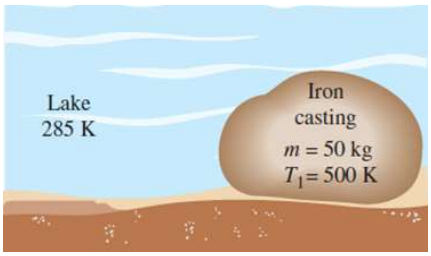
Given:

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

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

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

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

The entropy change of the lake is then given by

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

The entropy generated during the process is then found by an entropy balance of the block which begins with

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

The is no entropy entering the system, only leaving the system so

$$S_{gen} = \Delta S_{sys} + \Sigma S_{out} = \Delta S_{block} + \Delta S_{Lake}$$

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