1)

a) ein -> aus isobar

$0 = \dot{m}_{ein}[h_{ein} - h_{aus}] + \dot{Q}_{aus} - \dot{Q}_R - \dot{W}_t^{\,0}$

$\dot{Q}_{aus} = \dot{Q}_R + \dot{m}_{ein}[h_{aus} - h_{ein}]$

$k_{ein} \rightarrow k_{aus}$

$0 = m$

a) ein -> aus isobar

$0 = \dot{m}_{ein}[h_{ein} - h_{aus}] + \dot{Q}_{aus} + \dot{Q}_R - \dot{W}_t^{\,0}$

$\dot{Q}_{aus} = -\dot{Q}_R + \dot{m}_{ein}[h_{aus} - h_{ein}]$

A2 / $h_{aus} = 419{,}04 \frac{kJ}{kg}$

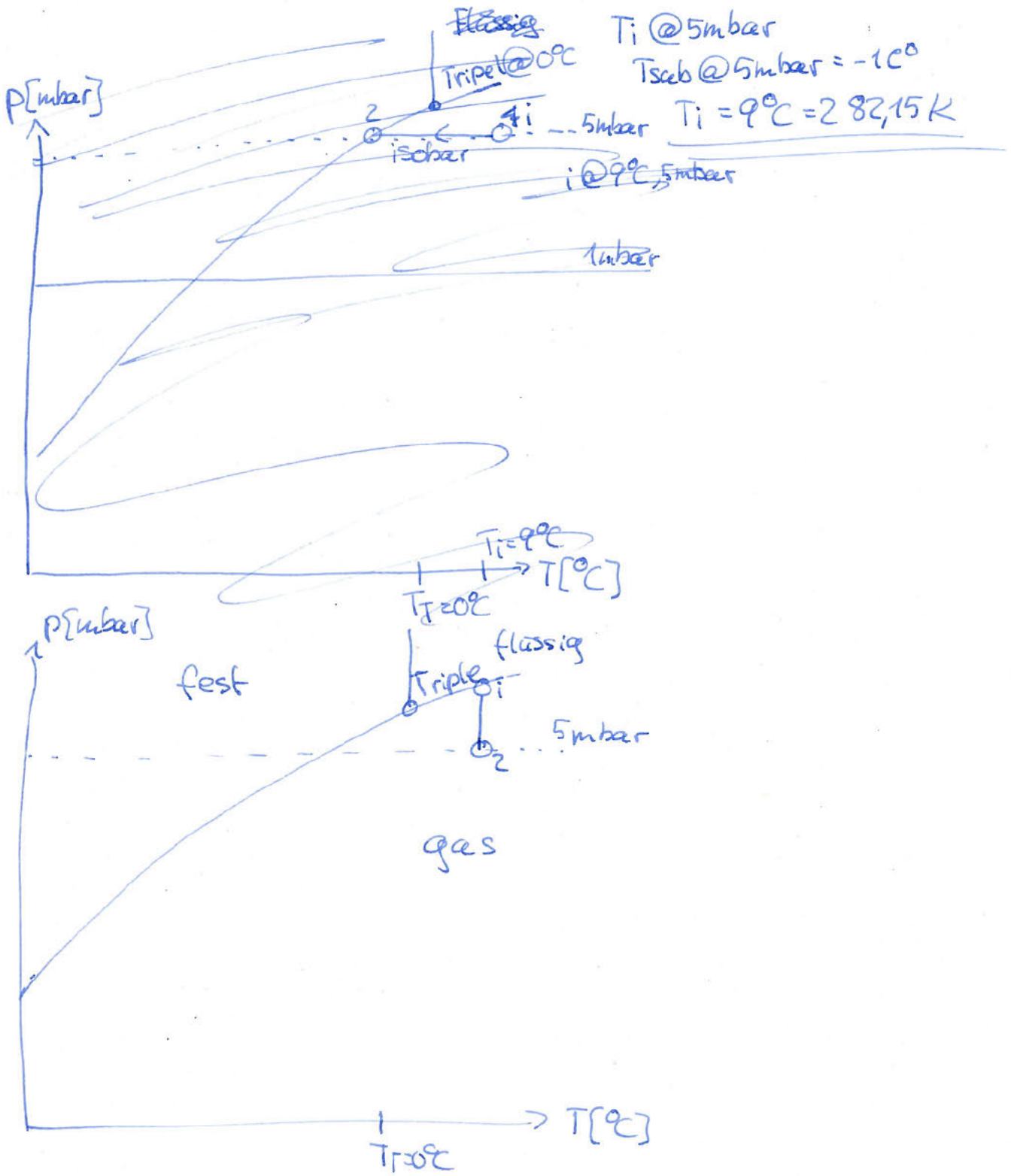
A2 $h_{ein} = 292{,}98 \frac{kJ}{kg}$ ~~$- 2626{,}8 \frac{kJ}{kg}$~~

$\dot{Q}_{aus} = -62{,}182 \frac{kJ}{s}$

c)

4) a) $x_2 = 1$ $x_4 = 0$ $T_K = T_i - 6K$ ~~$T_i = 10K$~~

$T_i \hat{=} 10K$ unter Sublimationsdruck



T_i @ 5mbar

T_{Sub} @ 5mbar = -1C°

$T_i = 9°C = 282{,}15K$

i @ 9°C, 5mbar

b) siehe

4(b)

$\dot{m}_{R134a}$ adiabat.

2→3 isentrop $\dot{W}_K = 28\,W$ $p_3 = 8\,bar$ $x_3 = 1$ $p_2 = p_1 =$

$h_1 = h_4$ $x_4 = 0$ $p_4 = 8\,bar$

$$0 = \dot{m}\left[h_2 - h_3 + \cancel{\emptyset}^{ke} + \cancel{\emptyset}^{pe}\right] + \cancel{\dot{Q}}^{0} - \dot{W}_K$$

adgewandet

$h_1 = h_4 = 93{,}42\,\frac{kJ}{kg}$ A11

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

$T_1 = 9°C$

$s_2 = s_3$ h_2 @ $x_2 = 1$ $T_2 = 9°C$

$$h_2 = \frac{254{,}03 - 251{,}80}{12 - 8}(9 - 8) + 251{,}8 = 252{,}358\,\frac{kJ}{kg}$$ A10

$$s_3 = s_2 = \frac{0{,}9132 - 0{,}9150}{12 - 8}(9 - 8) + 0{,}9150 = 0{,}91455\,\frac{kJ}{kgK}$$ A10

@8bar; s_3

$$h_3 = \frac{273{,}66 - 264{,}15}{0{,}9374 - 0{,}9066}(0{,}91455 - 0{,}9066) + 264{,}15$$ A12

$$h_3 = 266{,}605\,\frac{kJ}{kg}$$

$$\dot{m}_{R134a} = \frac{-|\dot{W}_K|}{h_2 - h_3} = \frac{1{,}965\,\cancel{kg}}{\cancel{s}} \quad 1{,}965\,\frac{g}{s}$$

c) $h_1 = h_4$ $x_4 = 0$ $p_4 = 8\,bar$

$h_1 = h_4 = 93{,}42\,\frac{kJ}{kg}$ A11

$x_1 = ??$ $h_1 = h_f + x_1(h_g - h_f)$

h_f @ 9°C A10

$$h_f = \frac{66{,}18 - 60{,}73}{12 - 8}(9 - 8) + 60{,}73$$

$h_f = 62{,}093\,\frac{kJ}{kg}$

$$\rightarrow \frac{h_1 - h_f}{h_g - h_f} = x_1 = 0{,}1647$$

h_g @ 9°C A10

$$h_g = \frac{254{,}03 - 251{,}80}{12 - 8}(9 - 8) + 251{,}80 = 252{,}34\,\frac{kJ}{kg}$$

d) e)

⟶

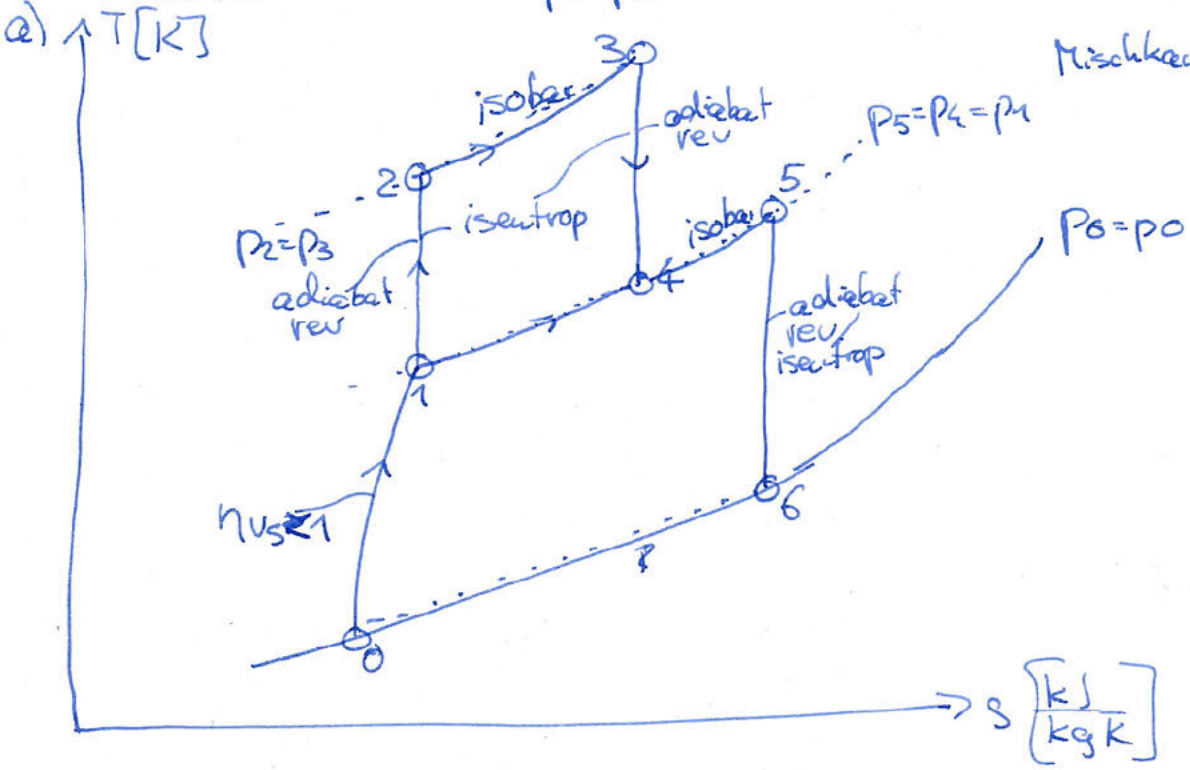
4)

d)

$$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{ab}|}{|\dot{W}_t|}$$

2) isobare Einheiten $p_6 = p_0$

a)



b) ~~$w_5 = 20$~~ w_6 & T_6

5 → 6 rev adiabat isentrop $n = k = 1{,}5$

$$0 = \dot{m}_{ges}\left[h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right] + \dot{Q}^{0} - \dot{W}_t^{0}$$

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

~~$\dot{W}_t = \dot{m}_{ges}$~~

$$w_6^2 = 2\,\dot{m}_{ges}\left[h_5 - h_6\right] = 2\,\dot{m}_{ges}\,c_v\,(T_5 - T_6)$$

$$w_6 = \sqrt{2\,c_p \cdot k\,(T_5 - T_6)}$$

~~$c_v = p_s c_p = R$~~

~~$\dot{W}_t$~~ $w_6 = 540{,}8\ \frac{m}{s}$

$k = \frac{c_p}{c_v} \rightarrow c_v = c_p \cdot k$

c) ~~ges~~ $\Delta ex_{str} = ex_{str6} - ex_{str0}$

$$\Delta \dot{e}_{x\,str} = \dot{m}\left[h_a - h_e - T_0(s_a - s_e) + \Delta ke + \Delta pe\right]$$

$$= h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2 - w_0^2}{2} \qquad p_6 = p_0 \text{ geg. Wert}$$

$$= c_p \cdot K(T_6 - T_0) - T_0\left[c_p \ln\left(\frac{T_6}{T_0}\right) - R\ln\left(\frac{p_6}{p_0}\right)\right] + \frac{w_6^2 - w_0^2}{2}$$

(T_6: geg. Wert)

$$\Delta \dot{e}_{xst} = -26019{,}4 \frac{kJ}{s\,kg}$$

d) $e_{x,verl}$ ~~gesucht~~

$$0 = -\Delta \dot{e}_{str} + \dot{e}_{xQ} - \dot{W}_t - \dot{e}_{xverl}$$

($\dot{e}_{xQ}$: geg. Wert; $\dot{W}_t = 0$)

$$\dot{e}_{xverl} = -\Delta \dot{e}_{str} + \left(1 - \frac{T_0}{T_B}\right) q_B = 869{,}58 \frac{kJ}{kg\,s}$$

$$= -26$$

$$= -100 \frac{kJ}{kg} + \left(1 - \frac{273{,}15K}{1289K}\right)$$

3)

a) p_{g1} m_g $M_g = 50 \frac{kg}{kmol}$

$A = R^2\pi = D^2 \frac{\pi}{4}$

$p_{g1} V_{g1} = m_g R T_{g1}$

$p_{g1} = \frac{m_K \cdot g}{A} + \frac{m_{EW} \cdot g}{A} + p_{amb} = \frac{g}{D^2 \frac{\pi}{4}} (m_K + m_{EW}) + p_{amb} = p_{g1} = 140094$

$p_{g1} = 1{,}4\,bar$

$m_g = \frac{p_1 V_1}{R T_1}$ $\quad R = \frac{\overline{R}}{M_g} = \frac{8{,}314 \frac{kJ}{kmol K}}{50 \frac{kg}{kmol}} = 0{,}16628 \frac{kJ}{kg K}$

$m_g = 0{,}003422\,kg$

$= 3{,}422\,g$

b) $p_{g2} = p_{g1}$ weil noch immer selbes Gewicht auf Gas drückt

$\rho_{eis} = \rho_{H2O}$

$p_{g2} = 1{,}4\,bar$

$T_{g2} = T_{g1}$ nach dem idealen Gas gesetz bleibt die Temperatur gleich wenn $p = konst$ & $V = konst$ $m = konst$

$T_{g2} = 0°C$

Kolben wird nicht größer

c) Q_{12} Gas isobar

$1 \rightarrow 2$

$W_v = \int_1^2 p\,dv = \frac{R(T_2 - T_1)}{1 - n}$

$\Delta E = m(u_2 - u_1) = Q_{ab} - W_v - W_v$

$Q_{ab} = m c_v (T_2 - T_1) = 0{,}00684\,J = 684\,mJ$

geg ↑ gesucht, geg ↑ Wert

3)

c) 1→2

~~0~~ $= \Delta E = m(u_2 - u_1) = Q_{ab} - W_V^{0}$ ← gegW

$Q_{ab} = m(u_1 + u_2) = \bar{m} c_V (T_1 - T_2) = -1139{,}4\,J$

gegWert

d) $x_{es,2}$ $|Q_{12}| = 1500\,J$ zugeführt > 0

$\Delta E = E_2 - E_1 = m_{EW}(u_2 - u_1) = Q_{12} - W_V^{0}$ ≙ EW dehnt sich nicht aus

$u_2 - u_1 = \frac{Q_{12}}{m_{EW}} = \frac{1{,}5\,kJ}{0{,}1\,kg} = 15\,\frac{kJ}{kg}$

u_2 @ 0°C $x_{es1} = 0{,}6$ $p_{es1} = \frac{m_{kg}}{A} + p_{amb} = \frac{g}{D^2 \frac{\pi}{4}} m_k + p_{amb}$

$u_{fest\,13{,}997} = \frac{-334{,}224 - -333{,}812}{(20-10)}(13{,}997 - 10) - 333{,}812$ Tab1

$= 13997\,Pa = 13{,}997\,bar$

$u_{fest} = -333{,}97\,\frac{kJ}{kg}$

$u_{fl\,13{,}997} = \frac{-0{,}643 - -0{,}322}{(20-10)}(13{,}997 - 10) - 0{,}322 =$

$= -0{,}450\,\frac{kJ}{kg}$

$u_2 = u_1 + 15\,\frac{kJ}{kg}$

$u_1 = u_{fl} + x_1(u_{fe} - u_{fl}) = -167{,}21\,\frac{kJ}{kg}$ $u_2 = -152{,}21\,\frac{kJ}{kg}$

3)d)

~~PEP~~ PLEW = PEW

$u_2 = -152{,}21 \frac{kJ}{kg}$

$u_2 = u_{fL} + x_2(u_{fe} - u_{fL})$

$$\frac{u_2 - u_{fL}}{u_{fe} - u_{fL}} = x_{2eis} = \frac{-152{,}21 - -0{,}450}{-333{,}97 - -0{,}450} = 0{,}455 = x_{2eis}$$