1)a) $\dot{Q}_{aus} = ?$

E-Bil: $0 = \dot{m}_{ein}(h_e - h_a) + \dot{Q}_R - \dot{Q}_{aus}$

$h_e = 2626{,}8 \frac{kJ}{kg}$ TAB A-2, $h_a = 2676{,}1 \frac{kJ}{kg}$ TAB A-2

$\dot{Q}_{aus} = \dot{m}_{ein}(h_e - h_a) + \dot{Q}_R = \underline{85{,}29\,kW}$

b) $\overline{T}_{KF} = ?$ $\overline{T} = \frac{\int_{e}^{a} T\,ds}{s_a - s_e}$

$s_a - s_e = \int_{T_e}^{T_a} \frac{c_{ip}}{T}\,dT = c_{ip} \ln\left(\frac{T_a}{T_e}\right)$

$T\,ds = q$ E-Bil: $0 = \dot{m}_{KF}(h_e - h_a) + \dot{Q}_{aus}$

$q = \frac{\dot{Q}_{aus}}{\dot{m}_{KF}}$ $\dot{m}_{KF} = \frac{\dot{Q}_{aus}}{h_a - h_e} = \frac{\dot{Q}_{aus}}{c_p(T_a - T_e)}$ $q = c_p(T_a - T_e)$

$\overline{T}_{KF} = \frac{c_p(T_a - T_e)}{c_p \ln\left(\frac{T_a}{T_e}\right)} = \underline{293{,}12\,K}$

c) $\dot{S}_{erz} = ?$

$\frac{\dot{Q}_{aus}}{\overline{T}_{KF}} = \dot{S}_{erz} = \underline{0{,}29 \frac{kJ}{kg\,K}}$

d) E-Bil: $\Delta U_{12} = Q_{R,12}$

$\Delta U_{12} = m_2 u_2 - m_1 u_1$ $m_1 = 5755\,kg$, $m_2 = m_1 + \Delta m_{12}$

$u_1 = 418{,}94 + x_D(2506{,}5 - 418{,}94) = 429{,}386 \frac{kJ}{kg}$ TAB A-2

$u_2 = u_g(70°C) = 2469{,}6 \frac{kJ}{kg}$ TAB A-2

$m_1 u_2 + \Delta m_{12} u_2 - m_1 u_1 = Q_{R,12} \Rightarrow \Delta m_{12} = (Q_{R12} + m_1 u_1 - m_1 u_2) \cdot \frac{1}{u_2}$

$\Delta m_{12} =$

e) $\Delta m_{12} = 3600\,kg$ Annahme $\Delta S_{12} = ?$ $m_2 = m_1 + \Delta m_{12} = 9355\,kg$

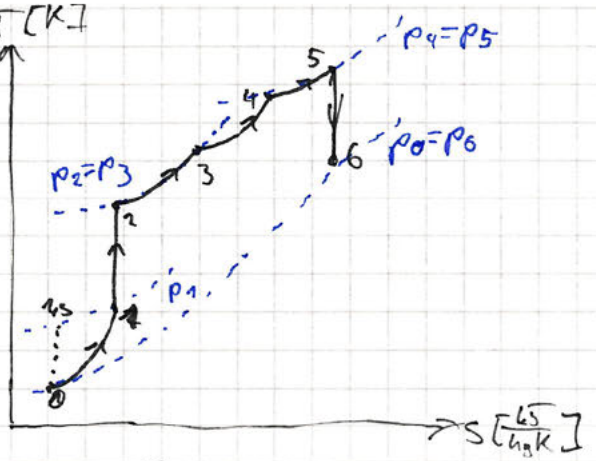
S-Bil: $\Delta S_{12} = \frac{Q_{R,12}}{T_{KF}} + \dot{S}_{erz}$ $\Delta S_{12} = S_2 - S_1$

$s_2 = s_g(70°C) = 7{,}7553 \frac{kJ}{kg\,K}$ $S_2 = m_2 s_2 = 72{,}55 \frac{MJ}{K}$ TAB A-2

$s_1 = 1{,}3069 + x_D(7{,}3549 - 1{,}3069) = 1{,}337714 \frac{kJ}{kg\,K}$ $S_1 = m_1 s_1 = 7{,}70 \frac{MJ}{K}$ TAB A-2

$\Delta S_{12} = S_2 - S_1 = \underline{64{,}85 \frac{MJ}{K}}$

2) a)



b) $\omega_6 = ?$, $T_6 = ?$

adiabat reversibel = isentrop $n = 1{,}4$

$p_6 = p_0 = 0{,}191\,bar$ $p_5 = 0{,}56\,bar$ $T_5 = 431{,}9\,K$ $T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$

$T_6 = 328{,}07\,K$

E-Bil: $0 = \dot{m}_{ges}(h_5 - h_6) + \dot{m}_{ges}\left(\frac{\omega_5^2}{2} - \frac{\omega_6^2}{2}\right)$

$h_5 - h_6 = c_p^L (T_5 - T_6)$ $\omega_6 = \sqrt{2 c_p^L (T_5 - T_6) + \omega_5^2}$

$= 20880{,}96 \frac{J}{kg}$ $\omega_5^2 = 48400 \frac{J}{kg}$

$\omega_6 = 507{,}25 \frac{m}{s}$

c) $\dot{m}_{ges} = ?$, $\Delta e_{x,str} = ?$

$\Delta e_{x,str6} = e_{x,str6} - e_{x,str0} = h_6 - h_0 - T_0(s_6 - s_0) + \frac{\omega_6^2}{2} - \frac{\omega_6^2}{2}$

bzw. $h_6 - h_0 = c_p (T_6 - T_0)$, $s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right) = c_p \ln\left(\frac{T_6}{T_0}\right)$

$h_6 - h_0 = 8542{,}52 \frac{J}{kg}$

$T_0(s_6 - s_0) = 73272{,}22 \frac{J}{kg}$, $\frac{\omega_0^2}{2} = 20000 \frac{J}{kg}$, $\frac{\omega_6^2}{2} = 128{,}65 \frac{kJ}{kg}$

$\Delta e_{x,str} = 50{,}04 \frac{kJ}{kg}$

d) Ex-Bil: $0 = \Delta e_{x,str} \cdot \dot{m} \left(1 - \frac{T_0}{T_B}\right) q_B + \dot{e}_{x,verl}$

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

$e_{x,verl} = 969{,}58 \frac{kJ}{kg} - 50{,}04 \frac{kJ}{kg} = 919{,}54 \frac{kJ}{kg}$

3) a) $p_{g,1} = ?$, $m_g = ?$

$p_{g,1} = p_{amb} + \frac{F}{A} = p_{amb} + \frac{mg}{A}$ $\quad A = \pi r^2 = \pi \frac{D^2}{4} = 0{,}0079\,m^2$

$mg = (m_K + m_{EW})\,g = 32{,}1kg \cdot g = 314{,}901\,N$ $\quad \frac{mg}{A} = 0{,}4bar$

$p_{g,1} = 1bar + 0{,}4bar = \underline{1{,}4bar}$

$pV = mRT$ $\quad p = p_{g,1}$ $\quad V = 3{,}14 \cdot 10^{-3}\,m^3$ $\quad T = 273{,}15K$

$R = \frac{\bar{R}}{M} = 166{,}28\,\frac{J}{kgK}$

$m_g = \frac{pV}{RT} = \underline{3{,}42g}$

b) ~~$T_2 = ?$~~ $\quad T_{g,2} = ?$ $\quad p_{g,2} = ?$

$c_p = R + c_v = 0{,}799\,\frac{kJ}{kgK}$ $\quad p_{1,g} = p_{2,g} = 1{,}4bar$

E-Bil: ~~$m_g \cdot u_2 = m_{EW} \cdot u_{EW,2}$~~

$m_g (u_2 - u_1)^{**} + m_{EW}(u_{2,EW} - u_{1,EW}) = 0$

$u_2 - u_1 = c_v (T_2 - T_1)$

$m_g u_2 = m_{EW} \cdot u_{EW,2}$

Rückseite

c) E-Bil: $\Delta U_{12}^{G} = -Q_{12}$

$\Delta U_{12}^{G} = c_v m_g (T_2 - T_1) = -1{,}086\,\mathrm{J}$

$Q_{12} = -\Delta U_{12}^{G} = \underline{1{,}086\,\mathrm{J} = 1082{,}42\,\mathrm{J}}$

d) $x_{2,EW} = ?$

~~$\frac{u_2 - u_2^+}{u_2^- - u_2^+} = x_2$~~ $\quad T_{2,EW} = T_{2,g} = 0{,}003\,^\circ\mathrm{C} \quad p_{2,EW} = 1{,}46\,\mathrm{bar}$

E-Bil: $\Delta U_{12}^{EW} = Q_{12}$

$\Delta U_{12}^{EW} = m_{EW}(u_2 - u_1)$ $\quad u_1 = (-333{,}458\, x_1^{EW}) + (-0{,}045(1 - x_1^{EW}))$

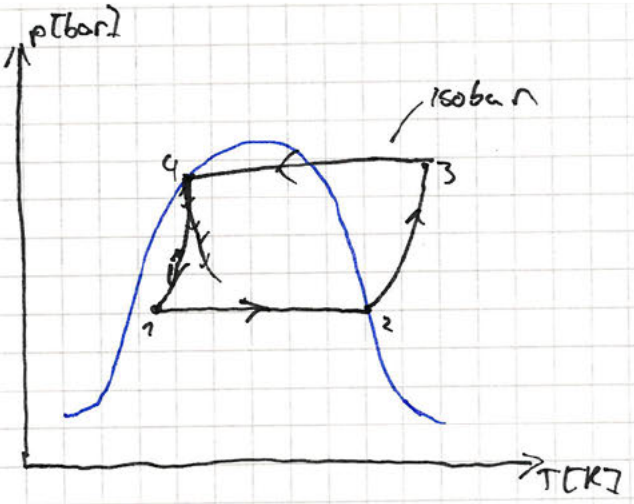
$= -200{,}09\ \frac{\mathrm{kJ}}{\mathrm{kg}}$

$u_2 = u_1 + \frac{Q_{12}}{m_{EW}} = -189{,}29\ \frac{\mathrm{kJ}}{\mathrm{kg}}$

$x_2 = \frac{u_2 - u_2^{fl}}{u_2^{fe} - u_2^{fl}}$ $\quad u_2^{fl} = -0{,}033\ \frac{\mathrm{kJ}}{\mathrm{kg}}$, $u_2^{fe} = -333{,}42\ \frac{\mathrm{kJ}}{\mathrm{kg}}$

$\underline{x_2 = 0{,}568}$ $\quad x_2 < x_1 \checkmark$

4) a)



b) $x_2 = 1$ $p_1 = p_2$ $p_3 = 8\,bar$ $x_4 = 0$

E-Bil Verdichter: $0 = \dot{m}_{Kältemittel}(h_2 - h_3) - \dot{W}_K$

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

$s_2 = s_3$ $p_4 = p_3 = 8\,bar$ $p_{Innenraum} = 1\,mbar$

c) $\dot{m} = \frac{4\,kg}{h}$, $T_2 = -22°C$ aus annahmen

$p_2 = 1{,}2192\,bar$ TAB A-10 $p_2 = p_1$

E-Bil Drossel: $0 = \dot{m}(h_4 - h_1) \Rightarrow h_4 = h_1$

$h_4 = 93{,}42 \frac{kJ}{kg} = h_1$ (TAB A-11) $h_1^f = 21{,}77 \frac{kJ}{kg}$ $h_1^g = 234{,}08 \frac{kJ}{kg}$ TAB A-10

$x_1 = \frac{h_1 - h_1^f}{h_1^g - h_1^f} = \underline{0{,}337}$

d) $\varepsilon_K = ?$

$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_T|}$ $\dot{Q}_{zu} = \dot{Q}_K$, $\dot{W}_T = \dot{W}_K$

E-Bil Verdampfer: $0 = \dot{m}(h_1 - h_2) + \dot{Q}_{zu}$

h_1 aus c) $h_2 = 234{,}08 \frac{kJ}{kg}$ TAB-A 10

$\dot{Q}_{zu} = \dot{m}(h_2 - h_1) = 0{,}001 \frac{kg}{s}(234{,}08 \frac{kJ}{kg} - 93{,}42 \frac{kJ}{kg}) = 0{,}14\,kW$

$\varepsilon_K = \frac{0{,}14\,kW}{28\,kW} = \underline{0{,}005}$

e) Die Temperatur würde sinken. Der Innendruck ist konstant 1 mbar und Volumen bleibt auch unverändert. Die einzige Möglichkeit Energie aus dem System zu entnehmen ist durch sinken der Temperatur.