mc\Delta T = (2 \, \text{kg})(2,000 \, \text{J/(kg·°C)})(-50°C)
$$

3. Calculate Q:
$$
Q = 2 \times 2,000 \times (-50) = -200,000 \, \text{J}
$$

Answer: The heat released is 200,000 J.

Example 3: Melting Ice

Problem: How much heat is required to melt 1 kg of ice at 0°C to water at 0°C? The latent heat of fusion for ice is 334,000 J/kg.

Solution:
1. Use the latent heat formula:
$$
Q = mL = (1 \, \text{kg})(334,000 \, \text{J/kg})
$$

2. Calculate Q:
$$
Q = 334,000 \, \text{J}
$$

Answer: The heat required to melt the ice is 334,000 J.

Practice Problems

To further reinforce the concepts discussed, here are some practice problems. Try solving them before checking the answer key.

1. Calculate the heat required to raise the temperature of 3 kg of copper from 25°C to 200°C. The specific heat capacity of copper is 385 J/(kg·°C).

2. A 1.5 kg block of aluminum cools from 250°C to 100°C. The specific heat capacity of aluminum is 897 J/(kg·°C). How much heat is released?

3. How much heat is needed to vaporize 2 kg of water at 100°C? The latent heat of vaporization for water is 2,260,000 J/kg.

Answer Key

1. Problem 1 Answer:
- Calculate $\Delta T = 200°C - 25°C = 175°C$
- $Q = mc\Delta T = (3 \, \text{kg})(385 \, \text{J/(kg·°C)})(175°C) = 80,625 \, \text{J}$

2. Problem 2 Answer:
- Calculate $\Delta T = 100°C - 250°C = -150°C$
- $Q = mc\Delta T = (1.5 \, \text{kg})(897 \, \text{J/(kg·°C)})(-150°C) = -201,075 \, \text{J}$

3. Problem 3 Answer:
- $Q = mL = (2 \, \text{kg})(2,260,000 \, \text{J/kg}) = 4,520,000 \, \text{J}$

Conclusion

Understanding thermal energy calculations is fundamental for various applications in science and engineering. By practicing these calculations and familiarizing oneself with the formulas and concepts, individuals can enhance their problem-solving skills and better understand the principles of thermodynamics. The practice thermal energy calculations answer key provided in this article serves as a valuable resource for reinforcing learning and aiding in the mastery of thermal energy concepts.

Frequently Asked Questions

What is thermal energy and how is it calculated?

Thermal energy is the total kinetic energy of the particles in a substance. It can be calculated using the formula Q = mcΔT, where Q is the thermal energy, m is the mass, c is the specific heat capacity, and ΔT is the change in temperature.

What units are commonly used in thermal energy calculations?

The most common units for thermal energy calculations are joules (J) for energy, kilograms (kg) for mass, and degrees Celsius (°C) for temperature change.

How do you calculate the thermal energy required to heat water?

To calculate the thermal energy required to heat water, use the formula Q = mcΔT. For example, to heat 2 kg of water from 20°C to 80°C, the calculation would be Q = 2 kg × 4.18 kJ/kg°C × (80°C - 20°C).

What role does specific heat capacity play in thermal energy calculations?

Specific heat capacity is a material property that indicates how much energy is required to raise the temperature of a unit mass of the substance by one degree Celsius. It directly affects the calculated thermal energy in the formula Q = mcΔT.

Can thermal energy calculations be applied in everyday life?

Yes, thermal energy calculations can be applied in everyday life, such as determining the energy needed to heat a home, cooking food, or understanding the energy efficiency of appliances.

What are some common mistakes to avoid in thermal energy calculations?

Common mistakes include using incorrect units, overlooking the sign of ΔT (which should be positive for heating), and miscalculating specific heat capacity based on the substance being analyzed.

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