1a) (SPECIFIC HEAT)

$$Q = C \cdot m \cdot \Delta T = 4.186 \frac{J}{gK} \cdot 150g \cdot 80K = 50,232\ J$$

$$P = \frac{E}{t} \quad \text{or} \quad t = E/P = Q/P$$

$$t = \frac{50,232\ J}{600\ W} = \underline{83.7\ sec}$$

b) $$Q_W = Q_{Ag}$$

$$m(H_2O)\,C(H_2O)\,(T^i(H_2O) - T_f) = m(Ag)\,c(Ag)\,(T_f - T^i(Ag))$$

DEFINE $mC(H_2O) \equiv m(H_2O)\,C(H_2O)$ ETC, SOLVE FOR T_f

$$T_f(mC(Ag) + mC(H_2O)) = mC(H_2O)\,T^i(H_2O) + mC(Ag)\,T^i(Ag)$$

$$\text{or } T_f = \frac{mC(H_2O)}{mC(Ag) + mC(H_2O)}\,T^i(H_2O) + \frac{mC(Ag)}{mC(Ag) + mC(H_2O)}\,T^i(Ag)$$

NUMBERS: $mC(H_2O) = 150g \times 4.186 \frac{J}{gK} = 627.9\ J/K$

$mC(Ag) = 30g \times 0.235 \text{ "} = 7.1\ J/K$

$$T_f = \frac{627.9}{635}\,100°C + \frac{7.1}{635}\,20°C$$

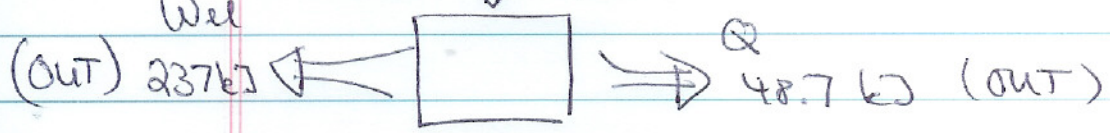
$$= 98.88°C + 0.22°C = \underline{99.1°C}.$$

2) (FUEL CELL)

a) $W_{el} = \Delta G_f = -237\ kJ$

$Q = \Delta H - \Delta G_f = -48.7\ kJ$

$P\Delta V = kNT = 1.5 \cdot R \cdot T = 3.6\ kJ$



b) $V = -\frac{\Delta G_f}{2 N_A Q_e} = \frac{237 \times 10^3\ J}{2 \cdot 6 \cdot 10^{23} \cdot 1.6 \cdot 10^{-16} C} = 1.23\ V$

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3) (OTTO ENGINE)

(12) ADIABATIC

$W_{12} = U_2 - U_1 = \frac{f}{2} Nk(T_2 - T_1) = \frac{f}{2}(P_2V_2 - P_1V_1)$

$Q_{12} = 0$

(23) V = CONST

$W_{23} = 0$

$Q_{23} \equiv Q_H = \frac{f}{2} Nk(T_3 - T_2) = \frac{f}{2} V_2 (P_3 - P_1)$

(34) ADIABATIC

$$W_{34} = U_4 - U_3 = \frac{f}{2} Nk(T_4 - T_3) = \frac{f}{2}(P_4 V_1 - P_3 V_2)$$
$$Q_{34} = 0$$

(41) V = CONST

$$W_{41} = 0$$
$$Q_{41} \equiv Q_c = \frac{f}{2} Nk(T_4 - T_1) = \frac{f}{2} V_1 (P_4 - P_1)$$

b) $$e = \frac{W}{Q_H} = \frac{Q_H - Q_c}{Q_H} = 1 - \frac{Q_c}{Q_H}$$

$$e = 1 - \frac{Q_c}{Q_H} = 1 - \frac{V_1(P_4 - P_1)}{V_2(P_3 - P_2)}$$

ADIABATIC $$\left.\begin{aligned} P_1 V_1^{\gamma} &= P_2 V_2^{\gamma} \\ P_4 V_1^{\gamma} &= P_3 V_2^{\gamma} \end{aligned}\right\} \Rightarrow \begin{aligned} P_1 &= P_2 \left(\frac{V_2}{V_1}\right)^{\gamma} \\ P_4 &= P_3 \left(\frac{V_2}{V_1}\right)^{\gamma} \end{aligned}$$

$$\Rightarrow (P_4 - P_1) = (P_3 - P_2)\left(\frac{V_2}{V_1}\right)^{\gamma}$$

$$\Rightarrow \boxed{e = 1 - \left(\frac{V_2}{V_1}\right)^{\gamma - 1}}$$

NUMBERS: $f = 5$ $\gamma = \frac{7}{5}$ $\gamma - 1 = 0.4$

$$e = 1 - (0.1)^{0.4} = 0.60$$

4) (HARMONIC OSCILLATOR)

a) $Z = \sum_n e^{-\beta \epsilon n} \qquad \epsilon = \hbar f$

$$= \frac{1}{1 - e^{-\beta\epsilon}} = \frac{1}{1 - e^{\hbar f / kT}}$$

$$F = kT \log\left(1 - e^{-\beta\epsilon}\right)$$

$$S = -\frac{\partial F}{\partial T} = -k \log\left(1 - e^{-\beta\epsilon}\right) + kT e^{-\hbar f / kT} \left(\frac{\hbar f}{kT^2}\right) \frac{1}{1 - e^{-\beta\epsilon}}$$

$$S = -k \log\left(1 - e^{-\beta\epsilon}\right) + k\beta\epsilon \frac{1}{e^{\beta\epsilon} - 1}$$

b) NUMBERS: $\frac{\hbar f}{kT} = \frac{6.626 \cdot 10^{-34} \cdot 4.8 \cdot 10^{13}}{1.381 \cdot 10^{-23} \cdot 700\,K} = 3.29$

$\beta\epsilon = 3.29 \qquad e^{-\beta\epsilon} = 0.037$

$$F = RT \log(1 - 0.037) = 5820\,J \cdot (-0.038)$$

$$= -219\,J$$

$$S = R\left[0.038 + 3.29 \cdot \frac{0.037}{1 - 0.037}\right]$$

$$= 8.315\,J/K\,[0.038 + 0.126]$$

$$= 1.36\,J/K$$