1.) a)

b) $\bar{T} = \frac{\int_{ein}^{aus} T\,ds}{s_{aus} - s_{ein}} =$

$dh = Tds + vdp$ (da sich der Druck nicht ändert)

$dh = Tds \quad \bar{T} = \frac{\Delta h}{s_{aus} - s_{ein}} = \frac{c_{if}(T_{aus}^{KF} - T_{ein}^{KF})}{c_{if}\ln\left(\frac{T_{aus}^{KF}}{T_{ein}^{KF}}\right)} = \frac{T_{aus}^{KF} - T_{ein}^{KF}}{\ln\left(\frac{T_{aus}^{KF}}{T_{ein}^{KF}}\right)} = 293{,}42\,K$

$\Delta h \int Tds$

c) $0 = \dot{m}\left[s_{ein}^{KF} - s_{aus}^{KF}\right] + \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{S}_{erz}$

$\dot{S}_{erz} = \frac{\dot{m}\left[s_{aus}^{KF} - s_{ein}^{KF}\right] - \frac{\dot{Q}_{aus}}{\bar{T}}}{c_{if}\ln\left(\frac{T_{aus}^{KF}}{T_{ein}^{KF}}\right)}$

$0 = \dot{m}\left[s_{ein} - s_{aus}\right] + \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{S}_{erz}$

a) $\Delta E = m_2 u_2 - m_1 u_1 = \Delta m_{12} h_{12} + Q_{aus\,12}$

$\Delta_{12} m (u_2 - u_1) = \Delta m_{12} h_{12} + Q_{aus\,12}$

~~$u_{f1}(x=0, T=70°C)$~~

~~$u_f(x=x_n)$~~

$u_f(100°C) = 418.94 \frac{kJ}{kg}$ Tabelle A2

$u_g(100°C) = 2506.5 \frac{kJ}{kg}$ Tabelle A2

$u_{Nass\,1} = u_f + x_n(u_g - u_f) = 429.3378 \frac{kJ}{kg}$

~~$u_2 (T=70°C$~~

isochor ~~$V_1 = V_2$~~ $V_1 = V_2$

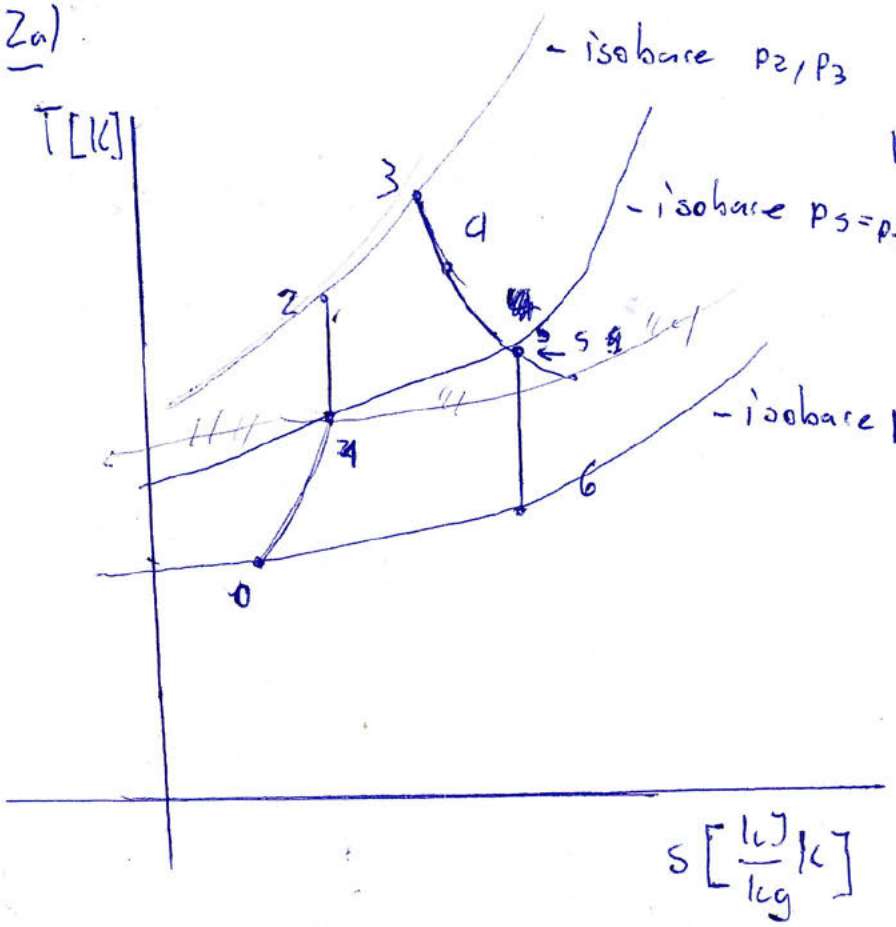
---

e) $\Delta S_{12} = m_2 s_2 - m_1 s_1 = \Delta m_{12} s_{12} + \frac{Q_{aus}}{T_{LF}}$

$s_{12}(T=20°, x=0) = 0.2966 \frac{kJ}{kg} K$

$\Delta S_{12} = 3600 kg \cdot 0.2966 \cdot 10^3 \frac{J}{kg} K + \frac{35 \cdot 10^6 J}{295 K} = 1186409.068 \frac{J}{kg} K$

2a)



$p_6 = p_0$ $\quad \overline{R} = \frac{pV}{nRT}$ $\quad pV = nRT$

$T = \frac{pV}{nR}$

b) $p_6 = p_0 = 0.194$ bar $\qquad s_5 = s_6$

$$0 = \dot{m}\left[h_5 - h_6 + \frac{(w_5^2 - w_6^2)}{2}\right] = 0$$

$$\Delta s = 0 = c_p \ln\left(\frac{T_{2,6}}{T_{1,5}}\right) - R \ln\left(\frac{p_{2,6}}{p_{1,5}}\right)$$

$$c_v = \frac{c_p}{\kappa} \qquad c_p \ln\left(\frac{T_6}{T_5}\right) = R \ln\left(\frac{p_6}{p_5}\right)$$

$$R = c_p - \frac{c_p}{\kappa}$$

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

$$0 = \dot{m}\left(c_p (T_6 - T_5) + \frac{(w_5^2 - w_6^2)}{2}\right)$$

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

c) $\dot{e}x_{STR} = \dot{m}\left[h_6 - h_0 - T_0\left[s_6 - s_0\right] + \text{alce}\right]$

$= \dot{m}\left[c_p\left(T_6 - T_0\right) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right) - R\ln\left(\frac{P_4}{P_0}\right) + \frac{1}{2}w_6^2 - \frac{1}{2}w_0^2\right)\right]$

d)

$\dot{E}x_{vel} = \dot{E}x$

$\dot{e}x_{vel} = \dot{e}x_{str} = 400 \frac{kJ}{kg}$

3. a) geg.: $T_{g1} = 500°C$ $V_{g1} = 3.14 \cdot 10^{-3}\,m^3$

$$p_{g1} = \frac{m R T}{V}$$

$$R = \frac{\bar{R}}{M} = \frac{8.314 \cdot 10^3\ J/kmol}{50\ \frac{kg}{kmol}} = 0.16628\ \frac{J}{kg}$$

$$p = \frac{F}{A} = \frac{32\,kg \cdot 9.81\frac{m}{s^2} + 0.1\,kg \cdot 9.81\frac{m}{s^2}}{25\pi\,(0.05)^2\pi} + 10^5\,Pa \quad (1\,bar = 10^5\,Pa)$$

$$p = 8.09944\,bar = 1\,809\,944.4406\,Pa$$

$$m = \frac{pV}{RT} = 5273\,kg \quad (\text{probably not!})$$

$$m = \frac{1\,809\,944.4\,Pa \cdot 3.14 \cdot 10^{-3}\,kg}{0.16628\ \frac{J}{kmol} \cdot (500K + 273.15K)} = 3.424\,kg$$

3b) thermodynamischen Gleichgewicht wenn

$\dot{Q} = 0$; $T_{g1} = T_{EW1}$

$R = c_p - c_v$

isentropen Zustandsänderung $n = \kappa$ $c_p = R + c_v = 0.79928\ \frac{J}{kg}$

$$\kappa = \frac{c_p}{c_v} = 1.262$$

$$T_2 = T_1 \left(\frac{p_2}{p_1}\right)^{\frac{\kappa-1}{\kappa}}$$

d) ~~$\Delta E = m_2 u_2 - m_1 u_1 + \Delta PE = Q$~~

$$E_2 - E_1 = Q - W = \Delta E \qquad W = 0$$

$$T_{g2} = 0.003\,^\circ C = T_{EW2}$$

$$E_{1\,\text{wasser}} = m_{\text{wasser}} \left(u_{f\,e2} \cdot m_{Eis} + u_{fL} \cdot m_{Fl} \right)_k = \left(-333.458 \frac{kJ}{kg} \cdot 0.6\,kg + -0.045 \cdot 0.1\,kg \right)$$

$$E_{1\,\text{wasser}} = -20.00928\ kJ$$

$$E_{2\,\text{Wasser}} = u_f (T = 0.003°) \cdot (1 - x) + u_{Eis} (T = 0.003\,^\circ C) \cdot x$$

$$\Delta_{E\,gas} = E_{2\,gas} - E_{1\,gas} = m (u_{2\,gas} - u_{1\,gas}) = c_v (T_2 - T_1) = -399.637 \frac{kJ}{kg}$$

$$\Delta E_{gas} = Q_{12} = 1500\,J$$

$$E_{2\,\text{wasser}} = Q_k - \Delta E_{gas} + E_{1\,\text{wasser}} = u_f^* - x u_f^* + u_{Eis}^* x$$

$$x = \frac{Q - \Delta E_{gas} + E_{1\,\text{wasser}} - u_f^*}{u_{Eis}^* - u_f^*} \leftarrow u_{Eis}^* - u_f^*$$

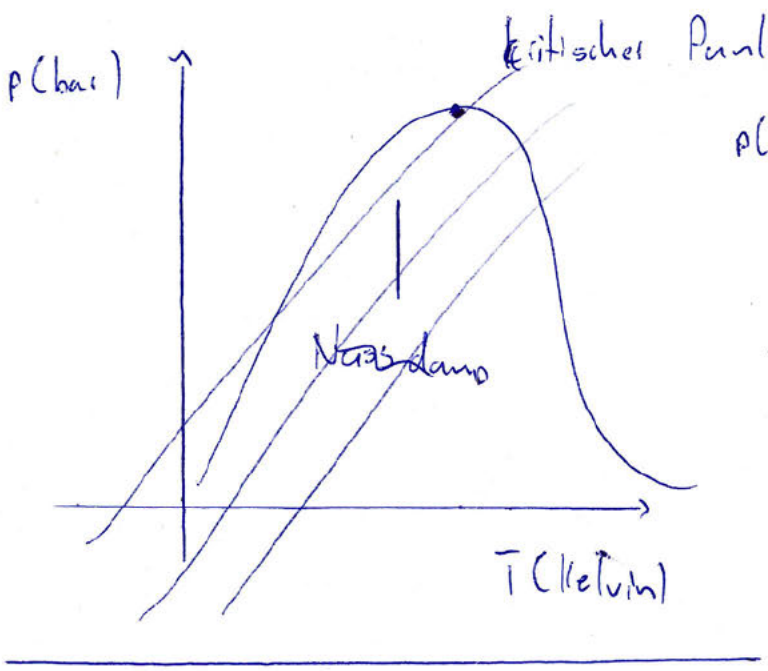
[redacted]

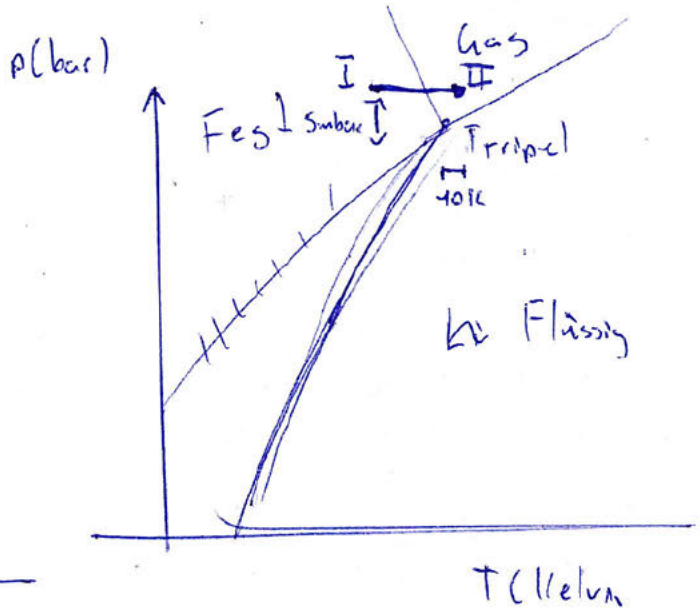
3c) Energiebilanz um Gas

$$\Delta E = Q$$

$$\Delta E = u_2 - u_1 = c_v \left(T_{g2} - T_{g1} \right) = -346.498 \text{ kJ}$$

4) a)





4b)

$\dot{m} \cdot [h_2 - h_3] = \dot{W}_{ic}$

$\dot{m} = \frac{\dot{W}_{ic}}{h_2 - h_3}$

$p_1 = p_2 \quad s_2 = s_3 \quad p_3 = 8\,bar$

$p_3 = p_4 \quad x_4 = 0 \quad x_2 = 1$

$T_1 = T_4 \quad T_{Verdampfer} = 9°C$

$T_{Innenraum} = 10°C \quad h_1 = h_4$

c)

$T_2 = -22°C$, $x_2 = 1$ $\quad p_2 = 1,1160\,bar = p_1$

$h_2 \rightarrow$ Tabelle $A_{10} = 0,1500 \frac{m^3}{kg}$ $\quad p_3 = p_4 = 8\,bar$

$x_0 = 0$

$0 = \dot{m}\,[h_1 - h_2] + \dot{Q}_{ic}$ $\quad h_4 = h_1$, da drossel

$h_4 \rightarrow$ tabelle $= 0,8454 \cdot 10^{-3} \frac{m^3}{kg}$

$p_1 = 1,1160\,bar$

$h_1 = 0,8454 \cdot 10^{-3} \frac{m}{kg}$

$$x = \frac{h_1 - h_f}{h_g - h_f}$$

$$h_f\,(1,1160\,bar) = (1,1160\,bar - 1\,bar) \cdot \frac{h_f(1,2\,bar) - h_f(1,0\,bar)}{(1,2\,bar - 1,0\,bar)} + h_f(1,0\,bar)$$

$$h_g\,(1,160\,bar) = (1,1160\,bar - 1\,bar) \cdot \frac{h_g(1,2\,bar) - h_g(1,0\,bar)}{1,2\,bar - 1,0\,bar} + h_g(1,0\,bar)$$

a) $$\varepsilon = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{zu}|}{|\dot{Q}_{ab} - \dot{Q}_{zu}|} = \frac{|\dot{Q}_{ic}|}{|\dot{Q}_{ic} - |\dot{Q}_{ab}|}$$

$\dot{Q}_{ic} = \dot{m}\,[h_2 - h_1]$

$\dot{Q}_{ab} = \dot{m}\,[h_4 - h_3]$