12.12 mass = 2kg

N_2 mf = 0.3

CO_2 mf = 0.4

O_2 mf = 0.3

Adiabatic compression from

①	②
$P_1 = 1\,bar$	$P_2 = 4\,bar$
$T_1 = 300K$	$T_2 = 500K$

(a) $W = ?$

$$\Delta E = Q - W$$

↳ no ΔKE or ΔPE, so $\Delta U = \cancel{Q} - W$ (adiabatic)

$$W = U_1 - U_2 \Rightarrow \frac{W}{m} = (u_1 - u_2)_{mix}$$

Assume all components are ideal gases.

From Table A-23 we get

N_2 $\bar{u}_1 = 6229\ \frac{kJ}{kmole}$ $\bar{u}_2 = 10423\ kJ/kmole$

$\bar{s}_1^\circ = 191.69\ \frac{kJ}{kmole \cdot K}$ $\bar{s}_2^\circ = 206.63\ kJ/kmole \cdot K$

CO_2 $\bar{u}_1 = 6939\ kJ/kmole$ $\bar{u}_2 = 13521\ kJ/kmole$

$\bar{s}_1^\circ = 213.92\ kJ/kmole \cdot K$ $\bar{s}_2^\circ = 234.8\ kJ/kmole \cdot K$

O_2 $\bar{u}_1 = 6242\ kJ/kmole$ $\bar{u}_2 = 10614\ kJ/kmole$

$\bar{s}_1^\circ = 205.21\ \frac{kJ}{kmole \cdot K}$ $\bar{s}_2^\circ = 220.59\ kJ/kmole \cdot K$

12.12 (continued)

$$(u_1 - u_2)_{mix} = \sum_i mf_i (u_1 - u_2)_i$$

$$= (0.3)\left(\frac{6229 - 10423 \text{ kJ/kmole}}{28.01 \text{ kg/kmole}}\right) + 0.4\left(\frac{6939 \text{ kJ/kmole} - 13521 \text{ kJ/kmole}}{44.0 \text{ kg/kmole}}\right) +$$

$$0.3\left(\frac{6242 \text{ kJ/kmole} - 10614 \text{ kJ/kmole}}{32 \text{ kg/kmole}}\right)$$

$$(u_1 - u_2)_{mix} = -145.7 \text{ kJ/kg}$$

$m = 2 \text{ kg}$ $\therefore$ $\boxed{W = -291.5 \text{ kJ}}$

(b) $\sigma = ?$ kJ/kg

Adiabatic

$$\Delta S = \int_1^2 \left(\frac{\delta Q}{T}\right)_b^{\nearrow 0} + \sigma \Longrightarrow \sigma = S_2 - S_1$$

$$\sigma = m(s_2 - s_1)_{mix} = m\left[\sum_i mf_i \left(s_i^\circ(T_2) - s_i^\circ(T_1) - \ln\left(\frac{P_{i2}}{P_{i1}}\right)\right)\right]$$

$$\bar{s}_2 - \bar{s}_1 = s^\circ(T_2) - s^\circ(T_1) - \bar{R}\ln\left(\frac{P_2}{P_1}\right)$$

$$(s_2 - s_1)_{mix} = 0.3\left[\frac{206.63 \frac{\text{kJ}}{\text{kmol}\cdot\text{K}} - 191.68 \text{ kJ/kmole}\cdot\text{K} - \left(8.314 \frac{\text{kJ}}{\text{kmole}\cdot\text{K}}\right)\ln\left(\frac{4 \text{ bar}}{1 \text{ bar}}\right)}{28.01 \text{ kg/kmole}}\right]$$

$$+ 0.4\left[\frac{234.9 \text{ kJ/kmole}\cdot\text{K} - 213.92 \text{ kJ/kmole}\cdot\text{K} - \left(8.314 \frac{\text{kJ}}{\text{kmole}\cdot\text{K}}\right)\ln\left(\frac{4}{1}\right)}{44.01 \text{ kg/kmole}}\right]$$

$$+ 0.3\left[\frac{220.59 \text{ kJ/kmole}\cdot\text{K} - 205.21 \text{ kJ/kmole}\cdot\text{K} - 8.314 \text{ kJ/kmole}\cdot\text{K} \ln\left(\frac{4}{1}\right)}{32 \text{ kg/kmole}}\right]$$

12.12 (continued)

$$(s_2 - s_1)_{mix} = 0.1578 \text{ kJ/kg}\cdot\text{K}$$

$$\therefore \boxed{\sigma = m(s_2 - s_1)_{mix} = 0.3157 \text{ kJ/K}}$$

Question: On the previous page I used the term $\Sigma \ln\left(\frac{4 \text{ bar}}{1 \text{ bar}}\right)$. Shouldn't I have used partial pressures in the numerator and denominator of the natural log term? What did I do? If you don't know, ask in class