Aufgabe 1

[redacted]

a) Energiebilanz stationär:

$$\cancel{0 = \dot{m}(h_e - h_a}$$

$$0 = \dot{m}_{ein} h_{ein} - \dot{m}_{aus} \cdot h_{aus} + \dot{Q}_{aus}$$

$$\Rightarrow \dot{Q}_{aus} = \dot{m}_{aus} h_{aus} - \dot{m}_{ein} h_{ein} \quad | \dot{m}_{ein} = \dot{m}_{aus}$$

$$= \dot{m}(h_{aus} - h_{ein})$$

$$\cancel{h_{ein}(T = 20°C)}$$

$$h^{if}_{aus} - h^{if}_{ein} = \int_{T_1}^{T_2} c^{if} \, dT + \cancel{v^{if}(p_2 - p_1)}$$

0, da isobar

$$=$$

b) $$\overline{T}_{KF} = \frac{\int_e^a T \, ds}{s_a - s_e}$$

$$= \frac{288.15 K + 298.15 K}{2} \approx \underline{\underline{293.15 K}}$$

c) Entropiebilanz stationär:

$$0 = \dot{m}(s_e - s_a) + \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = \dot{m}(s_a - s_e) - \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} - \cancel{\frac{\dot{Q}_R}{T_{Aus.}}}$$

$$s_a - s_e = \int_{T_1}^{T_2} c \cdot \frac{1}{T} \, dT = c \ln\left(\frac{T_2}{T_1}\right)$$

$$= c^{if} \ln\left(\frac{298.15}{288.15}\right)$$

d) $\frac{dE}{dt} = \dot{m}(h_1 - h_2) + \cancel{\sum \dot{Q}}^{0} - \cancel{\sum \dot{W}}^{0}$

$\Delta E = \Delta m_{12}(h_1 - h_2)$

$\Delta E = \Delta U = U_{12} = U_2 - U_1$

$\Rightarrow \Delta m_{12} = \frac{u_2 - u_1}{h_1 - h_2} = \frac{c(T_2 - T_1)}{c(T_1 - T_2)} = \neq 0$

e) $\frac{dS}{dt} = \dot{m}(s_1 - s_2) + \cancel{\sum \frac{\dot{Q}}{T}}^{0} + \cancel{\dot{S}_{erz}}^{0}$

$\Delta S_{12} = \Delta m_{12}(s_1 - s_2) + \frac{\dot{Q}}{T} + \dot{S}_{erz}$

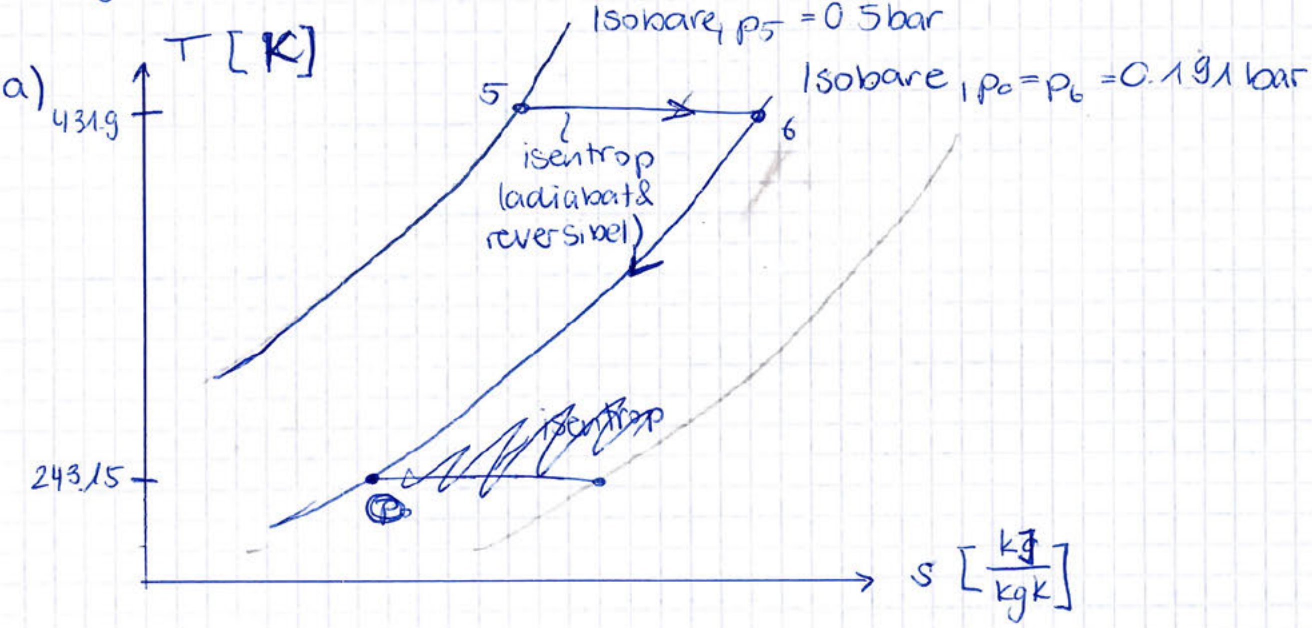
$= \Delta m_{12}(s_1 - s_2)$

$s_1 - s_2 = \int_{T_2}^{T_1} \frac{c}{T}\, dT = c \ln\left(\frac{T_1}{T_2}\right)$

Aufgabe 2

[redacted]

a)



b) ~~Entropiebilanz stationär:~~

$\cancel{0 = \dot m (s_e - s_a) + \sum \frac{\dot Q}{T} + \dot S_{erz}}$

$\cancel{\dot S_{erz} = 0}$, ~~da (adiabat &) reversibel~~

Energiebilanz stationär: zwischen 0, 6:

$$0 = \dot m \left(h_6 - h_0 + \frac{w_6^2 - w_0^2}{2} \right)$$

$$\Rightarrow \frac{w_6^2 - w_0^2}{2} = h_0 - h_6$$

$$\Rightarrow w_6 = \sqrt{2(h_0 - h_6) + w_1^2}$$

$$h_0 - h_6 = \int_{T_6}^{T_0} c_p \, dT = c_p (T_0 - T_6) = 1.006 \frac{kJ}{kgK} \left((-30 + 273.15)K - 293.91 K \right) \approx -50.76 \frac{kJ}{kg}$$

$$\Rightarrow w_6 = \sqrt{2(-50.75) + 200^2} \approx \underline{\underline{200.25 \frac{m}{s}}}$$

$$T_6 = T_5 \left(\frac{p_6}{p_5} \right)^{\frac{k-1}{k}} = 431.9 K \left(\frac{0.191}{0.5} \right)^{\frac{1.4-1}{1.4}} \quad | \, p_6 = p_0$$

$$\approx \underline{\underline{293.91 K}}$$

c) ~~$\Delta e_{x,str}$ = ... $\dot{m}$~~

$$+\Delta e_{x,str} = h_6 - h_0 - T_0 (s_6 - s_0) + \Delta ke$$

$$= -\left(h_0 - h_6 - T_0(\cancel{s_0 - s_6}^{\,0}) + \frac{w_0^2 - w_6^2}{2}\right)$$

gegeben aus Aufgabe

$$h_0 - h_6 = c_p (T_0 - T_6) = 1.006 \frac{kJ}{kgK} (243.15K - 340K)$$

$$T_0 = -30 + 273.15 = 243.15K$$

$$h_0 - h_6 \approx -97.43 \frac{kJ}{kg}$$

$s_0 - s_6 = 0$, da adiabat & reversibel

$$\Rightarrow \Delta e_{x,str} = -\left(h_0 - h_6 + \frac{w_0^2 - w_6^2}{2}\right)$$

$$= -\left(-97.43 \frac{kJ}{kg} + \frac{200^2 \frac{m^2}{s^2} - 510^2 \frac{m^2}{s^2}}{2}\right)$$

$$\approx \cancel{-97.43 \cdot 10^3 \frac{J}{kg}}$$

$$= \left(-97.43 \frac{kJ}{kg} + \frac{200^2 \frac{N \frac{J}{m}}{kgm} - 510^2 \frac{J}{kg}}{2}\right)$$

$$\approx +207.48 \frac{kJ}{kg}$$

d) ~~$0 = -\Delta e_{x,str} + \sum (1 - \frac{T_0}{T}) \dot{Q}_j - \sum \dot{W}_{t,in} - \dot{E}_{x,verl}$~~

~~$e_{x,verl} = T_0 s_{erz}$~~

~~$s_{erz} = 0$, da Flug~~

0, da adiabat & reversibel

0, da

$$0 = -\Delta e_{x,str} + \cancel{\sum \left(1 - \frac{T_0}{T}\right) \dot{Q}} - \cancel{\sum \dot{W}_{t,in}} - \dot{e}_{x,verl}$$

$$\dot{e}_{x,verl} = -\Delta e_{x,str}$$

$$= -207.48 \frac{kJ}{kg}$$

Aufgabe 3 [redacted]

a) $p_{g,1} = p_{amb} + (m_K + m_{EW}) \cdot g \cdot \frac{1}{A}$

$= 1 \cdot 10^5 \frac{Pa}{\cancel{bar}} + \frac{(m_K + m_{EW}) g}{A}$

$A = \cancel{0.05}\ r^2 \pi [m] = 0.05^2 \pi \approx 0.0079\ m^2$

$p_{g,1} = 1 \cdot 10^5\ Pa + \frac{(32kg + 0.1kg) \cdot 9.81 \frac{m}{s^2}}{0.0079\ m^2}$

$\approx 140094\ Pa$

$\approx \underline{\underline{1.4\ bar}}$

$m_{g,1}$: $pV = mRT$

$\Rightarrow m_{g,1} = \frac{RT_{g,1}}{p_{g,1} V_{g,1}}$

$R = \frac{\bar{R}}{M_{g,1}} = \frac{8.314 \frac{kJ}{kmolK}}{50 \frac{kg}{kmol}} \approx 0.166 \frac{kJ}{kgK}$

$m_{g,1} = \frac{0.166 \frac{kJ}{kgK} \cdot (500 + 273.15) K}{1.4 \cdot 10^5\ Pa \cdot 3.14 \cdot 10^{-3}\ m^3}$

~~$\approx 0.2292\ kg$~~

$\approx \underline{\underline{2.92\ g}}$

b) $V_{g,2} = V_{g,1}$

$p_{g,2} = \frac{\cancel{V_{g,1}}\ mRT_{g,2}}{V_{g,1}}$

~~$p_{g,1}$~~ $p_{g,2} = p_{g,1} = \underline{\underline{1.4\ bar}}$

c) $\Delta U = Q_{12} - W_{12}$

$U_{12} = Q_{12} - W_{12,V}$

$\Rightarrow Q_{12} = U_{12} + W_{12,V}$

$U_{12} = m c_V (T_2 - T_1) = m\, 0.633 \frac{kJ}{kgK} (273.153K - 773.15K)$

$= -316.498 \frac{kJ}{kg} \cdot \overset{2.92g}{m_{g,1}} = -92{,}496\, J$

$W_{12,V} = m \int p\, dV = m \frac{R(T_2 - T_1)}{1-n}$

$n = \frac{c_p}{c_V} \approx 1.263 \quad ; \quad c_p = R + c_V = \frac{\bar{R}}{M} + c_V = 0.166 \frac{kJ}{kgK} + 0.633 \frac{kJ}{kgK} \approx 0.799 \frac{kJ}{kgK}$

$W_{12,V} = 0.00292 kg \cdot \frac{0.166 (273.153K - 773.15K)}{1 - 1.263}$

$\approx 92.496\, J$

$\Rightarrow Q_{12} = -92.496\, J + 92.496\, J = 0\, J$

d) $\cancel{x_{Eis,2} = \frac{u_2 - u_f}{u_g - u_f}}$

$x_{Eis,2} = \frac{m_{Eis,2}}{m_{EW,2}} = \frac{m_{Eis,2}}{m_{EW,1}} \qquad | \, m_{EW,1} = m_{EW,2}$

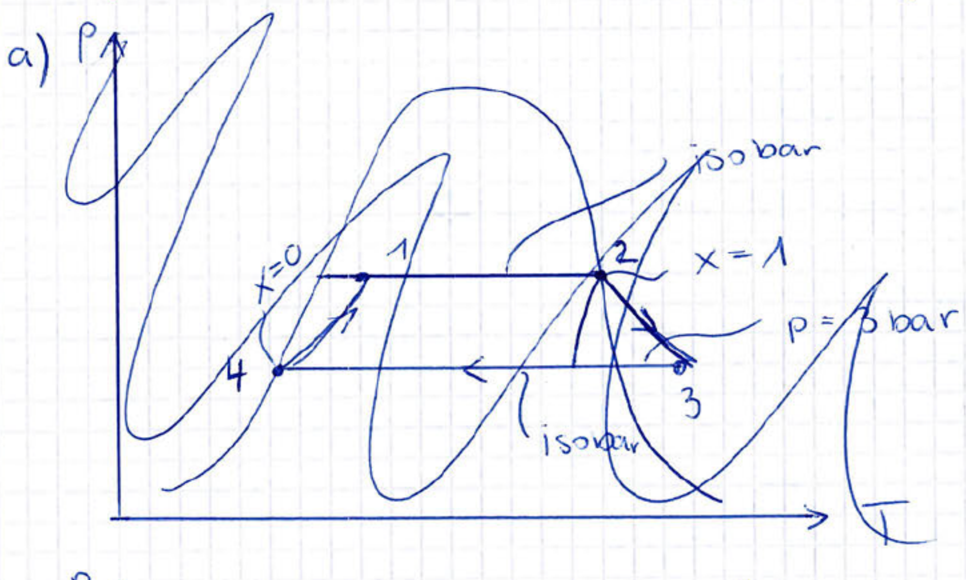
$= \frac{m_{Eis,2}}{0.1 kg}$

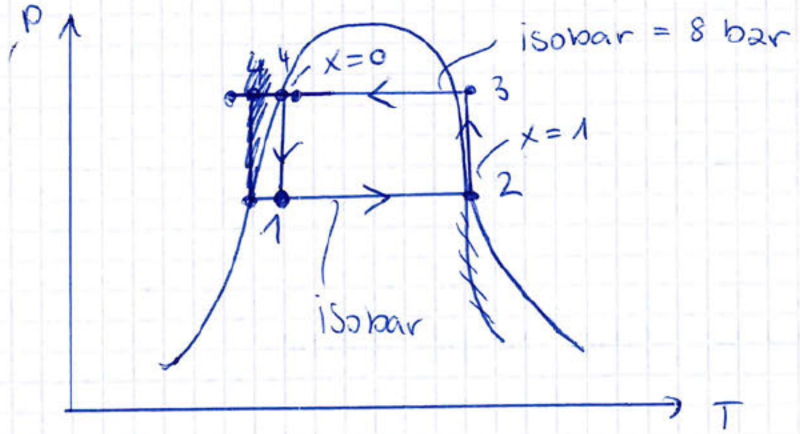
$m_{Eis,2}$:

[redacted]

Aufgabe 4

a)





b) $0 = \dot{m}_{R134a}(h_2 - h_3) - \dot{W}_K$

$\Rightarrow \dot{m}_{R134a} = \frac{\dot{W}_K}{h_2 - h_3}$

$h_2 = h_f + x(h_g - h_f) = h_f + h_{fg}$

TAB A-12: $h_3(p_3 = 8\ bar) =$

$T_3 = ?$

~~$h_2(T = -22°C) =$~~

~~h_f~~

TAB A-10: $h_2(T_2 = -22°C) = 21.77 + 212.32 = 234.09\ \frac{kJ}{kg}$

c) $h_1 = h_f + x_1(h_g - h_f)$

$$\Rightarrow x_1 = \frac{h_1 - h_f}{h_g - h_f}$$

$T_i = \cancel{10}\ 10 - 273.15 - 20 = -283.15\,°C$

TAB4- $h_1(T = -283.15\,°C)$

d) $$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{zu}|}{|\dot{Q}_{ab}| - |\dot{Q}_{zu}|}$$

$$\varepsilon_K = \frac{|\dot{Q}_K|}{|\dot{Q}_{ab}| - |\dot{Q}_K|}$$

e) die Temperatur würde immer mehr sinken