Aufgabe 1

a) $\dot{Q}_{aus}$

Bilanz: $0 = \dot{m}_{ein} h_{ein} - \dot{m}_{aus} h_{aus} + \dot{Q}_{aus} + \dot{Q}_R$

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

~~$h_{ein} = h_f(\quad) \quad h_{aus} =$~~

$h_{ein} = h_f(70°C) + v^{if}(p - p_{sat})$

$h_{aus} = h_f(100°C) + v^{if}(p - p_{sat})$

$\Rightarrow \dot{Q}_{aus} =$

b) $\overline{T}_{UF}$

$\overline{T} = \frac{\int T ds}{s_{aus} - s_{ein}} = \frac{h_{aus} - h_{ein}}{s_{aus} - s_{ein}} =$

$\int_e^a T\,ds = q_{rev} \Rightarrow$ Bilanz: $q_{rev} = h_{aus} - h_{ein}$

$s_{aus} = s_f(298.15K) \qquad s_{ein} = s_f(288.15K)$

c) $\dot{S}_{erz}$

Entropie-Bilanz: $\dot{S}_{erz} = \dot{m}_{aus} s_{aus} - \dot{m}_{ein} s_{ein} \pm \frac{\dot{Q}_R}{\overline{T}_{UF}} \pm \frac{\dot{Q}_{aus}}{\overline{T}_{UF}}$

$\dot{S}_{erz} =$

d) Δm_{12}, $T_{R,2} = 70°C$

Bilanz halboffenes System:

$m_2 v_2 - m_1 v_1 = \Delta m_{12} h_{12} + Q_{12} - \cancel{W_{12}}^{\,0}$ $\qquad m_2 = m_1 + \Delta m_{12}$

$(m_1 + \Delta m_{12}) v_2 - \Delta m_{12}(h_2 - h_1) = m_1 v_1 + Q_{12}$ $\qquad h_{12} = h_2 - h_1$

$\Delta m_{12} (v_2 - h_2 + h_1) = m_1 v_1 + Q_{12} - m_1 v_2 = m_1 (v_1 - v_2) + Q_{12}$

$\Delta m_{12} = \frac{m_1 (v_1 - v_2)}{v_2 - h_2 + h_1} + \frac{Q_{12}}{v_2 - h_2 + h_1}$

$h_2 = h_f(70°C)$

$h_1 = h_f(100°C)$

e) ΔS_{12}

Entropie-Bilanz halboffenes System:

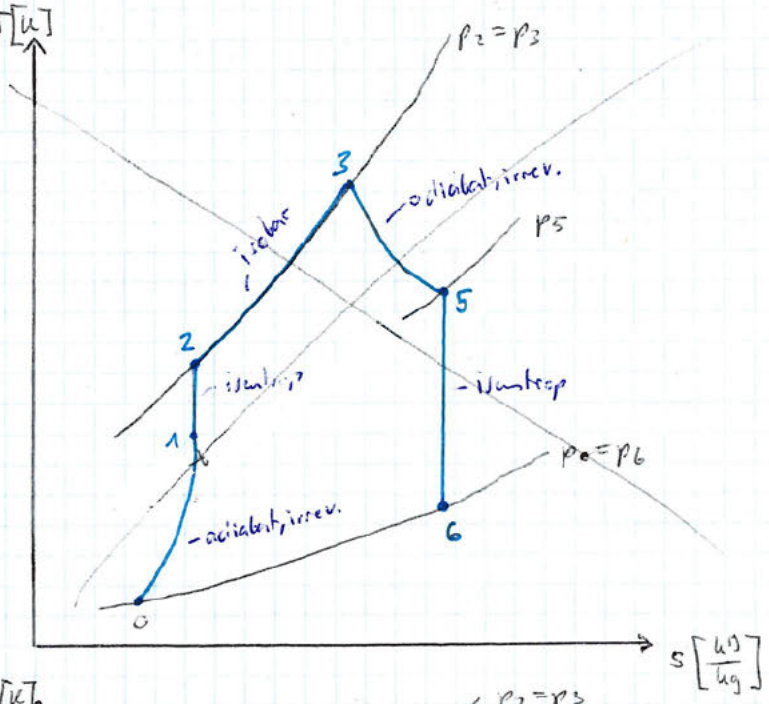
$\Delta S_{12} = m_2 s_2 - m_1 s_1$ $\qquad m_2 = m_1 + \Delta m_{12}$

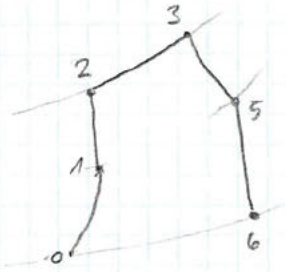
$\Delta S_{12} = m_1 (s_2 - s_1) + \Delta m_{12} s_2$

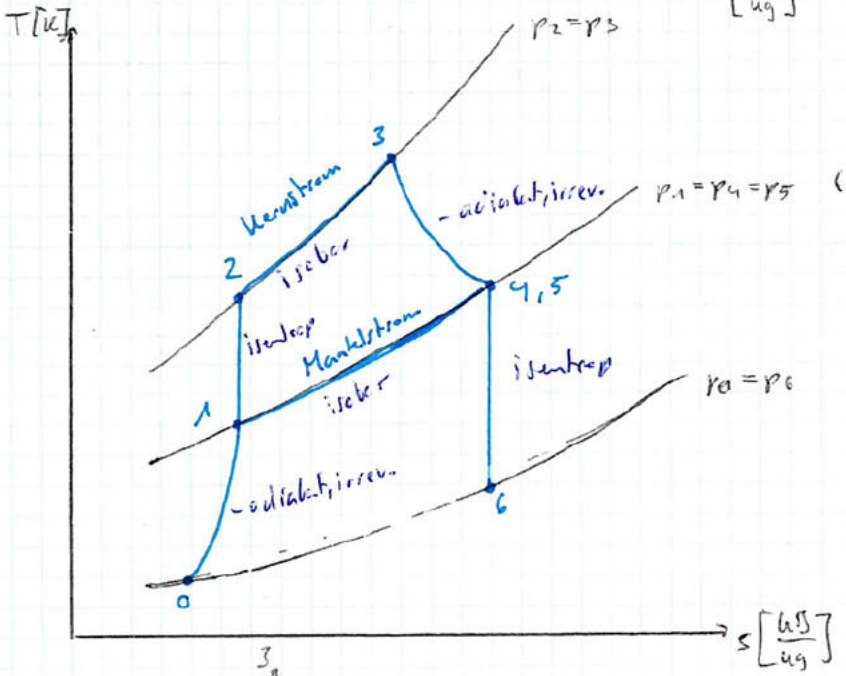
$=$

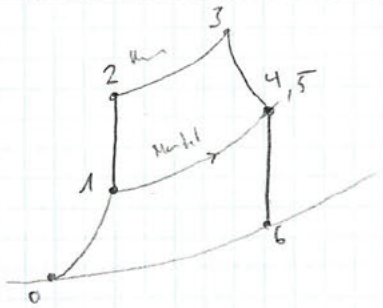
Aufgabe 2

a) T[K]









b) w_6, T_6

Bilanz Schaufelrad: $0 = \dot{m}_{ges}\left(h_5 - h_6 + \frac{1}{2}\left(w_5^2 - w_6^2\right)\right) + \cancel{\dot{Q}}^{0} - \cancel{W}^{0}$

$\frac{1}{2}\left(w_5^2 - w_6^2\right) = \underbrace{h_6 - h_5}_{c_p(T_6 - T_5)}$

$\Rightarrow w_6^2 = \underbrace{2(h_5 - h_6)}_{c_p(T_5 - T_6)} - w_5^2$

$\longrightarrow w_6 = \sqrt{2 c_p (T_5 - T_6) - w_5^2}$

$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}} = 431.9\,\mathrm{K}\left(\frac{0.19\,\mathrm{bar}}{0.5\,\mathrm{bar}}\right)^{\frac{1.4-1}{1.4}}$

c) ~~$e_{x,str,60} = (e_{x,str,01} + e_{x,str,M_m} + e_{x,str,14u} + e_{x,str,56})$~~

$\dot{m}_{ges} = \dot{m}_M + \dot{m}_u \quad \dot{m}_M = 5.293\,\dot{m}_u \rightarrow \dot{m}_{ges} = 6.293\,\dot{m}_u$

$\dot{m}_u = \frac{1}{5.293}\dot{m}_M \Rightarrow \dot{m}_{ges} = \frac{6.293}{5.293}\dot{m}_M$

$\Rightarrow e_{x,str,60} = \cancel{h_1} - h_6 - T_0(s_1 - s_0) + \frac{\cancel{w_{eff}^2}}{2} + h$

$e_{x,str,60} = h_6 - h_0 - T_0(s_6 - s_0) + \frac{1}{2}\left(w_6^2 - w_{Luft}^2\right)$

$h_6 - h_0 = c_p(T_6 - T_0)$; $s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right) - R\cancel{\ln\left(\frac{p_6}{p_0}\right)}^{\rightarrow 0,\ \text{isobar}}$

d) $e_{x,rel} = T_0 \dot{S}_{erz} = \cancel{T_0(s_0 - s_6)}\ T_0(s_6 - s_0)\ \cancel{q_B}\ \cancel{q_B}\ q_{B,ges}$

$q_{B,ges} = \frac{\dot{Q}_B}{\dot{m}_u} = \frac{\dot{Q}_B}{\dot{m}_{ges}}\,6.293 \Rightarrow \frac{\dot{Q}_B}{\dot{m}_{ges}} = \frac{1}{6.293}\,q_B = q_{B,ges}$

$\Rightarrow e_{x,rel} = T_0(s_6 - s_0) - \cancel{0.293\,q_B}\ \frac{1}{6.293}\,q_B \qquad s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right)$

Aufgabe 3

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

$$m_g = \frac{p_{g,1} V_{g,1}}{R T_{g,1}} \qquad R = \frac{\bar{R}}{M_g}$$

GLW: $p_{amb} + \frac{m_g g}{A} + \frac{m_{EW} g}{A} = p_{g,1}$ $\qquad A = \pi \left(\frac{D}{2}\right)^2$

b) $T_{g,2}$, $p_{g,2}$

$p_{g,2} = p_{g,1}$ ⇒ Der Druck, der von außen auf dem Kolben nicht (durch EW und Kolben) verändert sich nicht.

→ $T_{g,2} = \frac{p_{g,1} V_{g,2}}{m_g R}$ $\qquad T_{g,2}$ im GLW → Temperaturen gleichen sich an

→ $T_{g,2} = \frac{500°C + 0°C}{2} = 250°C$ $\qquad T_{g,2} = T_{EW,2}$

c) T_{EW_2}: $\Delta H = \Delta Q = m_{EW} c_v \Delta T = m_{EW} c_v (T_{EW,2} - T_{EW,1})$

Bilanz geschlossenes System am Kolben: $m_2 u_2 - m_1 u_1 = \Delta Q$

$u_2 =$

$u_1 = u\,(0°C)$

$m_{EW} (u_2 - u_1) = \Delta Q = \Delta H = m_{EW} (h_2 - h_1)$

ideale Fl. ⇒ $u_2 - u_1 = c_v (T_{2,EW} - T_{1,EW})$

→ $T_{EW,2} = T_{g,2} = \frac{\Delta Q}{m_{EW} c_v} + T_{EW,1}$

$m_{EW} c_v (T_{EW,2} - T_{EW,1}) =$

c) Q_{12}

Bilanz: $Q_{12} = m_2 u_2 - m_1 u_1 = m_{EW} c_v (\underbrace{T_{2,EW}}_{= T_{g,2}} - T_{1,EW})$

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

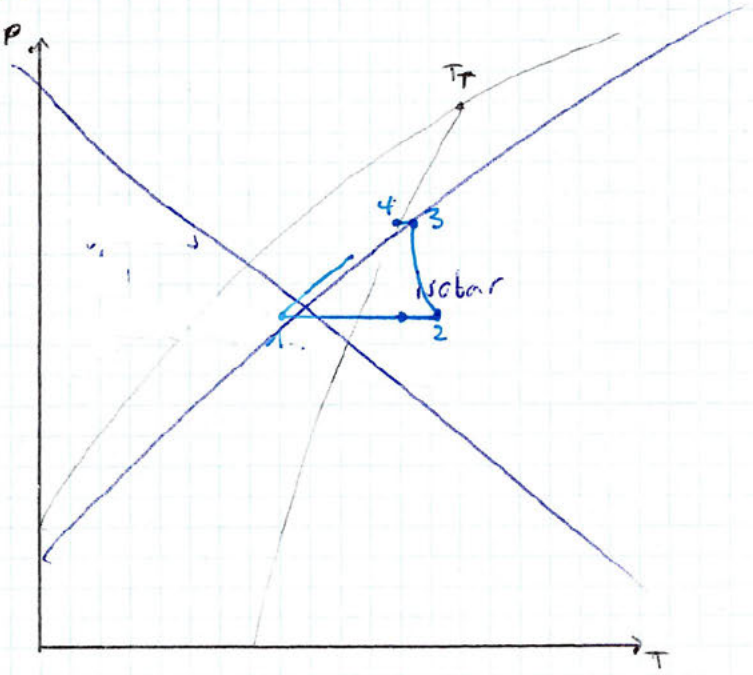
$u_2 =$

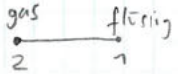
$u_f = u_f(0.003°C)$

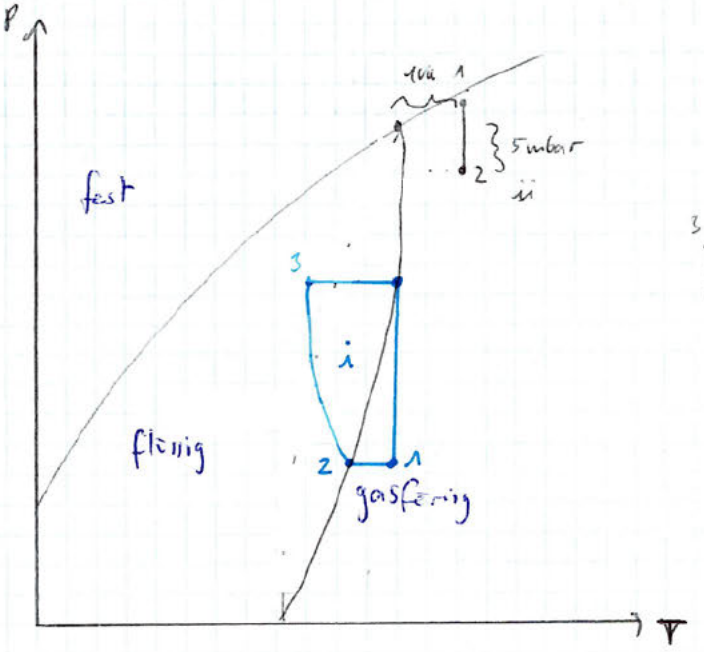
$u_g = u_g(0.003°C)$

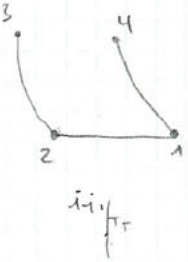
Aufgabe 4

a)









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

Bilanz Verdichter: $0 = \dot{m}_{R134a}\,(h_2 - h_3) - \dot{W}_K$

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

$h_2 = h_g$ (

$h_3 = h_f + v_f\,(p - p_{sat})$

p: 8 bar

c) $x_1 = \dfrac{h_1 - h_f}{h_g - h_f}$

d) $\varepsilon_k = \frac{|\underline{G}_{ZU}|}{|\underline{G}_{OU} - \underline{K}_{ZU}|} = \frac{|\underline{G}_U|}{|\underline{G}_{OG}| - \underline{K}_U|}$

e) Es würde alles verreisen