SAMPLE PROBLEM C

Calorimetry

PROBLEM

A 0.050 kg metal bolt is heated to an unknown initial temperature. It is then dropped into a calorimeter containing 0.15 kg of water with an initial temperature of 21.0°C. The bolt and the water then reach a final temperature of 25.0°C. If the metal has a specific heat capacity of 899 J/kg•°C, find the initial temperature of the metal.

SOLUTION

1. DEFINE

Given:

$m_{metal} = m_m = 0.050\ \text{kg}$ $\quad c_{p,m} = 899\ \text{J/kg•°C}$

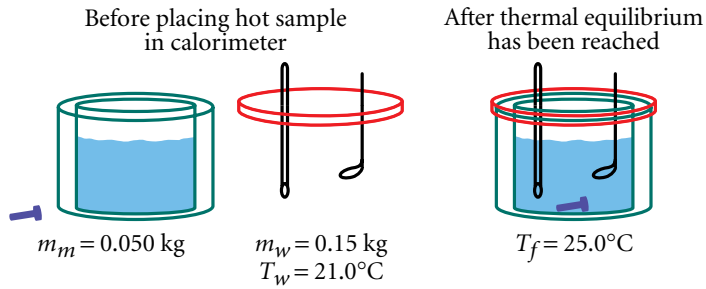
$m_{water} = m_w = 0.15\ \text{kg}$ $\quad c_{p,w} = 4186\ \text{J/kg•°C}$

$T_{water} = T_w = 21.0°\text{C}$ $\quad T_{final} = T_f = 25.0°\text{C}$

Unknown:

$T_{metal} = T_m = ?$

Diagram:



2. PLAN

Choose an equation or situation:

The energy absorbed by the water equals the energy removed from the bolt.

$$Q_w = -Q_m$$

$$c_{p,w} m_w \Delta T_w = -c_{p,m} m_m \Delta T_m$$

$$c_{p,w} m_w (T_f - T_w) = -c_{p,m} m_m (T_f - T_m)$$

Rearrange the equation to isolate the unknown:

$$T_m = \frac{c_{p,w} m_w (T_f - T_w)}{c_{p,m} m_m} + T_f$$

TIP *Because T_w is less than T_f, you know that T_m must be greater than T_f.*

3. CALCULATE

Substitute the values into the equation and solve:

$$T_m = \frac{(4186\ \text{J/kg•°C})(0.15\ \text{kg})(25.0°\text{C} - 21.0°\text{C})}{(899\ \text{J/kg•°C})(0.050\ \text{kg})} + 25.0°\text{C}$$

$$\boxed{T_m = 81°\text{C}}$$

4. EVALUATE

T_m is greater than T_f, as expected.