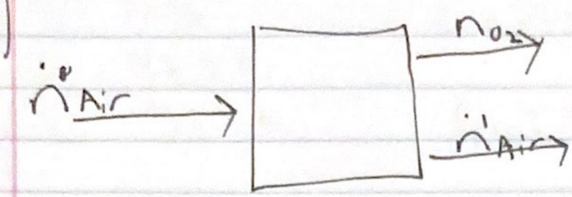
Josh Whitehead
Ch En 3853

HW #2

1)



$\dot{n}_{O_2} = 100 \frac{mol}{sec}$

$T = 300\,K \qquad P = 1\,atm$

Air = 21% O_2 $\therefore$ $y_{O_2} = 0.21 \qquad y_{air} = 0.79$

$\dot{W}_s = nT\Delta S_{mix}$

$\Delta S_{mix} = -R\sum y\ln(y) = -8.314\left[0.21\ln(0.21) + 0.79\ln(0.79)\right]$

$= 4.27 \frac{J}{mol\,K}$

$\dot{W}_s = \left(\frac{100}{0.21}\right)\frac{mol}{s}(300\,\cancel{K})\left(4.27\frac{J}{\cancel{mol}\,\cancel{K}}\right) = 610434\ W$

$\boxed{= 6.10\times10^3\ kW}$

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2) $T_1 = 283\,K$

$T_2 = 316.5\,K$

$T_{boil} = 309.2\,K$

$C_{p\ell} = 169 \frac{J}{mol\,K}$

$C_{pv} = 126 \frac{J}{mol\,K}$

$n = \frac{626\,kg}{m^3} \cdot 0.0005\,m^3 \cdot \frac{mol}{0.07215\,kg}$

$n = 4.34\,mol$

$dQ_{rev} = d\underline{H} = n C_p dT$

$$\therefore \Delta S_{\substack{\cancel{water} \\ pent}} = \int_{T_i}^{T_f} \frac{n C_p dT}{T_{sys}} = \cancel{n} C_p \ln\left(\frac{T_f}{T_i}\right)$$

$$\Delta S_{\cancel{water}}^{pent} = \Delta S^1_{T_1 \to T_{boil}} + \Delta S^{vap}_{T_{boil}} + \Delta S^2_{T_{boil} \to T_2}$$

$$\Delta S^1 = 4.34\,mol \cdot 169 \frac{J}{mol\,K} \ln\left(\frac{309.2}{283}\right) = \underline{64.9 \frac{J}{K}}$$

$$\Delta S^{vap} = \frac{\Delta H_{vap} \cdot n}{T_{boil}} = 4.34\,mol \cdot 25790 \frac{J}{\cancel{mol}} \cdot \frac{1}{309.2\,K} = \underline{361.8 \frac{J}{K}}$$

$$\Delta S^2 = 4.34\,mol \cdot 126 \frac{J}{mol\,K} \ln\left(\frac{316.5}{309.2}\right) = 12.7 \frac{J}{K}$$

$$\therefore \Delta S = 64.9 + 361.8 + 12.7 \boxed{= 439. \frac{J}{K}}$$

$$\Delta S_{sur} = -\int_{T_i}^{T_f} \frac{dQ}{T_{sur}} = -\frac{\cancel{n} C_p \Delta T}{T_{sur}}$$

$$\Delta S^1_{sur} = -\frac{4.34 \cdot 169\,(309.2 - 283)}{316.5} = \underline{60.7 \frac{J}{K}}$$

$$\Delta S^{vap} = \frac{\Delta H_{vap} \cdot n}{T_{boil}} = 4.34 \cdot 25790 \cdot \frac{1}{309.2} = \underline{361.8 \frac{J}{K}}$$

$$\Delta S^2 = \frac{-4.34 \cdot 126 \cdot (316.5 - 309.2)}{316.5} = \underline{-12.58 \frac{J}{K}}$$

$$\boxed{\Delta S_{sur} = -435. \frac{J}{K}}$$

$$\Delta S_{univ} = \sum \Delta S = \Delta S_{sur} + \Delta S_{pent} \boxed{= 4.37 \frac{J}{K}}$$

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3) $C_p = \frac{7}{2}R$, $T_1 = 600K$, $P_1 = 1 MPa$

Closed: $\Delta U = \cancel{\Delta E_K} + \cancel{\Delta E_p} + \cancel{W_s} + \cancel{W_{EC}}$

$\therefore \Delta U = 0$

$\therefore T_1 = \boxed{T_2 = 600\,K}$

$P_1V_1 = n_1RT_1 \rightarrow T_1 = T_2,\ 2V_1 = V_2,\ n_1 = n_2$

$P_2V_2 = n_2RT_2$

$P_2 = \frac{nRT}{V_2} = \frac{nRT}{2V_1}$ $\qquad P_1 = \frac{nRT}{V_1}$

$\therefore 2P_2 = P_1 \rightarrow \boxed{P_2 = 0.500\,MPa}$

$\Delta S^{ig} = \cancel{C_p \ln \frac{T}{T_i}} - R \ln \frac{P}{P_i} = -8.314 \cdot \ln\left(\frac{0.5}{1}\right) = \boxed{5.76 \frac{J}{mol\,K}}$

b) Steam: $P_1 = 1$, $T_1 = 600$ $\quad \underbrace{}_{P_2 = \frac{1}{2}P_1}$ $\quad \therefore \boxed{P_2 = 0.500\,MPa}$

Same # mol, 2x volume

~~Steam table~~: $\Delta U = \cancel{\Delta E_K} + \cancel{\Delta E_p} + \cancel{W_s} + \cancel{W_{EC}}$ $\therefore \Delta U = 0 \rightarrow$

$\rightarrow$ Steam table: 1 MPa, $\underbrace{600K}_{326.8^\circ C}$ $\rightarrow u_1 = 2837.7 \frac{KJ}{Kg}$

@ 0.5 MPa, $u_2 = 2837.7 \frac{KJ}{Kg}$ $\quad T_2 = 321.6^\circ C = \boxed{322.^\circ C}$

Interpolated using $y = y_1 + (x - x_1)\frac{y_2 - y_1}{x_2 - x_1}$

$S_1 = 7.22 \frac{KJ}{Kg K}$ $\quad S_2 = 7.536 \frac{KJ}{Kg K}$ $\quad \Delta S = 0.316 \frac{KJ}{Kg K}$

$Mw = 18.02 \frac{g}{mol} = 0.01802 \frac{Kg}{mol}$ $\quad 0.316 \frac{KJ}{\cancel{Kg}K} \cdot 0.01802 \frac{\cancel{KJ}}{mol}$

$\boxed{\Delta S = 5.69 \frac{J}{mol\,K}}$

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4) low pressure: $dS^{ig} = C_p^{ig} \frac{dT}{T}$

$$V = \frac{RT}{P} \rightarrow \frac{\partial V}{\partial T} = \frac{R}{P}$$

$$\int dS = \int C_p^{ig} \cdot \frac{dT}{T} - \int R \frac{dP}{P} \rightarrow \boxed{\Delta S = C_p^{ig} \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right)}$$

b) $T_1 = 298\,K$ $\quad P_1 = 1\,atm$

$T_2 = 400\,K$ $\quad P_2 = 10\,atm$

$$\Delta S = \frac{7}{2} R \ln\left(\frac{400}{298}\right) - R \ln\left(\frac{10}{1}\right) = \boxed{-10.6 \frac{J}{mol\,K}}$$