Answer on Question #45567, Physics, Molecular Physics | Thermodynamics

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

Solution:

Given:

$m = 0.5\ \text{kg},$

$c = 600\ \frac{\text{J}}{\text{kgK}},$

$T_1 = 300℃ = 573\ \text{K},$

$T_2 = 20℃ = 293\ \text{K},$

$\Delta S = ?$

The change in entropy S_f - S_i of a system during a process that takes the system from an initial state *i* to a final state *f* as

$$\Delta S = S_f - S_i = \int_i^f \frac{dQ}{T}$$

The assumption that piece of metal has a constant heat capacity allows us to integrate this equation giving

$$\Delta S = \int_1^2 \frac{cm}{T} dT = cm \int_1^2 \frac{dT}{T} = cm \ln\left(\frac{T_2}{T_1}\right)$$

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.

$$\Delta S_1 = cm \ln\left(\frac{T_2}{T_1}\right) = 600 \cdot 0.5 \cdot \ln\left(\frac{293}{573}\right) = -201.214\ \frac{\text{J}}{\text{K}}$$

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

$$\Delta S_2 = \frac{\Delta Q}{T_2} = \frac{cm\Delta T}{T_2} = \frac{cm(T_1 - T_2)}{T_2}$$

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

$$\Delta S_2 = \frac{600 \cdot 0.5 \cdot (573 - 293)}{293} = 286.689\ \frac{\text{J}}{\text{K}}$$

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

$$\Delta S = \Delta S_1 + \Delta S_2 = -201.214 + 286.689 = 85.475 \approx 85.5\ \frac{\text{J}}{\text{K}}$$

Answer: $\Delta S = 85.5\ \frac{\text{J}}{\text{K}}.$