System A | System B

$$Q_{A,out} = Q_{B,in} \longrightarrow$$

heat leaving A equals heat entering B

defined as heat IN → Q_A

$$dS_A = \frac{Q_A}{T_A} = \frac{-Q_{A,out}}{T_A} \neq dS_B = \frac{Q_{B,in}}{T_B}$$

assume $T_A > T_B$

negative, but smaller in magnitude . . . than this

$$dS = dS_A + dS_B > 0$$

irreversible
spontaneous

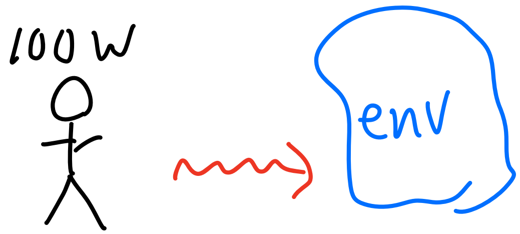
$$\frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_{V,N}$$

No work, no particles exchanged

$$dS = \text{đ}Q / T$$

dS ← of system; đQ ← into system; T ← of system

All quantities INTO or OF system



37 °C + 273 K = 310 K

0 °C + 273 K = 273 K

$$\frac{dS_{env}}{dt} = \frac{+100\,W}{273\,K} = 0.3663\ \frac{J/K}{s}$$

+100 W ← into environment

Environment so big T_{env} doesn't change

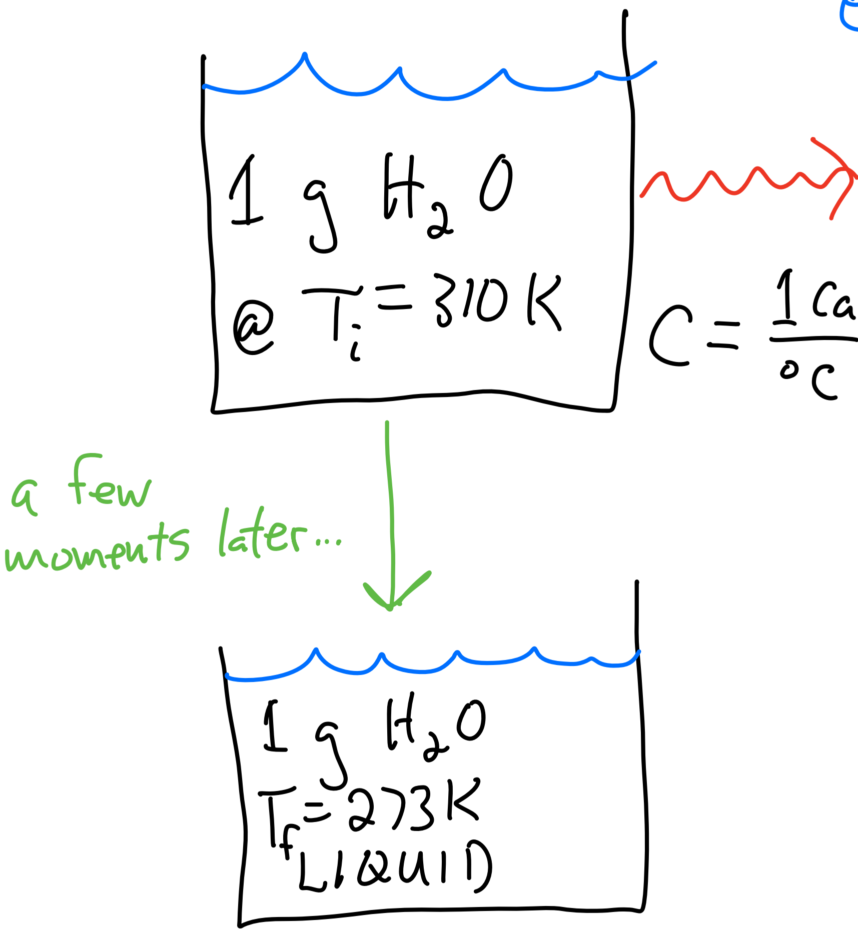
$$\frac{dS_{body}}{dt} = \frac{-100\,W}{310\,K} = -0.3226\ \frac{J/K}{s}$$

−100 W ← lost by body

$$\frac{dS_{universe}}{dt} = 0.3663 - 0.3226\ \frac{J/K}{s}$$

$$= +0.0437\ \frac{J/K}{s}$$

$$\frac{dS_{body}}{dt} = \frac{\text{đ}Q/T}{dt}$$



environment at $T_{env} = 0°C$

$$C = \frac{1\ \text{cal}}{°C} = \frac{1\ \text{cal}}{K} = \frac{4.184\ J}{K}$$

$$dS_w = \frac{đQ}{T}$$

$$đQ = C\,dT$$

$$\int_{T=310K}^{T=273K} dS_w = \int_{310K}^{273K} C\frac{dT}{T} = C \ln\frac{273}{310}$$

$$\Delta S_{H_2O} = -0.5318\ J/K$$

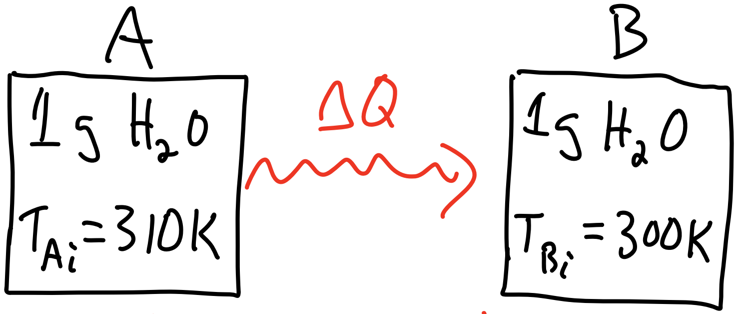
$$\Delta S_{univ} = (0.5671 - 0.5318)\ \frac{J}{K} = +0.0353\ J/K$$

environment: $dS_{env} = đQ/T$

$$\int_{init}^{final} dS_{env} = \int_{init}^{final} \frac{đQ}{T} = \frac{1}{T_{env}} \int_{init}^{final} đQ = \frac{1}{273K} Q_{\text{lost by water}}$$

$$= \frac{1}{273K} \times 4.184\ \frac{J}{K} \times (310K - 273K)$$

$$\boxed{\Delta S_{env}\ \ +0.5671\ J/K}$$



lost by A — gained by B

$$-\Delta Q_A = -C_A \Delta T_A = \Delta Q_B = C_B \Delta T_B$$

$$-C_A(T_f - T_{Ai}) = C_B(T_f - T_{Bi})$$

$$-C_A T_f + C_A T_{Ai} = C_B T_f - C_B T_{Bi}$$

$$(C_A + C_B) T_f = C_B T_{Bi} + C_A T_{Ai}$$

$$T_f = \frac{C_B T_{Bi} + C_A T_{Ai}}{C_A + C_B}$$

$$= \frac{T_{Bi} + T_{Ai}}{2} = 305\ K$$

$$\Delta S_A = \int_{T_A = T_{Ai}}^{T = T_f} dQ/T_A = \int_{310K}^{305K} \frac{C_A\, dT_A}{T_A}$$

$$= C_A \ln \frac{305}{310} = -0.0680\ J/K$$

$$\Delta S_B = \int_{T_B = T_{Bi}}^{T = T_f} dQ/T_B = \int_{300K}^{305K} \frac{C_B\, dT_B}{T_B}$$

$$= C_B \ln \frac{305}{300} = +0.0692\ J/K$$

$$\Delta S_{univ} = \Delta S_A + \Delta S_B = 0.0011\ J/K$$