[redacted]

(1.)

a)

$$\cancel{\dot{m}_{ein}(h_{ein}) - \dot{m}_{aus}(h_{aus}) + \dot{Q} - \underbrace{\dot{W}}_{0} = 0}$$

$$\cancel{\dot{Q} = \dot{m}_{aus} h_{aus} - \dot{m}_{ein} h_{ein}}$$

$$\dot{m}_{aus} =$$

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

$$\cancel{\dot{m}_{ein}}$$

$$h_e = h_f(70°C) \quad \text{(Tabelle A-2)}$$
$$= 292{,}98 \frac{kJ}{kg}$$

$$h_a = h_f(100°C) \quad \text{(Tab. A-2)}$$
$$= 419{,}04 \frac{kJ}{kg}$$

$$\dot{Q} = \dot{m}(h_a - h_e)$$
$$= 0{,}3 \frac{kg}{s}\left(419{,}04 \frac{kJ}{kg} - 292{,}98 \frac{kJ}{kg}\right)$$
$$= 37{,}81 \, kW$$

$$-\dot{Q}_{aus} = \dot{Q} - \dot{Q}_R$$
$$= 37{,}81 kW - 100 kW$$
$$= -62{,}18 \, kW$$
$$\Downarrow$$
$$\dot{Q}_{aus} = \underline{\underline{62{,}18 \, kW}}$$

b)

$$\bar{T} = \frac{\int_1^2 T \, ds}{s_2 - s_1} \qquad ds = \frac{dQ}{T}$$

$$\cancel{Q = \dot{m} \Delta h}$$

$$= \frac{\int dQ}{s_2 - s_1} \qquad \cancel{\dot{m} \, c \, \ln\left(\frac{T_2}{T_1}\right)}$$

$$= \frac{\cancel{c} \Delta T}{\cancel{c} \ln\left(\frac{T_2}{T_1}\right)} = \frac{T_2 - T_1}{\ln\left(\frac{T_2}{T_1}\right)} = \frac{298{,}15K - 288{,}15K}{\ln\left(\frac{298{,}15K}{288{,}15K}\right)} = \underline{\underline{293{,}12 K}}$$

c) nur um Grenze:

$$0 = \frac{\dot{Q}}{T} + S_{erz}$$

$$S_{erz} = \frac{\dot{Q}}{T}$$

$$= \frac{62{,}18\,kW}{293{,}12\,K}$$

$$= 0{,}21\,\frac{kW}{K}$$

$$= \underline{\underline{212{,}13\,\frac{W}{K}}}$$

d)

~~m_2 ~~

$$m_2 u_2 - m_1 u_1 = \Delta m\, h + Q - \cancel{W}_0$$

$$m_2 = 5755\,kg - \Delta m$$

$$m_1 = 5755\,kg$$

bei 100°C (Tab A-2)

$$u_1 = u_f + x(u_g - u_f) = 418{,}94\,\frac{kJ}{kg} + 0{,}005\left(2506{,}5\,\frac{kJ}{kg} - 418{,}94\,\frac{kJ}{kg}\right)$$

$$= 429{,}38\,\frac{kJ}{kg}$$

(Tab A-2)

$$u_2 = u_f(70°C) + x\left(u_g(70°C) - u_f(70°C)\right) = 292{,}95\,\frac{kJ}{kg} + 0{,}005\cdot\left(2469{,}6\,\frac{kJ}{kg} - 292{,}95\,\frac{kJ}{kg}\right)$$

$$= 303{,}83\,\frac{kJ}{kg}$$

$$h = h_f(20°C) \quad \text{(Tab A-2)}$$

$$= 83{,}96\,\frac{kJ}{kg}$$

$\Downarrow$ einsetzen

$$(5755\,kg - \Delta m)\cdot 303{,}83\,\frac{kJ}{kg} - 5755\,kg\cdot 429{,}38\,\frac{kJ}{kg} = \Delta m\; 83{,}96\,\frac{kJ}{kg} - 35\cdot 10^3\,kJ$$

$\downarrow$ solve for Δm

~~$1{,}662\cdot 10^3\,kg$~~

$$\Delta m = 1{,}77292\cdot 10^3\,kg$$

$$= \underline{\underline{1773\,kg}}$$

7 e)

[redacted]

$\cancel{\Delta S = s_2 - s_1 = m(s_2 - s_1)}$

$\Delta S = m_2 s_2 - m_1 s_1$

$$\left.\begin{aligned}
s_1 &= s_f(100°C) + x \cdot (s_g(100°C) - s_f(100°C)) \\
&= 1{,}3069 \tfrac{kJ}{kgK} + 0{,}005 \cdot (7{,}3549 \tfrac{kJ}{kg} - 1{,}3069 \tfrac{kJ}{kg}) \\
&= 1{,}332 \tfrac{kJ}{kgK} \\
s_2 &= s_f(20°C) + x \cdot (s_g(20°C) - s_f(20°C)) \\
&= 0{,}9549 \tfrac{kJ}{kgK} + 0{,}005 \cdot (2{,}7853 \tfrac{kJ}{kg} - 0{,}9549 \tfrac{kJ}{kgK}) \\
&= 0{,}9889 \tfrac{kJ}{kgK}
\end{aligned}\right\} \text{(Tab A-2)}$$

Θ

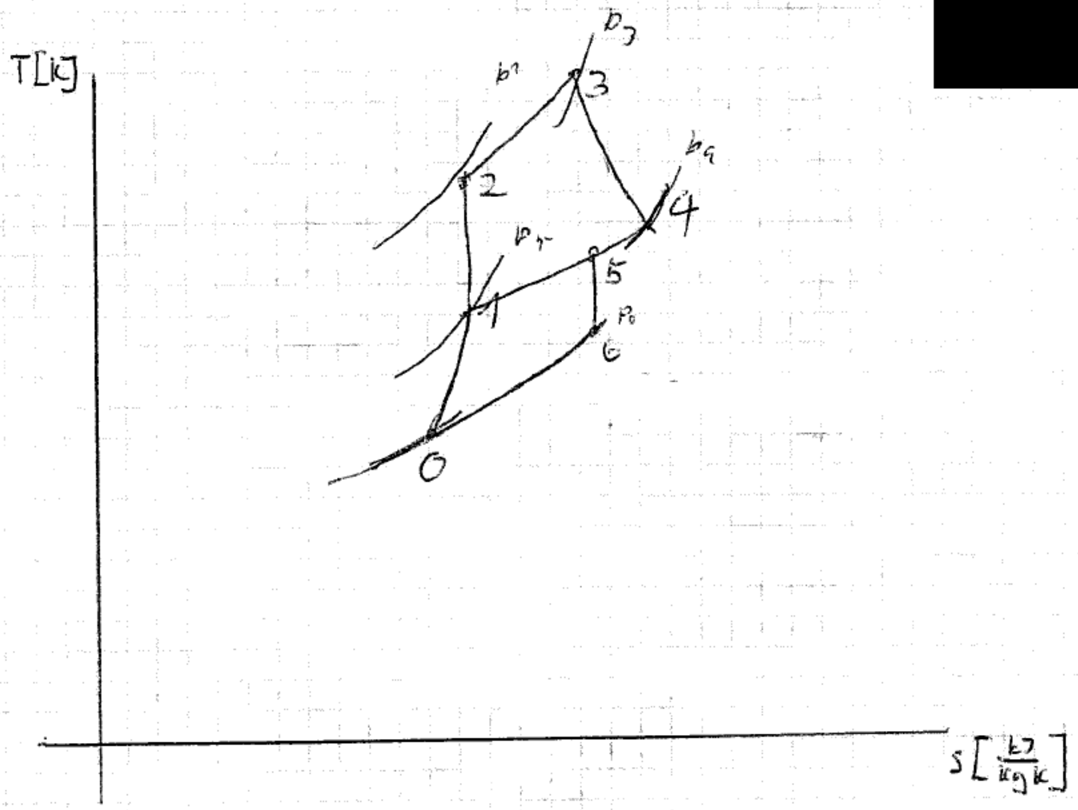
$\Delta S = (5755\,kg - 3600\,kg) \cdot 0{,}9889 \tfrac{kJ}{kgK} - 5255\,kg \cdot 1{,}332 \tfrac{kJ}{kgK}$

$= \underline{\underline{5563{,}4\ kW}}$

[redacted]

2

a)



b)

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

$$= 437{,}9\,K \cdot \left(\frac{0{,}191 \cdot 10^5\,\frac{N}{m^2}}{0{,}5 \cdot 10^5\,\frac{N}{m^2}}\right)^{\frac{1{,}4-1}{1{,}4}}$$

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

$\cancel{p\,V = m\,R\,T}$

$\cancel{p \cdot \dot{V} = \dot{m}\,R\,T}$

$$0 = \dot{m}\left(h_e - h_a + \frac{w_e^2 - w_a^2}{2}\right)$$

$$h_a - h_e = \frac{w_e^2 + w_a^2}{2} \quad \ominus$$

$$c_p^{ig}\left(T_6 - T_5\right) = \frac{w_5^2 - w_6^2}{2}$$

$$\sqrt{-2 c_p^{ig}\left(T_6 - T_5\right) + w_5^2} = w_6$$

$$w_6 = \sqrt{-2 \cdot 1{,}006\,\frac{kJ}{kg\,K}\left(328{,}07\,K - 437{,}9\,K\right) + \left(220\,\frac{m}{s}\right)^2}$$

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

c)

$$R = c_p^{ig} - c_v^{ig}$$

$$R = c_p^{ig} - \frac{c_p^{ig}}{n}$$

$$= 1{,}006\,\frac{kJ}{kg\,K} - \frac{1{,}006\,\frac{kJ}{kg\,K}}{1{,}4}$$

$$= 722{,}88\,\frac{kJ}{kg\,K}$$

~~Stationärer Fließprozess~~

$$e_{x,str,6} - e_{x,str,0} = (h_6 - h_0 - T_0(s_6 - s_0) + \Delta ke)$$

$$= \left(c_{p,Luft}^{ig}(T_6 - T_0) - T_0\left(\int_{T_0}^{T_6} \frac{c_{p,Luft}^{ig}}{T}\,dT - R\ln\left(\frac{p_6}{p_0}\right)\right) + \frac{w_6^2 - w_0^2}{2}\right)$$

$$= \left(c_{p,Luft}^{ig}(T_6 - T_0) - T_0\left(c_{p,Luft}^{ig}\ln\left(\frac{T_6}{T_0}\right) - R\ln\left(\frac{p_0}{p_0}\right)\right) + \frac{w_6^2 - w_0^2}{2}\right)$$

$$= \left(1{,}006\,\frac{kJ}{kgK}(328{,}07\,K - 243{,}15\,K) - 243{,}15\,K\left(1{,}006\,\frac{kJ}{kgK}\ln\left(\frac{328{,}07\,K}{243{,}15\,K}\right) - 722{,}88\,\frac{kJ}{kgK}\ln(1)\right) + \frac{(507{,}29\,\frac{m}{s})^2 - (200\,\frac{m}{s})^2}{2}\right)$$

$$= \cancel{(1{,}2\ldots\,\frac{kJ}{kgK})}$$

$$= \cancel{1{,}21\ldots}$$

$$= \underline{\underline{120{,}8\,\frac{kJ}{kg}}}$$

d)

alles kein „e"

$$0 = -(e_{x,str,6} - e_{x,str,0}) + \cancel{\dot{E}_{x,Q,i}} - \dot{W}_n - \dot{E}_{x,verl} + \dot{E}_{x,Q,\ldots}$$

adiabat $\rightarrow 0$

klein „e"

$$\hookrightarrow \dot{E}_{x,verl} = -(e_{x,str,6} - e_{x,str,0}) + \left(1 - \frac{T_0}{T}\right)\cdot q$$

$$= -120{,}8\,\frac{kJ}{kg} + \left(1 - \frac{243{,}15\,K}{1289\,K}\right)\cdot 1195\,\frac{kJ}{kg}$$

$$= \underline{\underline{848{,}78\,\frac{kJ}{kg}}}\ (= e_{x,verl})$$

[redacted]

3.

a) $R = \frac{\bar{R}}{M} = \frac{8{,}314 \frac{kJ}{kmol\,K}}{50 \frac{kg}{kmol}} = 0{,}16628 \frac{kJ}{kg\,K}$

$p_{Gas} = p_{amb} + \frac{F_K}{A} + \frac{F_{EW}}{A}$

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

$= 1 \cdot 10^5 \frac{N}{m^2} + \frac{32kg \cdot 9{,}81 \frac{m}{s^2}}{(\frac{0{,}1m}{2})^2 \pi} + \frac{0{,}1kg \cdot 9{,}81 \frac{m}{s^2}}{(\frac{0{,}1m}{2})^2 \pi}$

$= 1{,}401 \cdot 10^5 \frac{N}{m^2}$

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

$p \cdot V = mRT$

$m = \frac{p \cdot V}{RT}$

$m_g = \frac{p_{Gas} \cdot V_{g,1}}{R \cdot T_{g,1}}$

$= \frac{1{,}4 \cdot 10^5 \frac{N}{m^2} \cdot 3{,}14 \cdot 10^{-3} m^3}{166{,}28 \frac{J}{kgK} \cdot 773{,}15 K}$

$= 3{,}419 \cdot 10^{-3} kg$

$= \underline{\underline{3{,}42 g}}$

b) $T_{g,2} = \underline{\underline{0°C}}$, da das Eis ab 0°C Gastemperatur nicht mehr schmelzen kann

$p_{g,2} = p_{an}$

$= \underline{\underline{1{,}4\ bar}}$ (druck würde nie in (a) berechnet werden) c)

geschlossenes System in Gas:

$$E_2 - E_1 = Q - \cancel{W}_0$$

$$m(u_2 - u_1) = Q_{12}$$

$$m_{Gas}\, c_v (T_2 - T_1) = Q_{12}$$

$$Q_{12} = 3{,}419 \cdot 10^{-3}\,\text{kg} \cdot 0{,}633\,\frac{\text{kJ}}{\text{kgK}}\,(273{,}15\,\text{K} - 773{,}15\,\text{K}) = -1082{,}11\,\text{J}$$

$$\underline{\underline{|Q_{12}| = 1082{,}11\,\text{J}}}$$

d)

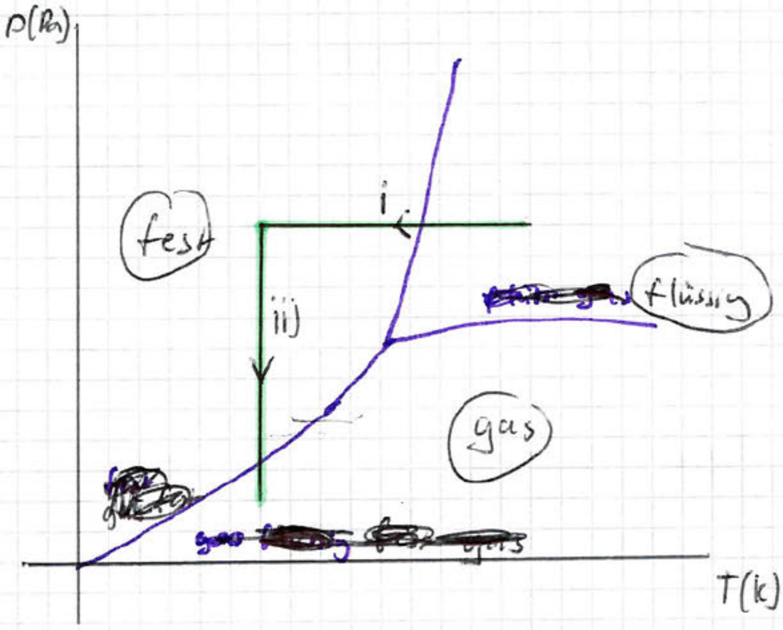
$$E_2 - E_1 = Q_{12} - \cancel{W}$$

$$m_{Eis,2}(u_{Eis,2}) + m_{Wasser}(u_{Wasser,2}) - m_{Eis,1}\,u_{Eis,1} - m_{Wasser,1}\,u_{Wasser,1} = Q_{12}$$

[redacted]

4

a)



b)

e) Sie würden weiterhin sinken

d)

c)

$$h_1 = h_{1,f} + x \cdot (h_{1,g} - h_{1,f}) = h_4$$

drossel

$$h_4 = h_f(8\,\text{bar}) \quad (\text{Tab A-11})$$
$$= 93{,}42\ \frac{kJ}{kg}$$

$\Downarrow$

$$x = \frac{h_1 - h_{1,f}}{h_{1,g} - h_{1,f}}$$

$$x = \frac{h_4 - h_{1,f}}{h_{1,g} - h_{1,f}}$$ ← Werte für $h_{1,flüssig}$ & $h_{1,gas}$ finden & einsetzen

d)

$$\varepsilon_K = \frac{\dot{Q}_{zu}}{|\dot{W}_t|} = \frac{\dot{Q}_K}{28W}$$

b)

Druck in x_2 hoch

~~gleich~~

Energiebilanz um ~~äußeren~~ Kompressor