[redacted]

1. a) Energiebilanz:

$$\dot{m}(h_e - h_a) + \dot{Q}_R - \dot{Q}_{aus} = 0 \qquad \text{Stationär}$$

$$\dot{Q}_{aus} = \dot{m}(h_e - h_a) + \dot{Q}_R$$

$$h_e = h_f(70°C) = 292.98 \frac{kJ}{kg}$$

$$h_a = h_f(100°C) = 419.04 \frac{kJ}{kg}$$

$$\Rightarrow \dot{Q}_{aus} = 0.3\,(h_e - h_a) + 100\,kW = 62.182\,kW$$

Vorzeichen nach Skizze.

b) $T\,dS = \delta Q$

2. HS

$$\bar{T}(s_2 - s_1) = q_{12}$$

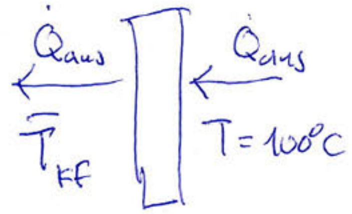
$$q_{12} = h_2 - h_1 \qquad \text{da isobar} \qquad 1.\,HS$$

$$\bar{T} = \frac{h_2 - h_1}{s_2 - s_1}$$

$$\left.\begin{aligned} h_2 - h_1 &= c^{if}(T_2 - T_1) \\ s_2 - s_1 &= c^{if} \ln\left(\frac{T_2}{T_1}\right) \end{aligned}\right\} \Rightarrow \bar{T} = \frac{T_2 - T_1}{\ln\left(\frac{T_2}{T_1}\right)} = 293.1216\,K$$

[redacted]

1.c)



Wand als ~~[illegible]~~ Systemgrenze

Entropiebilanz:

$$\frac{\dot{Q}_{aus}}{T_{reaktor}} - \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} + \dot{S}_{erz} = 0$$

$$\dot{S}_{erz} = \dot{Q}_{aus}\left(\frac{1}{\overline{T}_{KF}} - \frac{1}{T_{reaktor}}\right)$$

$$= 4.5496 \cdot 10^{-2}\,\frac{kW}{K} = 45.496\,\frac{W}{K}$$

d) $T_2 = 70°C$

Energiebilanz:

$$\cancel{\frac{dE}{dt}}\ \Delta E = \Delta m_{12} \cdot h_{ein} + \cancel{Q_{aus} + Q_R}^{0} - \cancel{W}^{0}$$

m_2 ~ $m_1 u_1$

$$(m_1 + \Delta m_{12})\,u_2 - m_1 u_1 = \Delta m_{12} h_e$$

$$m_1 u_2 - m_1 u_1 = \Delta m_{12}(h_e - u_2)$$

$$\frac{m_1(u_2 - u_1)}{h_e - u_2} = \Delta m_{12}$$

1.d) Fortsetzung [redacted]

TAB A2

$$u_1 = u_f + x(u_g - u_f) = 418.94 + 0.005(2506.5 - 418.94)$$

$$= 429.3778 \frac{kJ}{kg}$$

$$u_2 = u_f(70°C) = 292.95 \frac{kJ}{kg}$$

$$h_e = h_f(20°C) = 83.96 \frac{kJ}{kg}$$

$$\Rightarrow \Delta m_{12} = 3756.84 kg$$

e) $\Delta S_{12} = (m_1 + \Delta m_{12}) \cdot s_2 - m_1 s_1$

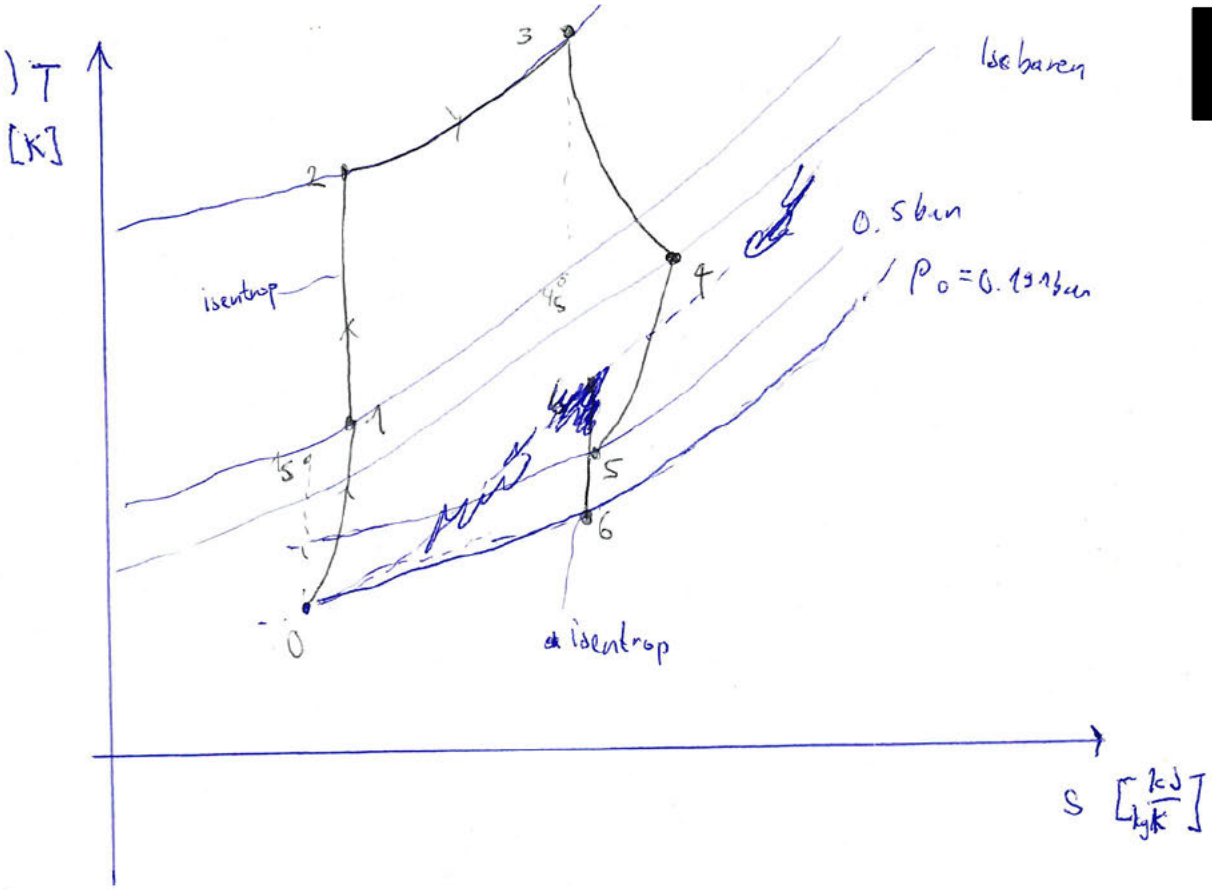
$$s_1 = 1.3069 \frac{kJ}{kgK}$$

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

$$\Rightarrow \Delta S_{12} = 1561.65 \frac{kJ}{K}$$

[redacted]

2.a)



$p_2 = p_3$

b) Energiebilanz:

$\dot{m}_{ges} \left(h_5 - h_6 + ke_5 - ke_6 \right) = 0$

~~Entropiebilanz für reversiblen Fall:~~

Polytropenkoeffizient

$\cancel{s_5 - s_6 = 0}$

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \Leftrightarrow T_6 = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} T_5 = 328.0747 \text{ K}$$

$$h_5 - h_6 + \frac{1}{2} w_5^2 - \frac{1}{2} w_6^2 = 0$$

$$w_6 = \sqrt{2(h_5 - h_6) + w_5^2} = \sqrt{2\, c_p (T_5 - T_6) + w_5^2} = \sqrt{2 \cdot 1.006 \cdot (103.8) \cdot 1000 + 220^2}$$

$= 507.24$ m/s

[redacted]

2c) $\Delta e_{x,str} = h_a - h_e - T_0(s_a - s_e) + \Delta ke$

$$h_a - h_e = c_p(T_6 - T_0) = 85.\cancel{\ldots}4342 \frac{kJ}{kg}$$

$$T_0(s_a - s_e) \overset{p_0=p_6}{=} T_0 c_p \ln\left(\frac{T_6}{T_0}\right) = \cancel{\ldots} \; 73.2757 \frac{kJ}{kg}$$

$$\Delta ke = \frac{1}{2}(w_6^2 - w_0^2) = 108.648 \frac{kJ}{kg}$$

$$\Delta e_{x,str} = 267.358 \frac{kJ}{kg}$$

d) Exergiebilanz

$$0 = -e_{x,str} + \frac{1}{\dot m_{ges}}\left(1 - \frac{T_0}{T_B}\right)\dot Q_B - \cancel{\ldots}\, e_{x,verl}$$

$$e_{x,verl} = -e_{x,str} + \left(1 - \frac{T_0}{T_B}\right) q_B$$

$$= -267.358 + \left(1 - \frac{273.15 - 30}{1289}\right) 1195$$

$$= 702.223 \frac{kJ}{kg}$$

[redacted]

3.a) $R_g = \frac{\overline{R}}{M_g} = 166.289 \frac{J}{kg\,K}$

$A = \pi \left(\frac{D}{2}\right)^2 = \frac{\pi D^2}{4} = 78.5398\ cm^2 = 78.5398 \cdot 10^{-4} m^2$

Kräftegleichgewicht

$(m_{EW} + m_K) g + p_0 \cdot A = p_{g,1} \cdot A$

$\frac{(m_{EW} + m_K) g}{A} + p_0 = p_{g,1} \Rightarrow \frac{32.1 \cdot 9.81}{A} + 1 bar = 1.40094 bar$

Ideales Gasgesetz:

$p_{g,1} V_{g,1} = m_g R T_{g,1}$

$\frac{p_{g,1} V_{g,1}}{R \cdot T_{g,1}} = m_g = 3.4215 g$

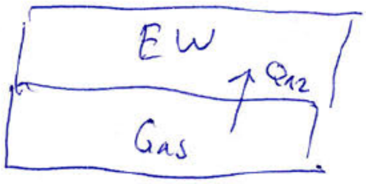
b) $T_{g,2} = T_{EW,1} = 0°C$ Es herrscht thermisches Gleichgewicht in Zustand 2.

$p_{g,1} = p_{g,2} = 1.40094 bar$ Es herrscht weiterhin Kräftegleichgewicht

3.c) Perfektes Gas + Isobar: [redacted]

$m(h_2 - h_1) = Q_{12}$

Systemgrenze Gas



$m(c_v + R)\,\underbrace{(T_2 - T_1)}^{-500\,K} = Q_{12}$

$Q_{12} = -1.367\ kJ$

d) $m_{EW}(u_2 - u_1) = Q_{12}$

$u_1 = u_f(0°C) + x\,(u_s(0°C) - u_f(0°C))$

$= -0.045 + 0.6\,(-333.458 + 0.045) = -200.0928\ kJ$

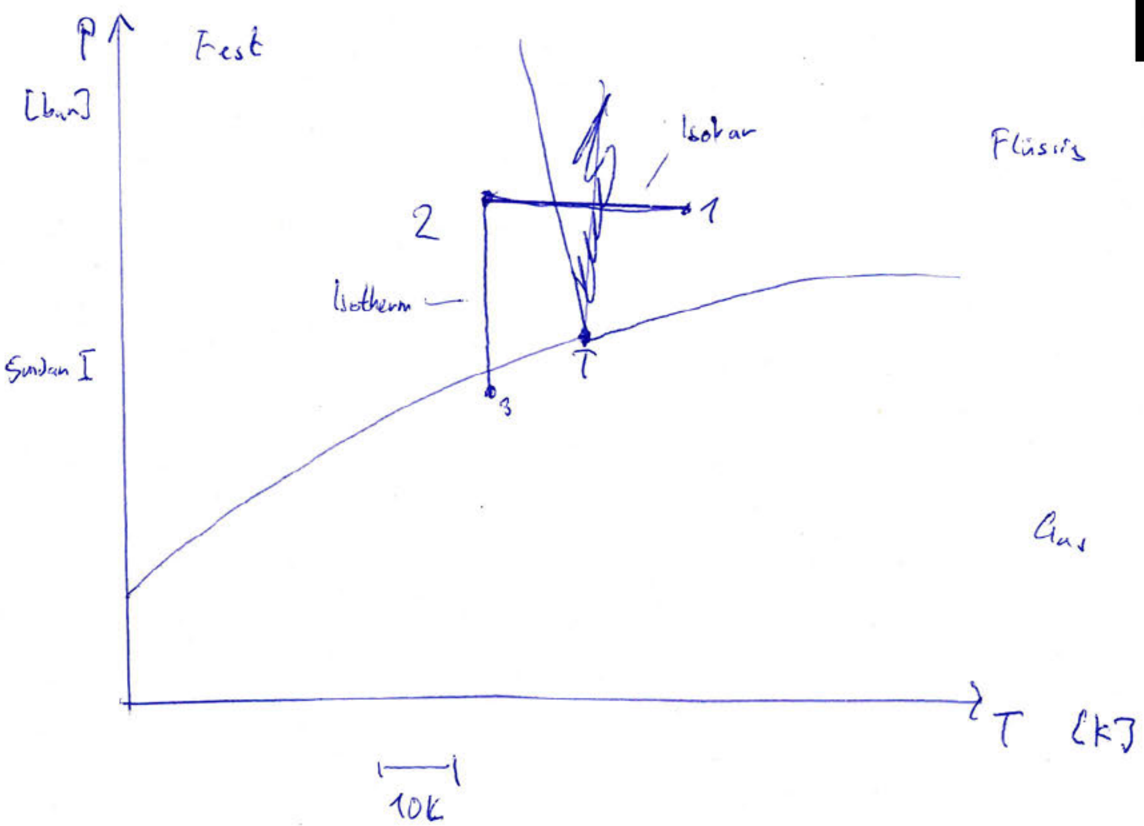
$u_2 = \frac{Q_{12}}{m_{EW}} + u_1 = -186.418\ \frac{kJ}{kg}$

$u_2 = u_f + x_2(u_s - u_f)$

$\frac{u_2 - u_f}{u_s - u_f} = x_2 = \frac{-186.418 + 0.045}{-333.458 + 0.045} = 0.559$

[redacted]

4.a)



TAB A-11

b) $p_3 = p_4$ $\quad T_4 = 31.33\,°C$

$p_1 = p_2$ $\quad h_4 =$

Drossel isenthalp:

$h_1 = h_4 = h_f(8\,\text{bar}) = 93.42\,\frac{kJ}{kg}$

$T_2 = T_1$

[redacted]

4. e) Es ~~w~~ würde irgendwann ein thermisches Gleichgewicht eintreffen und der ~~Kühl~~ Innenraum die Temperatur im Kondensator einnehmen

c) $T_2 = -22°C$

$\cancel{\dot{m}(h_2 - h_1) + \dot{Q}_K = 0}$

$T_2 = T_1$

~~in~~ $h_4 = h_1$

$h_1 = h_f(-22°C) + x\, h_{fg}(-22°C)$

$$\frac{h_1 - h_f}{h_{fg}} = x_1 = \frac{93.42 - 21.77}{212.32} = 0.3374$$

d) $\varepsilon_K = \dfrac{\dot{Q}_K}{\dot{W}_K} = 17.9.155$

$\dot{Q}_K = \dot{m}_{R134a}(h_2 - h_1)$

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

$\dot{Q}_K = 0.1562\, kW$