[redacted]

(A1)

a) ~~0 = ṁ~~ ~~$\Delta Q_{KF} = \Delta U_{KF}$ =~~

$$0 = \dot{m}(h_1 - h_2) + \dot{Q}_R + \dot{Q}_{AUS}$$

h_1 : $T_1 = 70°C$, ⇒ Flüßig $h_1 = 292{,}98 \frac{kJ}{kg}$

h_2 : $T_2 = 100°C$, Flüßig $h_2 = 419{,}04 \frac{kJ}{kg}$

$-\dot{Q}_{AUS} = 0{,}3 \frac{kg}{s} (292{,}98 - 419{,}04) + 100 \text{ kW}$

$\dot{Q}_{AUS} = -62{,}182 \text{ kW}$

b) $\bar{T} = \dfrac{\int_{ein}^{aus} T\,ds}{\underbrace{S_a - S_e}_{= \int_{T_{ein}}^{T_{aus}} \frac{c}{T}\,dT}} =$ ~~T~~ $\bar{T} = \dfrac{(298{,}15 + 288{,}15)\,K}{2} =$

$= 293{,}15 K$

c) $0 = \dot{m}(s_e - s_a) + \dfrac{\dot{Q}_{AUS}}{\bar{T}} + \dot{S}_{erz}$

$\dot{S}_{erz} = -0{,}3 \frac{kg}{s} (0{,}9549 - 1{,}3069) \frac{kJ}{kg \cdot K} \quad \frac{62{,}182 \text{ kW}}{293{,}15 K} =$

$=$ ~~0,317~~ $0{,}318 \frac{kJ}{kgK}$

d) $m_2 u_2 - m_1 u_1 = \Delta m_{12} h_{ein}$ ⇒ $83{,}95 \frac{kJ}{kgK}$ ⇒ $T = 20°$ ⇒ Flüßig

u_2 ⇒ $T_2 =$ ~~20~~ $70°C$, Flüßig ~~⇐~~ ⇒ $u_2 = 292{,}95 \frac{kJ}{kgK}$

$m_2 = 5755 + \Delta m_{12}$

$u_1 = 418{,}94 + 0{,}005(2506{,}5 - 418{,}94) = 429{,}378 \frac{kJ}{kgK}$

$m_1 = 5755 kg$

$(5755 kg + \Delta m_{12}) \cdot 292{,}95 \frac{kJ}{kgK} - 5755 kg \cdot 429{,}378 \frac{kJ}{kgK} = \Delta m_{12}\, 83{,}95 \frac{kJ}{kgK}$

$\Delta m_{12} \cdot 292{,}95 \frac{kJ}{kgK} - \Delta m_{12}\, 83{,}9 \frac{kJ}{kgK} = 785143{,}14 \frac{kJ}{K}$

$\Delta m_{12} = 3756{,}67 kg$

e) $s_1 = 1{,}3069 + 0{,}005\,(7{,}3549 - 1{,}3069) =$

$= 1{,}337 \frac{kJ}{kgK} \Rightarrow S_1 = 1{,}337 \frac{kJ}{kgK} \cdot 5755\,kg = 7694{,}435 \frac{kJ}{K}$

$s_2 = 0{,}9549 \rightarrow S_2 = \sout{0{,}954}\ 0{,}9549 \cdot 9511{,}67 = 9082{,}694 \frac{kJ}{K}$

~~$\Delta S_1 = S_2 - S_1 = -0{,}3827 \frac{kJ}{kgK}$ → wir haben eine negative Δentropie, aber~~ mit den anderen Prozessen: $\dot{Q}_{aus}$, $\dot{Q}_{ab}$

$\Delta S = S_2 - S_1 = (9081{,}694 - 7694{,}435) \frac{kJ}{K} = 1387{,}259 \frac{kJ}{K}$

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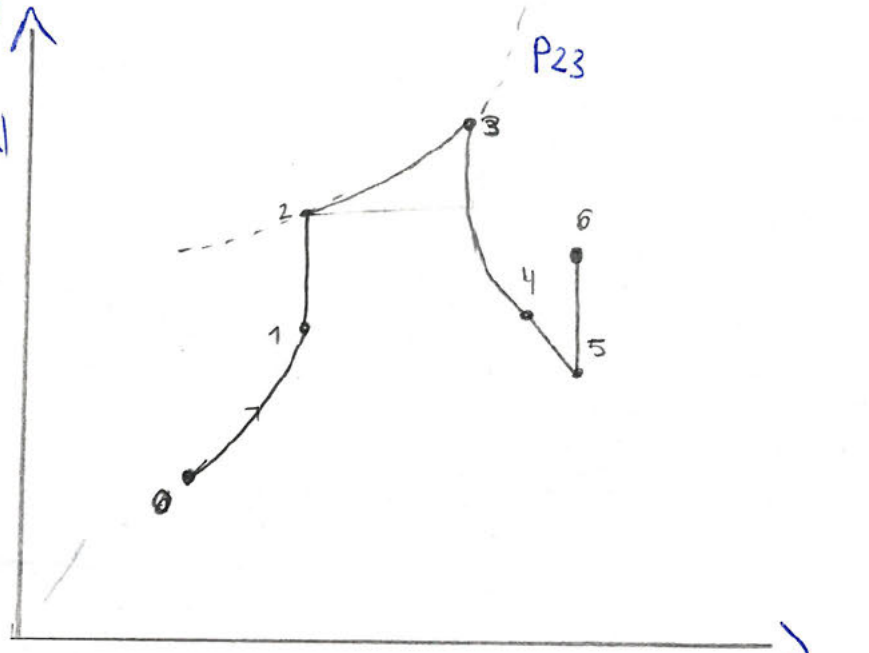

b) w_6, T_6 $\quad T_5 = 431,9\,K$ $\quad p_5 = 0,5\,bar$ $\quad w_5 = 220\,\frac{m}{s}$

$p_6 = 0,191\,bar$

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

$$h_5 - h_6 = -\int_{T_5}^{T_6} c_p\,dT = -1,006\,\frac{kJ}{kg\,K}\,(328,07 - 431,9)\,K = 104,453\,\frac{kJ}{kg}$$

$$T_6 = T_5\left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 328,07\,K$$

$$v = \frac{RT}{p}$$

$$w_{s,t} = -\int_5^6 v\,dp$$

$$w_v = \frac{R(T_6 - T_5)}{1-k} = \frac{1,725\,\frac{kJ}{kg\,K}\,(328,07 - 431,9)\,K^{k}}{1 - 1,4} = 44,77\,\frac{kJ}{kg}$$

$$R = c_p + \frac{c_p}{\kappa} = 1,725\,\frac{kJ}{kg\,K}$$

$$w = \Delta ke \quad \frac{kJ}{kg}\ 44,77 = \frac{1}{2}\,w_6^2 - w_5^2$$

$$w_6 = \sqrt{44,77 \cdot 2 + 2w_5^2} = 312,56\,\frac{m}{s}$$

c)

~~$0 = \dot{m}(h_1 - h_6 - T_0(s_1 - s_6) + \Delta ke)$~~ $T_0 = 243,15 K$

$\Delta ex_{str} = \dot{m}(h_6 - h_5$

$\dot{m}\left(h_6 - h_0 - T_0(s_6 - s_0) + ke_6\right) - \dot{m}\left(h_5 - h_0 - T_0(s_5 - s_0) + ke_5\right) =$

$= \dot{m}\left(h_6 - h_5 - T_0(s_6 - s_5) + \frac{w_6^2 - w_5^2}{2}\right)$ $\overset{243,15}{=}$ $85,43 \frac{kJ}{kg}$

$h_6 - h_5 = \int_{T_0}^{T_6} c_p \, dT = 1,006\left(328,07 + 243,15\right) =$ ~~$-104,35 \frac{kJ}{kg}$~~

$s_6 - s_5 = \int_{T_0}^{T_6} \frac{c_p}{T} dT - R \ln\left(\frac{p_6}{p_0}\right) =$

$= 1,006 \cdot \ln\left(\frac{328,07}{243,15}\right) - 1,725 \frac{kJ}{kgK} \left(\ln\left(\frac{1}{1}\right)\right)$

$= 0,301 \frac{kJ}{kgK}$ $\quad \| \quad 0$

$\Delta Ex_{str} = \dot{m}_{ges}\left(85,43 \frac{kJ}{kg} - 243,15 K \cdot 0,301 \frac{kJ}{kK} + 24644,88 \frac{kJ}{kg}\right)$

$= \dot{m}_{ges}\left(24659,122 \frac{kJ}{kg}\right)$ $\quad ex = 24659,122 \frac{kJ}{kg}$

d) ~~$0 = \dot{m}_{ges}(24659,122 \frac{kJ}{kg})$~~ $0 = \dot{m}\left(100 \frac{kJ}{kg}\right) + \left(1 - \frac{T_0}{T_B}\right)\dot{Q}_B - \underbrace{(W_{vw} + W_t)}_{0} - Ex_{ver}$

$ex_{ver} = 100 \frac{kJ}{kg} + \left(1 - \frac{243,15}{1288}\right) 1195 \frac{kJ}{kg} = 1069,41 \frac{kJ}{kg}$

(A3)

a) $p_{g,1}$, m_g

$p_{g,1} = p_{amb} + \frac{32\,kg \cdot 9{,}81\,\frac{m}{s^2}}{(5\cdot10^{-3}\,cm)^2\,\pi} + \frac{0{,}1\,kg \cdot 9{,}81\,\frac{m}{s^2}}{(5\cdot10^{-3})^2\,\pi}$ ($= 10^5\,Pa$)

$= 4109444{,}059\,Pa$ ⇒ very different → von Lösung gezogen

$pV = mRT$ $\quad \frac{4109444{,}059\,Pa \cdot 3{,}14\cdot10^{-3}\,m^3}{0{,}166\,\frac{kJ}{kgK} \cdot 773{,}15} = 0{,}1\,kg$ **

$R = \frac{8{,}314\,\frac{kJ}{kmolK}}{50\,\frac{kg}{kmolK}} = 0{,}166\,\frac{kJ}{kgK}$

b) ~~$T_{g,2}$ und $p_{g,2}$ sind gleich zum T~~

$V_{g2} < V_{g1}$ $\quad pV = mRT$

p_g muss gleich sein, weil der Load auf den Kolben gleich ist. Wenn ~~$p_{2g} = p_{1g}$~~ $p_{2g} = p_{1g}$ und $V_{2g} < V_{1g} \Rightarrow T_{2g} < T_{1g}$ weil der Gas perfekt ist.

$p_{2g} = p_{1g} = 1{,}5\,bar$ * $\quad T_{2g} = 0°C$

c) $X_1 = \frac{m_{eis}}{m_{ew}} = 0{,}6$ $\quad \Delta U = m_g \int_{T_1}^{T_2} c_{v_g}\,dT = c_{v_g}(T_2 - T_1)$

$Q = \Delta U = 3{,}16\cdot10^{-3}\,kg$ ** $\cdot\ 0{,}633\,\frac{kJ}{kgK}\,(273{,}15\,K - 773{,}15\,K) =$

$= -1\,kJ$

d) $T_2 = 0°C$

$$\Delta u = \pm \frac{1\,kJ}{0{,}1\,kg} = +10\,\frac{kJ}{kg}$$

$$u_1 = -333{,}458 + 0{,}6\,(-0{,}045 + 333{,}458) = -133{,}4102\,\frac{kJ}{kg}$$

$$u_2 = -133{,}4102\,\frac{kJ}{kg} + 10\,\frac{kJ}{kg} = -123{,}4102\,\frac{kJ}{kg}$$

$$u_2 = u_{2f} + x_2\,(u_{2g} - u_{2f})$$

$$x_2 = \frac{u_2 - u_{2f}}{u_{2g} - u_{2f}} = 0{,}63$$

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(A4) a) ⇒ auf diagram

b) $0 = \dot{m}(h_2 - h_3) - \dot{W}_K$

$\frac{28\,W}{(h_2 - h_3)} = \dot{m}$ $\qquad h_2$?

c) ~~$0 \neq$~~ ($h_4 = h_1$ $\Rightarrow$ $0 = \dot{m}(h_4 - h_1)$

$\neq 0$ / $= 0$ —

$h_4 \hat{=} 93{,}42 \frac{kJ}{kg} = h_1$

$93{,}42 =$

e)