1.) $\dot{m}_{ein} = 0.3 \frac{kg}{s}$ $T_{ein} = 70°C$

$\dot{m}_{ein} = \dot{m}_{aus}$ $T_{aus} = 100°C$

1.a) $T_{KF,aus} = 298.15\,K = 25°C$

$T_{KF,ein} = 288.15\,K = 15°C$

Stat. FP im Reaktor: ($ke = 0$, $pe = 0$, $\dot{W}_t = 0$ (keine Arbeit))

$$0 = \dot{m}_R \left(h_2 h_1 - h_2 + \frac{w_1^2 - w_2^2}{2} + g(z_1 - z_2) \right) - \dot{Q}_{aus} - \dot{W}_t$$

$\rightarrow \dot{Q}_{aus} = (h_2 - h_1)\,\dot{m}_R$

$h_2 = h_f(100°C) = 419.04 \frac{kJ}{kg}$ (Tab. A-2)

$h_1 = h_f(70°C) = 292.88 \frac{kJ}{kg}$ (Tab. A-2)

$\rightarrow \dot{Q}_{aus} = -(419.04 - 292.88) \frac{kJ}{kg} \cdot 0.3 \frac{kg}{s}$

$= -37.848\,kW$

1. c.) Entropiebilanz zw. Kühlmittel und Reaktor:

$$\frac{dS}{dt} = \frac{\dot{Q}_{aus}}{T} + \dot{S}_{erz}$$

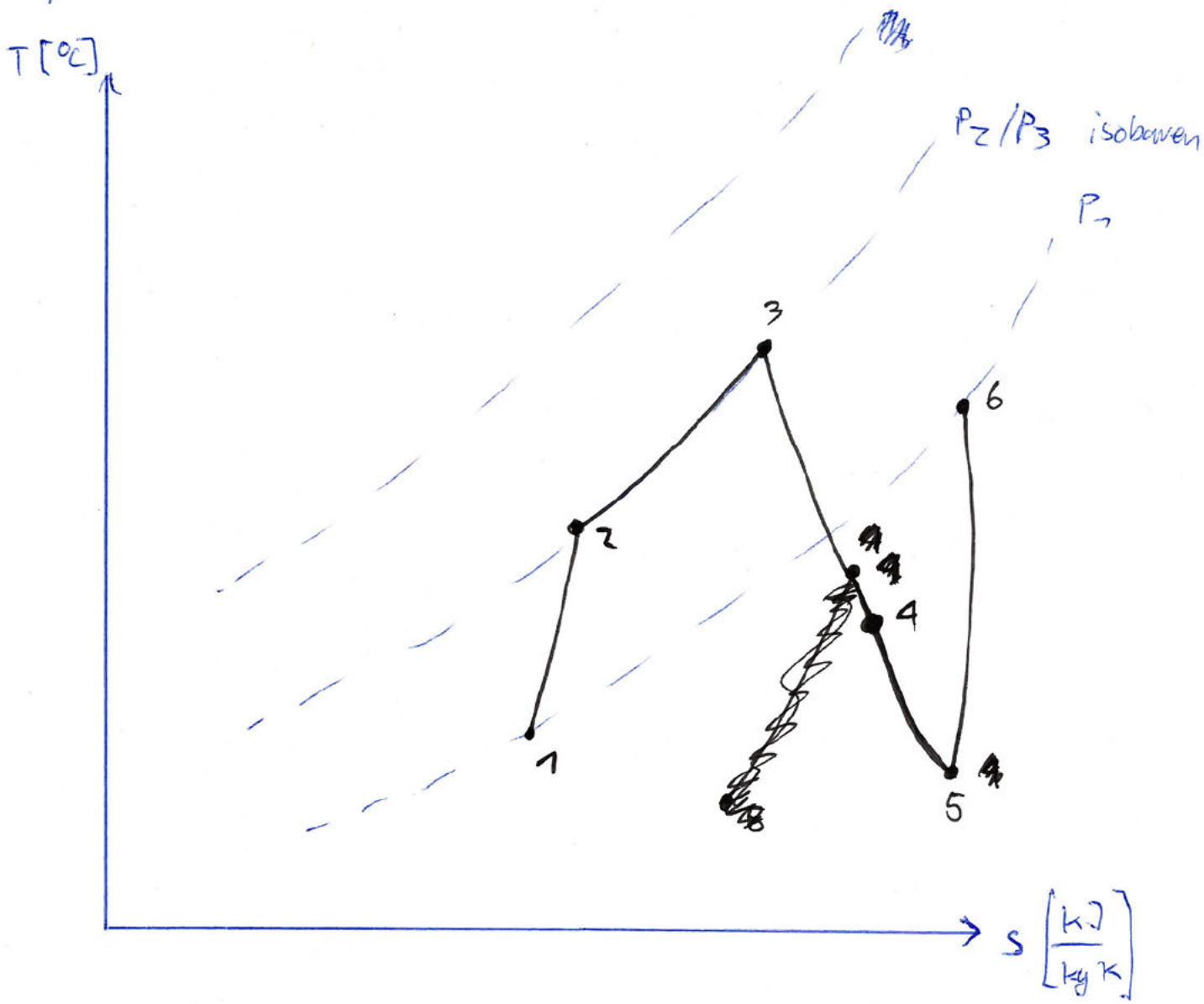
beides nicht geschlossen

$$\rightarrow 0 = \frac{\dot{Q}_{aus}}{T} + \dot{S}_{erz}$$

$$\rightarrow \dot{S}_{erz} = -\frac{\dot{Q}_{aus}}{T_{KF}} = \frac{-(-37.848\,kW)}{295\,K} = 0.1283\,\frac{kJ}{kg\,K}$$

1. d.) $T_{K,2} = 70°$

2.) $w_{Luft} = 200 \frac{m}{s}$ $p_0 = 0.791\ bar_a$ $T_0 = -30°C$



	p [bar]	T [°C]	q [kJ/kg]		
0	0.791	-30°			adiabat isentrop. WG: $\eta_{s,C}$
1					
2			1195 q_B		
3					
4	0.5				isobar
5	0.5	431.9 K			
6					

1

2b) w_6 ? $\quad p_6 = p_0$

Energiebilanz von 5 → 6 : stat. FP.

$pe = 0$; adiabat ; reversibel

$$0 = \dot{m} g_s \left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2} + g(z_5 - z_6) \right) + \dot{Q} - \dot{W}_T$$

$$0 = \dot{m} g_s \left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2} \right)$$

$$\rightarrow \quad h_6 - h_5 = \frac{w_5^2 - w_6^2}{2}$$

$$\rightarrow w_6^2 = 2 \cdot (h_5 - h_6) + w_5^2$$

(?) (?) (✓)

5 → 6 ; isentrop → $n = 1.4$;

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5} \right)^{\frac{n-1}{n}} \rightarrow T_6 = T_5 \left(\frac{p_6}{p_5} \right)^{\frac{n-1}{n}}$$

$$= 431.9\,K \cdot \left(\frac{0.79.1\,bar}{0.5\,bar} \right)^{\frac{0.4}{1.4}}$$

$$= 328.0747\,K$$

$$\rightarrow w_6^2 = 2 \cdot (h_5 - h_6) + w_5^2 = 2 \cdot c_p (T_5 - T_6) + w_5^2$$

$$w_6 = \sqrt{2 \cdot 1.006 \frac{kJ}{kg\,K} (431.9\,K - 328.0747\,K) + \left(220 \frac{m}{s} \right)^2}$$

~~$\rightarrow w_6 = 234.453 \frac{m}{s}$~~

$$w_6 = 234.453 \frac{m}{s}$$

2 c.) $\Delta e_{x,str} = e_{x,str6} - e_{x,str,0}$

$e_{x,str_6} = h_6 - h_0 - T_0(s - s_0) + ke + \cancel{pe}$ (pe = 0)

$= h_6 - h_5 - T_0(s_6 - s_5) + \frac{1}{2} m_{ges} \cdot w_5^2$

3a) $c_v = 0.633 \frac{kJ}{kg\,K}$ $M_g = 50 \frac{kg}{kmol}$

$p_{g,1}$? m_g ?

$V_{g,1}$ ✓ $T_{g,1}$ ✓

$$R_g = \frac{8.314 \frac{kJ}{kmol\,K}}{50 \frac{kg}{kmol}} = \frac{\bar{R}}{M_g}$$

$$= 0.16628\ kJ/kg\,K$$

~~$p_{g,1} = \frac{m_K \cdot g}{\pi \cdot \left(\frac{D}{2}\right)^2} = \frac{32\,kg}{\pi \cdot \left(\frac{D}{2}\right)^2}$~~

~~$p_{g,1} = m_K \cdot g$~~

$$p_{g,1} = p_{amb} + \frac{m_K \cdot g}{\pi \left(\frac{D}{2}\right)^2} = \frac{32\,kg \cdot 9.81\,m/s^2}{\pi \cdot (0.05\,m)^2} + 1\,bar$$

$$= 1.3997\,bar$$

$$m_g = \frac{p_{g,1} \cdot V_1}{R_g \cdot T_1} = \frac{1.3997 \cdot 10^5\,Pa \cdot 3.14 \cdot 10^{-3}\,m^3}{0.16628 \cdot 10^3 \frac{J}{kg\,K} \cdot (500 + 273.15)\,K}$$

$$= 0.0034186\,kg = 3.4187\,g$$

3b) Energiebilanz:

$$\frac{dE}{dt} = \dot{Q} - \dot{W}_t^{\,0}$$

$$\rightarrow m_g (u_2 - u_1) = m_{EW} \cdot (u_{1,EW} - u_{2,EW})$$

3c) Q_{12}?

$T_{g,2} = 0.003°C$

Energiebilanz:

$$\frac{dE}{dt} = \dot{Q}_{12} - \dot{W}_{12} \quad | \int dt$$

~~$m\Delta u = \dot{Q}_{12} - \dot{W}_{12}$~~

$$m\Delta u = Q_{12} - W_{12} \qquad m_g = 3.6g \text{ (gegeben)}$$

$$W_{12} = \int_1^2 p\,dV = \cdot$$

$$\Delta u = u_2 - u_1 = c_v^{ig}(T_{g2} - T_1) = 0.633 \frac{kJ}{kg\,K} \cdot (0.003°C - 500°C)$$

$$= -376.498 \frac{kJ}{kg}$$

~~$p_{g,2} = p_{g,1} +$~~

$$m_g \cdot \Delta u = Q_{12} - W_{12}$$

$$\rightarrow Q_{12} = m_g \Delta u + W_{12}$$

3) d)

$$x_{Eis,2} = \frac{m_{f,2}}{m_{f,2} + m_{F,2}}$$

$u_{EW,1}$ ...

$T_{EW,1} = 0°C \rightarrow u_{EW,1,Fest} = -333.458 \frac{kJ}{kg}$ (Tab. 1)

...

Energiebilanz $1 \rightarrow 2$:

$$m_{EW}(u_2 - u_1) = |Q_{12}| \rightarrow u_2 = \frac{Q_{12}}{m_{EW}} + u_1$$

$$= \frac{1500\,J}{0.1\,kg} - 333.458 \frac{kJ}{kg}$$

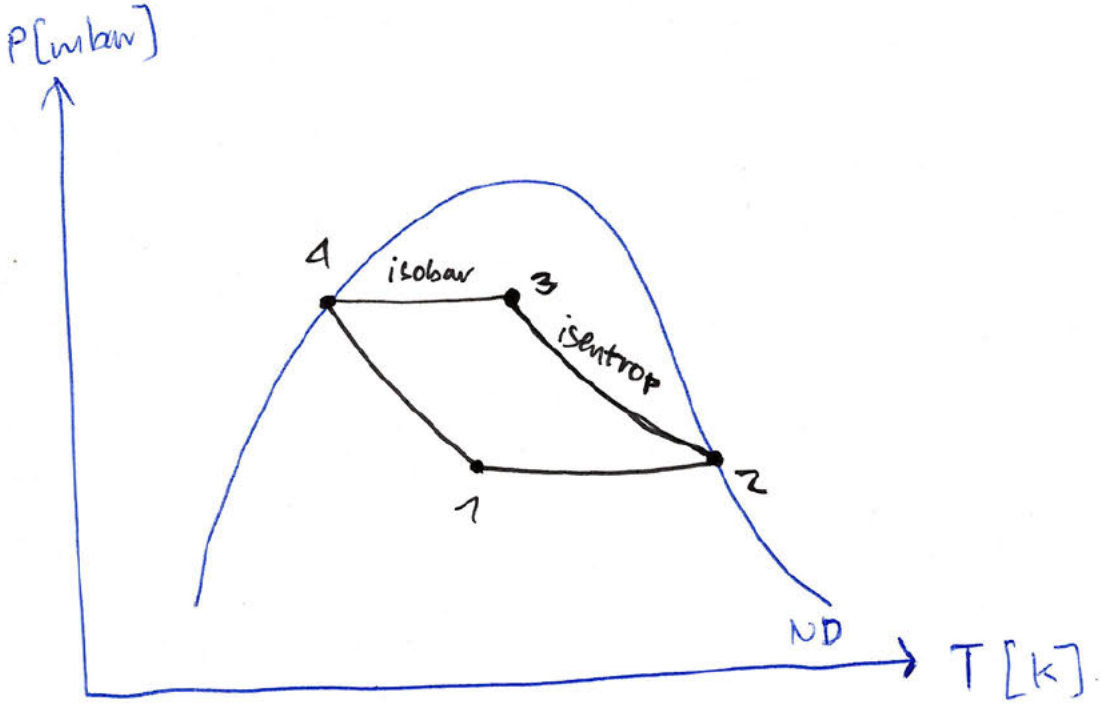
$$= \frac{1500\,J}{0.1\,kg} - 333.458 \cdot 10^3 \frac{J}{kg}$$

$$= -318.458 \frac{kJ}{kg}$$

$\rightarrow T_{2,EW} = T\left(-318.458 \frac{kJ}{kg}\right)$

$\rightarrow m_2 =$

4 a)



4b) $\dot{m}_R$ $\dot{W}_K = 28\,W$

Stat. FP. um Kondensator mit $ke = pe = 0$ und $\dot{q}$ adiabat

$$0 = \dot{m}_K \left(h_2 - h_3 + \frac{w_2^2 - w_3^2}{2} + g(z_2 - z_3) \right) + \dot{q}_K - \dot{W}_K$$

$$\rightarrow \dot{W}_K = \dot{m}_K (h_2 - h_3)$$

$$\rightarrow \dot{m}_K = \frac{|\dot{W}_K|}{|h_2 - h_3|}$$

$s_2 = s_3 \rightarrow$ isentrop

$x_A = 0$ $h_A = h_f(8\,bar) = 93.42 \frac{kJ}{kg}$ (Tab. A-11)

T_i ? $T_i = T_{subl.} + 10\,K = 10\,K$

$\rightarrow T_2 = T_i - 6\,K = 4\,K$

$h_2 = h_g(4\,K) = h_{gl}$

T_i ? $\rightarrow T_i = T_{subl.} + 10\,K = 0°C + 10\,K = 10°C$

$\rightarrow T_2 = 10°C - 6°C = 4°C$

$h_2 = h_g(4°C) = 194.19 \frac{kJ}{kg}$ (Tab. A-10)

$s_3 = s_2 \rightarrow s_2 = s_g(4°C) = 0.9169 \frac{kJ}{kgK}$

$$x_3 = \frac{s_3 - s_f(8\,bar)}{s_g(8\,bar) - s_f(8\,bar)} = \frac{0.9169 - 0.3459}{0.9066 - 0.3459} =$$

a.c) x_1? $\dot{m}_{R134a} = 4 \frac{kg}{h}$ $T_2 = -22°C$

$T_1 = T_2 + 6K = -16°C$

stat. FP. von 4 → 1:

$ke = 0$, $pe = 0$, adiabat

$$0 = \dot{m}_{R134a} \cdot \left(h_4 - h_1 + \frac{w_4^2 - w_1^2}{2} + g(z_4 - z_1) + \dot{Q} - \dot{W}_t \right)$$

$\rightarrow h_4 = h_1$

$h_4 = h_f(8bar) = 93.42 \frac{kJ}{kg} = h_1$

stat. FP. von 1 → 2:

$$0 = \dot{m}_R \cdot \left(h_1 - h_2 + \frac{w_1^2 - w_2^2}{2} + g(z_1 - z_2) \right) + \dot{Q}_K - \dot{W}_t$$

$\rightarrow \dot{Q}_K = \dot{m}_R (h_2 - h_1)$

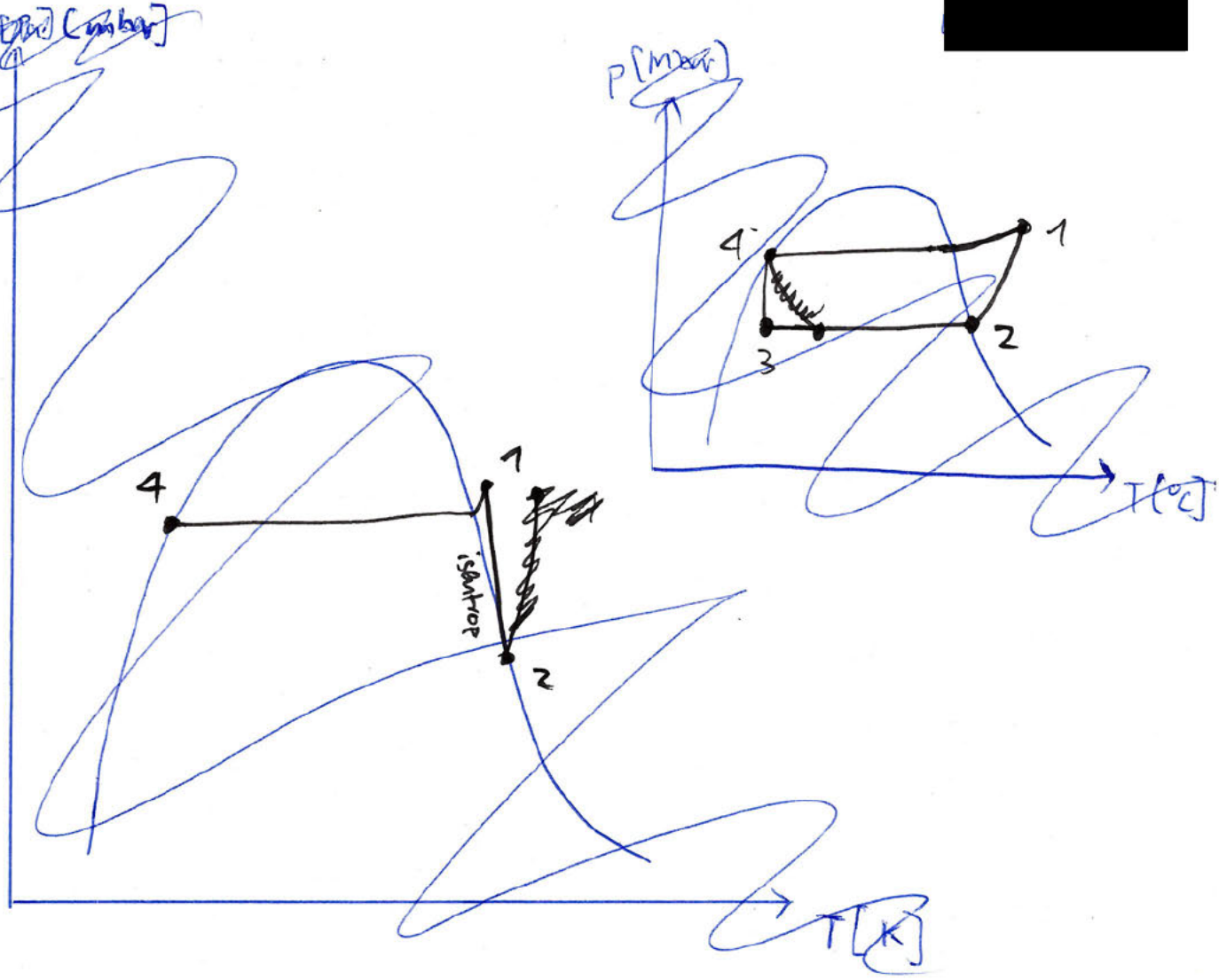
$h_2 = h_g(-22°C) = 234.08 \frac{kJ}{kg}$

$\rightarrow \underline{\dot{Q}_K} = 4 \frac{kg}{h} \cdot \frac{1\,h}{3600\,s} \cdot \left(234.08 \frac{kJ}{kg} - 93.42 \frac{kJ}{kg} \right)$

$= 0.15629\,kW = \underline{156.29\,W}$

$$x_1 = \frac{h_1 - h_{f1}}{h_{g1} - h_{f1}} =$$

4) a.)



Nr	P [bar]	T [°C]	h [kJ/kg]	$\dot{Q}$ / $\dot{W}$ [kW]	x	Notes
1				$\dot{Q}_K$		
2				$\dot{W}_K = 28\,W$	1	adiabat reversibel
3	8			$\dot{Q}_{ab}$		
4	8				0	