[redacted]

1) a) $T_{KF\,ein} = 288,15\,K$

$T_{KF,aus} = 298,15\,K$

$p_{KF\,ein} = p_{KF\,aus}$ -> isobar

Energiebilanz

$0 = \dot{m}_{ein}(h_{ein} - h_{aus}) + \dot{Q}_F - \cancel{\dot{W}}^{\,0}$ siedende Flüssigkeit (Wasser)

$\dot{Q}_R - \dot{Q}_F = \dot{Q}_{aus}$

$\dot{m}_{ein} = 0,3\,\frac{kg}{s}$

$x_{ein} = ?$

$x_{aus} = ?$ -> $x_{aus} = x_D = 0,005$

$T_{ein} = 70°C$

$T_{aus} = 100°C$

$\to h_{aus} = h_f(100°C) + 0,005(h_g(100°C) - h_f(100°C))$

$= 419,04 + 0,005(2257,0)$

$= 430,325\,\frac{kJ}{kg}$

$h_{ein} = h_f(70°C) + x_{ein}(h_g(70°C) - h_f(70°C))$

$= 292,98 + x_{ein}(2333,8)$

wenn $x_{ein} = x_D \to h_{ein} = 304,649\,\frac{kJ}{kg}$

$\dot{Q}_F = \dot{m}_{ein}(h_{aus} - h_{ein})$

$= 0,3(430,325 - 304,649)$

$= 37,7\,\frac{kg}{s}$

$\dot{Q}_R - \dot{Q}_F = \dot{Q}_{aus}$

$\dot{Q}_{aus} = 100\,kW - 37,7\,kW = \underline{\underline{63,297\,kW}}$

b) $\dot{m}_{KF} = ?$

$0 = \dot{m}_{KF}(h_e - h_a) + \dot{Q}_{aus}$

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

$\frac{\dot{Q}_{aus}}{\int_{T_{KF\,ein}}^{T_{KF\,aus}} c^{if}(T)\,dT + \cancel{v^{if}(p_2 - p_1)}^{\,0}} = \dot{m}_{KF} \Rightarrow \frac{63,3\,kW}{c^{if}(298,15 - 288,15)} = \dot{m}_{KF}$

$6,33\,\frac{kW}{K} = \dot{m}_{KF} \cdot c^{if}$

1b) $\overline{T} = \frac{\int_e^a T ds}{s_a - s_e} = \frac{h_a - h_e}{s_a - s_e} = \frac{\frac{\dot{Q}_{aus}}{\dot{m}_{KF}}}{s_a - s_e} = \frac{\frac{63{,}3\,kW}{6{,}33\,\frac{kW}{K}} \cdot \cancel{c_{if}}}{\cancel{c_{if}} \ln\left(\frac{T_{aus}}{T_{ein}}\right)}$

$\rightarrow \frac{10\,K}{\ln\left(\frac{298{,}15\,K}{288{,}15\,K}\right)} = \underline{\underline{293{,}12\,K}}$

1c) $0 = \dot{m}_{KF}(s_e - s_a) + \frac{\dot{Q}_{aus}}{\overline{T}} + \dot{S}_{erz}$

$\Rightarrow$ ~~$0 = \frac{6{,}33\,\frac{kW}{K}}{c_{if}} \cdot c_{if}($~~

$0 = \frac{6{,}33\,\frac{kW}{K}}{\cancel{c_{if}}} \cdot \cancel{c_{if}} \left(\ln\left(\frac{T_{ein}}{T_{aus}}\right)\right) + \frac{63{,}3\,kW}{293{,}12\,K} + \dot{S}_{erz}$

$0 = 6{,}33\,\frac{kW}{K} \cdot \ln\left(\frac{288{,}15\,K}{298{,}15\,K}\right) + \frac{63{,}3\,kW}{293{,}12\,K} + \dot{S}_{erz}$

$\rightarrow \dot{S}_{erz} = 0$ da kein Druckabfall

1d) $m_2 u_2 - m_1 u_1 = \Delta m\,(h_{12}) + Q_{R,12}$

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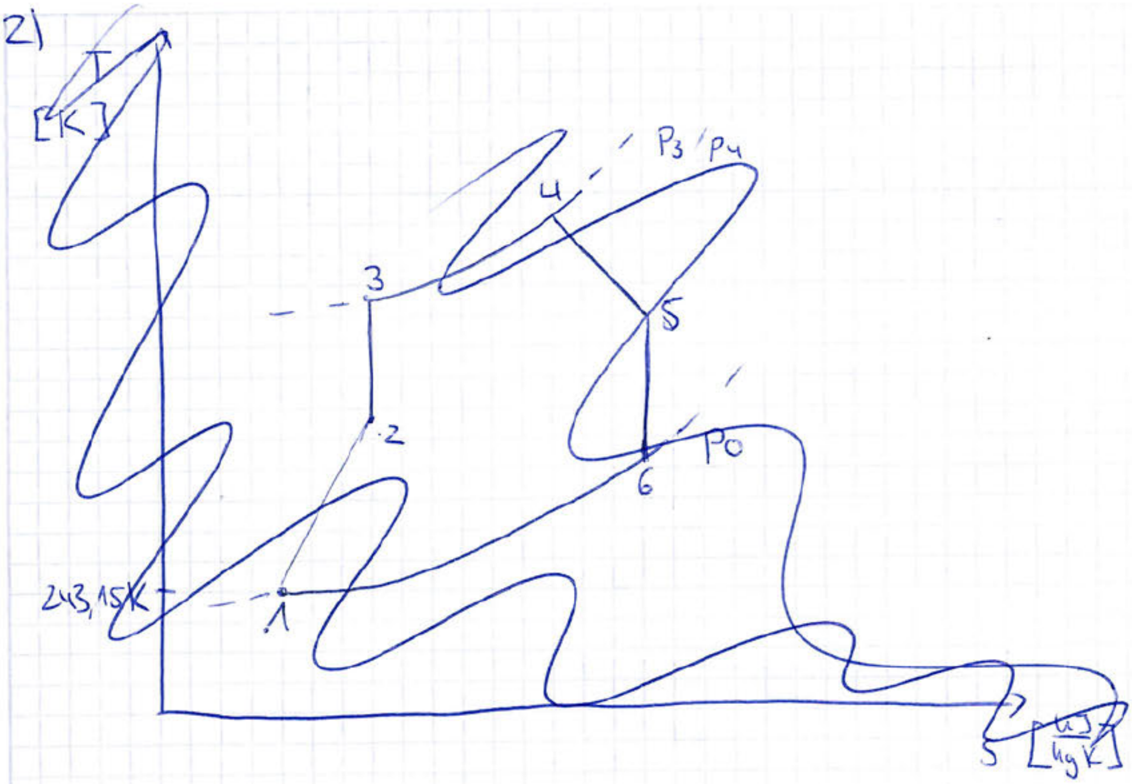
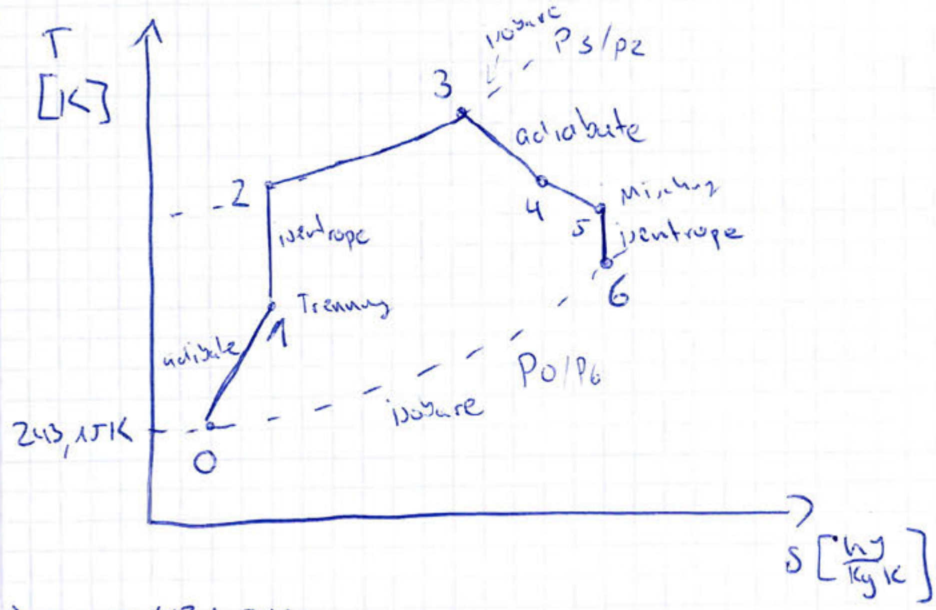
2)



a)



b) $T_5 = 431{,}9\,K$

$p_5 = 0{,}5$ bar

$w_5 = 220\,\frac{m}{s}$

$$0 = \dot m_{ges}\left((h_5 - h_6) + \frac{w_5^2 - w_6^2}{2}\right) + \cancel{\dot Q}^{\text{adiabat}=0} - \cancel{\dot W_{tn}}^{0}$$

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

$$c_p^{ig}(T_0 - T_5) = \frac{w_5^2 - w_6^2}{2}$$

$$\rightarrow w_6 = \underline{\underline{507{,}24\,\frac{m}{s}}}$$

mit $c_p^{ig} = 1{,}006\,\frac{kJ}{kgK}$

$T_6 = 328{,}075\,K$

$T_5 = 431{,}9\,K$

$w_5 = 220\,\frac{m}{s}$

isentrop 5-6 : $n = k = 1{,}4$

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

$$\rightarrow T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{0,4}{1,4}}$$

$$\Rightarrow T_6 = 431{,}9\,K \left(\frac{0{,}191\text{ bar}}{0{,}5\text{ bar}}\right)^{\frac{0,4}{1,4}} = \underline{\underline{328{,}075\,K}}$$

2c) $\dot m_{ges} \cdot \Delta e_{x,str} = \cancel{\ldots}\ \dot m_{ges} \left(h_6 - h_0 - T_0 (s_6 - s_0) + \frac{w_6^2 - w_0^2}{2} \right)$

$= \dot m_{ges} \left(c_p^{ig} (T_6 - T_0) - T_0 \left(c_p^{ig} \left(\ln \left(\frac{T_6}{T_0} \right) \right) + \frac{w_6^2 - w_0^2}{2} \right) \right.$

$= \dot m_{ges} \left(1006 \frac{J}{kgK} (328{,}075K - 243{,}15K) - 243{,}15K \left(1006 \frac{J}{kgK} \left(\ln \left(\frac{328{,}075K}{243{,}15K} \right) \right) \right. \right.$
$+ \frac{(507{,}24 \frac{m}{s})^2 - (200 \frac{m}{s})^2}{2} \Big)$

$= \dot m_{ges} \left(120{,}73\ \cancel{\ldots} \frac{kJ}{kg} \right)$

$\rightarrow \Delta e_{x,str} = 120{,}73 \frac{kJ}{kg}$

2d) $\cancel{0 = \Delta e_{x,str} + \dot E_{x}Q - \dot W_t - \dot E_{x\,verl}}$ adiabat

alles von Turbine zu Verdichter

$0 = \Delta e_{x,str} + \Delta e_x Q - \cancel{w_t} - \Delta e_{x,verl}$

$\Delta e_x Q = \left(1 - \frac{T_2}{T_B} \right) \cdot q_B = \left(1 - \frac{T_2\ \cancel{243{,}15K}}{1289K} \right) 1195 \frac{kJ}{kg}$

$\Delta e_{x,verl} = \Delta e_{x,str} + \Delta e_x Q$

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3)

$p_{g1} = p_{amb} + p_{Kolben} + p_{EW}$

~~= 1 bar + (32 kg + 0,1 kg) · (0,05 m)² · π~~

$= 1\,bar + \frac{(32kg + 0{,}1kg) \cdot 9{,}81 \frac{m}{s^2}}{(0{,}05m)^2 \cdot \pi}$

$= \underline{\underline{1{,}4\,bar}}$

$V_{g1} = 3{,}14L = 0{,}00314 m^3$

$R = \frac{\bar{R}}{M} = \frac{8{,}314 \frac{kJ}{kmol K}}{50 \frac{kg}{kmol}} = 0{,}16628 \frac{kJ}{kg K}$ $T_{g1} = 500°C = 773{,}15 K$

$\frac{p_{g1} \cdot V_{g1}}{R \cdot T_{g1}} = m_{g1} = \underline{\underline{3{,}42g}}$

b) die Temperatur T_{g2} ist $= 0°C$ da das Eiswasser eine Temperatur von 0°C hat, und sich Gas & EW in thermodynamischem GG befinden. (da Eis noch vorkommt)

Da das Gewicht von oben (Kolben, Eis, Atmosphärendruck) immer noch gleich ist → ist der Druck $p_{2g} = p_{1g} = 1{,}4\,bar$.

c) $\Delta E = E_2 - E_1 = m_{g1} \cdot u_2 - m_{g1} \cdot u_1 = Q - W_V$

$T_{g2} = 0°C$ $u_2 - u_1 = c_v^{pg}(T_2 - T_1) = 316{,}5 \frac{kJ}{kg}$

$T_{g1} = 500°C$

$\frac{W_V}{m} = \frac{R(T_2 - T_1)}{1-n}$ reibungsfrei → isentrop

$\rightarrow n = \frac{R + c_v}{c_v} = 1{,}263$

$= \frac{0{,}16628(500)}{1 - 1{,}263} = -316{,}5 \frac{kJ}{kg}$

~~⇒ $m_{g1}(316{,}5)$ +~~

3a)

$$\Delta E = (u_2 - u_1) m = Q_{12} - \cancel{W_V}$$ Volumen ändert nicht

$Q_{12} = 1{,}5\,kJ$

$$u_1 = u_{fl}(0°C) + 0{,}6\,(u_{fe}(0°C) - u_{fl}(0°C))$$

$$= -0{,}045 + 0{,}6\,(-333{,}458 + 0{,}045)$$

$$= -200{,}093\,\frac{kJ}{kg}$$

$$u_2 = \frac{Q_{12}}{m} + u_1 = \frac{1{,}5\,kJ}{0{,}1\,kg} - 200{,}093\,\frac{kJ}{kg} = -185{,}093$$

$T_{g2} = 0{,}003°C$

$$u_2 = -185{,}093 = u_{fl}(0{,}003°C) + x_2\,(u_{fe}(0{,}003°C) - u_{fl}(0{,}003°C))$$

$$= -0{,}0033 + x_2\,(-333{,}442 + 0{,}0033)$$

$$\rightarrow x_2 = 0{,}5551 = \underline{\underline{0{,}555}}$$

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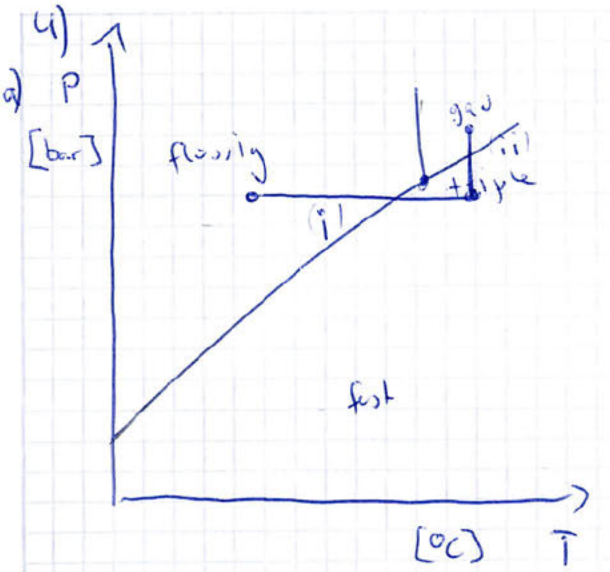
4)

a)



b)

$$0 = \dot{m}\,(h_e - h_a) + \dot{Q} - \dot{W}_K$$ adiabat

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

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

$$h_2 = h_g(\cancel{p_2}\,T_2) = 259{,}405\ \frac{kJ}{kg}$$

$$\cancel{h_3 = h_f(8\,bar) = 93{,}42\ \frac{kJ}{kg}}$$

$p_1 = p_2$

$p_3 = 8$ bar

$x_2 = 1$

$T_2 = T_1 - 6\,K \quad -22°C$

$$h_g(22°C) = \frac{260{,}45 - 258{,}36}{24 - 20} \cdot (22 - 20) + 258{,}36 = 259{,}405\ \frac{kJ}{kg}$$

c) $h_4 = h_1$ da isenthalp → adiabate Drossel

$x_4 = 0$

$p_4 = p_3 = 8$ bar

$$h_4 = h_1 = h_f(8\,bar) = 93{,}42\ \frac{kJ}{kg}$$

$$h_1 = h_f(p_1) + x_1\,(h_g(p_1) - h_f(p_1))$$

$\rightarrow x_1$

$T_2 = -22°C$