Aufgabe 1: Reaktor

a) 1. HS: $0 = \dot{m}_{ein}(h_{ein} - h_{aus}) + \dot{Q}_R + \dot{Q}_{aus} + \cancel{\dot{W}_t}^{0}$

h_{ein} => siedende Flüssigkeit bei 70°C $\overset{TABA2}{\Rightarrow} h_{ein} = \cancel{2333,8}\ 292,98\ \frac{kJ}{kg}$

h_{aus} = " " 100°C $\overset{TABA2}{\Rightarrow} h_{aus} = \cancel{2257,0}\ 419,04\ \frac{kJ}{kg}$

$\Rightarrow \dot{Q}_{aus} = \dot{m}_{ein}(h_{aus} - h_{ein}) - \dot{Q}_R = -62,1824\,kW$

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

$= \frac{\int_e^a dQ}{s_a - s_e} = \frac{q_a - q_e}{q_a - s_e} = \frac{u_a - u_e}{s_a - s_e} \overset{\text{ideale Flüss.}}{=} \frac{c_f(\bar{T}_a - \bar{T}_e)}{c_f \ln\left(\frac{\bar{T}_a}{\bar{T}_e}\right)}$

$= 293,12\,K$

c) ~~falsch~~

$0 = \dot{m}(s_e - s_a) + \frac{\dot{Q}_{aus}}{\bar{T}_{ur}} + \dot{S}_{erz}$

$\dot{S}_{erz} = \dot{m}(s_a - s_e) - \frac{\dot{Q}_{aus}}{\bar{T}_{ur}} = \dot{m}(s_a - s_e) + \frac{\dot{Q}_{aus}}{\bar{T}_{ur}}$

TABA2:

$s_e = s_f(70°C) = 0.9549\ \frac{kJ}{kg\,K}$

$s_a = s_f(100°C) = 1.3069\ \frac{kJ}{kg\,K}$

$\Rightarrow \dot{S}_{erz} = 0.3178\ \frac{kJ}{K}$

d) Halboffenes System:

$$\Delta E = \Delta m_{12} h_{12} + \cancel{Q_{R12}} + \cancel{Q_{aus,12}} \quad (\dot{m} = 0)$$

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

$$\Rightarrow \Delta m_{12} = \frac{m_2 u_2 - m_1 u_1}{h_{12}} =$$

Tab A2

$$u_1 = u_f(100°C) + x_D (u_g - u_f) = 429{,}378 \frac{kJ}{kg}$$

$$u_2 = u_f(20°C) + x_D (u_g - u_f) = 303{,}968 \frac{kJ}{kg}$$

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

$$h_{12} = h_1 - h_2 = \cancel{-126{,}06} \; -126{,}06 \frac{kJ}{kg}$$

$$\Rightarrow \Delta m_{12} = \frac{(m_1 - \Delta m_{12}) u_2 - m_1 u_1}{h_{12}}$$

$$\Delta m_{12} + \frac{m_{12} u_2}{h_{12}} = \frac{m_1 u_2 - m_1 u_1}{h_{12}} \Leftrightarrow \Delta m_{12} \left(1 + \frac{1}{h_{12}}\right) = \frac{m_1 u_2 - m_1 u_1}{h_{12}}$$

$$\Delta m_{12} = \frac{m_1 u_2 - m_1 u_1}{h_{12}\left(1 + \frac{1}{h_{12}}\right)} = 5680\,kg$$

e) $\Delta S = S_2 - S_1 = m(s_2 - s_1) = \cancel{\frac{\dot{Q}_R - \dot{Q}_{aus}}{T_0}}^{\,0} + S_{erz}$

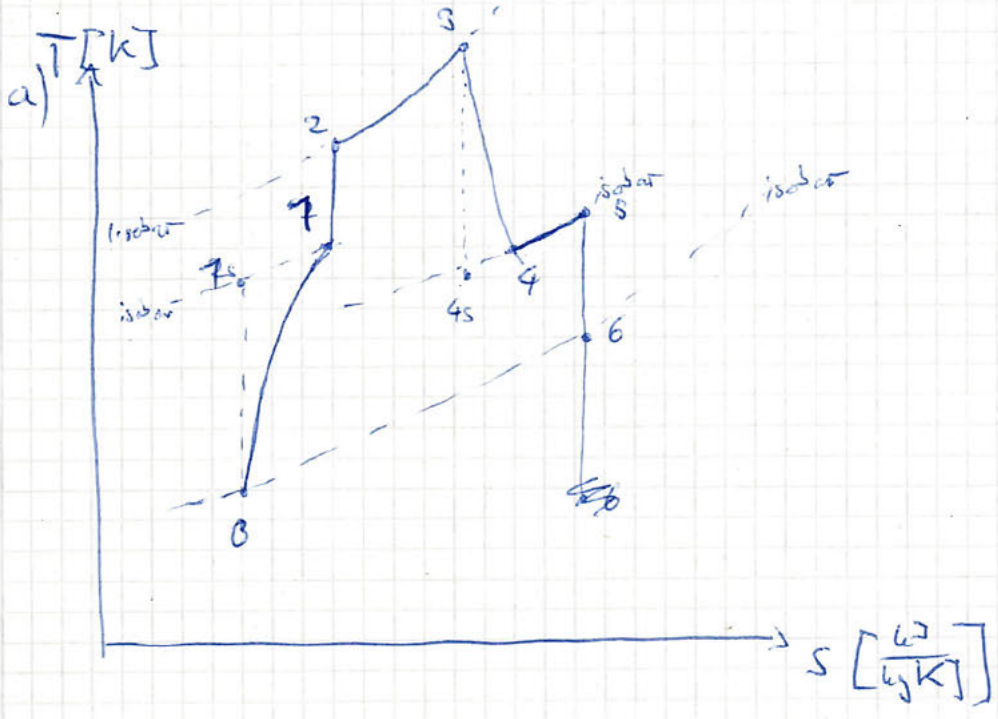
$$\Rightarrow \Delta S_{12} = S_{erz}$$

Aufgabe 2

Z	p[bar]	T[K]	h	s
1				
2				
3				
4				
5	0.5	431,9		
6	0.191	328,075		

isobar

a)



b) 5 -> 6 adiabat reversibel

$$\Rightarrow T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 431{,}9 \left(\frac{0.191}{0.5}\right)^{\frac{0.4}{1.4}} = 328{,}075\,K$$

(1.HS) $0 = \dot{m}_{Ges}(h_5 - h_6) + \cancel{\dot{Q}}^{\text{adiabat}} - \cancel{\dot{W}} + \frac{w_5^2 - w_6^2}{2}$

$$\cancel{\dot{m}_{Ges}}\,0 = \cancel{\dot{m}_{Ges}}\frac{w_5^2}{2} - \frac{w_6^2}{2} = \cancel{\dot{m}_{Ges}}(h_6 - h_5) \Rightarrow w_5^2 + 2(h_5 - h_6) = w_6^2$$

$$\sqrt{w_5^2 + 2(c_p(T_5 - T_6))} = w_6 = 220{,}474\ \frac{m}{s}$$

$\bar{T}_0 = 262,15\,K$

c) $\Delta e_{xstr\,6} = [h_6 - h_0 - \bar{T}_0 (s_6 - s_0)]$

$\Delta e_{xstr_6} = c_p (T_6 - T_0) - T_0 \left(c_p \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)\right) + \frac{w_6^2 - w_0^2}{2}$

$= (12,462 \frac{kJ}{kg}) + 110'050 \frac{m^2}{s^2} \Rightarrow \Delta e_{xst} = 122,512 \frac{kJ}{kg}$

d) $e_{xvol} = \Delta e_{xstr} + e_{xq}$

$= \Delta e_{xstr} + \left(1 - \frac{T_6}{T_B}\right) q_B = 1070,508 \frac{kJ}{kg}$

Aufgabe 3

a) $p_{G,1} \overset{!}{=} p_{amb} + \frac{m_k \cdot g}{A} + \frac{m_{ew} \cdot g}{A} \Rightarrow A = \pi \left(\frac{D}{2}\right)^2 = 0,00785\,m^2$

$= 1\,bar + \frac{(m_k + m_{ew}) g}{A} = \underline{1,401\,bar}$

$pV = mRT \Rightarrow R = \frac{\bar{R}}{M} = 166,28 \frac{J}{kg\,K}$

$\Rightarrow m_g = \frac{p_{G1} V_{G1}}{R\, T_{G1}} = \underline{3,422\,g}$

e) $\Delta U = Q_{12} - \cancel{W_{12}}^{0}$

$\Delta U = m_g (u_2 - u_1) = Q_{12}$

$\Rightarrow m_g (c_v (T_{2G} - T_{1G})) = Q_{12} = \underline{-1,083\,kJ}$

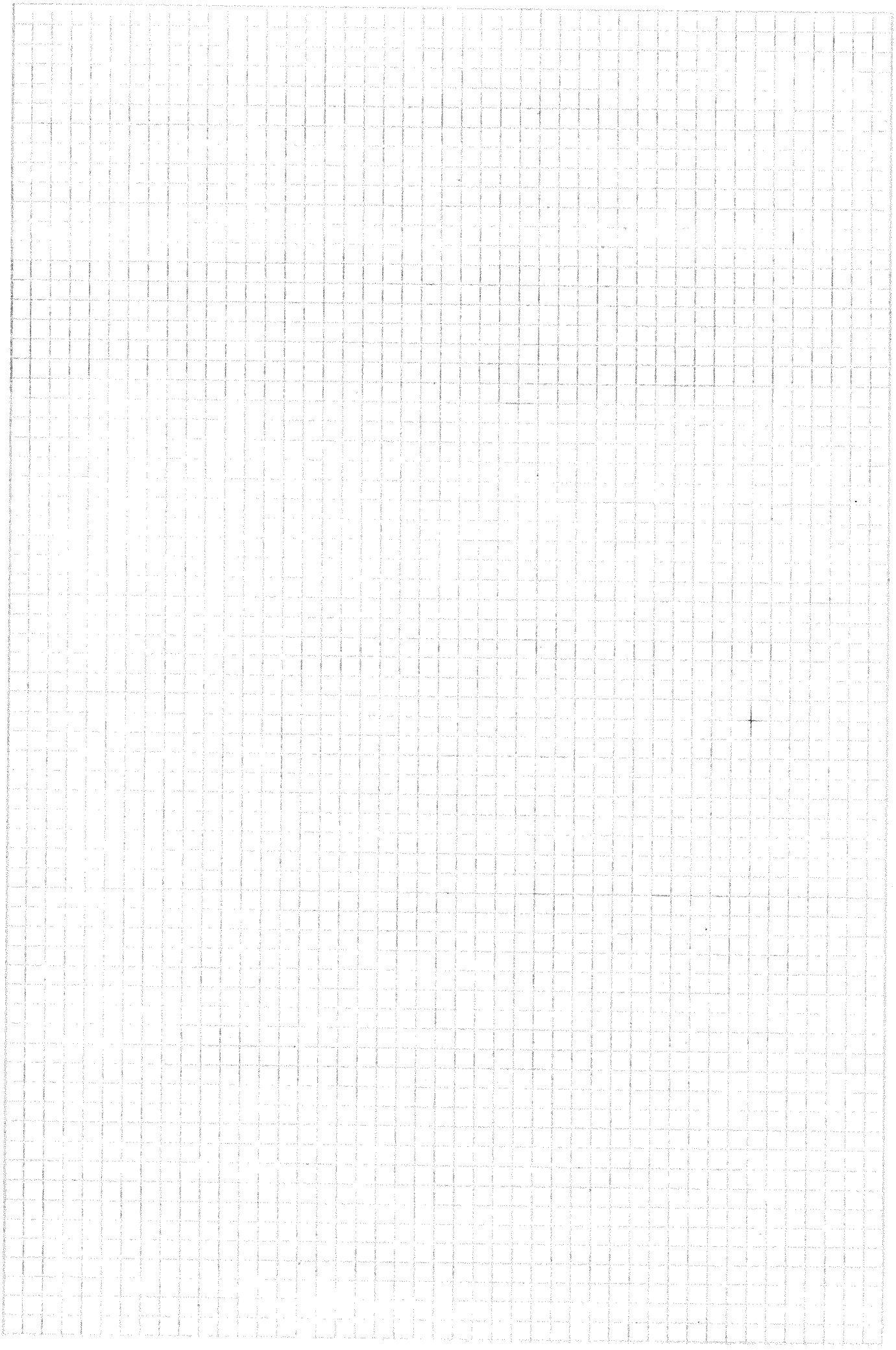
d) $u_{1,eis} = u_{last} + x_1 (u_{fg} - u_{last} = -200,092 \frac{kJ}{kg}$

$u_{2,eis} = -333,401 + x_2 (0 + 333,401)$

$\Rightarrow m(u_2 - u_1) = Q_{12} - \cancel{W_{12}}$

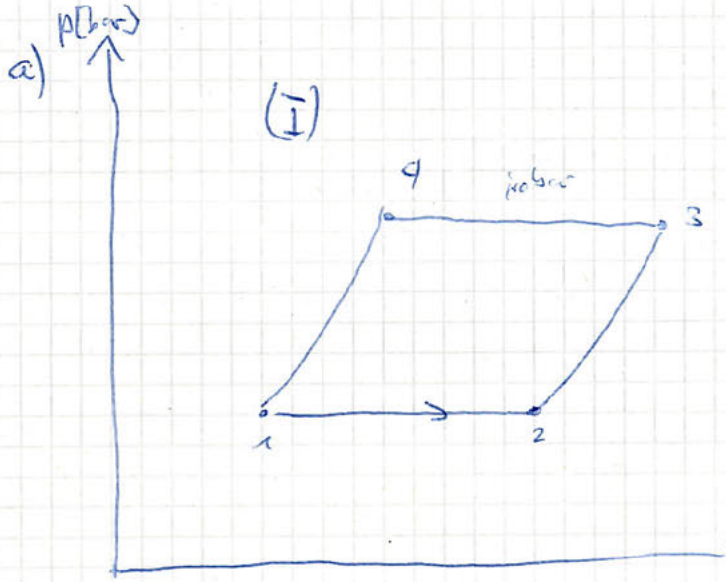
$u_2 - u_1 = \frac{Q_{12}}{m} \Rightarrow u_2 = \frac{Q_{12}}{m} + u_1$

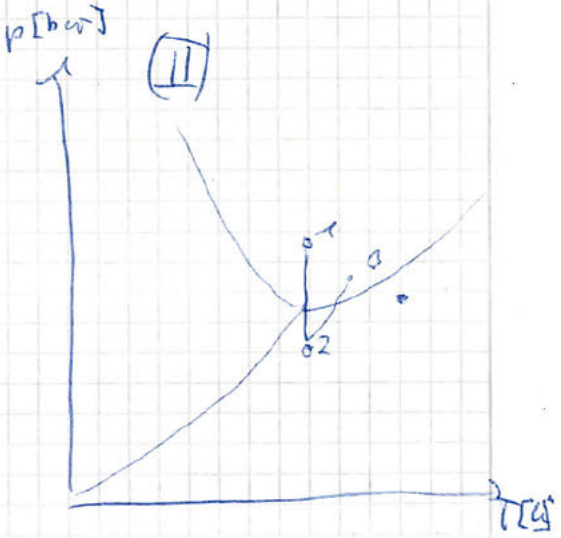
$\Rightarrow x_2 = \frac{\frac{Q_{12}}{m} + u_1 + 333,401}{333,401} = \underline{0,43233}$

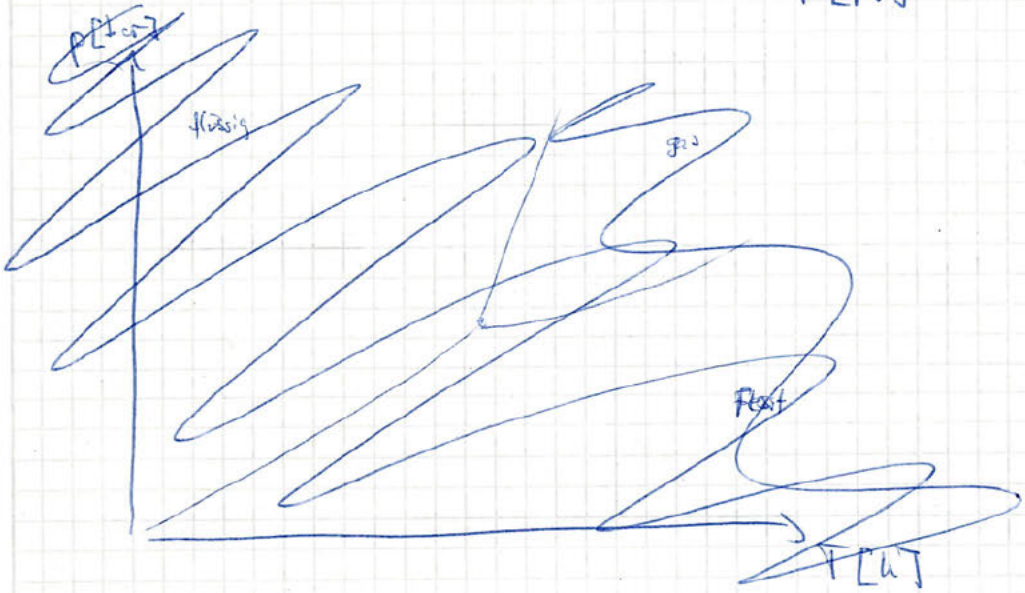


Aufgabe 4

a)







b) $x_2 = 1$ $\quad x_4 = 0$

TABA11 $s_4 = s_f = 0,3459 \frac{kJ}{kg\,K}$ $\quad h_4 = 93,42 \frac{kJ}{kg}$

$T_1 = 10°C$

$\Rightarrow T_{Verdampfer} = 4°C$

$\Rightarrow s_2 = s_g = 0.9169 \frac{kJ}{kg\,K}$ $\quad h_2 = 249,53 \frac{kJ}{kg}$

	p	
1		
2		
3	8	
4	8	x=0

$0 = \dot{m}\,[h_2 - h_3] + \dot{W}_K$

$s_3 = s_2 = 0.9169$

~~$s_4 < s_3 < 0.9169$~~

$h_3 = ?$ $\quad$ Interpol AK2 $\quad h_3 = h_{sat} + \frac{s_3 - s_{sat}}{s_{gas} - s_{sat}} (h_{gas} - h_{sat}) = 264,1501 \frac{kJ}{kg}$

$\dot{m} = \frac{\dot{W}_H}{h_2 - h_3} = 0.00193 \frac{kg}{s} = 6.894 \frac{kg}{h}$

$T_2 = ??$

c) $h_4 \Rightarrow x = 0$ und 8 bar $\Rightarrow h_4 = 93,42 \frac{kJ}{kg}$ (TABLE)

$Q = \dot{m}(h_4 - h_1) \Rightarrow h_4 = h_1$

$p_1 = 1,2 kg$

$x_1 = \frac{h_4 - h_f}{h_g - h_f} = 0,337$

d) $\varepsilon_k = \frac{\dot{Q}_{zu}}{|W_H|} \Rightarrow \varepsilon_k = \frac{156,28 W}{\dot{W}_k} = 5,581$

$0 = \dot{m}(h_1 - h_2) + \dot{Q}_{zu} \Rightarrow Q_{zu} = \dot{m}(h_2 - h_1) = 156,28 W$

e) Die Temperatur würde weiter sinken und sich tiefer einpendeln, da weiterhin 28 W Leistung in den Kühlkreislauf gegeben wird.