1) a) Energiebilanz:

$$0 = \dot{m}\left[h_{ein} - h_{aus}\right] + \dot{Q}_R - \dot{Q}_{aus}$$

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

$h_{ein} = h_f(70°C) = 292.98 \frac{kJ}{kg}$ (Tab. A-2)

$h_{aus} = h_f(100°C) = 419.04 \frac{kJ}{kg}$ (Tab. A-2)

$$\dot{Q}_{aus} = 0.3 \frac{kg}{s}\left(292.98 \frac{kJ}{kg} - 419.04 \frac{kJ}{kg}\right) + 100\,kW$$

$$= \underline{\underline{62.782\,kW}}$$

b) $$T = \frac{\int_{ein}^{aus} T\,ds}{s_{aus} - s_{ein}}$$

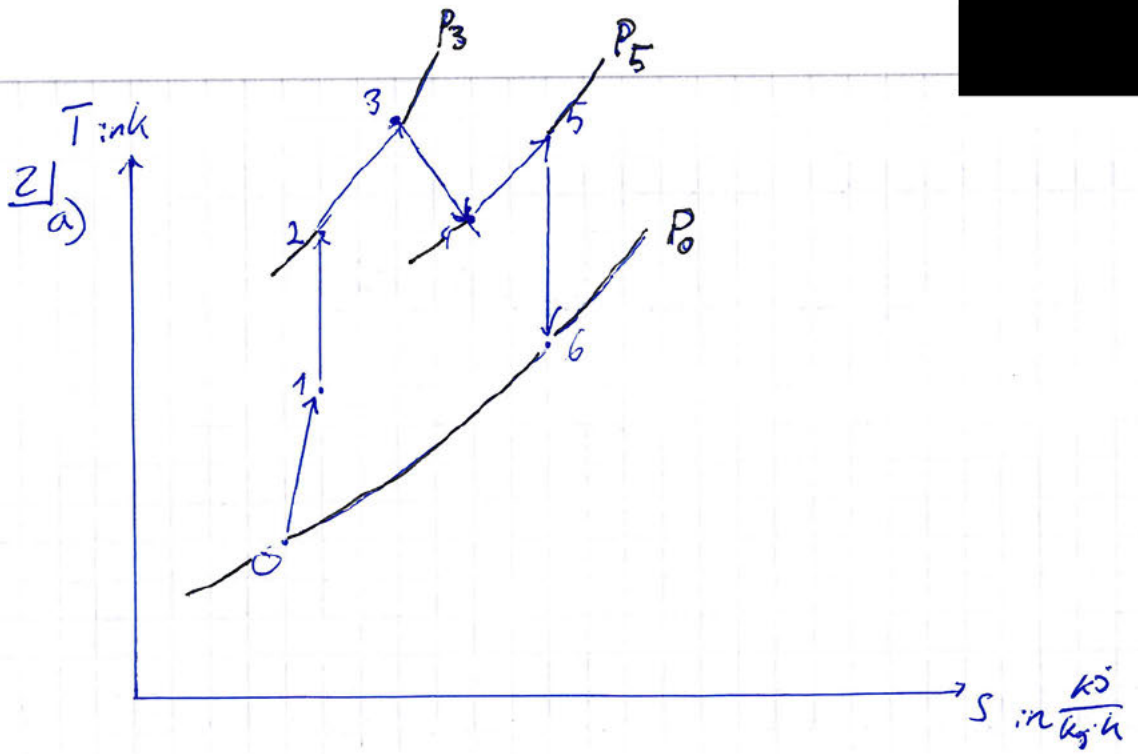
c) $$\dot{s}_{erz} = \dot{m}\left(s_{aus} - s_{ein}\right) - \frac{\dot{Q}_R}{T_{Reaktor}} + \frac{\dot{Q}_{aus}}{T_{Luft}}$$

$$= 0.3 \frac{kg}{s}\left(1.3069 \frac{kJ}{kg\,K} - 0.9549 \frac{kJ}{kg\,K}\right) - \frac{100\,kW}{372.15\,K} + \frac{62.782\,kW}{295\,K}$$

$$= \underline{\underline{0.0684 \frac{kJ}{K}}}$$

2)

a)



b)

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

$$T_6 = T_5 \left(\frac{p_0}{p_5}\right)^{\frac{n-1}{n}} = 431.9\,K \cdot \left(\frac{0.791\,bar}{0.5\,bar}\right)^{\frac{0.4}{1.4}} = 328.1\,K$$

Energiebilanz:

$$0 = \dot{m}\left[h_5 - h_6 + \frac{(w_5^2 - w_0^2)}{2}\right]$$

$$h_5 - h_6 = c_{p,Luft}^{ig}(T_5 - T_6) = 1.006\,\frac{kJ}{kg\,K}(431.9 - 328.1) = 104.42\,\frac{kJ}{kg}$$

~~$w_6^2 = 2(h_5 - h_6)$~~

$$w_6^2 = 2(h_5 - h_6) + w_5^2$$

$$= 2 \cdot 104420\,\frac{J}{kg} + 220^2\,\frac{m^2}{s^2} = 257240\,\frac{m^2}{s^2}$$

$$w_6 = \sqrt{257240\,\frac{m^2}{s^2}} = 507.19\,\frac{m}{s}$$

c) ~~$e_{x,str,6} = h_6 - h_0 - T_0(s_6 - s_0) + p_0(v - v_0)$~~

$$\Delta e_{x,str} = \left(h_{aus} - h_{ein} - T_0(s_{aus} - s_{ein}) + \frac{w_{aus}^2 - w_{ein}^2}{2}\right)$$

$$h_{aus} - h_{ein} = h_6 - h_0 = c_{p,Luft}^{ig}(T_6 - T_0) = 1.006 \frac{kJ}{kg \cdot K}(328.14 - 243.154)$$

$$= 85.4597 \frac{kJ}{kg}$$

$$T_0(s_{aus} - s_{ein}) = T_0(s_6 - s_0) = T_0\left(c_{p,Luft}^{ig} \cdot \ln\left(\frac{T_6}{T_0}\right) - \underbrace{R \ln\left(\frac{p_6}{p_0}\right)}_{=0\ (p_6 = p_0)}\right)$$

$$= 243.154\left(1.006 \frac{kJ}{kgK} \cdot \ln\left(\frac{328.1}{243.15}\right)\right) = 73.2946 \frac{kJ}{kg}$$

$$\frac{w_{aus}^2 - w_{ein}^2}{2} = \frac{w_6^2 - w_0^2}{2} = \frac{507.71 \frac{m^2}{s^2} - 200 \frac{m^2}{s^2}}{2} = 108620.85 \frac{J}{kg}$$

$$= 108.621 \frac{kJ}{kg}$$

$$\Delta e_{x,str} = 85.4597 \frac{kJ}{kg} - 73.2946 \frac{kJ}{kg} + 108.621 \frac{kJ}{kg}$$

$$= 120.786 \frac{kJ}{kg}$$

d) Exergiebilanz, stationär, massenspezifisch

~~$0 = \dots$~~

$$0 = \underbrace{(h_{ein} - h_{aus} - T_0(s_{ein} - s_{aus}) + \Delta k e)}_{= -\Delta e_{x,str}} + \left(1 - \frac{T_0}{T_B}\right) q_B - \underbrace{w_{ein}}_{=0} - e_{x,zu}$$

$$e_{x,zu} = -\Delta e_{x,str} + \left(1 - \frac{T_0}{T_B}\right) q_B$$

$$= -120.786 \frac{kJ}{kg} + \left(1 - \frac{243.154}{1289}\right) \cdot 1195 \frac{kJ}{kg} = 848.796 \frac{kJ}{kg}$$

3) a) $p_{g,1} = p_{EW} + p_{amb} + p_k$

$p_{EW} = \frac{m_{EW} \cdot g}{\pi \cdot (0.05\,m)^2}$ ~~$\pi \cdot 0.05^2$~~ ~~$= 0.4\,kg \cdot 9.81 \frac{m}{s^2} \cdot \pi \cdot 0.0025\,m^2$~~

~~$= 7.705 \cdot 10^{-3}$~~

$= \frac{0.1\,kg \cdot 9.81 \frac{m}{s^2}}{\pi \cdot 0.0025\,m^2} = 124.905\,Pa$

$p_{amb} = 1\,bar = 100000\,Pa$

$p_k = \frac{m_k \cdot g}{\pi \cdot (0.05\,m)^2} = 39969.5\,Pa$

$p_{g,1} = 140094\,Pa = 1.4\,bar$

$p_{g,1} \cdot V_{g,1} = m_{g,1} \cdot R \cdot T_{g,1}$ $\quad T_{g,1} = 500°C = 773.15\,K$

$R = \frac{\bar{R}}{M_g} = \frac{8.314 \frac{J}{mol \cdot K}}{50 \frac{kg}{kmol}} = 166.28 \frac{J}{kg \cdot K}$

$m_g = \frac{p_{g,1} \cdot V_{g,1}}{R \cdot T_{g,1}} = \frac{140094\,Pa \cdot 3.14 \cdot 10^{-3}\,m^3}{166.28 \frac{J}{kg \cdot K} \cdot 773.15\,K} = 3.4217 \cdot 10^{-3}\,kg$

$= 3.4217\,g$

b) $p_{g,2} = p_{g,1}$ da sich das Gewicht des Kolbens und das Gewicht des Eis-Wasser-Gemischs, sowie der Umgebungsdruck nicht verändern

~~Innere Energie des Systems bleibt unverändert~~

~~16.54~~

$T_{gg} = \frac{0.1\,kg \cdot 273.15 + 3.4274 \cdot 10^{-3}\,kg \cdot 773.15\,K}{0.1\,kg + 3.4217 \cdot 10^{-3}\,kg} = 289.69\,K$

$= 16.54\,°C$

c) $E_2 - E_1 = Q_{12}$

$U_2 - U_1 = Q_{12}$

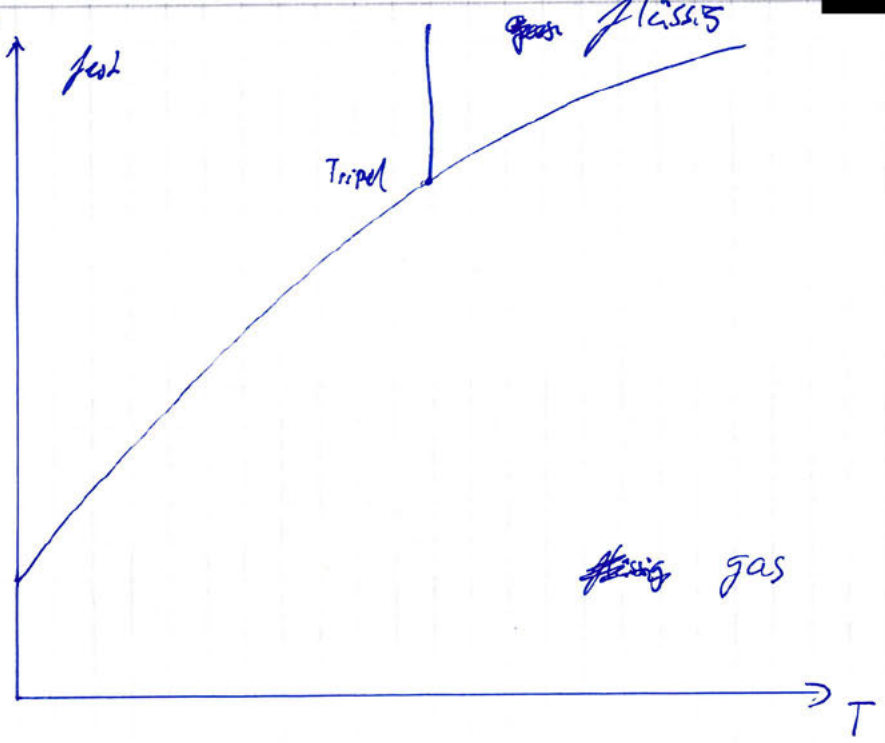
$m_g (u_2 - u_1) = Q_{12}$

$Q_{12} = m_g c_v^{*} (T_{2,g} - T_{g,1}) = 3.4217 \cdot 10^{-3}\,kg \cdot 0.683 \frac{kJ}{kg \cdot K} \cdot (0.003°C - 500°C)$

$= -1.08296\ kJ = -1082.96\ J$

d)

4) a)



b) $0 = \dot{m}_{R134a} (h_2 - h_3) - \dot{W}_K$