Aufgabe 1

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

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

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

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

$h_{aus} = h_f(100°C) = 419,04 \frac{kJ}{kg}$ TAB A2

$$\dot{Q}_{aus} = 0,3 \frac{kg}{s}(419,04 \frac{kJ}{kg} - 292,98)\frac{kJ}{kg} - 100\,kW$$

$$= -62,182\,kW$$

=> Vorzeichen nach Vorzeichenkonvention wie auf Zusammenfassung

b) $$\overline{T}_{kT} = \frac{\int_e^a T\,dS}{S_a - S_e}$$

$$\overline{T}_{kT} = \frac{295,15\,K + 295,15\,K}{2}$$

$$= 293,15\,K$$

$S_a - S_e = -C_1$

$\bar{T}_{Luft} = 295\,K$

c)

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

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

~~$= 0.3$~~

$s_{ein} = s_f(20°C) = 0{,}9549 \frac{kJ}{kg\,K}$

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

$$\dot{S}_{erz} = 0.3 \frac{kg}{s}\left(1{,}3069 \frac{kJ}{kg\,K} - 0{,}9549 \frac{kJ}{kg}\right) + \frac{62{,}152\ \frac{kJ}{s}}{295\,K}$$

$= 0{,}316 \frac{kW}{K}$

Fortsetzung Aufgabe 4)

d) Δm_{12}

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

$m_1 = 5755\,kg$

$m_2 = 5755\,kg + \Delta m_{12}$

$u_2 = u_{2,f}(70°C) = 292{,}95 \frac{kJ}{kg}$ TAB A2

$u_1 = u_f + x_D (u_g - u_f)$ ✓ Werte aus TAB A2 bei 100°C

$= \left(418{,}94 + 0.005\,(2506{,}5 - 418{,}94)\right) \frac{kJ}{kg}$

$= 429{,}3778 \frac{kJ}{kg}$

$h_{12} = h_f(20°C) = 83{,}96 \frac{kJ}{kg}$ TAB A2

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

$$\Delta m_{12} = \frac{m_1 u_2 - m_1 u_1 - Q_{R,12}}{h_{12} - u_2}$$

$= 3538{,}57\,kg$

e)

$$\Delta S_{12} = m_2 s_2 - m_1 s_1 + \Delta m_{12} s_{12}$$

$$s_2 = s_f(70°C) = 0{,}9554 \frac{kJ}{kg\,K} \quad \text{TAB A2}$$

$$s_1 = s_f + x_D (s_g - s_f) \quad \text{Werte aus TAB A2 bei } 100°C$$

$$= 1.337 \frac{kJ}{kg\,K}$$

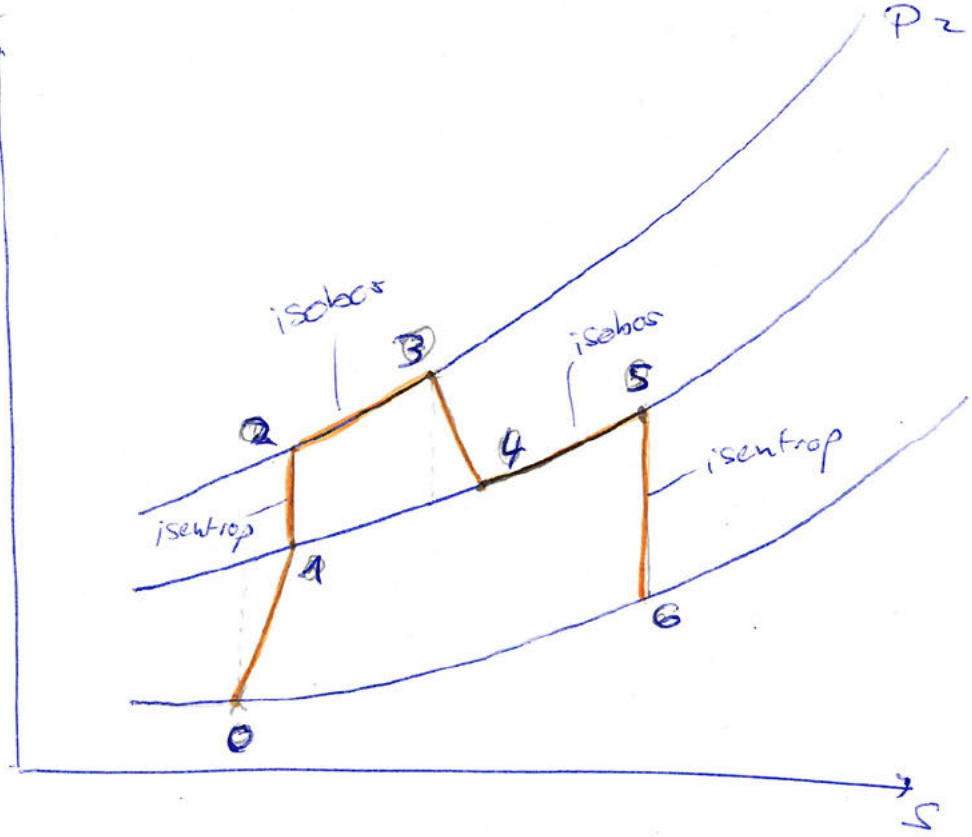
$$s_{12} = s_f(20°C) = 0{,}2966 \frac{kJ}{kg\,K} \quad \text{TAB A2}$$

$$\Delta S_{12} = 130{,}455 \frac{kJ}{K}$$

[redacted]

Aufgabe 2

a)



$p_1 > p_0$ $\quad p_6 = p_0$ $\quad p_5 = 0.5$ bar

$p_2 = p_3$

b) c_6, T_6

Energiebilanz: adiabat, 0

$$0 = \dot{m}_5 \left(h_5 - h_6 + \frac{(c_5^2 - c_6^2)}{2} \right) + \dot{Q} - \dot{W}^{0}$$

$$h_5 - h_6 = c_p (T_5 - T_6)$$

T_6:

$$T_6 = T_5 \left(\frac{0,191 \text{ bar}}{0.5 \text{ bar}} \right)^{\frac{n-1}{n}}$$

$$T_6 = 431,9\,\text{K} \left(\frac{0,191}{0.5} \right)^{\frac{0.4}{1.4}} = 328,075\,\text{K}$$

$$c_6 = \sqrt{c_5^2 + 2 \cdot (h_5 - h_6)}$$

$$c_{6} = \sqrt{\left(220 \frac{m}{s}\right)^2 + \left(2 \cdot 1.006 \frac{kJ}{kgK} (631{,}4K - 328{,}075K)\right)}$$

$$= 507{,}243 \frac{m}{s}$$

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

$\Delta e_{x,str} = h_e - h_a - T_0 (s_e - s_a) + \Delta k_e$

$= h_0 - h_6 - T_0 (s_0 - s_6) + (k_{e_1} - k_{e_6})$

$h_0 - h_6 = c_p (T_0 - T_6)$

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

$= -c_p \ln\left(\frac{T_6}{T_0}\right)$

$k_{e_1} - k_{e_2} = \frac{(w_{Luft})^2}{2} - \frac{(w_6)^2}{2}$

$T_0 = -30°$
$= 243{,}15K$

$e_{x,str} = c_p (T_0 - T_6) - T_0 \left(-c_p \ln\left(\frac{T_6}{T_0}\right) + \frac{(w_1)^2}{2} - \frac{w_0^2}{2}\right)$

$= 1.006 \frac{kJ}{kgK} (328{,}075K - 243{,}15K) + 243{,}15K \left(1.006 \frac{kJ}{kgK} \ln\left(\frac{328{,}075}{243{,}15}\right)\right.$
$+ \frac{(200 \frac{m}{s})^2}{2} - \frac{(507{,}243 \frac{m}{s})^2}{2}$

$=$

[redacted]

Fortsetzung Aufgabe 2)

d) $e_{x,kin,1}$ $\rightarrow \Delta e_{x,str} = 100 \frac{kJ}{kg}$ aus Aufgabenstellung

$e_{x,kin,1} =$

c)

$$e_{x,str} = h_6 - h_0 - T_0 (s_6 - s_0) + ke_6 - ke_1$$

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

$$= 120,806 \frac{kJ}{kg}$$

d) $e_{x,kin,1}$

$e_{x,kin,1} = T_0 \cdot S_{erz}$

S_{erz}

Entropiebilanz:

$$-\dot{S}_{erz} = \dot{m} (s_0 - s_6) + \frac{\dot{Q}_0}{T_0}$$ (adiabat)

$$-S_{erz} \dot{m} = \dot{m} (s_0 - s_6)$$

$$S_{erz} = +c_p \left(\ln \left(\frac{T_6}{T_0} \right) \right.$$

$$= 1.006 \frac{kJ}{kgK} \cdot \ln \left(\frac{328,15 K}{243,15} \right.$$

$$= 0,3014 \frac{kJ}{kgK}$$

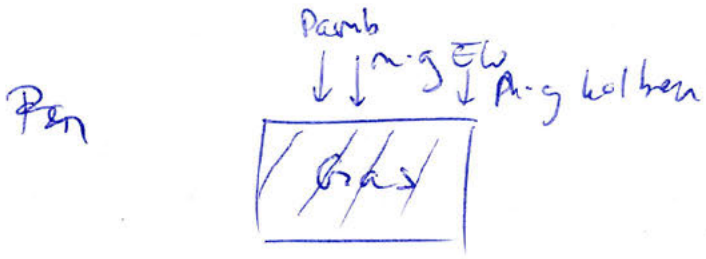
$e_{x,kin} = 243,15 K \cdot 0,3014 \frac{kJ}{kgK}$

$= 73,285 \frac{kJ}{kg}$

Aufgabe 3

a) $p_{G,1}$ m_G

$$p_{G,1} \cdot V_{g,1} = m_g \cdot \bar{R} \cdot T_{g,1} \cdot \frac{1}{M_G}$$



$$p_{G,1} = p_{amb} + p_{Kolben} + p_{FW}$$

$$= 1\,bar + \frac{m_{FW} \cdot g}{\pi (\frac{D}{2})^2} + \frac{m_K \cdot g}{\pi (\frac{D}{2})^2}$$

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

$$= 140094{,}441 \frac{N}{kg}$$

$$= 1{,}401\,bar$$

$$m_g = \frac{p_{G,1} \cdot M_G \cdot V_{g,1}}{\bar{R} \cdot T_{g,1}}$$

$$= \frac{1{,}401 \cdot 10^5 \frac{N}{m^2} \cdot 50 \frac{kg}{kmol} \cdot 3{,}14 \cdot 10^{-3} m^3}{8{,}314 \frac{kJ}{kmol\,K} \cdot 773{,}15\,K}$$

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

b) $T_{g,2}$ $p_{G,2}$

keine Wärmeübertragung: $T_{g,2} = T_{EL0,2}$

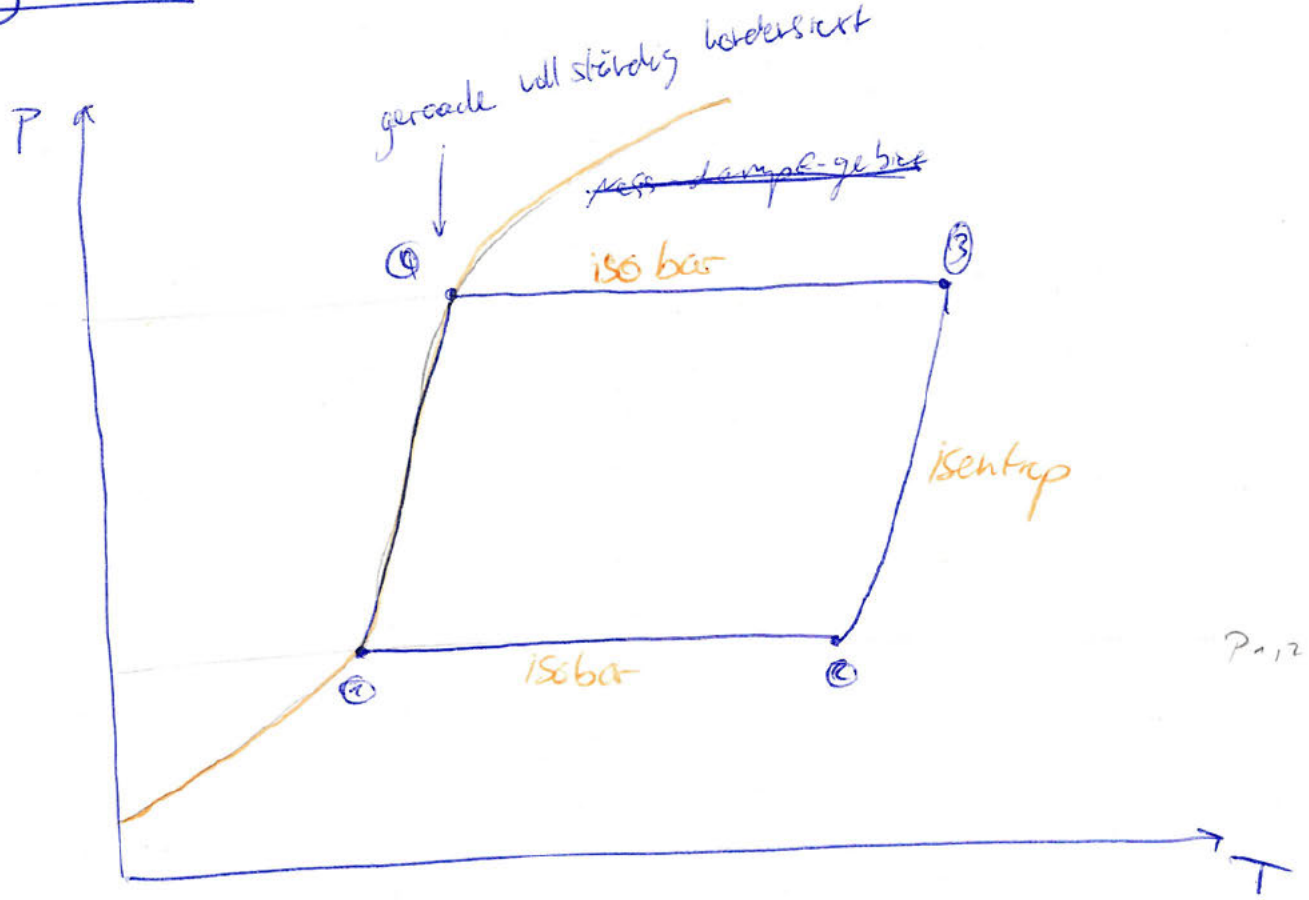
c) Q_{12}

Energiebilanz um gas:

$$\Delta E = Q_{12} - W_{12}$$

Aufgabe 4

a)



b) $\dot{m}_{KM34a}$

Energiebilanz um Kompressor

$$0 = \dot{m}_{KM34a}(h_2 - h_3) + \cancel{\dot{Q}}^{0} - \dot{W}_K$$

$$\frac{\dot{W}_K}{h_2 - h_3} = \dot{m}_{KM34a}$$

$h_2 = h_{2,g}(T_2)$

$T_2 = T_i - 6\,K$

mit Bedingungen aus ii) lässt sich T_i ~~bei~~ über das p-T-Diagramm bestimmen: $T_i = 10°C$

$= 283{,}15\,K$

c) $T_2 = -22\,°C$ $T_1 = -16\,°C$

$p_3 = p_4$

$s_3 = s_F(5\,bar) = 0{,}3105\,\frac{kJ}{kgK}$ TABLA

$s_2 = s_3$