[redacted]

1.

a) Energiebilanz in dem Wasser im Reaktor.

$$SFP: \; 0 = \dot{m}_{ein}\left[h_e - h_a\right] + \dot{Q}_R - \dot{Q}_{aus}$$

$$\dot{Q}_{aus} = \dot{m}\left[h_e^{H_2O} - h_a^{H_2O}\right] + \dot{Q}_R$$

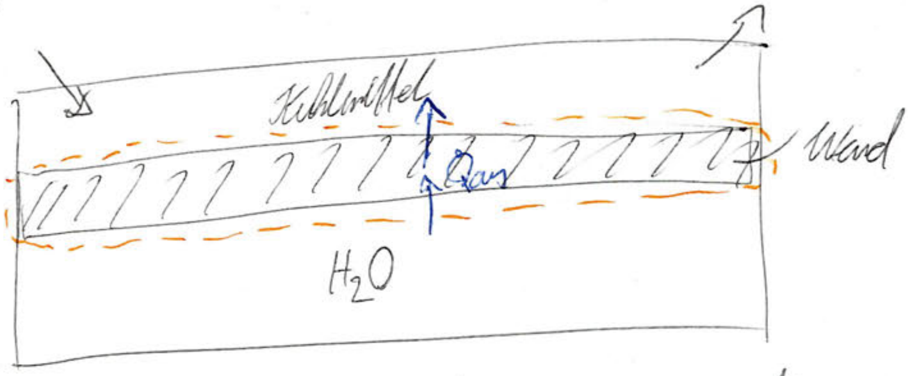
$h_e = h_f(70°C) \rightarrow$ TAB-A2:

$\boxed{h_e = 292{,}98 \frac{kJ}{kg}}$

$\boxed{h_a = h_f(100°C) = 419{,}04 \frac{kJ}{kg}}$

$$\underline{\underline{\dot{Q}_{aus} = 62{,}18 kW}}$$

b) $\overline{T}_{KF} = \dfrac{\int_{s_e}^{s_a} T\,dS}{s_e - s_a}$ Kühlmantel ist adiabat & isobar c)



Bilanzgrenze: Entropiebilanz um die Wand:

$$0 = \frac{\dot{Q}_{aus}}{\overline{T}_{H_2O}} - \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} + \dot{S}_{erz} \qquad \overline{T}_{H_2O} = T_R = 100°C = 373{,}15°K$$

$$\dot{S}_{erz} = \dot{Q}_{aus}\left(-\frac{1}{\overline{T}_{H_2O}} + \frac{1}{\overline{T}_{KF}}\right) \qquad \overline{T}_{KF} = 295°K$$

$$\dot{S}_{erz} = 65kW\left(\frac{1}{295°K} - \frac{1}{373{,}15°K}\right) = \underline{\underline{4{,}614 \times 10^{-2} \frac{kJ}{kg\,K}}}$$

	$\dot{Q}$	W
Δm_{12}	$Q_{aus,12}$ 35 MJ	

Z	T
0	
1	100°C
2	70°C

[redacted]

A1

d) Energiebilanz um den Reaktor (kein SFP)

$$\Delta E = \Delta m_{12}[h_1 - h_2] - Q_{aus1,2}$$

$$\underbrace{U_2 - U_1}_{= m_2 u_2 - m_1 u_1} = \Delta m_{12}\underbrace{[h_1 - h_2]}_{\text{aus a)}} - Q_{aus1,2}$$

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

TAB-A-2:

$$u_1 = u_f(100°C) = 418{,}94 \frac{kJ}{kg}$$

$$u_2 = u_f(70°C) = 292{,}95 \frac{kJ}{kg}$$

$$(m_1 + \Delta m_{12})u_2 - m_1(u_1) = \Delta m_{12}[h_1 - h_2] - Q_{aus,12}$$

$$m_1 u_2 + \Delta m_{12} u_2 - \Delta m_{12}[h_1 - h_2] = m_1 u_1 - Q_{aus,12}$$

$$\Delta m_{12}(u_2 - [h_1 - h_2]) = m_1(u_1 - u_2) - Q_{aus1,2}$$

$$\Delta m_{12} = \frac{m_1(u_1 - u_2) - Q_{aus,12}}{u_2 - h_1 + h_2}$$

1)

e) ~~Geschlossenes~~

$$\Delta S = \Delta m_{12} s$$

$$\cancel{\Delta S = m_2 s_2 - m_1 s_1 + \frac{Q_{aus12}}{\overline{T}_2} + S_{erz}}$$

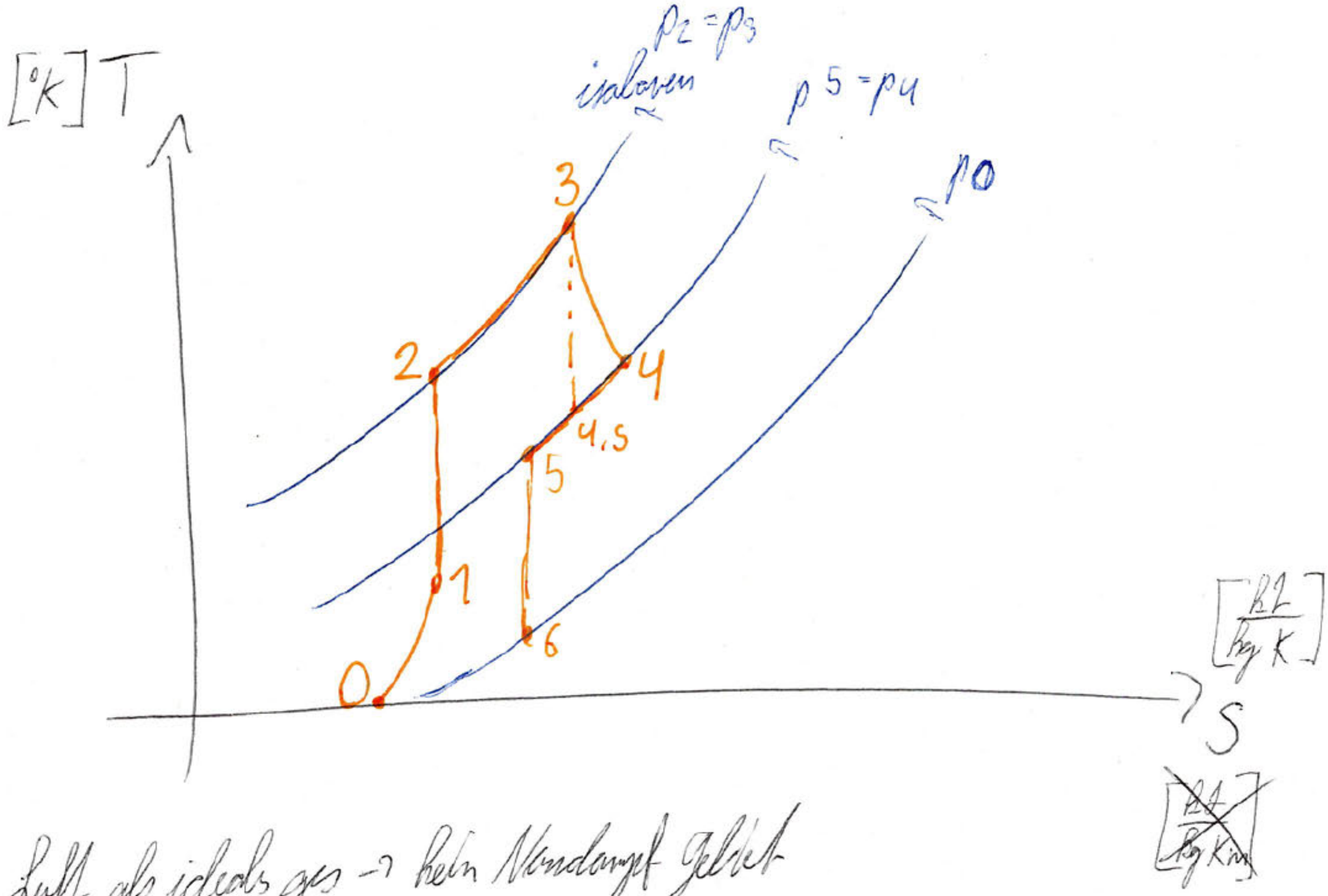
$$\Delta S = \Delta m_{12} \cdot s_2 + \frac{Q_{aus12}}{\overline{T}_2} + S_{erz}$$

$$s_2 = s_f(70°C) \rightarrow TAB\ \cancel{8}\text{-}2 = 0{,}9549 \frac{kJ}{kg\,K}$$

[redacted]

2

a)



Luft als ideales gas → kein Nassdampf Gebiet

b) 5 → 6 isentrope Zustandsänderung

$k_e = \frac{w^2}{2}$ / $\dot{m} = \rho A w$

$k = 1{,}4$ $\qquad \frac{T_6}{T_5} = \left(\frac{p_5}{p_6}\right)^{\frac{k-1}{k}}$

$p_6 = p_0 = 0{,}191$ bar

$T_5 = 431{,}9$ °K

$p_5 = 0{,}5$ bar

$$T_6 = T_5 \cdot \left(\frac{p_5}{p_6}\right)^{\frac{k-1}{k}} = \underline{\underline{568{,}58\,°K}}$$

2 b) Energiebilanz SFP um Schubdüse

$$0 = \dot{m}_{ges}\left[\underbrace{h_5 - h_6}_{\text{Stoffmodell IG}} + \frac{w_5^2 - w_6^2}{2}\right] + 0$$

$$0 = \dot{m}_{ges}\left[\cancel{f} c_p^L (T_5 - T_6) + \frac{w_5^2 - w_6^2}{2}\right]$$

$$\left(\frac{w_6^2 - w_5^2}{2}\right)\cancel{\dot{m}_{ges}} = \cancel{\dot{m}_{ges}}\left[c_p^{L\,\text{ges}}(T_5 - T_6)\right]$$

$$w_6^2 = 2\left(c_p^L(T_5 - T_6)\right) - w_5^2$$

$$w_6 = \sqrt{2c_p^L(T_5 - T_6) - w_5^2}$$

$w_6 =$

c) Exergiebilanz SFP:

$$\cancel{0 = \dot{m}_{ges}[\Delta E_{x,str}}$$

$$\Delta e_{x,str} = \left[\underbrace{h_1 - h_6}_{\text{Stoffmodelle IG}} - T_0\underbrace{(s_1 - s_6)} + \frac{w_1^2 - w_6^2}{2}\right]$$

$c_p = R + c_v$

$$h_1 - h_6 = c_p^W (T_1 - T_6) \qquad s_1 - s_6 = c_p \ln\left(\frac{T_1}{T_6}\right) - R \ln\left(\frac{p_1}{p_6}\right)$$

	W	Q
adiabat		
$\dot{m}_K$ adiabat-rev isentrop		
$T_B = 1289\,K$ isobar		$q_B = \frac{\dot{Q}}{\dot{m}_K}$ $1795\,\frac{kJ}{kg}$
adiabat nicht isentrop		
isobar		
isentrop		

Z	p	T	w
0	0,191 bar	-30°C	
1			
2			
3			
4			
5	0,5 bar	431,9	$220\,\frac{m}{s}$
6			

[redacted]

[redacted]

2

d) Exergiebilanz: STP:

$\cancel{\Delta S = m}$

$\cancel{0 = \Delta e_{x,str} + E_{x,Q} - E_{x,verl}}$

$0 = \Delta e_{x,str} + e_{x,Q} - e_{x,verl}$

$e_{x,verl} = \Delta e_{x,str} + e_{x,Q}$

$\frac{1}{m}\left(1 - \frac{T_0}{T}\right) Q$

$\hat{=} \left(1 - \frac{T_0}{T_B}\right) q_B$

$$e_{x,verl} = \Delta e_{x,str} + \left(1 - \frac{T_0}{T_B}\right) q_B$$

[redacted]

3

a) $p_g = p_{amb} + p_{gewicht} + p_{ew}$

$$p_g = 1\,bar + \frac{\cancel{A}\, mg}{A} + \frac{m_{ew} g}{A}$$

$$m_g = \frac{RT}{pV} \quad \Rightarrow R = \frac{\bar{R}}{M_g}$$

b) p_{g2} = Temperatur ist gesunken, weil das Eis geschmolzen ist.

~~Der Druck ist durch die abkühlung auch~~

Der Druck ist gleich geblieben.

c) Energiebilanz

$$\frac{dE}{dt} = \Sigma Q - \Sigma W$$

$$\Delta U = Q_{ab} - \int_1^2 p\,dv$$

d)

c) 4 → 1 isentrop $\quad s_1 = s_4 = \cancel{s_f(p_1)} = s_f(8\,bar)$

$$X_1 = \frac{s_1 - s_f}{s_g - s_f}$$

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

$$\dot{W}_t = \frac{W_t^{rev}}{\eta} \rightarrow W_t^{rev} = -\int_1^2 v\,dp$$

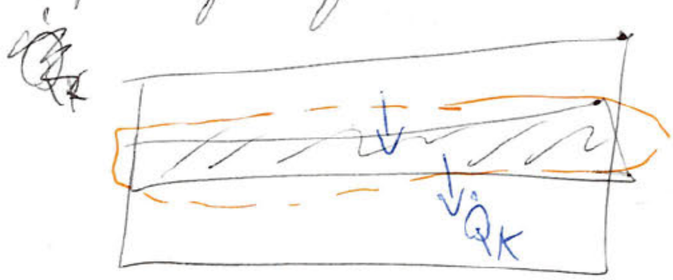
e)

[redacted]

b) Energiebilanz um das ~~Wasser~~ Kühlmittel im Wärmeübertrager

SFP: $0 = \dot{m}_R [h_1 - h_2] + \dot{Q}_K$

~~Entropi~~ Entropie ~~Energiebilanz~~ um Wand:



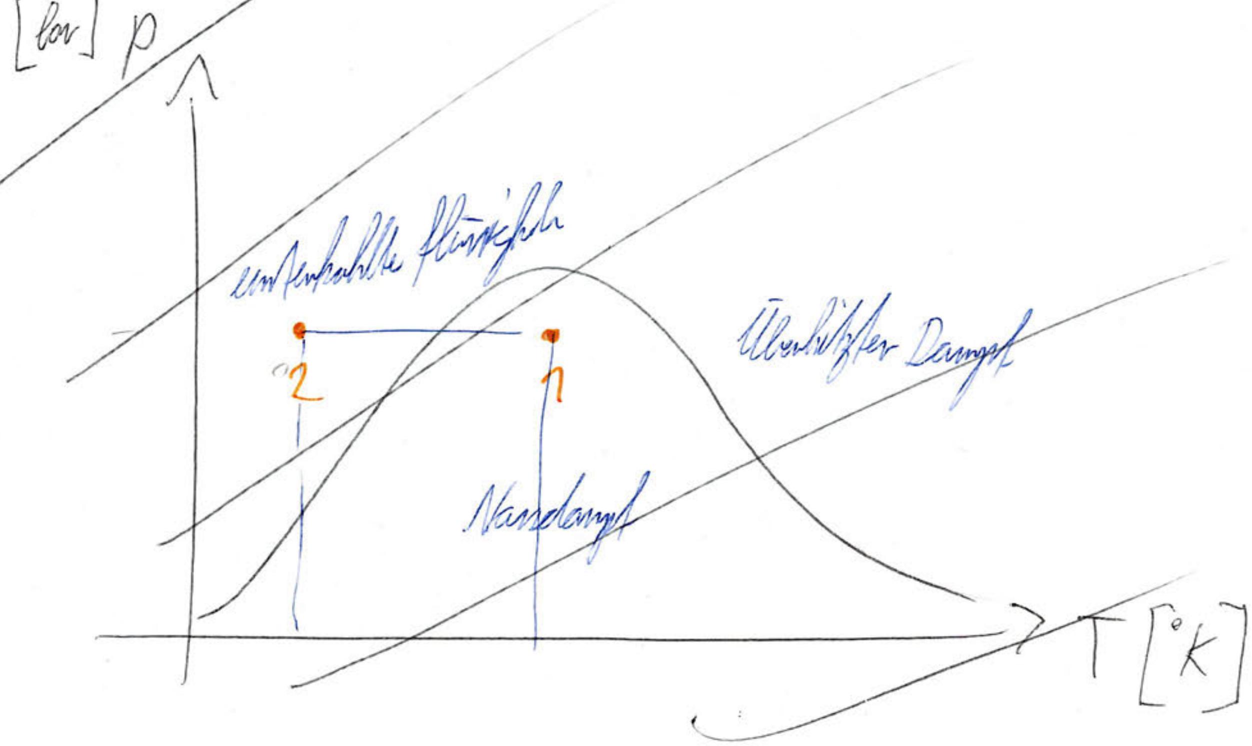
$\cancel{Q} = m(s_2 - s_1) = \frac{Q_K}{T_i} - \frac{Q_K}{T_{ii}}$

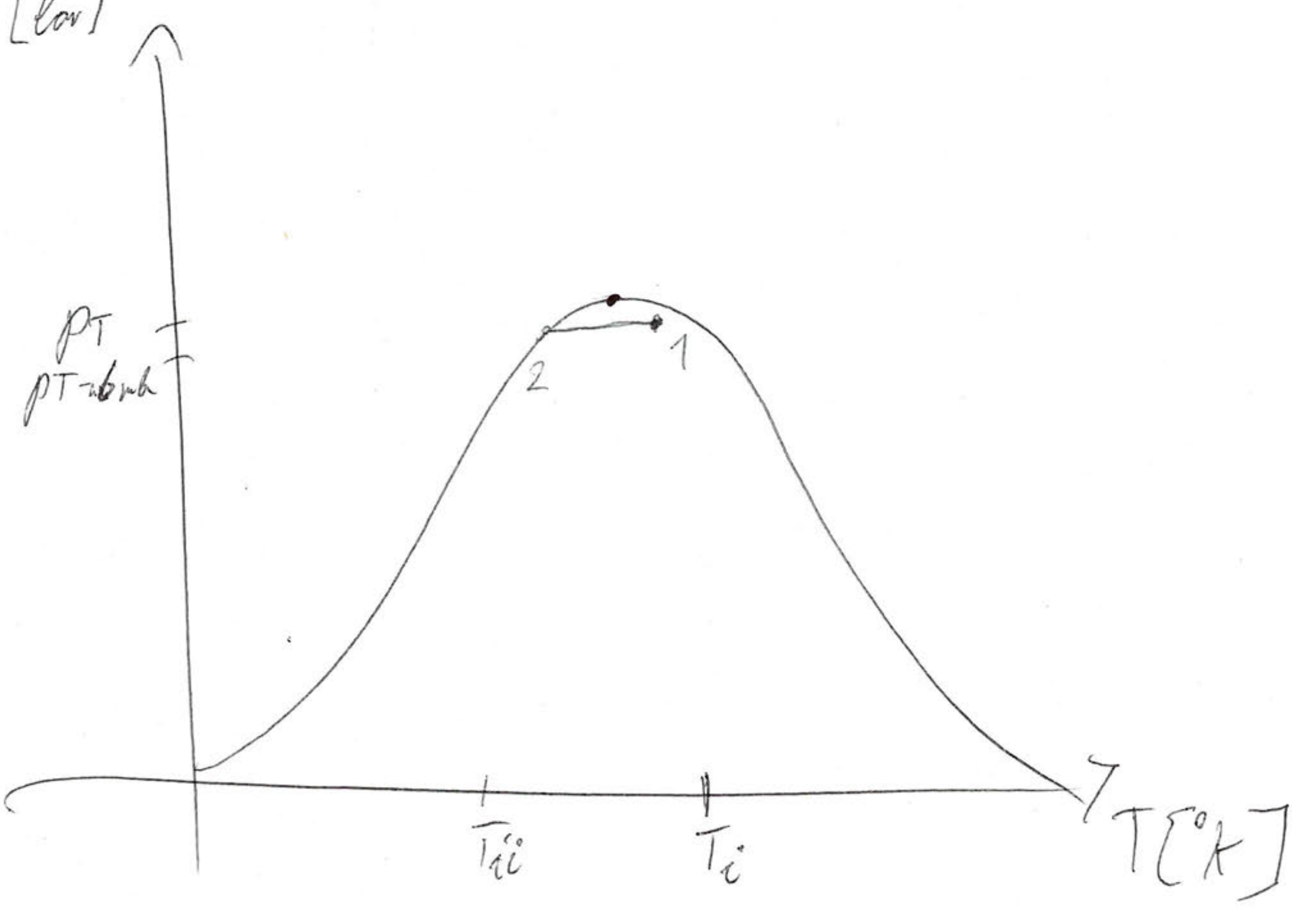
$\dot{Q}_K = m(s_2 - s_1) \cdot (-T_{ii} + T_{i})$

~~$Q = \dot{m}_R h_1 = -\dot{m}$~~

$$\dot{m}_R = \frac{-Q_K}{h_1 - h_2}$$

4]

a) 
[bar] p
unterkühlte Flüssigkeit
überhitzter Dampf
Nassdampf
2
1
T [°K]

a) 
p [bar]
p_T
2
1
T [°K]

[redacted]

	W	Q
izobár		
izentropikus kompresszió	28W	
~~izentróp~~ izobár hőelvonás kondenzátor		
kondenz adiabat		

Z	p	T
0		
1		
2		
3	8bar	
4	p_1	
1		