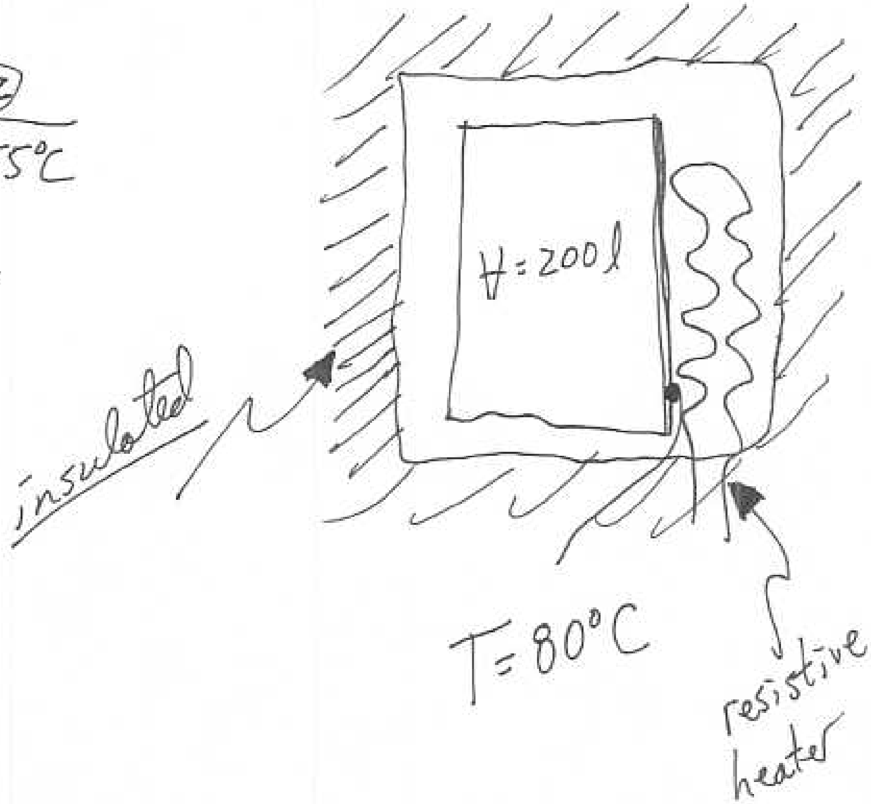
6.65

①	②
$T_{w1} = 23°C$	$T_{w2} = 55°C$



Given: - Incompressible Water
- H.T. is only from heater to water

(a) $\sigma_{water} = ?$

(b) $\sigma_{\substack{water\\ and\\ heater}} = ?$

$$\Delta S = \sum_j \frac{Q_j}{T_j} + \sigma$$

In both cases, ΔS will be the change in entropy of the water because we are told that the state of ~~the~~ tank and heater do not change significantly.

$$\Delta E = Q - W \quad \text{since } \Delta KE = \Delta PE = 0$$

$$\Delta U = Q - \cancel{W}^{\,0}$$

From ME 203 we know that for an incompressible liquid

$$c_v = \left(\frac{\partial u}{\partial T}\right)_v \cong \frac{du}{dT}$$

From Table A-19 $\quad c_v = 4.18\ kJ/kg \cdot K$

$$\therefore\ Q = mc_v\Delta T = \left(1000\ \frac{kg}{m^3}\right)(0.2\,m^3)(4.18\ kJ/kg\cdot K)(55°C - 23°C)$$

$$Q = 26{,}752\ kJ$$

↳

6.65 (continued)

$$T\,ds = du + p\,dv$$

$$ds = \frac{du}{T} + \cancel{\frac{p}{T}dv}^{\,0} \quad \text{for incompressible}$$

$$s_2 - s_1 = c_v \int_1^2 \frac{dT}{T} = c_v \ln\left(\frac{T_2}{T_1}\right)$$

$$s_2 - s_1 = \left(4.18 \frac{kJ}{kg \cdot K}\right)\left(\ln\left(\frac{(55+273)K}{(23+273)K}\right)\right) = 0.429 \frac{kJ}{kg \cdot K}$$

$$S_2 - S_1 = 85.8\ kJ/K$$

(a) $\Delta S = \frac{Q}{T} + \sigma$

$$\sigma = 85.8 \frac{kJ}{K} - \frac{26752\,kJ}{(80+273)K}$$

$$\boxed{\sigma = 10\ kJ/K}$$

(b) $Q = 0$ in this case. So $\Delta S = \sigma$

$$\therefore \boxed{\sigma = 85.8 \frac{kJ}{K}}$$

The entropy production is greater in part (b) because the system includes the resistive heater. Hence, irreversibilities associated with generating the heat (as opposed to transferring it) are included in part (b), but not in part (a).