Specific Heat Problems Answer Key

Answers

$Q = mc\Delta T$, where Q = heat energy, m = mass, and ΔT = change in temp.
Remember, **$\Delta T = (T_{final} - T_{initial})$**. Show all work and proper units.

1. A 15.75-g piece of iron absorbs 1086.75 joules of heat energy, and its temperature changes from 25°C to 175°C. Calculate the specific heat capacity of iron.

   $C = \frac{Q}{m(T_f - T_i)} = \frac{1086.75}{15.75(175-25)}$ = **0.46 J/g°C**

2. How many joules of heat are needed to raise the temperature of 10.0 g of aluminum from 22°C to 55°C, if the specific heat of aluminum is 0.90 J/g°C?

   $Q = mC(T_f - T_i)$ = 10.0g (0.90J/g°C)(55-22) = **297 J**

3. Calculate the specific heat capacity of a piece of wood if 1500.0 g of the wood absorbs 67,500 joules of heat, and its temperature changes from 32°C to 57°C.

   $C = \frac{Q}{m(T_f - T_i)} = \frac{67500\ J}{(1500\ g)(57-32)}$ = **1.8 J/g°C**

4. 100.0 g of 4.0°C water is heated until its temperature is 37°C. Calculate the amount of heat energy needed to cause this rise in temperature.

   $Q = mC(T_f - T_i)$ = 100g(4.184J/g°C)(37 – 4) = **14000 J**

5. 25.0 g of mercury is heated from 25°C to 155°C, and absorbs 455 joules of heat in the process. Calculate the specific heat capacity of mercury.

   $C = \frac{Q}{m(T_f - T_i)} = \frac{455\ J}{(25g)(155-25)}$ = **0.14 J/g°C**

Specific heat problems answer key are essential tools for students and educators alike in the field of thermodynamics and physical science. Understanding these problems helps in grasping the concepts of heat transfer, temperature changes, and energy conservation. Specific heat refers to the amount of heat required to change the temperature of a unit mass of a substance by one degree Celsius (or Kelvin). In this article, we will delve into the specifics of solving specific heat problems, examine the formulas involved, and provide an answer key for various example problems.

Understanding Specific Heat

Specific heat is a fundamental concept in physics and chemistry, representing the thermal properties of materials. The specific heat capacity (c) of a substance is defined as:

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

where:

- Q = heat energy absorbed or released (in Joules)
- m = mass of the substance (in kilograms)
- ΔT = change in temperature (in degrees Celsius or Kelvin)

Why is Specific Heat Important?

The concept of specific heat is crucial for a variety of reasons:

1. Thermal Management: In engineering and design, understanding specific heat helps manage heat flow in systems.
2. Climate Science: It plays a role in understanding how different materials absorb and release heat, affecting climate models.
3. Everyday Applications: Cooking, heating, and cooling systems rely on principles of specific heat to function efficiently.
4. Material Selection: Certain materials with high specific heat are chosen for specific applications, such as in thermal insulators.

Common Formulas Related to Specific Heat

To solve specific heat problems, several key formulas are utilized:

1. Heat Transfer Formula:

$$ Q = mc \Delta T $$

- This formula calculates the heat energy transferred when a substance changes temperature.

2. Calculating Final Temperature:

$$ T_f = T_i + \frac{Q}{mc} $$

- This formula finds the final temperature after a given amount of heat is added or removed.

3. Heat Transfer Between Two Bodies:

$$ m_1 c_1 (T_{f} - T_{1}) + m_2 c_2 (T_{f} - T_{2}) = 0 $$

- This formula is used when two bodies reach thermal equilibrium, meaning they exchange heat until they reach the same temperature.

Example Problems and Solutions

Let’s explore a series of example problems related to specific heat, along with their solutions.

Problem 1: Heating Water

Question: How much heat is required to raise the temperature of 250 grams of water from 20°C to 100°C? (Specific heat of water = 4.18 J/g°C)

Solution:

1. Identify the known values:

- Mass $m = 250$ g
- Specific heat $c = 4.18$ J/g°C
- Initial temperature $T_i = 20$ °C
- Final temperature $T_f = 100$ °C
- Change in temperature $\Delta T = T_f - T_i = 100 - 20 = 80$ °C

2. Apply the heat transfer formula:

$$
Q = mc \Delta T
$$

$$
Q = 250 \times 4.18 \times 80
$$

$$
Q = 83600 \text{ J}
$$

Answer: 83,600 Joules.

Problem 2: Cooling Metal

Question: A metal block with a mass of 2 kg is cooled from 150°C to 50°C. If the specific heat of the metal is 0.9 J/g°C, how much heat is lost by the metal?

Solution:

1. Convert mass to grams:

$$
m = 2 \text{ kg} = 2000 \text{ g}
$$

2. Identify the known values:

- Specific heat $c = 0.9$ J/g°C
- Initial temperature $T_i = 150$ °C
- Final temperature $T_f = 50$ °C
- Change in temperature $\Delta T = T_f - T_i = 50 - 150 = -100$ °C

3. Apply the heat transfer formula:

$$
Q = mc \Delta T
$$

$$
Q = 2000 \times 0.9 \times (-100)
$$

$$
Q = -180000 \text{ J}
$$

Answer: The metal loses 180,000 Joules of heat.

Problem 3: Thermal Equilibrium

Question: A 500 g piece of copper at 200°C is placed in 1 kg of water at 25°C. What will be the final equilibrium temperature? (Specific heat of copper = 0.385 J/g°C)

Solution:

1. Identify known values:

- Mass of copper $m_1 = 500$ g, $c_1 = 0.385$ J/g°C, $T_1 = 200$ °C
- Mass of water $m_2 = 1000$ g, $c_2 = 4.18$ J/g°C, $T_2 = 25$ °C

2. Set up the equation for heat transfer:

$$
m_1 c_1 (T_f - T_1) + m_2 c_2 (T_f - T_2) = 0
$$

$$
500 \times 0.385 (T_f - 200) + 1000 \times 4.18 (T_f - 25) = 0
$$

3. Simplify and solve for T_f:

$$
192.5 (T_f - 200) + 4180 (T_f - 25) = 0
$$

$$
192.5T_f - 38500 + 4180T_f - 104500 = 0
$$

$$
4372.5T_f = 143000
$$

$$
T_f \approx 32.7 \text{ °C}
$$

Answer: The final equilibrium temperature is approximately 32.7°C.

Answer Key Summary

To summarize the specific heat problems discussed:

1. Heating Water: 83,600 Joules required to raise the temperature.
2. Cooling Metal: 180,000 Joules lost by the metal.
3. Thermal Equilibrium: Final temperature reached is approximately 32.7°C.

Conclusion

Understanding and solving specific heat problems answer key is fundamental to mastering heat transfer concepts in physics and chemistry. By working through various examples, students can gain a clearer insight into how different materials respond to temperature changes and the significance of specific heat in everyday applications and scientific contexts. Whether in educational settings or practical applications, the principles of specific heat remain a cornerstone of thermal dynamics.

Frequently Asked Questions

What is specific heat and why is it important in solving heat transfer problems?

Specific heat is the amount of heat required to raise the temperature of one gram of a substance by one degree Celsius. It is important in solving heat transfer problems because it helps determine how much energy is needed to change the temperature of a substance.

How do you calculate the amount of heat absorbed or released by a substance?

The amount of heat absorbed or released can be calculated using the formula $Q = mc\Delta T$, where Q is the heat energy, m is the mass of the substance, c is the specific heat capacity, and ΔT is the change in temperature.

What units are used for specific heat in calculations?

Specific heat is typically expressed in units of joules per gram per degree Celsius (J/g°C) or calories per gram per degree Celsius (cal/g°C).

What is the specific heat of water and why is it significant?

The specific heat of water is approximately 4.18 J/g°C. This high specific heat is significant because it allows water to absorb and store large amounts of heat, moderating climate and supporting life.

How can specific heat problems be applied in real-life scenarios?

Specific heat problems can be applied in various real-life scenarios such as cooking, climate science, engineering applications, and understanding meteorological phenomena.

What are some common mistakes to avoid when solving specific heat problems?

Common mistakes include forgetting to convert units, miscalculating the mass or temperature change, and confusing specific heat with heat capacity, which is a different concept.

How can you find the specific heat of an unknown substance using a calorimeter?

You can find the specific heat of an unknown substance by using a calorimeter to measure the temperature change when the substance is added to a known mass of water. By applying the principle of conservation of energy, you can set the heat lost by water equal to the heat gained by the substance to solve for its specific heat.

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