A 0.5kg piece of metal (c = 600/kgK) at 300 degree celcius is dumped into a large pool of water at 20 degrees Celcius. Assuming the change in temperature of water to be negligible, calculate the overall change in entropy for the system

Solution:

We assume that piece of metal undergoes an internally reversible heat transfer such that $dS = \frac{dQ}{T} = \frac{mcdT}{T}$. The assumption that piece of metal has a constant heat capacity allows us to integrate this equation giving $\Delta S = mcln\left(\frac{T2}{T1}\right)$. In this calculation the temperature must be in kelvins. We can apply this equation to piece of metal, here using units of kelvins for the heat capacity.

$$\Delta S_1 = 0.5\text{kg} * 600\frac{\text{J}}{\text{kgK}} * \ln\frac{293\text{K}}{573\text{K}} = -201{,}24\frac{\text{J}}{\text{K}}$$

Assuming the change in temperature of water to be negligible, we can calculate change in entropy for the large pool of water

$dS = \frac{dQ}{T} -> \Delta S_2 = \frac{Q}{T} = \frac{mc\Delta T}{T2}$,

$$\Delta S_2 = 0.5\text{kg} * 600\frac{\text{J}}{\text{kgK}} * \frac{(300-20)\text{K}}{293\text{K}} = 286{,}68\ \frac{\text{J}}{\text{K}}$$

where ΔQ is the amount of heat received from the piece of metal

The overall change in entropy for the system is simply the sum of these two entropy changes.

$\Delta S = \Delta S_1 + \Delta S_2 = -201{,}24\frac{\text{J}}{\text{K}} + 286{,}68\ \frac{\text{J}}{\text{K}} = 85{,}44\frac{\text{J}}{\text{K}}$.

Answer : $\Delta S = 85{,}44\frac{\text{J}}{\text{K}}$.