Answer on Question #46610-Physics-Other

A $m = 0.5kg$ piece of metal ($c = 600\frac{J}{kgK}$) at 300 degree 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

The initial temperature of metal is $T_1 = 300 + 273 = 573\ K$. The temperature of water is $T_2 = 20 + 273 = 293\ K$.

According to the Second Law of thermodynamics for the reversible processes:

$$dS\ = \frac{\delta Q}{T}.$$

We assume that piece of metal undergoes an internally reversible heat transfer such that:

$$dS\ = \frac{\delta Q}{T} = \frac{m \cdot c \cdot dT}{T}.$$

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

$$\int_{S_1}^{S_2} dS = \int_{T_1}^{T_2} \frac{m \cdot c \cdot dT}{T}.$$

$$\Delta S_{metal} = mc\ \ln T|_{T_1}^{T_2} = mc \ln \frac{T_2}{T_1}.$$

We can apply this equation to piece of metal:

$$\Delta S_{metal} = 0.5 \cdot 600 \ln \frac{293}{573} = -201.2 \frac{J}{K}.$$

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

$$\Delta S_{water} = \frac{\Delta Q}{T_2} = \frac{mc(T_1 - T_2)}{T_2} = \frac{0.5 \cdot 600(573 - 293)}{293} = 286.7 \frac{J}{K}.$$

The total change in entropy for the system is equal to the sum of these two entropy changes:

$$\Delta S = \Delta S_{metal} + \Delta S_{water} = -201.2 \frac{J}{K} + 286.7 \frac{J}{K} = 85.5 \frac{J}{K}.$$

Answer: $85.5 \frac{J}{K}$.