1. a) $0 = \dot{m}_{ein}\,(h_{ein}) - \dot{m}_{Aus}\,h_{aus} + \dot{Q} - \underbrace{\cancel{\dot{W}}}_{=0} + \dot{Q}_R$

TAB A-2

$h_{ein} = h_f(70°C) = 292.98\,\frac{kJ}{kg}$

$h_{aus} = h_f(100°C) = 419.04\,\frac{kJ}{kg}$

$\dot{Q}_{aus} = \dot{m}_{Aus}\,h_{aus} - \dot{m}_{ein}\,h_{ein} - \dot{Q}_R = \dot{m}_{ein}(h_{aus} - h_{ein}) - \dot{Q}_R$

$\dot{Q}_{aus} = -62.18\,kW$

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

$dH = Tds + \underbrace{\cancel{Vdp}}_{=0,\ \text{weil isobar}}$

[redacted]

$\bar{T} = \frac{h_2 - h_1}{s_2 - s_1} = \frac{c(T_2 - T_1) + v(\underbrace{\cancel{p_2 - p_1}}_{=0})}{c\ln\left(\frac{T_2}{T_1}\right)}$

$\bar{T} = \frac{T_2 - T_1}{\ln\left(\frac{T_2}{T_1}\right)} = 293.12\,K$

c) $0 = \frac{\dot{Q}_{aus}}{T_{Reakto}} - \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{S}_{erz}$

$\dot{S}_{erz} = \frac{\dot{Q}_{aus}}{\bar{T}} - \frac{\dot{Q}_{aus}}{T_{Rea}} = 0.045\,\frac{kW}{K}$

d) $m_2 u_2 - m_1 u_1 = \Delta m_{12} (h_{ein}) + \cancel{Q_R}$ $= 0$, weil Ein & Ausfluss gleich

$\Delta m_{12} = m_2 u_2 - m_1 u_1 - Q_R$

$\cancel{m_{1,3}(u_2 - u_1) - Q_R}$

$u_1 = \overbrace{u_f(100°C)}^{TAB\ A\text{-}2} + x_D (u_g(100°C) - u_f(100°C)) = 429.38 \frac{kJ}{kg}$

$h_{ein}(20°C) = h_f(20°C) = \cancel{8388.1} \frac{kJ}{kg}\ 83.95 \frac{kJ}{kg}$

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

$\cancel{\Delta m_{12}}$

$\Delta m_{12} = m_2 - m_1$

$m_2 u_2 - m_1 u_1 = (m_2 - m_1) h_{ein} + Q_R$

[redacted]

$m_2 = \frac{m_1 u_1 - m_1 h_{ein} \cancel{Q_R}}{u_2 - h_{ein}}$

$m_2 = \cancel{9813.82 kg}\ 9511.72\ kg$

$\Delta m_{12} = \cancel{4058.82 kg}\ 3756.72\ kg$

e) $m_2 s_2 - m_1 s_1 = \Delta S_{12}$

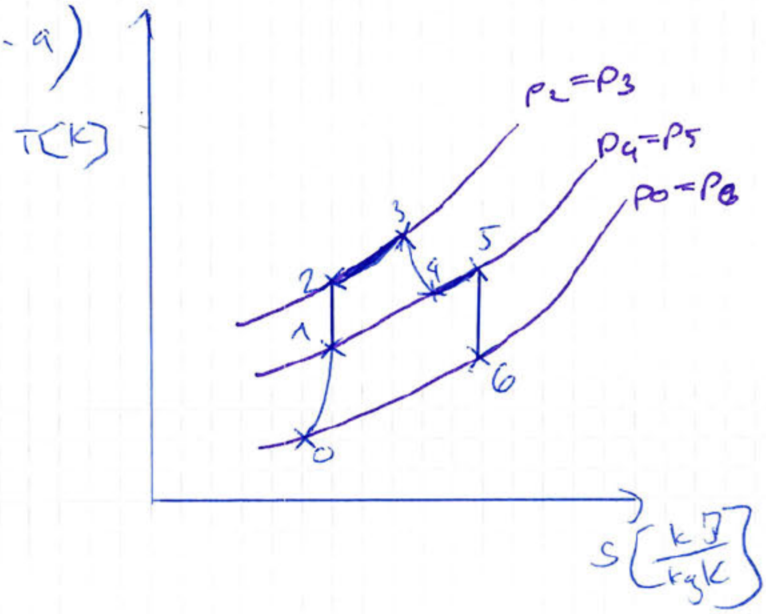
$s_2 = s_f(70°C) = 0.9549$

$s_1 = s_f(100°C) + x_D (s_g(100°C) - s_f(100°C)) = 1.33714$

$\cancel{\Delta S = -3815.47 \frac{kJ}{kg K}}$

$\Delta S = 1387.5 \frac{kJ}{kg K}$

2. a)



b) 5 − 6 ⇒ isentrop ⇒ $\Delta s = 0$

$$\cancel{0 = \int_{T_5}^{T_6} \frac{c}{T}\, dT \Rightarrow 0 = c \ln\left(\frac{T_6}{\ldots}\right)}$$

[redacted]

$$0 = c_p \ln\left(\frac{T_6}{T_5}\right) - R \ln\left(\frac{p_6}{p_5}\right)$$

$$\kappa = \frac{c_p}{c_v} \Rightarrow c_v = \frac{c_p}{\kappa} = 0.7186 \frac{kJ}{kg\,K}$$

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

$$T_6 = T_5\, e^{\frac{R}{c_p} \ln\left(\frac{p_6}{p_5}\right)}$$

$$T_6 = 328.084\,K$$

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

$$w_6 = \sqrt{2h_5 - 2h_6 + w_5^2} = \sqrt{2\left(c_p\left(T_5 - T_6\right)\right) + w_5^2}$$

$$= 507.23 \frac{m}{s}$$

c) $e_{xstr,6} - e_{xstr,0} = \left(h_6 - h_0 - T_0(s_6 - s_0) + ke\right)$

$$= c_p(T_6 - T_0) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right) - \underbrace{\cancel{R \ln\left(\frac{p_6}{p_0}\right)}}_{=0}\right) + \frac{w_6^2 - w_0^2}{2}$$

$$= 120.802 \frac{kJ}{kg}$$

d) $\cancel{0 = \Delta e_{x,s}}$

$$0 = (e_{xst,6} + e_{xstr,0})\cancel{\ldots} + \left(1 - \frac{T_0}{T_k}\right)\dot{Q} - \underbrace{\cancel{w}}_{=0} - \dot{E}_{x,verl}$$

$$\dot{e}_{x,ver} = e_{xstr,0} - e_{xstr,6} + \left(1 - \frac{245.15K}{1289K}\right) 1195 \frac{kJ}{kg}$$

$$e_{x,verl} = 848.78 \frac{kJ}{kg}$$

[redacted]

3. a) $\cancel{m_g = \frac{V_g}{v_g}}$

$\cancel{v_g(T,p) = v_f(T)}$ ~~, weil inkompressible Flüssigkeit~~

$\cancel{v_f(500°C) =}$

$p_1 \cdot A = p_0 \cdot A + m_k g$

$\Rightarrow p_{g,1} = p_0 + \frac{m_k g}{A} \qquad A = \pi \cdot \frac{D^2}{4} = \frac{\pi}{400}\ m^2$

$= 1.46 bar$

$pV = mRT \qquad R = \frac{\bar{R}}{M} = \frac{8314 \frac{J}{kmol\,K}}{50 \frac{kg}{kmol}} = 166.28 \frac{J}{kg \cdot K}$

$m_g = \frac{p_1 V_1}{R T_1} = 3.42 \cdot 10^{-3} kg$

$= 3.42\ g$

[redacted]

b) $p_{g,2} = p_{g,1}$, da ~~...~~ keine zusätzliche Kraft dazukommt, & somit sich das Kräftegleichgewicht nicht ändert

$T_{g,2} = T_{EW,1}$, da $x_{Eis,2} > 0$, muss noch Eis in EW sein & somit kann die Temperatur nicht ansteigen, & da Gas & EW im thermodynamischen GGW sind, müssen die Temperaturen gleich sein

c) $m(u_2 - u_1) = \dot{Q}$ ~~...~~ $-\dot{W}$

$\dot{W} + m(c_v(T_1 - T_2)) = \dot{Q} \qquad m = m_1 = m_2$

$\Rightarrow \dot{Q} = 1133.73\ J$

$\dot{W}_{rev} = p_1(v_2 - v_1) \cdot m = -3.724 \cdot 10^{-7} kJ$

weil reibungsfrei

$v_1 = \frac{mRT_1}{p_1} = 3.14 \cdot 10^{-6} \frac{m^3}{kg}$

$v_2 = \frac{mRT_2}{p_2} = 1.109 \cdot 10^{-6} \frac{m^3}{kg}$

d) $m_{EW}(u_2-u_1) + m_g(u_2-u_1) = \overset{=0}{\cancel{Q}} - \overset{=0}{\cancel{W}}$

$\cancel{m_{EW}(u_2-u_1) = m_{EW}(}$

$p_g = p_{EW}$

$u_{1,EW} = -333.458\,\frac{kJ}{kg} + x\left(-0.045\,\frac{kJ}{kg} + 333.458\,\frac{kJ}{kg}\right) = -133.41\,\frac{kJ}{kg}$

$m_g(u_2-u_1) = m_g c_v(T_2-T_1) = -1.082\,kJ$

$u_{2,EW} = u_1 - \frac{m_g(u_2-u_1)}{m_{EW}} = -122.53\,\frac{kJ}{kg}$

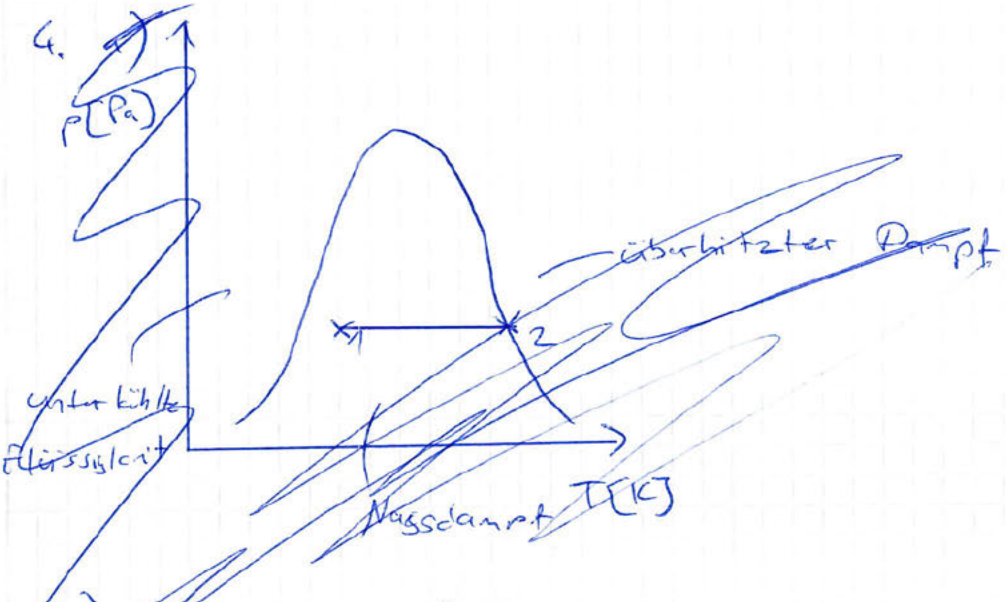
[redacted]

$p_{2,EW} = p_{1,EW} = 1.4\,bar$

$T_{1,EW} = T_{2,EW}$

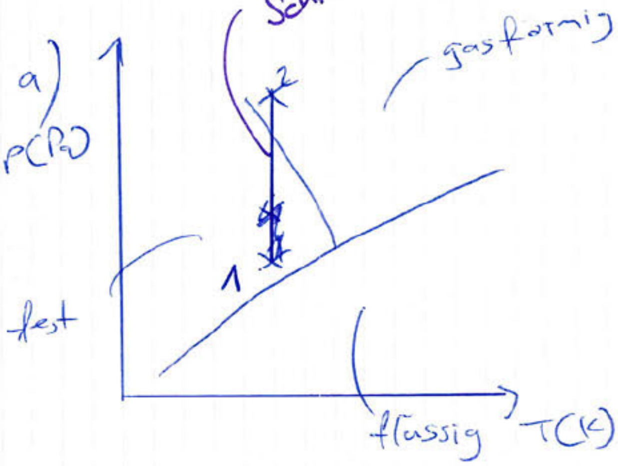
$x = \frac{u_{2,EW} + 333.458\,\frac{kJ}{kg}}{-0.045\,\frac{kJ}{kg} + 333.458\,\frac{kJ}{kg}} = 0.632$

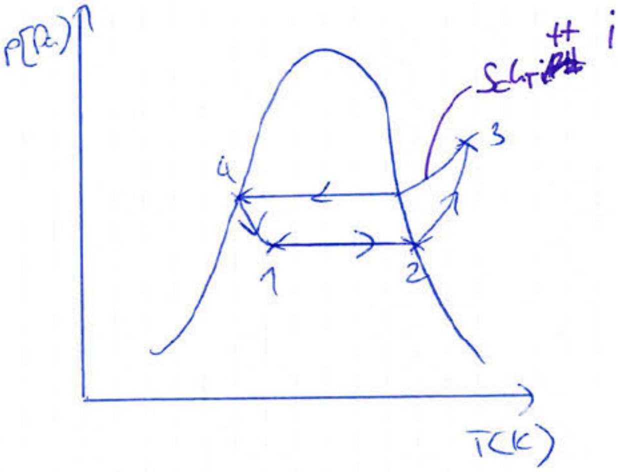
4. ~~a)~~



~~b)~~

a)





b) $0 = \dot{m}_R (h_2 - h_3) + \underbrace{\cancel{\dot{Q}}}_{=0} - \dot{W}_k$

TAB A-10

$h_2 = \cancel{h_g(4{,}5\,bar)} = h_g(277.15\,K) = 249.53\ \frac{kJ}{kg}$

$s_2 = s_3 = s_g(4°C) = 0.9169\ \frac{kJ}{kg \cdot K}$

$T_i = 10°C = 283.15\,K$

$p_{Triple} = 6\,mbar$

$p_1 = 1\,mbar = p_2$

$T_2 = 283.15\,K - 6\,K = 277.15\,K$

~~TAB A-11~~

$\cancel{h_3(8\,bar) = \frac{s_i - s_f}{s_g - s_f}(h_g - h_f) + h_f =}$

b) ~~θ_{23}~~

~~$h_4($~~

c) $h_1 = h_4$, da adiabate Drossel

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

~~$h_1(4°C) =$~~

$$x_1 = \frac{h_4 - h_f(4°C)}{h_g(4°C) - h_f(4°C)} \overset{\text{TAB A10}}{=} 0.196$$

[redacted]

d) $\varepsilon_K = \frac{\overbrace{\dot{Q}_{zu}}^{= \dot{Q}_K}}{\underbrace{\dot{W}_t}_{= \dot{W}_K}}$

mit angegebenen Werten rechnen

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

$$\Rightarrow \dot{Q}_K = \dot{m}_R (h_2 - h_1) = 156.28\ W$$

$h_1 = h_4$

$$h_2 = h_g(-22°C) \overset{\text{TAB A-10}}{=} 239.08 \frac{kJ}{kg}$$

$$\varepsilon_K = 5.58$$

e) Die Temperatur würde abnehmen, da wir im festen Bereich sind & somit wenn Wärme abgenommen wird, sich die Temperatur senken muss.