Given: $kJ := 1000J$

A 50 kg iron block at 80°C is dropped into an insulated tank that contains 0.5 m^3 of liquid water at 25°C.

$m_{fe} := 50kg$ $T_{1,fe} := 80\,°C$ $V_w := 0.5m^3$ $T_{1,w} := 25\,°C$

Required:

Determine the temperature when thermal equilibrium is reached.

Solution:

Using the hint given, the following is true.

$$\Delta U_{fe} + \Delta U_w = 0$$

$$m_{fe} \cdot (u_{2,fe} - u_{1,fe}) + m_w \cdot (u_{2,w} - u_{1,w}) = 0$$

Assuming the specific heat value of both the iron and water remain constant over the temperature range of this process, the expression becomes

$$m_{fe} \cdot c_{fe} \cdot (T_{2,fe} - T_{1,fe}) + m_w \cdot c_w \cdot (T_{2,w} - T_{1,w}) = 0$$

If the final state is in thermal equilibrium, then the final temperature of the iron and water will be the same so

$T_{2,fe} = T_{2w} = T_2$ thus $m_{fe} \cdot c_{fe} \cdot (T_2 - T_{1,fe}) + m_w \cdot c_w \cdot (T_2 - T_{1,w}) = 0$

Solving for the final temperature yields

$$T_2 = \frac{m_{fe} \cdot c_{fe} \cdot T_{1,fe} + m_w \cdot c_w \cdot T_{1,w}}{m_{fe} \cdot c_{fe} + m_w \cdot c_w}$$

Assuming the density of water is 1000 kg/m^3, the mass of the water may be found by

$$m_w := 1000 \frac{kg}{m^3} \cdot V_w = 500\,kg$$

Going to Table A-3(a) @ water at 25°C shows

$$c_w := 4.18 \frac{kJ}{kg \cdot K}$$

Going to Table A-3(b) @ iron shows

$$c_{fe} := 0.45 \frac{kJ}{kg \cdot K}$$

The final temperature is then

$$\boxed{T_2 := \frac{m_{fe} \cdot c_{fe} \cdot T_{1,fe} + m_w \cdot c_w \cdot T_{1,w}}{m_{fe} \cdot c_{fe} + m_w \cdot c_w} = 298.7\,K}$$

$$\boxed{T_2 = 25.6 \cdot °C}$$