[redacted]

1a) $0 = \dot{m}(h_{ein} - h_{aus}) + \dot{Q}_R - \dot{Q}_{aus}$

$\dot{Q}_{aus} = \dot{m}(h_{ein} - h_{aus}) + \dot{Q}_R \qquad \dot{Q}_{aus} = -62.185\,kW$ //

$\dot{Q}_R = 100\,kW$

$\dot{m} = 0.3\,\frac{kg}{s}$

$h_{ein} = 292.96\,\frac{kJ}{kg}$

$h_{aus} = 419.04\,\frac{kJ}{kg}$

b) $\overline{T} = \frac{\int_e^a T\,ds}{s_e - s_a} = \frac{\cancel{c^{if}}(T_e - T_a)}{\cancel{c^{if}} \ln\left(\frac{T_e}{T_a}\right)} = 253.121\,K$ //

~~$T\,ds = \dot{q}_{rev}$~~

$T\,ds = dH = c^{if}(T_e - T_a) - v^{if}\overset{0}{\cancel{(p_e - p_a)}}$

c) $\dot{S}_{erz} = \dot{m}(s_a - s_e) - \frac{\dot{Q}_R}{\overline{\overline{T}}} + \frac{\dot{Q}_{aus}}{\overline{T}} = 4.3\,\frac{kW}{K}$ //

$s_e = 0.9546\,\frac{kJ}{kgK}$

$s_a = 1.3069\,\frac{kJ}{kgK}$

$\overline{\overline{T}} = 100\,°C = 373.15\,K$

d) Δm_{12}

$m_2 u_2 - m_1 u_1 = \Delta m_{12}(h_1) + \dot{Q}_{aus\,12}$

$m_2 = (m_1 + \Delta m_{12})$

[redacted]

$m_1 h_2 + \Delta m_{12} h_2 - \Delta m_{12} h_i = Q_{aus,12} + m_1 h_1$

$\Delta m_{12} (h_2 - h_i) = \dot{Q}_{aus,12} + m_1 h_1 - m_1 h_2$

$$\Delta m_{12} = \frac{\dot{Q}_{aus,12} + m_1 h_1 - m_1 h_2}{(h_2 - h_1)} = 3982.82\,kg \;//$$

$m_1 = 5755\,kg$

$h_1 = h_f + x_0 (h_g - h_f) = 437.4725\,\frac{kJ}{kg}$

$h_f = 418.94$

$h_g = 2506.5$

$h_2 = 292.95\,\frac{kJ}{kg}$

$h_i = 83.96\,\frac{kJ}{kg}$

e) ΔS_{12}

$\Delta S_{12} = m_2 s_2 - m_1 s_1 = 1603\,\frac{kJ}{K}$

$m_2 = \Delta m_{12} + m_1 = 9737.82\,kg$

$m_1 = 5755\,kg$

$s_2 = 0.9549\,\frac{kJ}{kgK}$

$s_1 = s_f + x(s_g - s_f) = 1.33714\,\frac{kJ}{kgK} \;//$

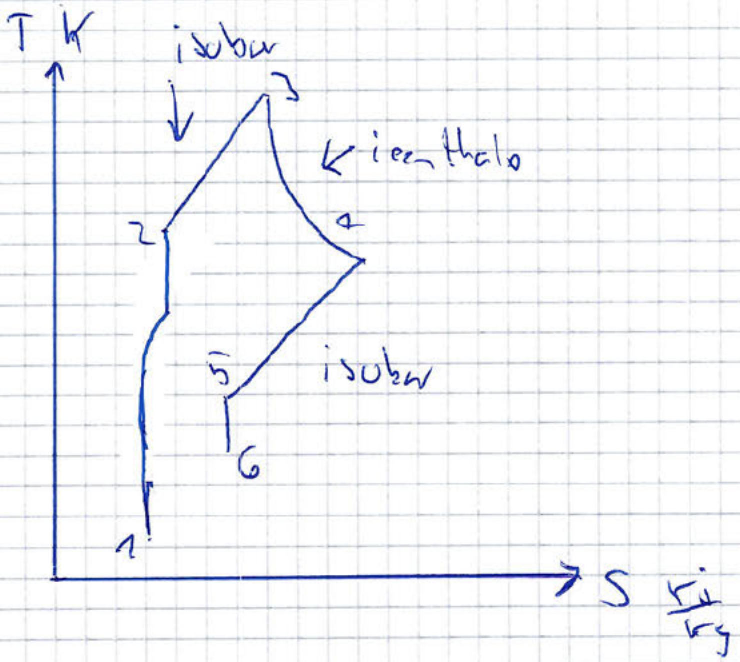
$s_f = 1.3069\,\frac{kJ}{kgK}$

$s_g = 7.3549\,\frac{kJ}{kgK}$

$x = 0.005$

[redacted]

2a)



b) v_6 T_6

$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 328.074\,K$ //

$T_5 = 431.9\,K$

$p_6 = 0.191\,bar$

$p_5 = 0.5\,bar$

$n = 1.4$

$q_B \cdot \dot{m}_K = \dot{Q}_B$

$0 = \dot{m}_K (h_2 - h_3) + q_B \cdot \dot{m}_K$

~~$\frac{-q_B}{(h_2 - h_3)} = \dot{m}_K$~~

~~$-q_b = 1195\,\frac{kJ}{kg}$~~

~~$(h_2 = h_3) = c_p(T_2 - T_3)$~~

[redacted]

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

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

$w_6 = \sqrt{2(h_0 - h_6) + w_0^2} = 199 \frac{m}{s}$

//

$w_6 = \sqrt{2\,c_p(T_0 - T_6) + w_0^2}$

$T_0 = -30°C$

$T_6 = 323.074\,K$

$c_p = 1.006 \frac{kJ}{kgK}$

c) $\Delta e_{xstr} = \left(h_0 - h_6 - T_0(s_0 - s_6) + \frac{w_0^2 - w_6^2}{2}\right)$,

$= \left(c_p(T_0 - T_6) - T_0\left(\ln\left(\frac{T_0}{T_6}\right) - \cancel{R\ln\left(\frac{p_0}{p_6}\right)}\right) + \frac{w_0^2 - w_6^2}{2}\right)$

$= 110.050 \frac{kJ}{kg}$

$w_6 = 770\, m/s$

$w_0 = 200\, m/s$

$T_0 = 243.15\,K$

d) $\dot{e}_{xverl} = T_0 \dot{S}_{erz}$

$= T_0(s_6 - s_0)$

$\dot{e}_{xverl} = T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right)\right) = 65.59 \frac{kJ}{kg}$

//

[redacted]

3a) $p_{g,1}$ m_g

$$\frac{F}{A} = p$$

$$\frac{m_K \cdot g + m_{EW} \cdot g}{A} + 100\,000 \, Pa = p_{g,1} = 140\,099 \, Pa \, //$$

$$= 1.4 \, bar \, //$$

$$A = \left(\frac{D}{2}\right)^2 \cdot \pi = 0.007853 \, m^2$$

$$\frac{pV}{RT} = m = 0.0034 \, kg = 3.419 \, g \, //$$

$p = 1.4 \, bar$

$V = 3.14 \, L$

$T = 500 \, °C$

$R = \frac{\bar{R}}{M}$ ~~$\frac{\frac{kJ}{kmol}}{\frac{kg}{kmol}}$~~ $\frac{kJ}{kg} =$

$M = 40 \, \frac{kg}{kmol}$

b) $x_{Eis,2} > 0$ $T_{g,2}$ $p_{g,2}$

[redacted]

c) Q_{12}

$E_2 - E_1 = Q_{12}$

$m(u_2 - u_1) = Q_{12}$

$m = 3.479 g$

$m(c_v(T_2 - T_1)) = Q_{12} = -1082.24 J$ //

$T_2 = 0.003°C$

$T_1 = 500°C$

d) $x_{Eis,2}$

1. Hauptsatz am EV

$E_2 - E_1 = + Q_{12}$

$m(u_2 - u_1) = Q_{12}$

$u_2 = \frac{Q_{12}}{m} + u_1 = -185.2704 \frac{kJ}{kg}$

$Q_{12} = 1082.24 J$

$m = 0.1 kg$

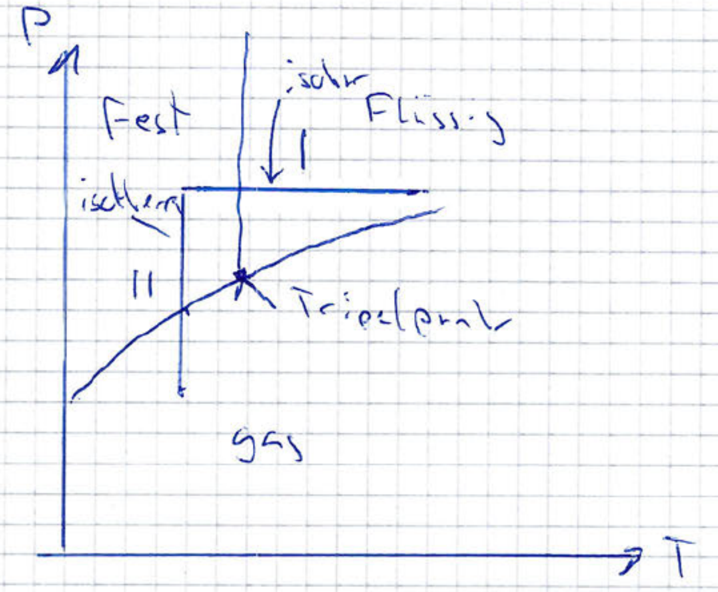
$u_1 = u_{flüssig} + x(u_{fest} - u_{flüssig}) = -200.0928 \frac{kJ}{kg}$ ✓

$u_{flü} = -0.045 \frac{kJ}{kg}$

$u_{fest} = -333.458 \frac{kJ}{kg}$

[redacted]

4a)



b) $\dot{m}_{R134a}$

	1	2	3	4
T		−6°C		37.332
p			8bar	8bar
h				

$T_2 = -6°C$

adiabar reversibel = isentrop

$s_2 = s_3 = 0.9273 + \left(\frac{-6+4}{-8+4}\right) 0.9239 - 0.9213 = 0.9226 \frac{kJ}{kgK}$

$\dot{m}(h_2 - h_3) + \dot{W}_t = 0$

$\dot{m} = \frac{-\dot{W}_t}{(h_2 - h_3} = 0.00110 \frac{kg}{s} = 3.973 \frac{kg}{h}$

$h_2 = 244.9 + \frac{-6+4}{-8+4}(242.54 - 244.90) = 243.72 \frac{kJ}{kg}$

$h_3 = ~~0.9066~~ + | ~~243.72~~ =$

$h_3 = 264.15 + \frac{0.9226 - 0.9066}{0.9374 - 0.9066}(273.66 - 264.15)$

$= 69.090 \frac{kJ}{kg}$

[redacted]

c) x_1

$p_1 = p_2$

$p_2 = 1.2192 \text{ bar} = p_1$

$p_2(-22°C) = 1.2192 \text{ bar}$

Drossel = isenthalp

$s_4 = s_1 = 0.3459 \frac{kJ}{kgK}$

$x = \frac{s_1 - s_f}{s_g - s_f} = 0.303$ //

$s_f = 0.0894$

$s_g = 0.9351$

d) $\varepsilon_K = \frac{\dot{Q}_{zu}}{\dot{W}_t} = 5.8313$ //

$\dot{W}_t = 28 kW$

$\dot{Q}_K = \dot{m}(h_2 - h_1) = 162.7 W = \dot{Q}_{zu}$

$\dot{m} = 0.00110 \frac{kg}{s}$

~~$h_1 = x_f + x(h_g - h_f)$~~

$h_1 = h_f + x(h_g - h_f) = 86.103 \frac{kJ}{kg}$ /

$h_f = 21.77 \frac{kJ}{kg}$

$h_g = 234.08 \frac{kJ}{kg}$

$h_2 = 234.08 \frac{kJ}{kg}$

e) Die Temperatur würde weiter sinken bis 0 Kelvin erreicht wird