# 4B – SPECIFIC HEAT

## Part 1 Analysis – Different Materials

Your mixture prediction:

***Table 1 – Different materials***

| Substance | Mass (g) | Initial temperature ($T_I$) (°C) | Final temperature ($T_F$) (°C) | Change in temperature (°C) ($\Delta T = T_F - T_I$) |
|---|---|---|---|---|
| Metal | | | | |
| Water | | | | |
| Mixed | – | | | – |

❷ 1. What are the final temperatures of the metal and the water? Record these values in Table 1.

❷ 2. What is the change in temperature for the metal and the water? Calculate this by subtracting the initial from the final temperature. Record these values in Table 1.

## Part 1 Questions – Different materials

❷ 1. Does the mixed temperature match your prediction? Explain your answer.

❷ 2. Which substance “lost” energy when the materials were mixed: the water or the metal? Explain your answer.

❓ 3. Where did the "lost" energy go?

❓ 4. What is counted as part of the system and what is counted as surroundings in this investigation? Is the system open, isolated or closed? Explain your answers.

❓ 5. Consider two scenarios:
   a. a 100 g sample of substance X at 0 °C is mixed with 100 g of substance X at 50 °C.
   b. a 100 g sample of substance Z at 0 °C is mixed with 100 g of substance X at 50 °C.

   Which of the two scenarios results in a mixture temperature closest to 25 °C? Support your answer with data from this investigation

## Part 2 Analysis – Specific heat capacity

***Table 2 – Thermal energy and specific heat capacity***

| Substance | Mass (g) | Initial temperature ($T_I$) (°C) | Final temperature ($T_F$) (°C) | Change in temp. (°C) ($\Delta T = T_F - T_I$) | $C_p$, Specific heat capacity (J/g·°C) | q, heat (J) |
|---|---|---|---|---|---|---|
| Metal | | | | | | |
| Water | | | | | | |

❓ 1. Calculate the temperature change of each sample by subtracting the initial temperature from final temperature ($\Delta T = T_F - T_I$). Negative answers are possible. Record results in Table 2.

❓ 2. If temperature change is negative, what does that say about energy? In other words, is a substance with a negative temperature change gaining thermal energy or losing thermal energy? Explain your answer.

❓ 3. Answer a and b:

   a. The specific heat of water is 4.18 J/g·°C. This means it takes 4.18 joules to increase the temperature of 1 gram of water by 1 °C. Record the specific heat of water in the space provided in Table 2.

   b. Use the heat equation given below to calculate water's energy after adding the metal. Show your work, and record the heat of water (q) in Table 2.

***Heat energy equation:***

$\text{heat}_{\text{water}}$ (J) = [$\text{mass}_{\text{water}}$ (g)] × [specific heat $\text{capacity}_{\text{water}}$ (J/g·°C)] × [change in $\text{temperature}_{\text{water}}$ (°C)]

$q_{\text{water}} = m_{\text{water}} \times C_{p\ \text{water}} \times \Delta T_{\text{water}}$

❓ 4. Answer a and b:

   a. Apply the law of conservation of energy to determine the heat, q, of the metal sample after adding it to the hot water. Record this value in Table 2.

   b. Should the heat of the metal sample after adding it to the water have a positive or a negative value? Explain your answer.

❓ 5. The heat equation can be rearranged to solve for specific heat as shown below:

***Specific heat equation:***

$C_{p\ \text{metal}} = \text{heat}_{\text{metal}}$ (J) / ($\text{mass}_{\text{metal}}$ × temperature $\text{change}_{\text{metal}}$)

$C_{p\ \text{metal}} = q_{\text{metal}} / (m_{\text{metal}} \times \Delta T_{\text{metal}})$

Use the specific heat equation to calculate the specific heat of the metal. Show your work below and record the value in Table 2.

## Part 2 Questions – Specific heat capacity

***Specific heat capacities of selected elements***

| Metal | Specific heat capacity (J/g·°C) |
|---|---|
| copper | 0.385 |
| aluminum | 0.897 |
| iron | 0.449 |
| lead | 0.129 |
| carbon | 0.709 |

$$\text{Percent Error} = \left| \frac{\text{accepted value - experimental value}}{\text{accepted value}} \right| \times 100$$

❷ 1. Specific heat capacity is an intrinsic property. Compare your calculated specific heat from Analysis Table 2 with specific heats in table above to identify the unknown metal used in Part 2. Calculate your percent error.

Identity of metal:

Percent error:

❷ 2. The flow of energy is called heat. Heat is based on a change in temperature.

heat (J) = mass (g) × specific heat capacity (J/g·°C) × temperature change (°C)
$q = m \times C_p \times \Delta T$

Suppose you add 1000. J of energy to 50.0 grams of water. How much would the temperature of the water increase? Rearrange the equation and show your work.

❷ 3. Which material listed in the table above would have the highest change in temperature per gram when 100 J of energy is added? Explain your answer.