

**Given:**

A 50 kg block of iron casting at 500 K is thrown into a large lake that is at a temperature 285 K. The iron block eventually reaches thermal equilibrium with the lake water.

$$m := 50 \text{ kg} \quad T_1 := 500 \text{ K} \quad T_{Lake} := 285 \text{ K}$$

**Required:**

Assuming an average specific heat of 0.45 kJ/kgK for the iron, determine the entropy changes of the block and of the lake and the entropy generated during the process.

**Solution:**

The average specific heat of the block is defined as

$$c_{avg} := 0.45 \frac{\text{kJ}}{\text{kg K}}$$

Since the block is a solid with a constant specific heat, the change in entropy of the block is given by

$$\Delta S_{block} = m \cdot (s_2 - s_1) = m \cdot c_{avg} \cdot \ln \left( \frac{T_2}{T_1} \right)$$

Assuming the lake is large enough that the block has negligible effect on its temperature, the change in entropy of the block is

$$\Delta S_{block} := m \cdot c_{avg} \cdot \ln \left( \frac{T_{Lake}}{T_1} \right) = -12.65 \frac{\text{kJ}}{\text{K}}$$

To determine the entropy change of the lake, the heat transferred from the block to the lake needs to be found. This is given by

$$Q_{transfer} := m \cdot c_{avg} \cdot (T_1 - T_{Lake}) = 4838 \text{ kJ}$$

The entropy change of the lake is then given by

$$\Delta S_{Lake} := \frac{Q_{transfer}}{T_{Lake}} = 16.97 \frac{\text{kJ}}{\text{K}}$$

To determine the entropy generated during this process, let's first consider our system (i.e., the block) and the surroundings (i.e., the lake). Any system combined with its surroundings is equivalent to a closed, adiabatic system. With this in mind, an entropy balance of the block and surroundings may be conducted.

$$\Delta S_{sys} = \Sigma S_{in} - \Sigma S_{out} + S_{gen}$$

For a closed, adiabatic system, the sum of the entropy coming in and out go to zero, leaving only the entropy generated on the right hand side. The left hand side is simply the change of entropy of each component within the system. For this case, that is the change of entropy of the block and the surroundings.

$$\Delta S_{sys} = \Delta S_{block} + \Delta S_{Lake}$$

Thus the entropy generated is

$$S_{gen} := \Delta S_{block} + \Delta S_{Lake} = 4.326 \frac{\text{kJ}}{\text{K}}$$

