Aufgabe 1

a) $0 = \dot{m}(h_1 - h_2) + \dot{Q}_R - \dot{Q}_{aus} - \dot{W}_t$

h_2, h_1: TAB A2 siedende Flüssigkeit $h_F(70°C) = 292.98 \frac{kJ}{kg} = h_1$

$h_f(100°C) = 419.09 \frac{kJ}{kg} = h_2$

$\dot{W}_t^{zu} = -\int_1^2 \dot{V}\, dp \cdot \dot{m}$ $\quad V = \frac{v_f(100°C) + v_f(70°C)}{2} = 1.03315 \frac{m^3}{kg}$

$= -1.03315 (p_2 - p_1) \cdot \dot{m} = -0.2153 \frac{m^3 bar}{s} \frac{100 kPa}{1 bar} = -21.513 kW$

$\dot{Q}_{aus} = \dot{m}(h_1 - h_2) + \dot{Q}_R - \dot{W}_t = 83.68 kW$

b) $p_{aus} = p_{ein} \rightarrow$ [redacted] $\Rightarrow$ reversibel $\Rightarrow \dot{S}_{erz} = 0$

$0 = \dot{m}(s_1 - s_2) + \frac{\dot{Q}_{aus}}{\bar{T}} \Rightarrow \bar{T} = \frac{1}{\dot{m}(s_2 - s_1)} \cdot \dot{Q}_{aus}$

$0 = \dot{m}_{KF}(h_{KF1} - h_{KF2}) + \dot{Q}_{aus}$

$\frac{-\dot{Q}_{aus}}{(h_{KF1} - h_{KF2})} = \dot{m}_{KF} = \frac{-\dot{Q}_{aus}}{c_{if}(T_1 - T_2)}$

$\bar{T} = \frac{1}{\frac{-\dot{Q}_{aus}}{c_{if}(T_1 - T_2)} c_{if} \ln\left(\frac{T_2}{T_1}\right) \cdot \dot{Q}_{aus}} = \frac{(T_1 - T_2)}{\ln\left(\frac{T_2}{T_1}\right)} \Rightarrow 293.12 K$

c) $0 = \frac{\dot{Q}_{aus}}{T_{Reaktor}} - \frac{\dot{Q}_{aus}}{T_{KF}} + \dot{S}_{erz}$ → Entropiebilanz um Wand

$\dot{S}_{erz} = \frac{\dot{Q}_{aus}}{T_{KF}} - \frac{\dot{Q}_{aus}}{T_{Reaktor}} = \frac{654 W}{295 K} - \frac{654 W}{373.15 K} = 0.0046.15 \frac{kW}{K}$

↳ Resultate aus Prüfung benutzt

d) $M_2 u_2 - M_1 u_1 = \Delta M_{12} [h_\Delta] + \cancel{Q_{ab} - Q_{aus}} - \cancel{W}$

$M_2 = M_1 + \Delta M_{12}$

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

$u_2 = u_f(70°C) = 292.98 \frac{kJ}{kg}$

$u_1 = u_f(100°C) + x_0 \left(u_g(100°C) \mp u_f(100°C)\right) = 429.3778 \frac{kJ}{kg}$

$M_1 = 5755\,kg$

$(M_1 + \Delta M_{12}) u_2 - M_1 (u_1) = \Delta M_{12} h_\Delta$

$\frac{u_2 M_1 - M_1 u_1}{h_\Delta - u_2} = \Delta M_{12} = 3756.84\,kg$

e) $M_2 s_2 - M_1 s_1 = \Delta M_{12} s_\Delta + \frac{Q_{ab}}{\bar{T}_{ein}} - \frac{Q_{ab}}{\bar{T}_{aus}} + S_{erz}$

$s_2 = s_f(70°C) = 0.9549 \frac{kJ}{kg\,K}$

$s_1 = s_f(100°C) + x_0 \left(s_g(100°C) - s_f(100°C)\right) = 1.337714 \frac{kJ}{kg\,K}$

$s_\Delta = s_f(20°C) = 0.296 \frac{kJ}{kg\,K}$

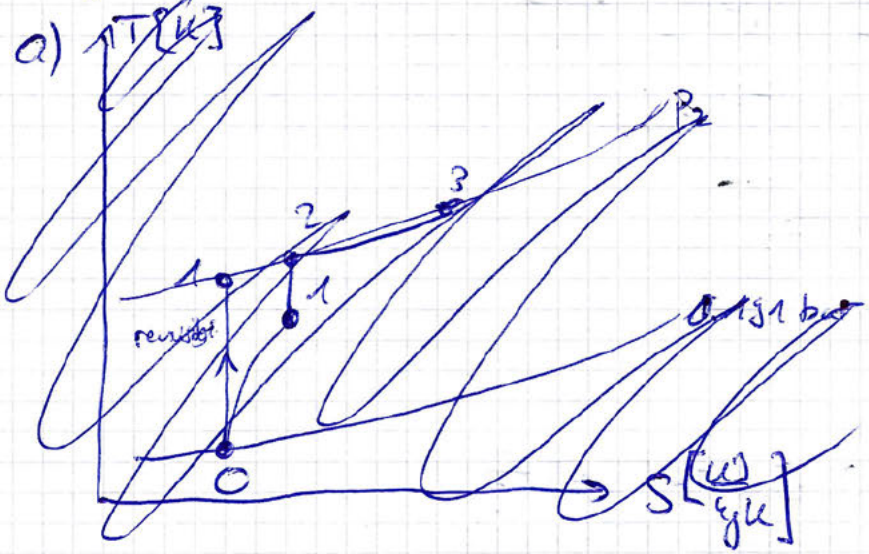
$\bar{T}_{ein} = \frac{q_{rev}}{s_a - s_e} = \frac{q_{rev}}{s_2 - s_1} = \frac{Q_{ab}}{s_2 - s_1} = \frac{35\cancel{45}000\,\cancel{kJ}}{(0.954 - 1.337714)\cancel{kJ}} \cdot$

$\bar{T}_{aus} = 298\,K$ (from b))

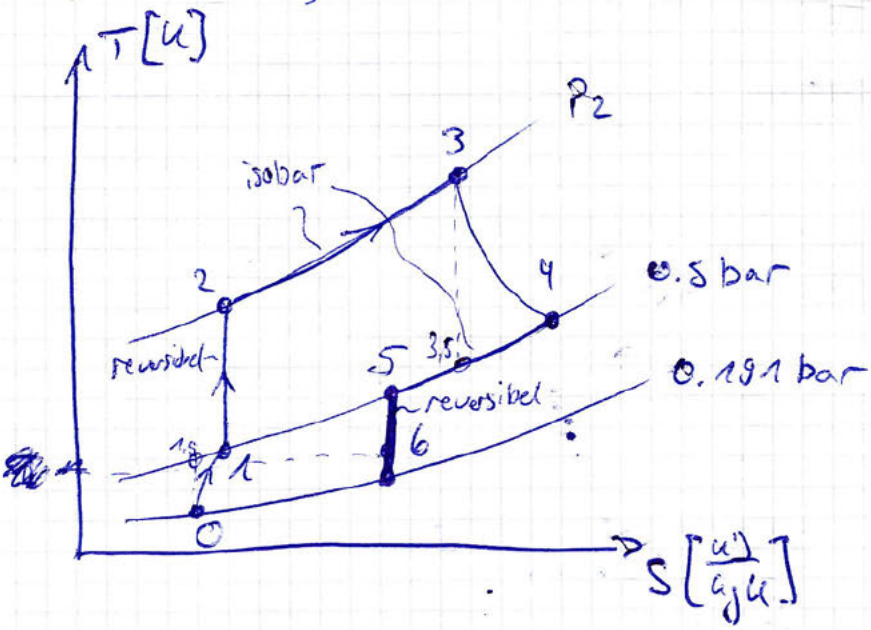
$S_{erz} = M_1 s_1 - M_2 s_2 - \Delta M_{12} s_\Delta - \frac{Q_{ab}}{\bar{T}_{ein}} + \frac{Q_{ab}}{\bar{T}_{aus}}$

Aufgabe 2

a)



Z	p	T
0	0.191 bar	-30°C
1		
2	p_2	
3	p_2	
4		
5	0.5 bar	431.9 K
6	0.191 bar	



b) $w_5 = 220 \frac{m}{s}$ $p_5 = 0.5\,bar$ $T_5 = 431.9\,K$
$p_6 = 0.191\,bar$

$0 = \dot{m}_{ges}\left(h_5 - h_6 + \frac{w_5^2}{2} - \frac{w_6^2}{2}\right) - W^{rev}$

$s_5 = s_6$ weil isentrop

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

$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 328.075\,K$

$$0 = \dot{m}_{ges}\, c_p\, \gamma\, (T_5 - T_6) + \dot{m}_{ges}\frac{w_5^2}{2} - \dot{m}_{ges}\frac{w_6^2}{2}$$

$$w_{rev} = \int_{V_1}^{V_2} p\,dV = \frac{R(T_2 - T_1)}{1-n} = 74.606$$

$$R = c_p - c_v = c_p - \frac{c_p}{n} = 0.2874\ \frac{kJ}{kg\,K}$$

$$c_v = c_p/n$$

$$w_6 = \sqrt{2\left(c_p(T_5 - T_6) + \frac{w_5^2}{2}\right)} = 507.2434\ \frac{m}{s}$$

c) $e_{xstr_6} - e_{xstr_0} = h_6 - h_0 - T_0(S_6 - S_0) + u_{e_6} - u_{e_0}$

$$= c_p\,\gamma\,(T_6 - T_0) - T_0\left(c_p\,\gamma\left(\ln\left(\frac{T_6}{T_0}\right)\right) - R\ln\left(\frac{p_6}{p_0}\right)\right) + u_{e_6} - u_{e_0}$$

$$= -26405.586\ \frac{kJ}{kg} = -26.406\ \frac{MJ}{kg}$$

d) $0 = -\Delta e_{xstr} + \dot{E}_a - \dot{\Phi}_t - \dot{e}_{vul}$

$$\dot{e}_{vul} = -\Delta e_{xstr} = -100\ \frac{kJ}{kg}$$

Aufgabe 3

a) $p_{g1} V_{g1} = m_{g1} R T_{g1}$

$p_{g1} = 1\,bar + \frac{M_{EW} g}{A} + \frac{M_K g}{A} = 100000\,Pa + \frac{0.14\,kg \cdot 9.81\,\frac{m}{s^2}}{\frac{25\pi}{100^2}\,m^2} + \frac{824\,kg \cdot 9.81\,\frac{m}{s^2}}{\frac{25\pi \cdot m^2 s^2}{100^2}}$

$A = 5^2\,cm^2 \cdot \pi = 25\pi\,cm^2$

$p_{g1} = 1.400934\,bar$

$m_{g1} = \frac{p_{g1} V_{g1}}{R T_{g1}} = 0.0039226\,kg$

$R = \frac{\overline{R}}{M}$

$V_{g1} = 3.14\,L \cdot \frac{m^3}{1000\,L}$

b) $p_{g2} = p_{g1} = 1.400934\,bar$ Es hat sich nichts am Ausgangsdruck oder den Massen geändert

$T_{g2} = \frac{p_{g2} V_{g2}}{R m_{g2}}$, $m_{g2} = m_{g1}$ $T_{g2} = T_{EW2}$ → Gleichgewicht

c)

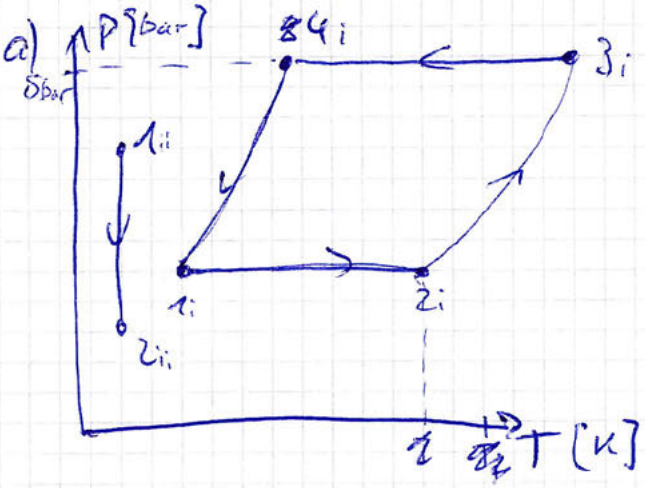
$\Delta U = 0 = c_v [T_{2g} - T_{1g}] +$

c) $Q_{12} = W_{12}$

d) $U_2 = U_{fest} + x_{Zeis} \left(U_{Fassung} - U_{Fest} \right)$

Aufgabe 4

a)



b) $T_1 = -20°C \qquad s_2 = s_3$

↳ $T_2 = -26°C$

$$0 = \dot{m}(h_2 - h_3) + \dot{Q}^{0} - \dot{W}_4 \qquad (\dot{W}_4 = -28W)$$

TAB A-10

$h_2 = h_g(-26°C) = 231.62 \frac{kJ}{kg}$

$s_2 = s_g(-26°C) = 0.9390 \frac{kJ}{kgK}$

$s_3 = s_2 \rightarrow h_3$ interpolieren in TAB-A12 8bar

$$h_3 = \frac{h(0.9711) - h(0.9374)}{0.9711 - 0.9374}(0.9390 - 0.9374) + h_1(0.9374)$$

$$= 274.169 \frac{kJ}{kg}$$

$$\frac{\dot{W}_4}{(h_2 - h_3)} = \dot{m} = \frac{-28\frac{J}{s} \cdot \frac{1kJ}{1000J}}{(231.64\frac{kJ}{kg} - 274.169\frac{kJ}{kg})} = 0.6584\frac{g}{s}$$

d) $\frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \varepsilon_4 \qquad W_t = 28W \qquad \dot{Q}_{zu} = \dot{Q}_4$

$0 = \dot{m}(h_1 - h_2) + \dot{Q}_4 \qquad \dot{Q}_4 = \dot{m}(h_2 - h_1) = 0.6584\frac{g}{s} \cdot \frac{kg}{1000g} \cdot (231.62 - 93.42)\frac{kJ}{kg}$ (TAB A11)

$\dot{Q}_4 = 0.09094kW$

$0 = \dot{m}(h_4 - h_1) \rightarrow h_4 = h_1 \qquad p_3 = p_4 = 8bar \qquad h_4 = h_f(8bar) = 93.42\frac{kJ}{kg}$

$\varepsilon_4 = \frac{0.09094kW}{0.028kW} = 3.2496$

c) $h_1 = 93.42 \frac{kJ}{kg}$ (aus d))

~~[illegible]~~

e) $T_i = 10°C$

→ Die Temperatur würde fallen, da der Prozess nicht mehr isotherm ~~[illegible]~~ wäre