[redacted]

Aufgabe 1:

a) 1. HS: stat. $\Rightarrow \dot{Q}_{aus} = \dot{m}_{ein}\left(h_{aus} - h_{ein}\right) - \dot{Q}_R$

$h_{aus}(100°C, x=0) = 419.04 \frac{kJ}{kg}$ aus A-2

$h_{ein}(70°C, x=0) = 292.98 \frac{kJ}{kg}$ aus A-2

$\dot{Q}_{aus} = 0.3 \frac{kg}{s}\left(419.04 - 292.98\right) = \cancel{37818\,kW}$ $-62.182\,kW$

b) $\bar{T}_{KF} = \frac{\int_e^a T\,ds}{s_a - s_e} \overset{p=const}{=} \frac{\int_e^a dH}{s_a - s_e} = \frac{c_{if}\left(T_{aus\,KF} - T_{ein\,KF}\right)}{c_{if} \ln\left(\frac{T_{aus\,KF}}{T_{ein\,KF}}\right)}$

$= \frac{298.15 - 288.15}{\ln\left(\frac{298.15}{288.15}\right)} = 293.12\,K$

c) 2. HS: $\dot{S}_{erz} = \dot{m}\left(\cancel{s_a - s_e}^{\,0}\right) - \frac{\dot{Q}_{aus}}{T_{reaktor}} - \frac{-\dot{Q}_{aus}}{\bar{T}_{KF}}$ an Wand!

$\Rightarrow \dot{S}_{erz} = \frac{\cancel{-}65kW}{\cancel{400}373.15K} + \frac{65kW}{293.12K} = 0.0476 \frac{kW}{K} = 47.56 \frac{W}{K}$

d) 1. HS: halboffenes System

$E_2 - E_1 = \Delta m_{12} h_{12} + Q_{aus}$

$h_{12}(20°C, x=0) = 83.96 \frac{kJ}{kg}$ aus A-2

$$E_2 - E_1 = (m_{ges} + \Delta_{12} m)\, u_2 - m_{ges}\, u_1$$

~~$u_1 (100°C, x = 0.052) =$~~

$u_1 (100°C, x = 0.005) = u_f + x (u_g - u_f) = 929.378 \frac{kJ}{kg}$ aus A-2

$u_2 (70°C, x = 0) = 292.95 \frac{kJ}{kg}$ aus A-2

$$\Rightarrow (m_{ges} + \Delta_{m12}) u_2 - m_{ges} u_1 = \Delta_{m12} h_{12} + Q_{aus}$$

$$\Delta_{m12} (u_2 - h_{12}) = Q_{aus} + m_{ges} u_1 - m_{ges} u_2$$

$$\Delta_{m12} = \frac{Q_{aus} + m_{ges} (u_1 - u_2)}{u_2 - h_{12}} = \frac{-35 MJ + 5755 kg (929.378 - 292.95)}{292.95 - 83.96}$$

$$= 358937 kg$$

e) $\Delta S = \Delta_{m12} s_{12} (m_{ges} + \Delta_{m12}) s_2 - m_{ges} s_1$

$s_1 (100°C, x = 0.005) = s_f + x (s_g - s_f) = 1.337 \frac{kJ}{kg \cdot K}$ aus A-2

$s_2 (70°C, x = 0) = 0.9599 \frac{kJ}{kg \cdot K}$ aus A-2

$$\Rightarrow \Delta S = 9349.37 kg \cdot 0.9599 - 5755 \cdot 1.337 = 1228.5 \frac{kJ}{K}$$

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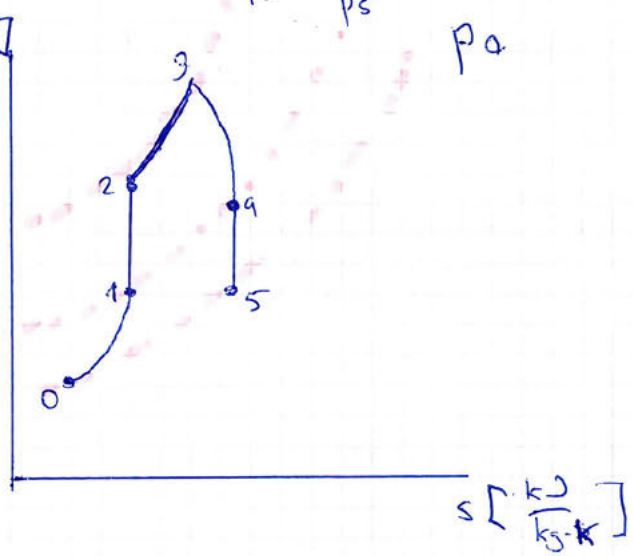
Aufgabe 2:

a)



b) ~~1.4187~~ Schubdüse ist isentrop!

~~Wärme~~

$$\Rightarrow T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{k-1}{k}} = 328.07\,K$$

c) ~~exstr,6 =~~

$$e_{x,str_6} - e_{x,str_0} = h_6 - h_0 - T_0 (s_6 - s_0) + \frac{w_6^2}{2}$$

$$= c_{p,L} (T_6 - T_0) - T_0 \left(c_p \ln\left(\frac{T_6}{T_0}\right)\right) + \frac{w_6^2}{2}$$

$$= 1.006 (328.07 - 293.15) - 293.15 \left(1.006 \ln\left(\frac{328.07}{293.15}\right)\right) + \frac{510^2}{2} \cdot \frac{1}{10^3}$$

$$= 192.2 \frac{kJ}{kg}$$

d) 2. HS stationär adiabt

$$0 = s_0 - s_6 + \dot{s}_{erz} \Rightarrow \dot{s}_{erz} = s_6 - s_0$$

$$s_{erz} = c_{p,L} \ln\left(\frac{T_6}{T_0}\right) - R_h \ln\left(\frac{p_6}{p_0}\right)^0$$

$$= 1.006 \ln\left(\frac{328.07}{243.15}\right) = 0.3 \frac{kJ}{kg \cdot K}$$

$$\Rightarrow e_{\dot{x},verl} = T_0 \dot{s}_{erz} = 73.27 \frac{kW}{kg}$$

Aufgabe 3:

a) Zustand 1 in GGW!

~~$\Rightarrow p_g = p_{ew}$~~

$\Rightarrow A_{pew} = A_{pamb} + m_K g \qquad A = (0.1m)^2 \pi$

$\Rightarrow p_{ew} = \frac{A_{pamb} + m_K g}{A} = \frac{(0.1m)^2 \pi \cdot 10^5 + 32 \cdot 9.81}{(0.1m)^2 \pi}$

$= 1.1\,bar$ ~~$= p_g$~~

$\Rightarrow A_{pg} = A_{pew} + m_{EK} g \Rightarrow p_g = \frac{A_{pew} + m_{EK} g}{A}$

$= 1.1\,bar$

$m_g = \frac{p_g \cdot V_g}{R_g \cdot T_g} = \frac{1.1\,bar \cdot 3.14\,l}{\frac{8314}{50} \cdot 773.15} = 2.687\,g$

b) Da wir annehmen, dass festes/flüssiges Wasser inkompressibel[1] ist und der Dichte-unterschied vernachlässigbar ist, bleibt das GGW gleich. $\Rightarrow p_{g,2} = p_{g,1} = 1.5\,bar$

$T_{g,2} = T_{g,1} = 500°C$

c) 1. HS geschlossen:

$$E_2 - E_1 = Q_{12} - W_{v,rev} \rightarrow m_g (u_2 - u_1) = Q_{12}$$

$$W_{v,rev} = \int_1^2 p \, dv \qquad m_g c_v (T_2 - T_1) = Q_{12}$$

d) 1. HS: $E_2 - E_1 = Q_{12} - W_{v,rev}$

$$m_2 u_2 - m_1 u_1 = 1500\,\text{J} - 0 \leftarrow \text{da inkompressibel}$$

$$m_{rev}(u_2 - u_1) = 1500\,\text{J}$$

$$u_1 (1.0\,\text{bar}, x = 0.6) = u_{f1} + x (u_g - u_f) = -0.033 + x(-333.942 + 0.033)$$

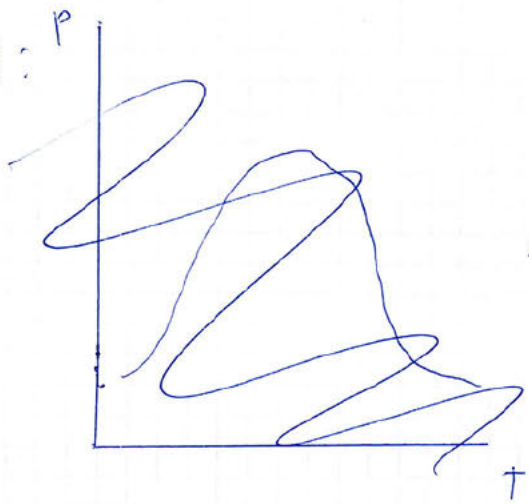
$$= -200 \frac{\text{kJ}}{\text{kg}}$$

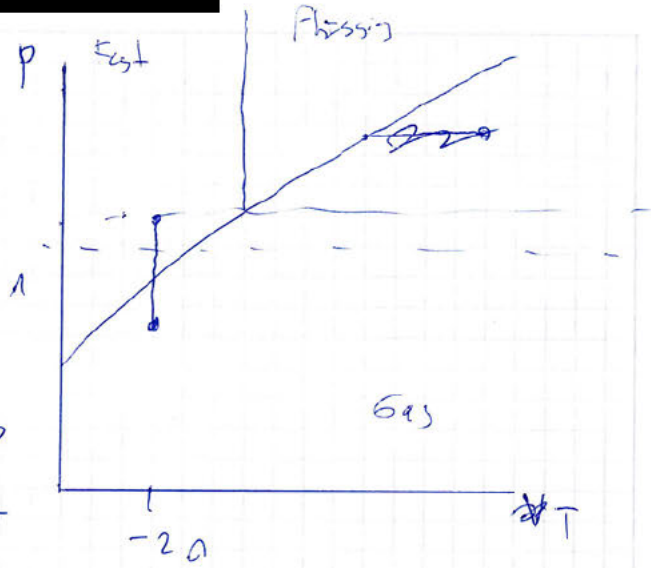
$$u_2 = \frac{1500}{m_{rev}} + u_1 = -185.0789 \frac{\text{kJ}}{\text{kg}}$$

bei 1,1 bar

$$x_{E,1,2} = \frac{u_2 - u_f}{u_g - u_f} = 0.555$$

Aufgabe 4:





b) 1. HS:

$\dot{W}_K = \dot{m}(h_2 - h_3)$ $\quad T_1 = -20°C$

$\Rightarrow T_2 = -26°C$, da $T_2 \overset{!}{=} T_1 - 6$

$h_2(-26°C, x=1) = 231.62 \frac{kJ}{kg}$ aus A-10

h_3: $s_2 = s_3 = 0.9390 \frac{kJ}{kg \cdot K}$

$\Rightarrow h_3(8bar, s_3) = \frac{289.39 - 273.66}{0.9771 - 0.9379}(0.9390 - 0.9379) + 273.66$ (95°C)

$= 279.15 \frac{kJ}{kg}$

$\Rightarrow \dot{m} = \frac{-28 \cdot 10^{-3}}{231.62 - 279.15} = 0.658 \frac{kg}{s}$ //

c) $p_1 = p_2 = 1.0199 bar$ aus A-10

$h_4 = h_1$ da Drossel

$h_4(8bar, x=0) = 93.42 \frac{kJ}{kg}$ aus A-11

bei p_4

$$\Rightarrow x = \frac{h_g - h_f}{h_g - h_f} = \frac{93.42 - 16.82}{231.62 - 16.82} = 0.356$$

d) $$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{\dot{W}_t}$$

$$\dot{Q}_{zu} = \dot{m}(h_2 - h_1) = 0.658\,(231.62 - 93.42) = 90.9\ \text{kW}$$

$$\Rightarrow \varepsilon_K = \frac{90.93}{28} = 3.2477$$

e) Irgendwann ist das Essen und der Gefriertrockner im Gleichgewicht und somit kann irgendwann keine Wärme entzogen werden!