Aufgabe 1

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

· Energiebilanz:

$$0 = \dot{m}_{Ein}(h_{ein} - h_{aus}) + \dot{Q}_{aus} + \dot{Q}_R - \dot{W}_T$$ (20)

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

$h_{aus}(100°C) = h_f = 419{,}04 \frac{kJ}{kg}$

$h_{ein}(70°C) = h_f(70°) = 292{,}98 \frac{kJ}{kg}$ | TAB A2

$\dot{Q}_{aus} = -62{,}182 kW$

↳ negativ von reaktor aus gesehen

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

$$\overline{T}_{kf} = \frac{\int_{ein}^{aus} T \cdot ds}{s_{aus} - s_{ein}}$$

$T \cdot ds = dU - p \cdot dV = dH$

$dH = dU + p dv$

$$\overline{T}_{kf} = \frac{\int_{ein}^{aus} dH}{s_{aus} - s_{ein}} = \frac{h_{aus} - h_{ein}}{s_{aus} - s_{ein}} = \frac{c \cdot (T_{aus} - T_{ein})}{s_{aus} - s_{ein}}$$

$$\overline{T}_{kf} = \frac{c(T_{aus} - T_{ein})}{c \cdot \ln\left(\frac{T_2}{T_1}\right)} = \frac{T_{aus} - T_{ein}}{\ln\left(\frac{T_{aus}}{T_{ein}}\right)} = 293{,}1216 °K$$

c) $\bar{T} = 295°C$ $\quad \dot{Q}_{aus} = 651\,kW$

$$0 = \dot{m}\,[s_e - s_a] + \frac{\dot{Q}_R - \dot{Q}_{aus}}{\bar{T}} + \dot{s}_{erz}$$

$$\dot{s}_{erz} = \dot{m}\,[s_a - s_e] + \frac{\dot{Q}_{aus} - \dot{Q}_R}{\bar{T}} = \left(-0{,}013044\right)$$

$s_a(100°C) = s_f(100°C) = 1{,}3069 \frac{kJ}{kg\cdot K}$

$s_e(70°C) = s_f(70°C) = 0{,}9549 \frac{kJ}{kg\cdot K}$

TAB-A2

nicht möglich

$\dot{s}_{erz} = 0$

$-0{,}013044$ von Rundungsfehler

d) $\frac{dE}{dt} \rightarrow \frac{dU}{dt}$

$$\frac{dE}{dt} = \sum_j Q_j - \sum_n W_n + \sum \dot{m}_i\,[h_i]$$

heben sich auf

$$m_2 u_2 - m_1 u_1 = \Delta m_{12} h(20°C) + Q_R - Q_{aus}$$

$$m_2 = m_1 + \Delta m_{12}$$

$u_1 = u_{1f} + x\,(u_{g1} - u_{fv}) = 429{,}7778 \frac{kJ}{kg}$

$u_{1f}(100°C) = 419{,}04 \frac{kJ}{kg}$

$u_{1g}(100°C) = 2'506{,}5 \frac{kJ}{kg}$ A-2

$u_2 = u_f(70°C) = 292{,}95 \frac{kJ}{kg}$

A2

nächste Seite

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

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

$\Delta m_{12} = \frac{m_1 (u_2 - u_1)}{h_{in} - u_2} = 3'756{,}84\ kg$

$h_{in} = h_f(20°C) = 83{,}96 \frac{kJ}{kg}$

e) $\Delta m = 3'600\ kg$

$\Delta S = m_2 s_2 - m_1 s_1 = \Delta m_{12} s_{in} + \frac{Q_R - Q_{abs}}{T} + \dot{S}_{erz}$

$S_{12} = (m_1 + \Delta m_{12}) s_2 - m_1 s_1$

$s_1 = s_{1f}(100°C) + x_1 \cdot (s_g(100°C) - s_f(100°C)) = 1{,}33724 \frac{kJ}{kg \cdot K}$

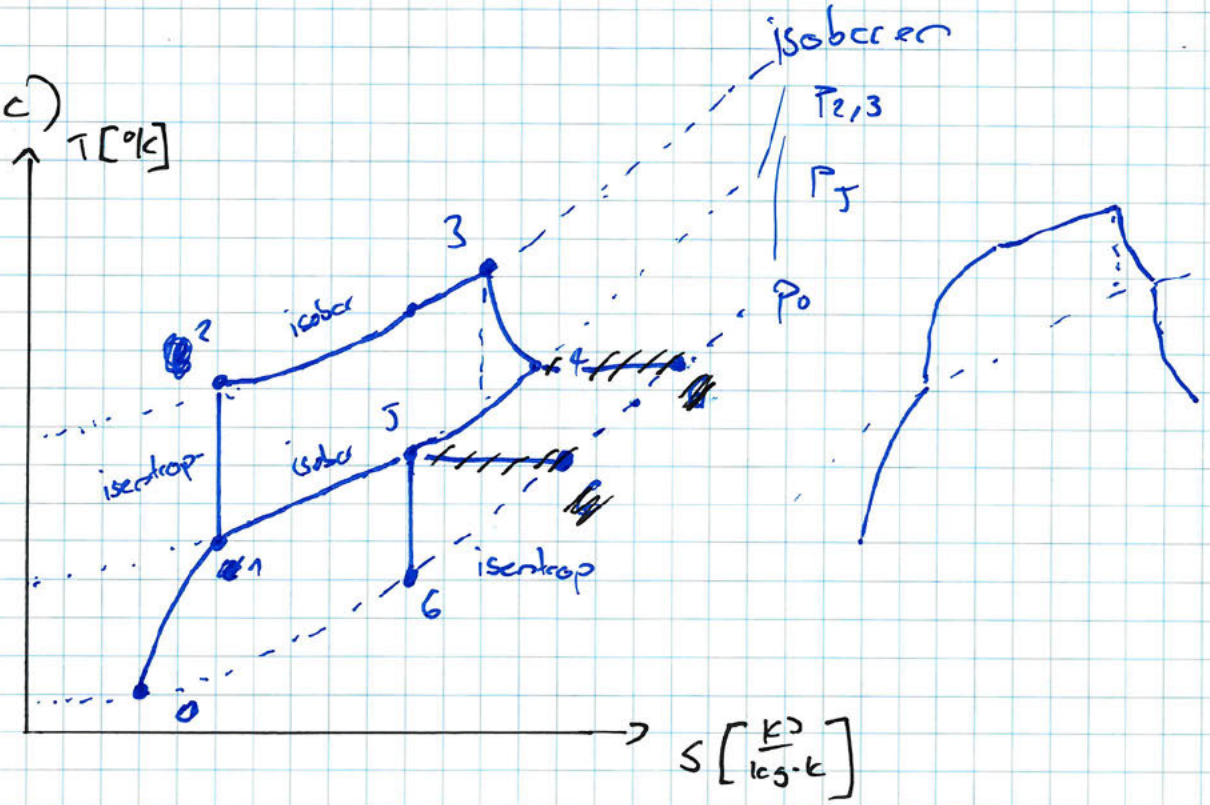
$s_f(100°C) = 1{,}3069 \frac{kJ}{kg \cdot K}$ $s_g = 7{,}3549 \frac{kJ}{kg \cdot K}$

$s_2 = s_f(70°C) = 0{,}9549 \frac{kJ}{kg \cdot K}$ / A2

$S_{12} = 1'237{,}85 \frac{kJ}{kg \cdot K}$

Aufgabe 2

c)



b)

$w_6 = ?$ $\quad T_6 = ?$

$s_5 = s_6$ $\quad n = \kappa = 1{,}4$ isentrop

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \qquad T_6 = T_5 \cdot \left(\frac{p_0}{p_5}\right)^{\frac{0{,}4}{1{,}4}} = 328{,}074697\ °K$$

~~$0 = \dot{m}\,[h_5 - h_6] + \dot{Q}_{56} - \dot{W}_{56}$~~

$$0 = \dot{m}_6 \left[h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right] + \dot{Q}_{56} + \dot{W}_{56} \qquad 1 = \dot{m}_6$$

$$0 = h_5 - h_6 + \frac{w_5^2}{2} - \frac{w_6^2}{2}$$

$$\frac{w_6^2}{2} = h_5 - h_6 + \frac{w_5^2}{2} = c_p (T_5 - T_6) + \frac{w_5^2}{2}$$

$$w_6 = \sqrt{2 c_p (T_5 - T_6) + w_5^2} = 507{,}244\ m/sec$$

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

$\Downarrow$ $\qquad T_6 = 740\,°K \qquad c_6 = 510 \frac{m}{sec}$

$\Delta e_{x,str} = [\, h_6 - h_0 - T_0 (s_6 - s_0) + \Delta kce \,]$

$h_6 - h_0 = c_p (T_6 - T_0) \qquad T_0 = 243,15\,°K$

$s_6 - s_0 = c_p \cdot \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)$

$\Delta kce = \frac{c_6^2 - c_{Luft}^2}{2} \qquad R = \frac{\bar{R}}{M_{Luft}} = \frac{8,314}{28,97 \cdot 10^{-3}} \frac{J}{mol} = 286,98 \frac{J}{kg \cdot K}$

$\Delta e_{x,str} = \left[c_p (T_6 - T_0) - T_0 \left(c_p \cdot \ln\left(\frac{T_6}{T_0}\right) - R \cdot \ln\left(\frac{p_6}{p_0}\right) \right) + \frac{c_6^2 - c_L^2}{2} \right]$

$= 125,47179 \frac{kJ}{kg}$

d)

3.

a) $p_{g1} = ?$ $\quad m_{g1} = ?$

$$p_{g1} = p_0 + \frac{m_{tot} g}{A}$$

$$A = r^2 \pi = \left(\frac{D}{2}\right)^2 \pi = 0{,}0078539\,m^2$$

$$m_{tot} = m_K + m_{EW} = 32{,}1\,kg$$

~~$p_{g1} = 1{,}040087$ bar~~

$p_{g1} = 1{,}40094$ bar

$$m_g = \frac{pV}{RT} \qquad R = \frac{\bar{R}}{M} = 166{,}28\,\frac{J}{kg \cdot K}$$

$m_g = 3{,}422\,g$

b) $p_{g2} = p_{g1} = 1{,}40094$ bar

Der Druck ändert sich nicht, da das System geschlossen ist und immer noch der selbe äußere Druck vorherrscht

Es gilt $T_{g2} = T_{EW} = 0°C$

Es hat immer noch Eis ($\hat{=} 0°C$) und es findet kein Wärmetausch mehr statt.

c) $Q_{12} = ?$

Energiebilanz folgt:

$$\frac{dE}{dt} = \dot{Q}_j - \cancel{\dot{W}_v} \quad \Rightarrow \Delta E = \Delta U = Q_{12}$$

$$\Delta U = m_2 u_2 - m_1 u_1 = m_g (u_2 - u_1) = Q_{12}$$

$$m_g c_v (T_{2g} - T_{1g}) = Q_{12} = -1'083{,}06\,\text{J}$$

↗ negativ, da Gas aus gesehen

d)

$T_{EW2} = 0\,°C = T_{EW1} = T_{g2}$

$m_{EW} = 0{,}1\,\text{kg}$

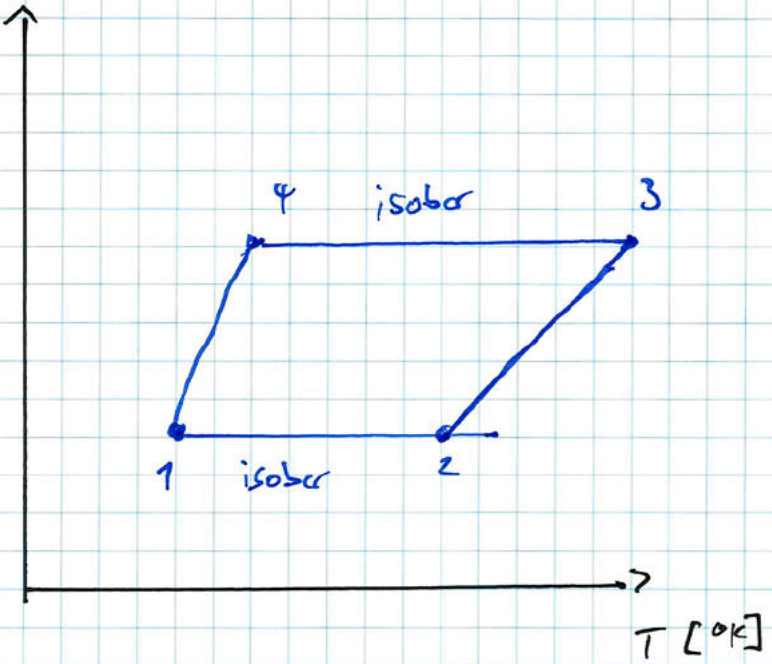
$X_1 = 0{,}6$

$Q_{12} = \cancel{-1083{,}06\,\text{J}}$ $1'500\,\text{J}$

$m_{Eis} = 0{,}6 \cdot m_{EW} = 0{,}06\,\text{kg}$

Aufgabe 4

a) p[Pa]



T [°K]

b)

$$0 = \dot{m}_R [h_2 - h_3] + \dot{Q}_{23}^{\nearrow 0} - \dot{W}_K$$

$h_3 (8\,bar, x_3 = 1) = h_g(8\,bar) = 93,42 \frac{kJ}{kg}$ A11

$x_3 = 1$ weil isentrop verdichtet

$s_{3f} = s_{2f} = 0,3959 \frac{kJ}{kg \cdot K}$ weil isentrop

$h_2 =$

c) $\dot{m} = \frac{4\,kg}{h}$ $\quad T_2 = -22°C$ $\quad x_2 = ?$

isenthalp: $h_4 = h_1$

$h_4(8bar) = h_g(8bar) = 264,77 \frac{kJ}{kg}$

d) $\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_T|}$

$0 = \dot{m}[h_1 - h_2] + \dot{Q}_K$

~~$\dot{Q}_K = \dot{m}[h_4 - h_2] = 0$~~,

$h_2[-22°C] = h_g(-22°C) = 27,77 \frac{kJ}{kg}$

h_1 aus c) TAB A-10

$0 = \dot{m}[h_1 - h_2] + \dot{Q}_K$

$\dot{Q}_K = \dot{m}[h_2 - h_1] = 9,265\,kW$

$\varepsilon = \frac{\dot{Q}_{zu}}{\dot{W}_K} = 9,61825$

e) Die Temperatur würde weiterhin sinken