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1.

1.1) Prinzipbild

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

$h_{ein} = h(78°C) \overset{A-2}{=} 293,35 \frac{kJ}{kg}$

$h_{aus} = h(100°C, x = 0,005) = 419,04 + 0,005(2676,1 - 419,04) = 430 \frac{kJ}{kg}$

b) $\bar{T} = \frac{\int T\,ds}{s_4 - s_2} = \frac{q_{zu}}{s_4 - s_2} = \frac{h_{aus} - h_{ein}}{s_4 - s_2}$ $\quad \frac{65'000\,kW}{5755\,kg}$

c) $\dot{S}_{ent} = \dot{m}(s_4 - s_2) - \frac{\dot{Q}}{\bar{T}}$

d) $0 = \dot{m}_{zu}(h_e - h_{ein}) + Q - W^{00}$

$m_2 u_2 - m_1 u_1 = \dot{m}_{zu}(h_e - h_{ein}) + Q$

$\dot{m}_{zu} = \frac{m_2 u_2 - m_1 u_1 - Q}{h_e - h_{ein}}$

e) $\Delta S = m_2 s_2 - m_1 s_1$

$m_1 = 5'755\,kg$

$m_2 = m_1 + \dot{m}_{zu} = 5755\,kg + 3600\,kg = 9355\,kg$

$s_1 = 7,3063 + x(7,5549 - 7,3063) = 7,33654 \frac{kJ}{kgK}$

$s_2 = s(70°C) =$

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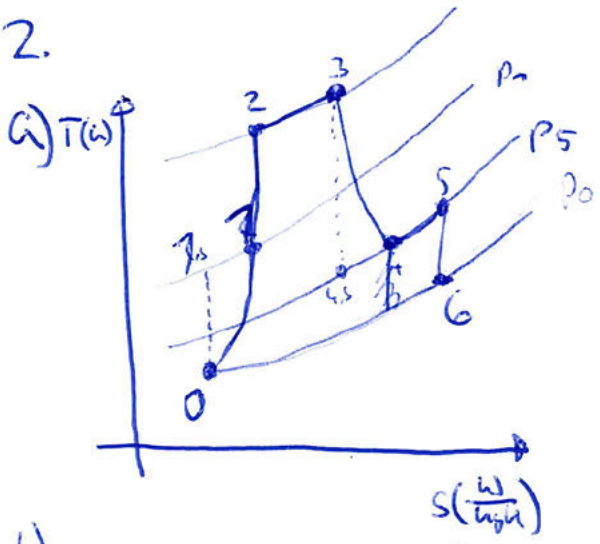
2.

a) 

b) $0 = \dot{m}\left(h_5 - h_6 + \frac{v_5^2 - v_6^2}{2}\right) + \dot{Q}^{\,\text{adiabat}\,\approx 0} - \dot{W}_v$

$\dot{W}_t = -(\dots) \quad W_v = \frac{1}{n-1}(p_6 v_6 - p_5 v_5) = \frac{R(T_6 - T_5)}{1-n} = \frac{\frac{\bar{R}}{M}(T_6 - T_5)}{1-n}$

$R = \frac{\bar{R}}{M} = \frac{8314 \cdot 2000}{28,97} = 286,9$

$e = \frac{286,9(273,15-30-437,94)}{1-1,4} = 477,875 \frac{kJ}{kg}$

$\dot{W}_v - \dot{m}(h_5 - h_6) = \dot{m}\left(\frac{v_5^2 - v_6^2}{2}\right)$

$v_6 = \sqrt{v_5^2 - \frac{2(\dot{W}_v - \dot{m}(h_5 - h_6))}{\dot{m}}} \qquad h_5 - h_6 = c_p(T_5 - T_6)$

c) $\dot{E}_{x\,6r} = \dot{m}\left(h_6 - h_0 - T_0(s_6 - s_0) + ke\right)$

$h_6 - h_0 = c_p(T_6 - T_0) = 1006 \frac{J}{kgK}(340K - 273,15+30K) = 57,077 \frac{kJ}{kg}$

$T_0(s_6 - s_0) = T_6 c_p \ln\left(\frac{T_6}{T_0}\right) = (273,15-30)K \cdot 1,006 \frac{kJ}{kgK} \ln\left(\frac{340K}{(273,15-30)K}\right) = 82 \frac{kJ}{kg}$

$ke = \frac{w_6^2 - w_0^2}{2} = \frac{570^2 - 200^2}{2} = 170 \frac{J}{kg}$

$\frac{\dot{E}_{x\,St}}{\dot{m}_{St}} = (37 - 82 + 170) = 65 \frac{kJ}{kg}$

d)

$$\dot{e}_{x\,vent} = \dot{e}_{x\,se} + \dot{e}_{x\,Q}$$

$$\dot{e}_{x,Q} = \left(1 - \frac{T_0}{T}\right)\dot{Q}$$

$\dot{m}_{gi} = \dot{m}_{H} + \dot{m}_{a}$

$\dot{m}_{a} = \dot{m}_{Gas} - \dot{m}_{m} = \dot{m}_{Gas} - 5{,}793\,\dot{m}_{a}$

$\dot{m}_{a}\left(1 + 5{,}793\right) = \dot{m}_{Gas}$

$\dot{m}_{a} = \frac{\dot{m}_{ae}}{6{,}793}$

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3.

a)

$$p_G = p_0 + \frac{m_K}{A} + \frac{m_{Ew} \cdot g}{A} = 1 \cdot 10^5 Pa + \frac{(32kg + 0,2kg)\,9,81 m/s^2}{(0,1m)^2 \pi} = 1,1 bar$$

$$m_G = \frac{p_G \cdot V_G}{R \cdot T_G} = \frac{p_G \cdot V_G}{\frac{\bar{R}}{M} \cdot T_G} = \frac{1,5 \cdot 10^5 Pa \cdot 0,00314 m^3}{\frac{8,314 \cdot 70000}{50} \cdot (500 + 273,15)K} = 0,00366 kg$$

b) $p_{Kolben} = p_0 + \frac{m_K \cdot g}{A} = 1 \cdot 10^5 Pa + \frac{32kg \cdot 9,81 m/s^2}{(0,1m)^2 \pi} = 1,5 bar$

$p_L = p_{Kolben} - p_{Gas} = 1,5 bar - 1,5 bar = 0,6 bar$

$V_{Luft} = \frac{m \cdot R \cdot T}{p}$

c) $\Delta E = Q_{12} - W_{12}^{10} = \Delta U = c_V (T_2 - T_1) = (c_p - \frac{\bar{R}}{M})(T_2 - T_1) = 0,46672 (0,003 - 500) = -233,4 kJ$

$V_2 = \frac{m_G R T_2}{p_1} = \frac{0,00x kg \cdot \frac{8,314 \cdot 2000}{50} \cdot (273,15 + 0,003) K}{1,5 \cdot 10^5 Pa} = 0,00$

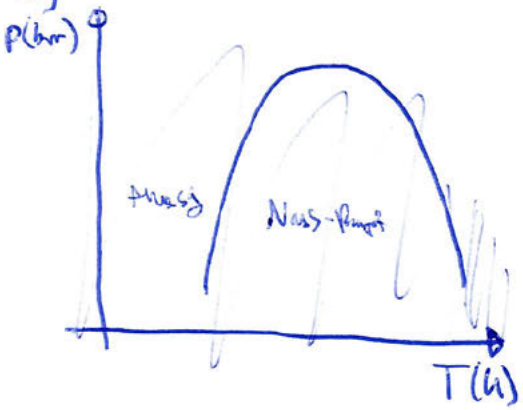
$c_V = c_p - \frac{\bar{R}}{M} = 0,46672$

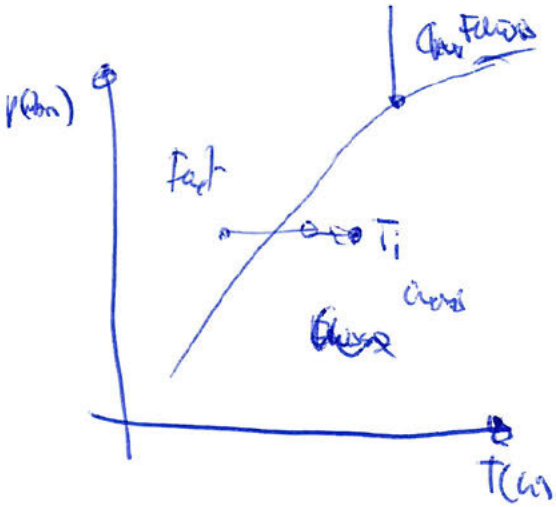
d) $x_2 = \frac{U_{Gas}}{U_{Gas} + U_{Umgebung}} = \frac{-333,462}{-333,462 + -0,03} = 0,999$

$T_G = T_{Gas} = 0,003°C$

4.

a)





b) 1. HS über Verdichter

$$0 = \dot{m}(h_2 - h_3) - \dot{V}_{th} \qquad \dot{m} = \frac{\dot{V}_{th}}{h_2 - h_3}$$

$T_2 = T_1 - 6 = 273{,}15 - 70 - 6 = 257{,}15\,K = -16\,°C$

$h_2 = h(x=1, T=-16\,°C) = 234{,}74\,\frac{kJ}{kg}$ (A-10)

$s_3 = s_2 = 0{,}9395\,\frac{kJ}{kgK}$

$h_3 = h(8\,bar, 0{,}9395\,\frac{kJ}{kgK}) = 269{,}75\,\frac{kJ}{kg}$ (A-11, isobar)

$x = 0{,}9395 - 0{,}$

c) $h_1 = h_4 = h(8\,bar, x=0) = 93{,}42\,\frac{kJ}{kg}$

$T = 35{,}15\,°C \qquad p_1 = p_2 = 1{,}57\,bar$

d) $\varepsilon_{th} = \frac{\dot{Q}_{zu}}{\dot{Q}_{ab} - \dot{Q}_{zu}} = \frac{\dot{Q}_{zu}}{\dot{V}_t}$

e) Die Temperatur würde sich in einem Mittel nicht ausgleichen