[redacted]

1a) 1. HS über Kühlmantel:

$$\Delta U = \dot{Q}$$

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

c) $$0 = \dot{m}\left[s_e - s_a\right] + \frac{\dot{Q}}{T} + \dot{S}_{erz}$$

$$\Rightarrow \dot{S}_{erz} = \dot{m}\left[s_a - s_e\right] - \frac{\dot{Q}}{T}$$

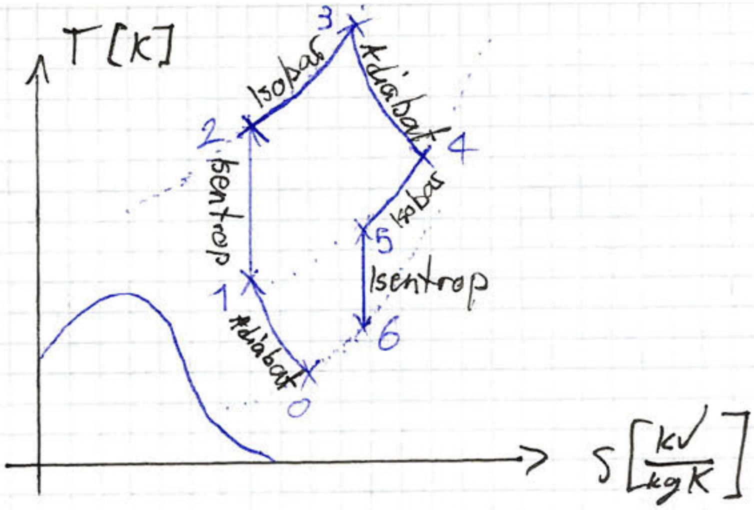
d) $\cancel{\frac{dE}{dt}}^{0} = \sum_i \dot{m}_i \left[h_i + \cancel{ke_i}^{0} + \cancel{pe_i}^{0} \right] + \sum_i \dot{Q}_i - \sum_n \cancel{\dot{W}_n}^{0}$

$\dot{Q} = \dot{m} [h_a - h_e] = \dot{m} [$

e) $\Delta S = m(s_2 - s_1)$

[redacted]

2a)



b) $p_5 = 0{,}5\ \text{bar} \quad p_6 = 0{,}191\ \text{bar}$

$T_5 = 431{,}9\ K \quad w_5 = 220\ \frac{m}{s}$

$$h_6 - h_5 = c_p (T_6 - T_5)$$

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \Rightarrow \underline{T_6} = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 431{,}9\,K \left(\frac{0{,}191\,\text{bar}}{0{,}5\,\text{bar}}\right)^{\frac{0{,}4}{1{,}4}} =$$

$$= \underline{\underline{328{,}075\ K}}$$

1. HS über Schubdüse:

$$\dot{Q} = -\dot{m}\left[h_e - h_a + \frac{(w_e^2 - w_a^2)}{2}\right]$$

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

$$w_6^2 = 2 \cancel{\dot{m}} [h_5 - h_6] + w_5^2$$

$$\underline{\underline{w_6}} = \sqrt{2 c_p [T_5 - T_6] + w_5^2} = \sqrt{2 \cdot 1{,}006 \frac{kJ}{kgK} [431{,}9\,K - 328{,}075\,K] + (220\ \tfrac{m}{s})^2} = \underline{\underline{507{,}29\ \frac{m}{s}}}$$

c) $\Delta e_{x,str} = e_{x,str6} - e_{x,str5} = [h_6 - h_5 - T_0(s_6 - s_5) + \Delta ke + \cancel{\Delta pe}^{0}] =$

$$= c_p(T_6 - T_5) - T_0(s_6 - s_5) + \frac{m}{2}\omega_6^2 - \frac{m}{2}\omega_5^2$$

$$\rightarrow s_6 - s_5 = c_p \int_{T_5}^{T_6} \frac{1}{T}\,dT - R\ln\left(\frac{p_6}{p_5}\right) = c_p\left(\cancel{T_6 - T_5}^{\ln\left(\frac{T_6}{T_5}\right)}\right) - R\ln\left(\frac{p_6}{p_5}\right)$$

$$\Rightarrow \Delta e_{x,str} = c_p(T_6 - T_5) - T_0\left(c_p\left(\cancel{T_6 - T_5}^{\ln\left(\frac{T_6}{T_5}\right)}\right) - R\ln\left(\frac{p_6}{p_5}\right)\right) + \frac{\omega_6^2 - \omega_5^2}{2}$$

$\boxed{T_0 = -30°C = 243{,}15K}$ $\Rightarrow R = c_p - c_v = c_p - \frac{c_p}{k}$

$$\Delta e_{x,str} = 1{,}006\frac{kJ}{kgK}(340K - 431{,}9K) - 243{,}15K\left(1{,}006\frac{kJ}{kgK}\left(\cancel{340K - 431{,}9K}^{\ln\left(\frac{340K}{431{,}9K}\right)}\right) - \left(1{,}006\frac{kJ}{kgK} - \frac{1{,}006\frac{kJ}{kgK}}{1{,}4}\right)\cdot\ln\left(\frac{0{,}991\,bar}{0{,}5\,bar}\right)\right) + \frac{(520\frac{m}{s})^2 - (220\frac{m}{s})^2}{2} = -4669{,}799\frac{kJ}{kg}$$

Unrealistisch

d) $e_{x,verl} = T_0\, s_{erz}$

$$s_{erz} = -\frac{Q}{mT} + (s_a - s_e) = s_6 - s_0 - \frac{q_B}{T_B}$$

$$= c_p\left(\ln\left(\frac{T_6}{T_0}\right) - R\ln\cancel{\left(\frac{p_6}{p_0}\right)}^{0}\right) - \frac{q_B}{T_B} = c_p\ln\left(\frac{T_6}{T_0}\right) - \frac{q_B}{T_B}$$

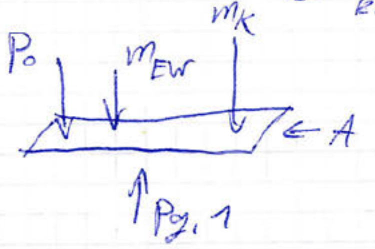
$$= 1{,}006\frac{kJ}{kgK}\ln\left(\frac{340K}{243{,}15K}\right) - \frac{1195\frac{kJ}{kg}}{1289K} = -0{,}5898\frac{kJ}{kgK}$$

Ich nehme einen Vorzeichen Fehler an

$$\underline{e_{x,verl}} = T_0|s_{erz}| = 243{,}15K \cdot 0{,}5898\frac{kJ}{kgK} = \underline{143{,}41\frac{kJ}{kg}}$$

[redacted]

3a) $R = \frac{\bar{R}}{M} = \frac{8,314 \frac{kJ}{kmol \cdot K}}{50 \frac{kg}{kmol}} = 0,1663 \frac{kJ}{kg K}$



$A = r^2\pi = \left(\frac{D}{2}\right)^2 \pi = \left(\frac{0,1}{2}\right)^2 \pi = 0,00785\, m^2$

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

$\underline{p_{G1}} = p_0 + \frac{g}{A}(m_K + m_{EW}) = 1\,bar + \frac{9,81 \frac{m}{s^2}}{0,00785\, m^2}(32\,kg + 0,1\,kg) =$

$= \underline{1,401\ bar}$

$pV = mRT$, $V_{G1} = 0,00314\, m^3$, $T_{G1} = 773,15\, K$

$\underline{m_G} = \frac{p_{G1} V_{G1}}{R T_{G1}} = \frac{1,401\,bar \cdot 0,00314\, m^3}{0,1663 \frac{kJ}{kg K} \cdot 773,15\,K} = \underline{3,4215 \cdot 10^{-3}\, kg}$

b) Da die Masse oberhalb der Membran gleich bleibt, muss der Druck unterhalb auch gleich bleiben $\Rightarrow p_{G1} = \underline{p_{G2}} = \underline{1,401\,bar}$

1. HS an Zylinder:

$\Delta E = \cancel{Q}^{0} - W = \Delta U$

$W_{12} = p_1 \int_1^2 dV = p_1 (V_2 - V_1) = U_1 - U_2 = c_v (T_1 - T_2)$

c) 1. HS an Gasbehälter:

$\Delta E = Q - W = \Delta U$

$Q = W + U_2 - U_1 = W + (m_G c_v (T_2 - T_1)$

$= p_1 (V_2 - V_1) + m_G c_v (T_2 - T_1)$

d) 1. HS an EW-Behälter

$\Delta U = Q - \cancel{W}^{0} = U_2 - U_1$

$u_2 = \frac{Q}{m_{EW}} + u_1 \Rightarrow u_1 = u_s + x_1 (u_f - u_s) = \cancel{-333{,}458 \frac{kJ}{kg}}$

$= -333{,}458 \frac{kJ}{kg} + 0{,}6 \left(-0{,}045 \frac{kJ}{kg} - (-333{,}458 \frac{kJ}{kg})\right) =$

$= -133{,}41 \frac{kJ}{kg}$ (TAB 1 @ 0 °C)

$u_2 = \frac{1500 J}{0{,}1 kg} + \left(-133{,}41 \frac{kJ}{kg}\right) = \cancel{148{,}41 \frac{kJ}{kg}} = -118{,}41 \frac{kJ}{kg}$

$u_2 = u_s + x_2 (u_f - u_s) \Rightarrow x_2 = \frac{u_2 - u_s}{u_f - u_s}$, $T_{g,2} = 0{,}003 °C$

$\underline{x_2} = \frac{-118{,}41 \frac{kJ}{kg} - (-333{,}442) \frac{kJ}{kg}}{-0{,}033 \frac{kJ}{kg} - (-333{,}442) \frac{kJ}{kg}} = \underline{0{,}6449}$ (TAB 1 @ 0,003 °C)

Sollte tiefer sein als Zustand 1?!

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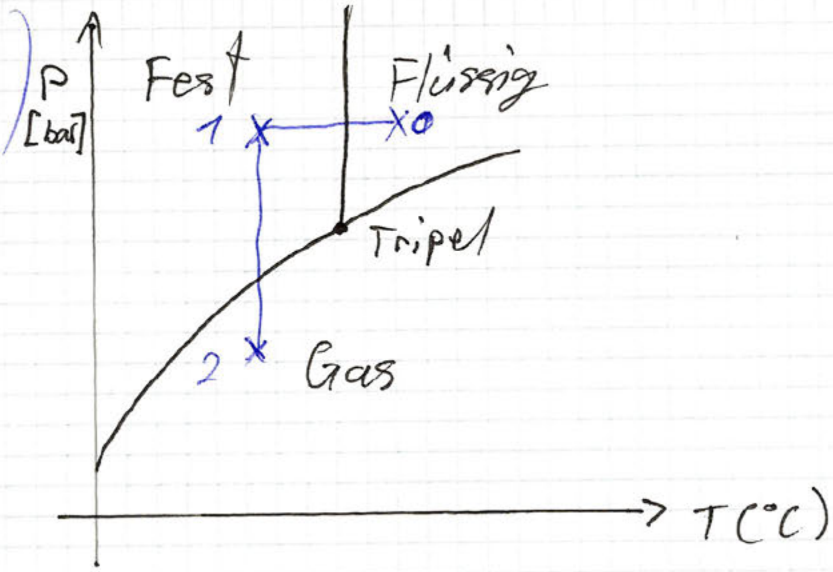
4a)



d) $\varepsilon_W = \frac{|\dot{Q}_{ab}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{ab}|}{|\dot{Q}_{ab}| - |\dot{Q}_{zu}|}$

e) Die Temperatur würde weiter sinken