[redacted]

1) a)

1.HS über Wasser stationär, $\dot{m}$ = konst:

$$0 = \dot{m}_{\text{wein}} (h_e - h_a) + \dot{Q}_R - \dot{Q}_{aus} - \cancel{\dot{W}}^{0}$$

$$\dot{Q}_{aus} = \dot{m}_{ein} \cancel{(\ldots)} (h_e - h_a) + \dot{Q}_R$$

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

A-2

$h_a = 419{,}04 \frac{kJ}{kg}$

$$\dot{Q}_{aus} = \underline{\underline{62{,}182\, kW}}$$

b)
$$\overline{T} = \frac{\int_e^a T\,ds}{s_a - s_e} \overset{IF}{=} \frac{h_a - h_e}{s_a - s_e} = \frac{c^{IF} (T_a - T_e)}{c^{IF} \cancel{(\ldots)} \ln\left(\frac{T_a}{T_e}\right)}$$

$$= \underline{\underline{293{,}12\, K}}$$

c) Kühlmittel: ~~geschlossenes System~~
stationärer Fliessprozess: $\dot{m}$ = konst

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

$$\dot{S}_{erz} = \cancel{\dot{m}(s_a - s_e)} - \frac{\dot{Q}_{aus}}{\overline{T}} = \underline{\underline{212{,}11 \frac{J}{s}}}$$

zwischen Reaktor
und Kühlmittel
nicht nur in Kühlmittel

d) $T_1 = 100°C$, $T_2 = 70°C$

$Q_{Kühlmittel} = 35 MJ$

1. HS ~~über geschlossenen~~ Tank! Halboffenes System.

$\Delta U_{12} = \sum Q - \sum W^{\to 0}$ $x_D = 0{,}005$

$\sum Q = Q_R$ $m_{ges,1}$

abgeführt durch Kühlmittel

(1) $m_2 u_2 - m_1 u_1 = \Delta m_{12} [h_\Delta] + (-Q_R)$ $m_2 = m_1 + \Delta m$

$u_1 \overset{A-2}{\underset{100°C}{=}} 418{,}94 + x_D (2506{,}5 - 418{,}94) = 429{,}37 \frac{kJ}{kg}$

$u_2 \overset{A-2}{\underset{70°C}{=}} 292{,}95 \frac{kJ}{kg}$ $x = 0$, da nur noch flüssig!

$h_\Delta \overset{A-2}{\underset{20°C}{=}} 83{,}96 \frac{kJ}{kg}$

$\overset{(1)}{\Rightarrow}$ $(m_1 + \Delta m) \cdot u_2 - m_1 u_1 = \Delta m_{12} h_\Delta - Q_R$

$\Delta m_{12} (u_2 - h_\Delta) = -Q_R + m_1 u_1 - m_1 u_2$

$\Delta m_{12} = \dfrac{-Q_R + m_1 u_1 - m_1 u_2}{u_2 - h_\Delta} = 3500{,}37\ kg$

[redacted]

(3) $p = \frac{F}{A}$

a) $p_1 = p_{amb} + m_k \cdot \frac{1}{\pi\left(\frac{D}{2}\right)^2} \cdot g + m_{EW} \cdot \frac{1}{\pi\left(\frac{D}{2}\right)^2} \cdot g$

$= \cancel{1{,}200435\,bar}\ p_{AmB} + \frac{m_k \cdot g}{\pi\left(\frac{D}{2}\right)^2} + \frac{m_{EW} \cdot g}{\pi\left(\frac{D}{2}\right)^2} = 1{,}40096\,bar$

IG: $\frac{p \cdot V}{RT} = m \qquad R = \frac{\bar{R}}{M} = 166{,}28 \frac{J}{kg}$

$m_1 = \frac{p_1 V_1}{R T_1} = 3{,}421 \cdot 10^{-3}\,kg$

b) $m_1 = m_2 \qquad p_1 = p_2$ → weil gleiches "Gewicht" von den drauf drückt!

→ isobare Polytrope Veraenderung ($n = 0$)

$T_2 = T_1 \left(\frac{v_1}{v_2}\right)^{-1}$

$p_2 \cdot v_2 = R T_2 \iff v_2 = \frac{R T_2}{p_2}$

$T_2 = T_1 \left(\frac{v_1}{\frac{RT_2}{p_2}}\right)^{-1} = T_1 \cdot \frac{R T_2}{v_1 p_2}$

c) $T_{g,2} = 0{,}003\,°C$ $\quad p_1 = 1{,}400$ bar $\quad , m_1 = 3{,}427\cdot 10^{-3}$ kg

1. HS über Gas: geschlossenes System:

$$\Delta U_{12} = Q_{12} - W^{\nearrow 0} \qquad , T_1 = 500K$$

KE+PE vernachlässigbar

$$\Delta u_{12} = c_v(T_2 - T_1) = -316{,}49\,\frac{kJ}{kg}$$

perfektes Gas

$$U_{12} = m_G \cdot \Delta u_{12} = 1{,}0824\ kJ = Q_{12}$$

d) 1. HS über EW: geschlossenes System

$$m_{EW}\cdot \Delta u_{12} = Q_{12} \cancel{\mp} W^{\nearrow 0}$$

$$\Delta u_{12} = \frac{Q_{12}}{m_{EW}} \qquad u_1(0°C) = \text{TAB. 1}$$

Druck auf EW: $p_{1,EW} = 1{,}399$ bar $\to 1{,}46$ bar

$$\Delta u_{12} = u_2 - u_1 \qquad u_1 = u_{fest} + x_1(u_{flüssig} - u_{fest})$$

$$= \cancel{[illegible]}\ -200{,}925\,\frac{kJ}{kg} \qquad x_1 = 1 - x_{Eis} = 0{,}4$$

$p_{1,EW} = p_{2,EW} = 1{,}46$ bar!

$$u_2(1{,}46\,bar) = u_{Fest} + x_2(u_{Flüssig} - u_{Fest}) \quad (1)$$

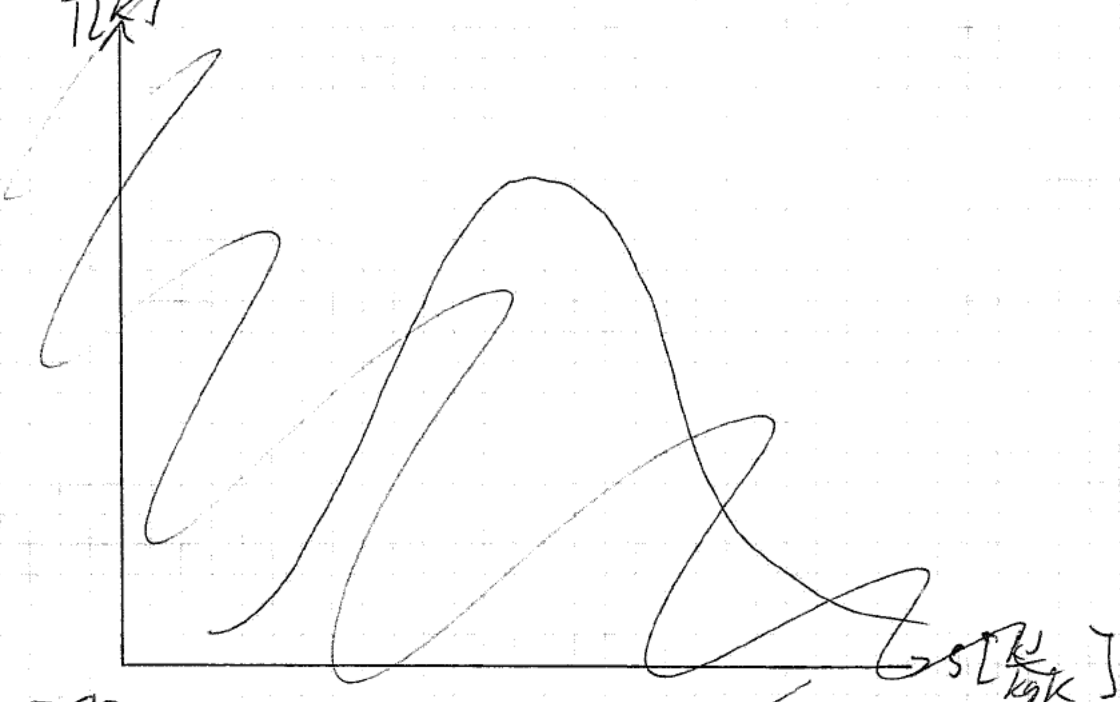
$$u_2 = \frac{Q_{12}}{m_{EW}} + u_1 \cdot m_{EW} = \cancel{[illegible]}\ -190{,}706\,\frac{kJ}{kg}$$

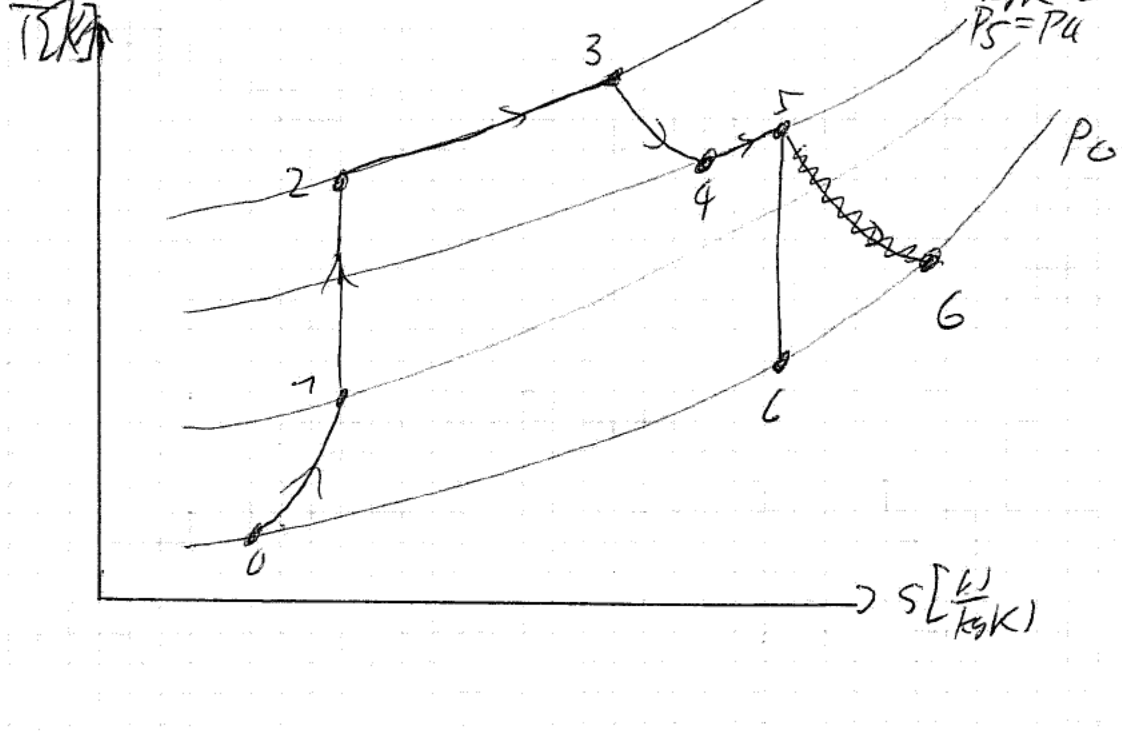
$$\overset{(1)}{\Rightarrow} x_2 = \frac{u_2 - u_{Fest}}{u_{Flüssig} - u_{Fest}} = 0{,}429 \qquad x_{2,Eis} = 1 - 0{,}429 = 0{,}570$$

[redacted]

Aufgabe 2

a)





b) 5-6: isentrop $n = 1{,}4$

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{1{,}4-1}{1{,}4}} = 328{,}0747 K$$

1. HS Düse:

$$0 = \dot m \left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2} \right) + \overset{\to 0 \text{ adiabat}}{\cancel{\dot Q}} \quad \overset{\to 0}{\cancel{\Sigma W}}$$

$$2(h_6 - h_5) = w_5^2 - w_6^2$$

$$\Rightarrow w_6^2 = w_5^2 - 2(h_6 - h_5) \Rightarrow w_6 = \cancel{210{,}...} \; 507{,}24 \frac{m}{s}$$

$$h_6 - h_5 = c_p (T_6 - T_5) = -109{,}49 \frac{kJ}{kg}$$

c) $$\Delta e_{x,str} = \left(h_6 - h_0 - T_0 (s_6 - s_0) + \frac{w_6^2 - \cancel{w_0^2}}{2}\right) \quad \to 0$$

stationärer Fließprozess $\dot m$ = konst!

$$h_6 - h_0 = c_p (T_6 - T_0) = \cancel{58} \; 95{,}434 \frac{kJ}{kg}$$

$$s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right) - R \cdot \ln\left(\frac{p_6}{p_0}\right) \to 0 = 0{,}30136 \frac{kJ}{kg}$$

$$c_v = \frac{c_p}{n} = 718{,}57 \; J \qquad R = c_p - c_v = 287{,}425 \quad (2)$$

$$\Rightarrow \Delta e_{x,str} = 1{,}408 \cdot 10^5 \frac{J}{kg} = 140{,}8 \frac{kJ}{kg}$$

[redacted]

2 e) 2. HS Halboffenes System:

$$\Delta S_{12} = \Delta m_{12} \cdot s_{\Delta} + \frac{Q_R}{\bar{T}} + \dot{S}_{erz}$$

[redacted]

2d) Stationärer Fliessprozess

$$\dot{e}_{x,ver} = \underbrace{\Delta e_{x,str}}_{\text{aus c)}} + \Delta e_{x,q} - \dot{w}_t$$

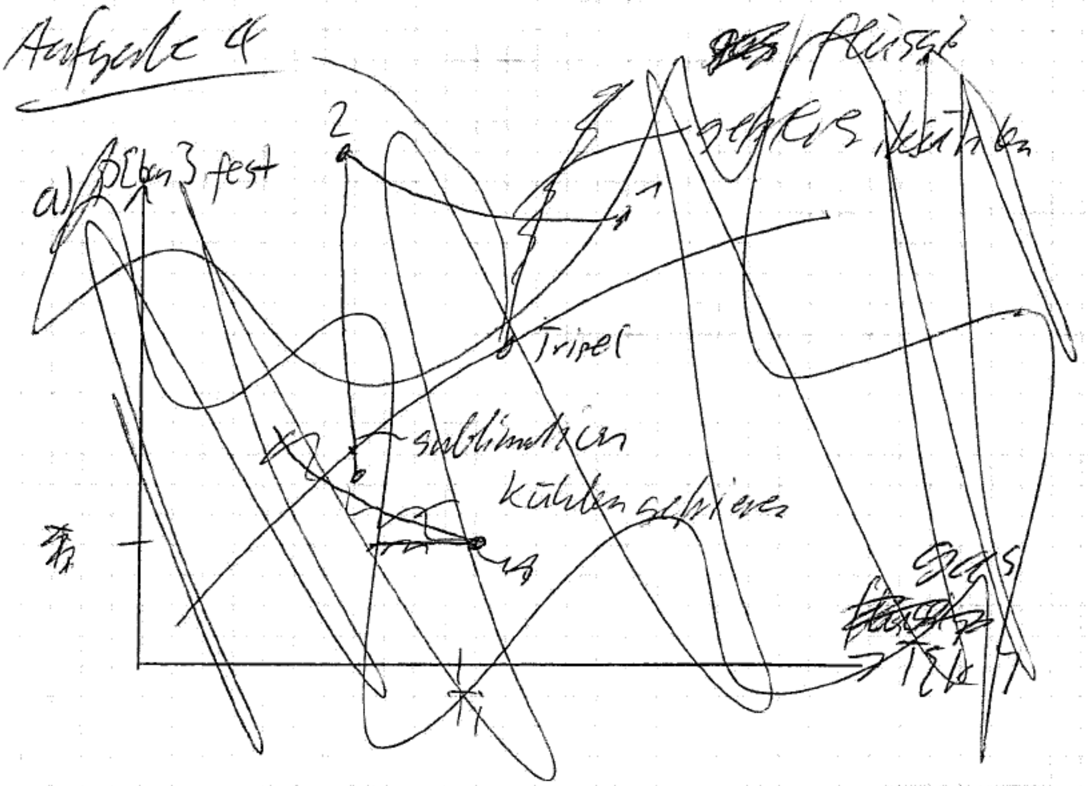
$\dot{w}_t \to 0$, da gesamte Leistung der Turbine in Verdichter geht!

$$\Delta e_{x,q} = \left(1 - \frac{T_0}{T_B}\right) \cdot q_B = 969{,}58 \frac{kJ}{kg}$$

$$e_{x,ver} = 1110{,}38 \frac{kJ}{kg}$$

Aufgabe 4

a)



Aufgabe 4

b) $p_1 = p_2$, $T = 6K = T_1 = T_2$

1. HS über Verdichter; $\dot{W}_K = 28W$

$$0 = \dot{m}_{R134} (h_2 - h_3) + \cancel{\dot{Q}}^{\text{adiabat}} + \dot{W}_K$$

$$\dot{m}_{R134} = \frac{-\dot{W}_K}{h_2 - h_3}$$

$h_2 = \cancel{\ldots}$ 249,53 $\frac{kJ}{kg}$

A-10

$\cancel{\ldots}$ 4°C

$T_1 = \cancel{\ldots}$ 4°C

$s_2 = \cancel{\ldots}$ 0,9169 $= s_3$

~~$\dot{Q}_1 =$~~

~~c) $\dot{m}_{R134} = 4°C$, $T_1 = 22°C$~~

$$s_3 = s_f + x_3 (s_g - s_f) \Rightarrow x_3 = \frac{s_3 - s_f}{s_g - s_f}$$

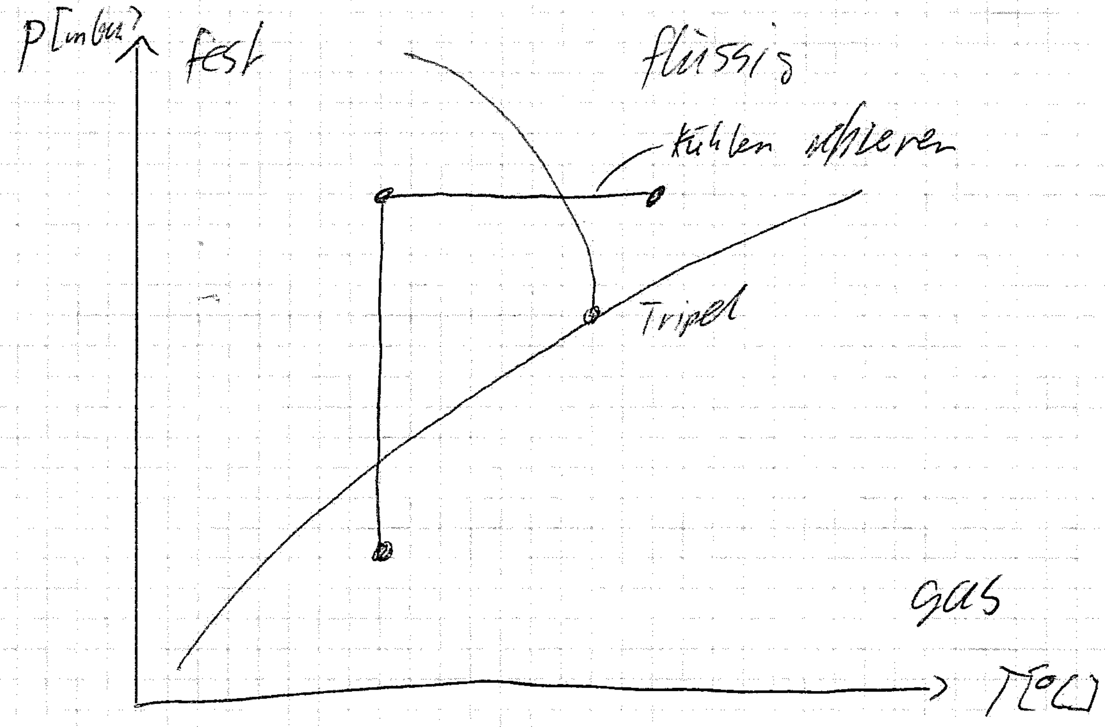
A-11

$$h_3 = h_f + x_3 \cdot (h_g - h_f)$$

A-11-8bar

$$\dot{m}_{R134} = \frac{\dot{W}_K}{h_f + x_3(h_g - h_f) - h_2}$$

Aufgabe 4 a



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Aufgabe 4 c)

1. HS über ~~Kühl~~

$$0 = \dot m_{R134a} [h_1 - h_2] + \dot Q_K$$

$$h_1 = -\frac{\dot Q_K}{\dot m_{R134a}} + h_2$$

$p_1 = p_2 = 3{,}3765\,\text{bar}$

A-10

4°C

~~$h_1 \geq h_f$~~ $h_1(3{,}3765\,\text{bar}) = h_f + x_1(h_g - h_f)$

$$x_1 = \frac{h_1 - h_f}{h_g - h_f}$$

d) $\varepsilon_K = \frac{\dot Q_{zu}}{|\dot Q_{ab}| - |\dot Q_{zu}|} = \frac{\dot Q_K}{\dot Q_{ab} - \dot Q_K}$

e)