Aufgabe 1:

a) Energiebilanz:

$$0 = \dot{m}_K \left(h_{ein} - h_{aus} \right) + \dot{Q}_{aus} - \cancel{\dot{W}^{\nearrow 0}}$$

$$\dot{Q}_{aus} = \dot{m}_K \left(h_{aus} - h_{ein} \right) = \dot{m}_K \int_{T_{ein}}^{T_{aus}} c^{if} \, dT + \cancel{v^{if} \left(p_{aus} - p_{ein} \right)^{\nearrow 0}}$$

$$= \dot{m}_K \, c^{if} \left(T_{aus} - T_{ein} \right)$$

b) $\dot{Q}_{aus} = 65\,kW$

$$\bar{T}_{KF} = \frac{\int_{ein}^{aus} T\,ds}{s_{aus} - s_{ein}} = \frac{q_{rev}}{s_{aus} - s_{ein}}$$

. aus Energiebilanz: $q_{rev} = h_{aus} - h_{ein} = c^{if}(T_{aus} - T_{ein})$

. $s_{aus} - s_{ein} = \int_{T_{ein}}^{T_{aus}} \frac{1}{T} c^{if}\,dT = c^{if} \ln\left(\frac{T_{aus}}{T_{ein}}\right)$

$$\Rightarrow \bar{T}_{KF} = \frac{T_{aus} - T_{ein}}{\ln\left(\frac{T_{aus}}{T_{ein}}\right)} = 293.123\,K$$

c) Entropiebilanz:

$$0 = \dot{m}_K (s_{ein} - s_{aus}) + \frac{\dot{Q}_{aus}}{\bar{T}_{KF}} + \dot{S}_{erz}$$

$$\rightarrow \dot{S}_{erz} = \dot{m}_K (s_{aus} - s_{ein}) - \frac{\dot{Q}_{aus}}{\bar{T}_{KF}}$$

$$= \dot{m}_K\, c_{if} \ln\left(\frac{T_{ein}}{T_{aus}}\right) - \frac{\dot{Q}_{aus}}{\bar{T}_{KF}}$$

d) Energiebilanz - Halboffenes System

$$\Delta E = m_2 u_2 - m_1 u_1 = \Delta m_{12} h_{12} + Q_{R,12} - Q_{aus,12}$$

- $m_1 = m_{ges,1} = 5755\,kg$
- $T_1 = 100°C$
- $m_2 = m_1 + \Delta m_{12}$
- $T_2 = 70°C$

~~$\rightarrow u_1 = u_f(100°C) = (TAB\ A2) = 418.94\,kJ/kg$~~

$\rightarrow u_2 = u_f(70°C) = (TAB\text{-}A2) = 292.95\,kJ/kg$

$\rightarrow h_{12} = h_f(20°C) = (TAB\text{-}A2) = 83.96\,kJ/kg$

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

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

$\rightarrow \Delta m_{12} = m_1 \dfrac{u_2 - u_1}{h_{12} - u_2}$ = ~~3459.480kg~~ 3761.52 kg

TAB-A2

$\rightarrow u_1 = u_f(100°C) + x_0\left(u_g(100°C) - u_f(100°C)\right) = 429.58\,kJ/kg$

e) $\Delta m_{12} = 3600\,kg$

Entropiebilanz:

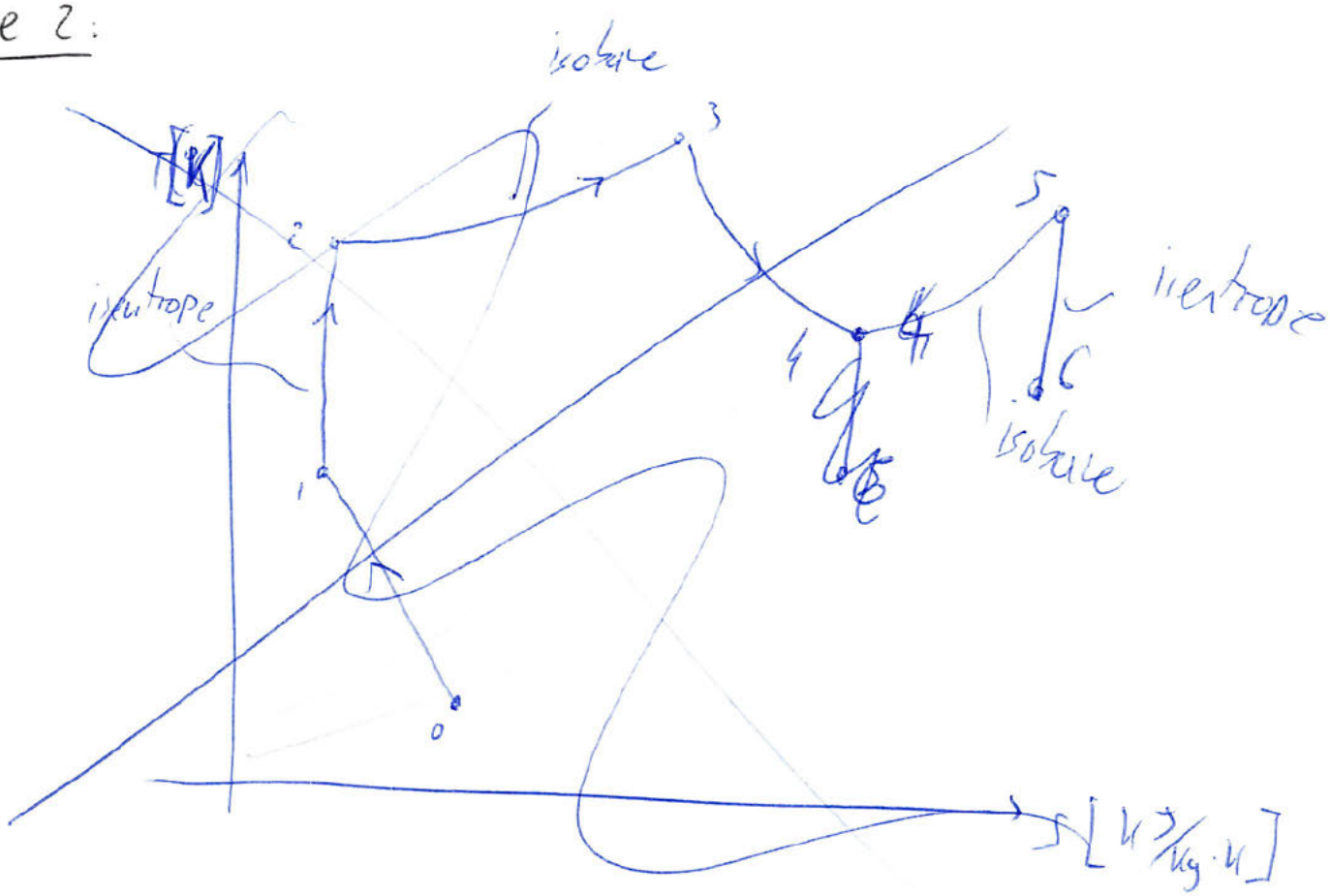
$$\Delta S = m_2 s_2 - m_1 s_1$$

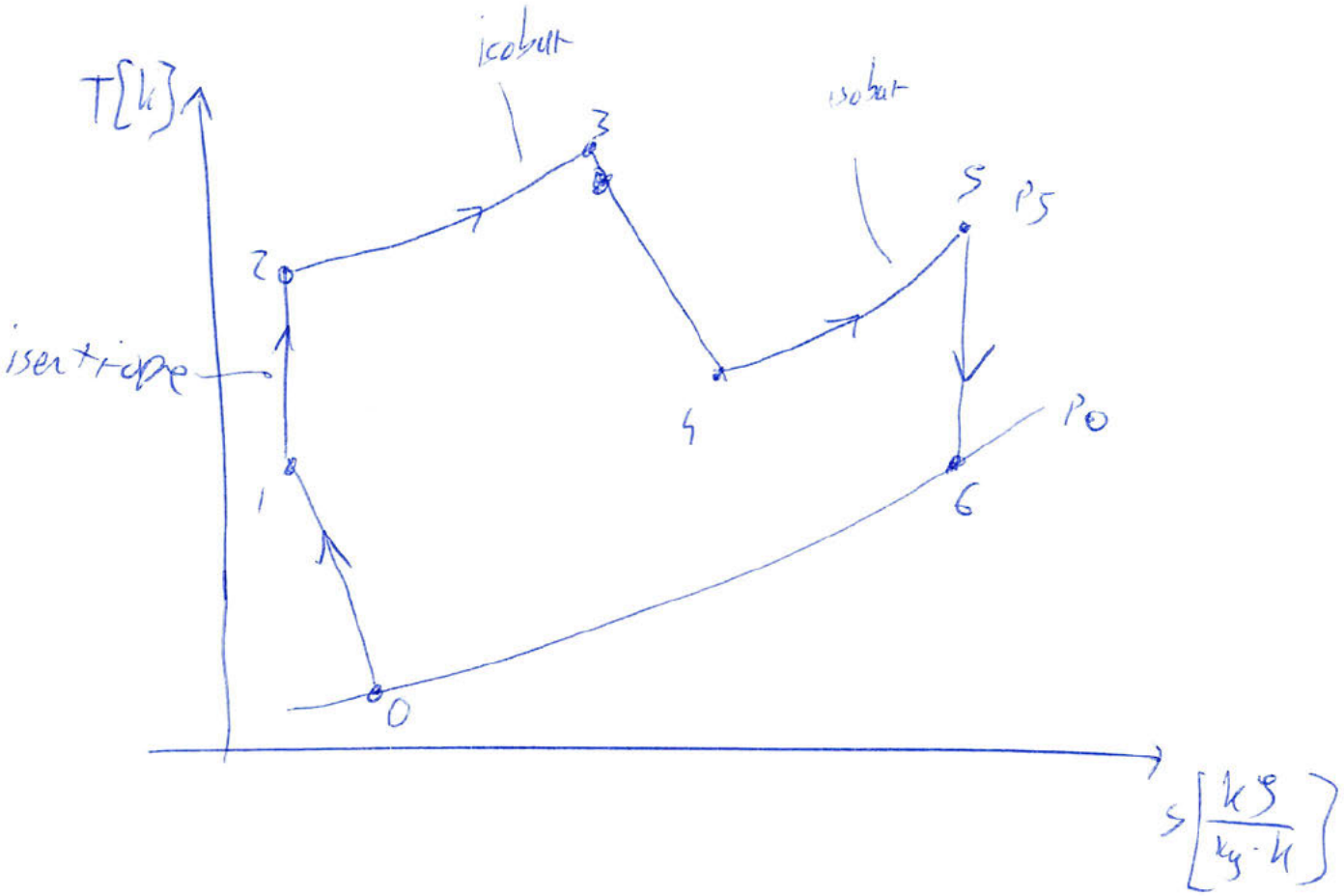
- $s_1 = (TAB - A2) = s_f(100°C) + x_D\left(s_g(100°C) - s_f(100°C)\right) = 1.33 + 14\ \frac{kJ}{kg\,K}$
- $s_2 = (TAB - A2) = s_f(70°C) = 0.954\ \frac{kJ}{kg\,K}$

$$\rightarrow \Delta s = (m_1 + \Delta m_{12})\, s_2 - m_1 s_1 = 1237.85\ \frac{kJ}{kg\,K}$$

Aufgabe 2:

a)


isobare
isentrope
isentrope
isobare
T[K]
s[kJ/kg·K]


T[K]
isobar
isobar
isentrope
p5
p0
s[kJ/kg·K]

b) $p_6 = p_0 = 0.191\,bar$

$T_6 = ?$; $T_5 = 431.9\,K$; $p_5 = 0.5\,bar$; $\kappa = 1.4$

→ Isentropengleichung:

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}} \rightarrow T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}} = 328.07\,K$$

Energiebilanz

$$0 = \dot{m}\left(h_0 - h_6\right) + \cancel{\sum_j \dot{Q}_j}^{0,\,adiabat} - \cancel{\sum_k \dot{W}_{t,k}}$$

$$0 = \dot{m}\left(h_0 - h_6 + \frac{1}{2}\left(\omega_0^2 - \omega_6^2\right)\right) + \cancel{\sum_j \dot{Q}_j}^{0,\,adiabat} - \cancel{\sum_k \dot{W}_{t,k}}$$

In Aufgabenstellung → Annahmen

$$2\left(h_6 - h_0\right) = \omega_0^2 - \omega_6^2$$

$$\omega_6^2 = \omega_0^2 + 2\left(h_0 - h_6\right)$$

$$\omega_6^2 = \omega_0^2 + 2\,c_{p,Luft}^{ig}\left(T_0 - T_6\right)$$

$$\omega_6^2 = 200^2\,\frac{m^2}{s^2} + 2 \cdot 1.006\,\frac{kJ}{kg \cdot K}\left(243.15 - 328.07\right)K$$

$$= 200^2\,\frac{m^2}{s^2} + 2 \cdot 1.006\,\frac{kJ}{kg} \cdot \frac{1\,kg\,m/s^2}{1\,N} \cdot \frac{1\,kg}{N/s^2/m}\left(\ldots\right) \cdot 1000$$

$$\omega_6 = \cancel{450\,m/s}\ 459.19\,m/s$$

c) $T_6 = 340\,K$; $w_6 = 510\,\frac{m}{s}$; $T_0 = 243.15\,K$

$$\Delta e_{x,str} = e_{x,str,6} - e_{x,str,0}$$

- $e_{x,str,6} = h_6 - h_0 - T_0(s_6 - s_0) + \frac{1}{2} w_6^2$

$$= c_{p,Luft}^{ig}\left(T_6 - T_0\right) - T_0\left(c_{p,Luft}^{ig} \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)\right) + \frac{1}{2} w_6^2$$

$M_{Luft} = 28.97\,\frac{kg}{kmol} \rightarrow R = \frac{\bar{R}}{M} = 0.28698\,\frac{kJ}{kg \cdot K}$

$\rightarrow e_{x,str,6} = 130\,\frac{kJ}{kg}$

- $e_{x,str,0} = \left(h_0 - h_0 - T_0(s_0 - s_0) + \frac{1}{2} w_0^2\right) = 40\,\frac{kJ}{kg}$

$\Rightarrow \Delta e_{x,str} = 90\,\frac{kJ}{kg}$

d) Exergiebilanz:

$$0 = \dot{m}_{ges}\,(-\Delta e_{x,Stk}) + \sum_j \left(1 - \frac{T_u}{T_j}\right)\dot{Q}_j - \sum \dot{W}_{t,k} - \dot{E}_{x,verl}$$

$$\Rightarrow \dot{E}_{x,verl} = -\dot{m}_{ges}\,\Delta e_{x,Stk}$$

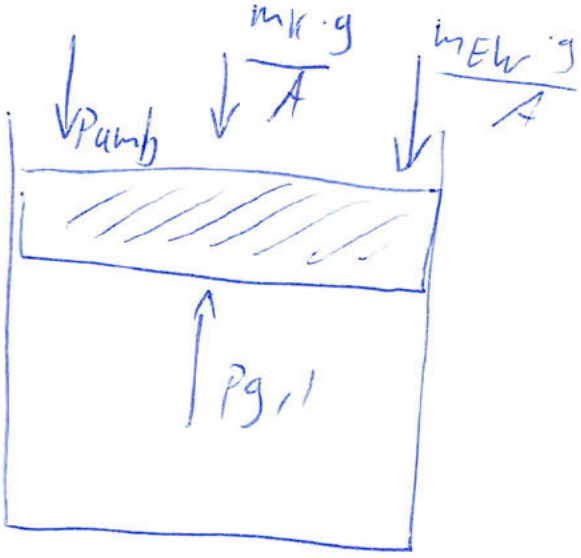
$$\Rightarrow e_{x,verl} = -\Delta e_{x,Stk} = -100\ \frac{kJ}{kg}$$

Aufgabe 3:

a) $T_{g,1} = 500\,°C$

$V_{g,1} = 3.14\,L$

$= 3.14 \cdot 10^{-3}\,m^3$



$\rightarrow p_{g,II} = p_{amb} + \frac{m_K \cdot g}{A} + \frac{m_{Ew} \cdot g}{A}$; $A = 7.854 \cdot 10^{-3}\,m^2$

$= 10^5 \frac{N}{m^2} + \frac{313.92\,N}{7.854 \cdot 10^{-3}\,m^2} + \frac{0.981\,N}{7.854 \cdot 10^{-3}\,m^2} = 1.4 \cdot 10^5\,Pa$

$= 1.4\,bar$

$p_{g,1} V_{g,1} = m_g R T_{g,1}$; $R = \frac{\bar{R}}{M_g} = 0.16628 \frac{kJ}{kg \cdot K}$

$\rightarrow m_g = \frac{p_{g,1} V_{g,1}}{R T_{g,1}} = 3.42\,g$

b) $p_{g,2} = p_{g,1}$ weil die gesättigt oben immer dasselbe ist

$p_{g,2} =$ ~~Umgebung~~ $= 1{,}4$ bar

$T_{g,2} = 0°C$ weil gleichgewicht mit eis-wasser liquid – solid ist.

c) $T_{g,2} = 0.003°C = 273.153K \Rightarrow v_{g,2} =$

~~$v_{g,2} =$~~

$E_2 - E_1 = Q_{12} - \cancel{W_{r,12}}^{0}$ Ew durch leistet keine arbeit

$m_{Ew}(u_2 - u_1) = Q_{12}$

$u_2 = \cancel{u_{f2}} + x_2(u_{g_2} - u_{f_2})$

$u_1 = \cancel{u_{f1}} + x_1(u_{g1} - u_{f1})$

usw

[redacted]

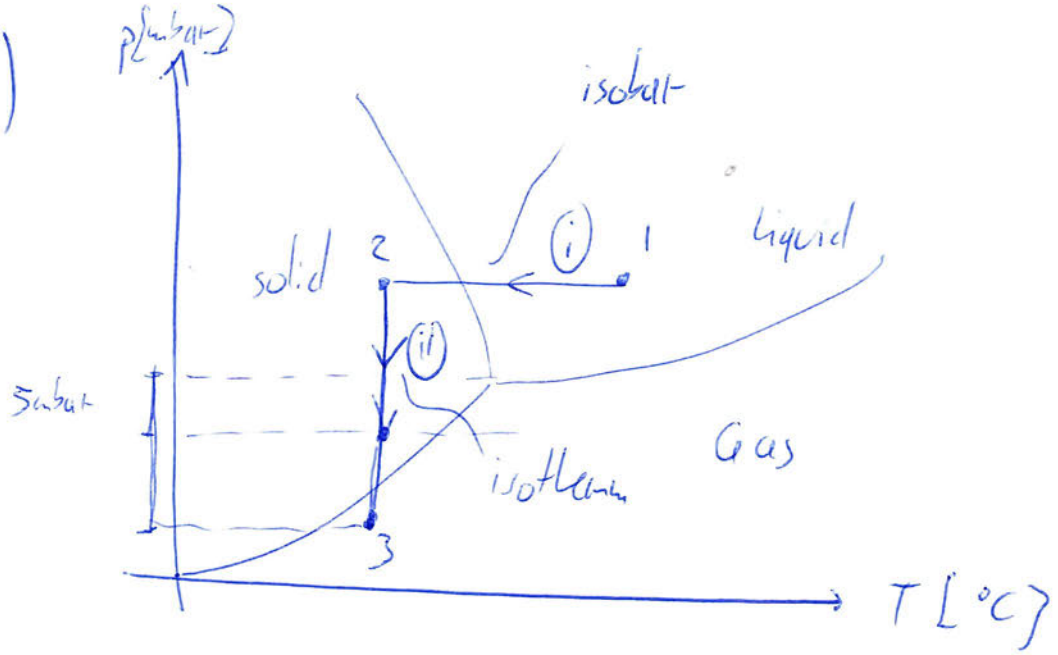
d) $\Delta E = E_2 - E_1 = \sum_j Q_j - \sum_k W_{v,k}$ ($\sum_k W_{v,k} \to 0$) ← an EW

$m_{EW}(u_2 - u_1) = Q_{12} = 1500\,J$

- $m_{EW} = 0.1\,kg$
- $u_2 = u_f(T_{EW,2}; p_{EW,2}) + x_2 \left(u_g(T_{EW,2}; p_{EW,2}) - u_f\right)$
- $u_1 = u_f(T_{EW,1}; p_{EW,1}) + x_1 \left(u_g(T_{EW,1}; p_{EW,1}) - u_f\right)$

Aufgabe 4:

a)



b) 2-3:

$\dot{W}_K = 28\,W$

$p_3 = 8\,bar$

Energiebilanz:

$$0 = \dot{m}\,(h_2 - h_3) + \cancel{\dot{Q}_{23}}^{\,0,\ adiabat} - \dot{W}_K$$

$$\rightarrow \dot{m}_{R134a} = \frac{\dot{W}_K}{h_2 - h_3}$$

Zustand 3: flüssig: TAB-A 11: $T_3 = 31.33°C$

$h_3 = 93.42\ \frac{kJ}{kg}$; $s_3 = 0.3459\ \frac{kJ}{kg\,K}$

Ua Zustand 2: gesättigten dampf

$T_4 = T_1 = 31.33°C = T_3$

c) $P_4 = P_3 = 8\,bar$
und vollständig condensiert

d) $\varepsilon_{KM} = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{ab}|}{|\dot{Q}_{ab}| - |\dot{Q}_{zu}|}$

~~$|\dot{Q}_{ab}| = \dot{m}_{R134a}(h_3 - h_4)$~~ $0 = \dot{m}_{R134a}(h_3 - h_4) + \dot{Q}_{ab}$ ~~$\dot{Q}_{zu}$~~ $\to 0$

$\to \dot{Q}_{ab} = \dot{m}_{R134a}(h_4 - h_3)$

$0 = \dot{m}_{R134a}(h_1 - h_2) + \dot{Q}_{zu}$ ~~$\dot{W}_t$~~ $\to 0$ $\to \dot{Q}_{zu} = \dot{m}_{R134a}(h_2 - h_1)$

$\to \varepsilon_{KM} = \frac{|h_3 - h_4|}{|h_3 - h_4| - |h_2 - h_1|}$

e) T im Innenraum wird tiefer werden aber immer weniger, kann nicht unendlich ~~tief~~ tief gehen.

(so ein Verlauf:

)