[redacted]

Aufg. 1

a) $\frac{dE}{dt} = \dot{m}_e(h_e - h_a) + \dot{Q}_R + \dot{Q}_{aus} - \dot{W}$ (da werte im behälter konstant; $\frac{dE}{dt}=0$, $\dot{W}=0$)

Tab - A2

$h_e = x_D h_g(70°) + (1-x_D) h_f(70°) = 304{,}65 \frac{kJ}{kg} = h_f(70°)$

$h_a = x_D h_g(100°) + (1-x_D) h_f(100°) = 430{,}33 \frac{kJ}{kg} = h_f(100°)$

$\dot{m}_e(h_e - h_a) + \dot{Q}_R = -\dot{Q}_{aus} = +62{,}182 \frac{kJ}{s}$

b) $\frac{dE}{dt} = 0$ stat fließ

$\dot{m}(h_e - h_a) = \dot{Q}_{aus} \Rightarrow \dot{m}(h_a - h_e) = -\dot{Q}_{aus} = c^{it} \Delta T \dot{m}$

$c^{it}\dot{m} = -\frac{\dot{Q}_{aus}}{\Delta T} = 6{,}2182 \frac{kJ}{sK}$

$\frac{dS}{dt} = 0$ nur fluss

$\dot{m}(s_e - s_a) = \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{S}_{erz}$

$\frac{\dot{Q}_{aus}}{\dot{m}(s_e - s_a)} = \frac{-\dot{Q}_{aus}}{\dot{m} c^{it} \ln\left(\frac{T_2}{T_1}\right)} = \bar{T}_1 = 293{,}12K$

c) $\bar{T}_1$ | $\bar{T}_2 = 393{,}15$

$\dot{Q}_{aus}$ | $-\dot{Q}_{aus}$

$\Rightarrow \frac{dS}{dt} = -\frac{\dot{Q}_{aus}}{T_2} + \frac{\dot{Q}_{aus}}{T_1} + \dot{S}_{erz}$

$-\frac{\dot{Q}_{aus}}{\bar{T}_1} + \frac{\dot{Q}_{aus}}{\bar{T}_2} = \dot{S}_{erz} = 0{,}053975 \frac{kJ}{sK}$

back

d) u_2 ?

$$\Delta E = (m_1 + \Delta m) u_2 - m_1 u_1 = \Delta m \left(h_f(20°) + \Delta Q_R - \Delta Q_R \right)$$

$h_f(20°) = 83.96 \frac{kJ}{kg}$ Tab A-2

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

$u_1 = x_D (u_g(100°)) + (1 - x_D) u_f(100°) = 429,38 \frac{kJ}{kg}$

$m_1 = 5755\,kg$

$$m_1 u_2 - m_1 u_1 = \Delta m \left(h_f(20°) - u_2 \right)$$

$$\frac{m_1 (u_2 - u_1)}{h_f(20°) - u_2} = \Delta m = 3756,9\,kg$$

e) $\Delta S = (m_1 + \Delta m) s_2 - m_1 s_1 = 1,3879\,MJ/K$ Tab A-2

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

$s_1 = x_D s_g(100°) + (1 - x_D) s_f(100°) = 1,3379 \frac{kJ}{kg\,K}$

[redacted]

Auf. 2

$T_0 = 263{,}15\,K$

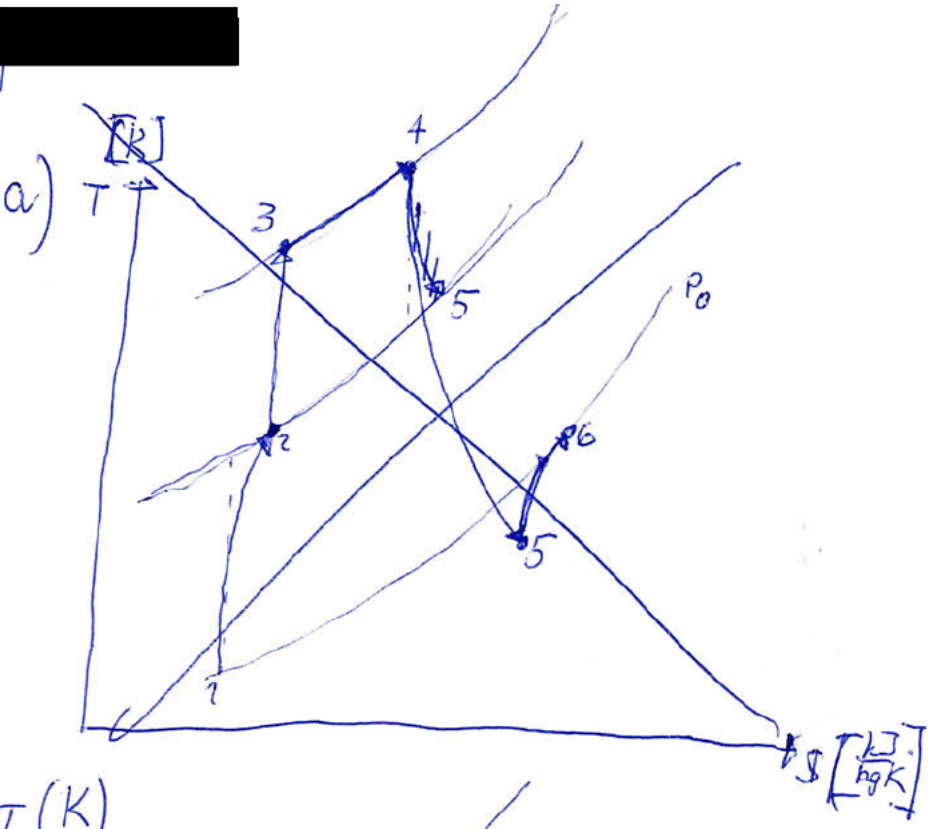
$p_0 = 0{,}497\,bar$

$\dot{m}_{Kühl} = 5{,}293\,\dot{m}_K$

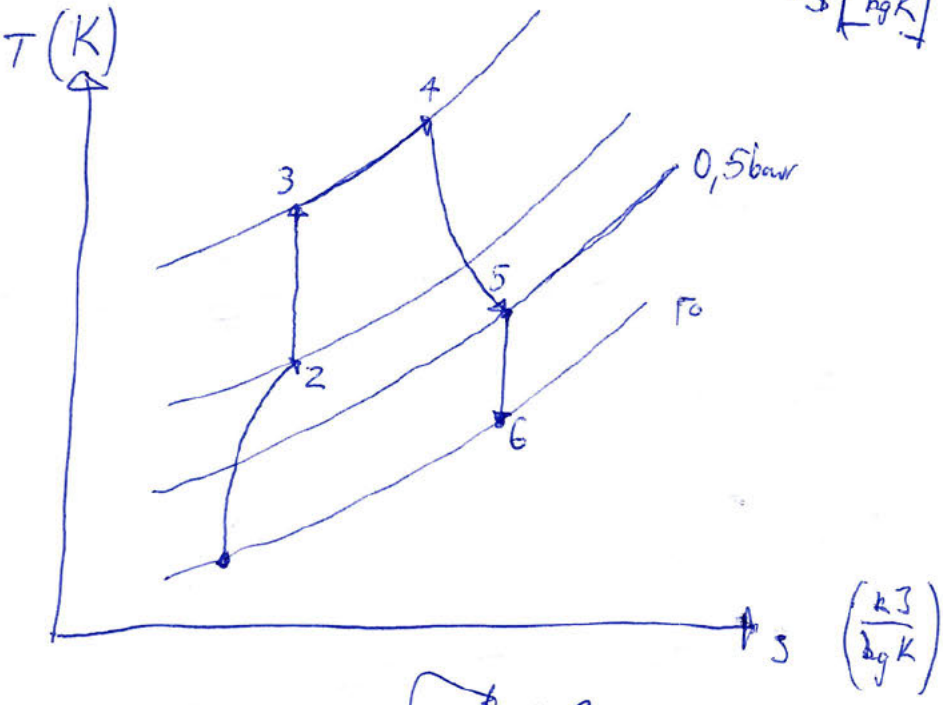
$c_p = 1{,}006\,\frac{kJ}{kgK}$

$\kappa = 1{,}4$

a)



a)



b) ~~$w_5 \approx 0$~~ ~~$\dot{Q} \approx 0$~~

$$\frac{dE}{dt} = \dot{m}_{ges}(h_5 - h_6) + \dot{Q} - \dot{W} \approx 0$$

$$T_B = T_5\left(\frac{p_0}{p_5}\right)^{\frac{\kappa-1}{\kappa}} = 328{,}07\,K$$

$$\frac{dE}{dt} \approx 0 = \dot{m}_{ges}\left(h_5 - h_6 + \frac{w_5^2}{2} - \frac{w_6^2}{2}\right) + \dot{Q} - \dot{W}$$

$$\sqrt{2\left(\frac{w_5^2}{2} - (h_6 - h_5)\right)} = w_6$$

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

$h_6 - h_5 = c_p \Delta T$

back

c)

~~ΔE_x~~ $\quad \Delta k_e$

$$\Delta e_{x\,str} = h_a - h_e - T_0(s_a - s_e) + \frac{w_6^2 - w_0^2}{2} = 232{,}33 \frac{kJ}{kg}$$

$$T_0(s_a - s_e) = 0 c_p \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right) = 58{,}373 \frac{kJ}{kg}$$

$$h_a - h_e = c_p \Delta T = 65{,}31 \frac{kJ}{kg}$$

$w_0 = 200\,m/s$

$\Delta k_e = 108{,}65\,kJ$

es wird mit $700 \frac{kJ}{kg}$ fortgefahren

d) $$0 = -\dot{m}_{ges} \Delta e_{x\,str} + \left(1 - \frac{T_0}{\overline{T}}\right) \dot{Q}_B - \dot{W}_t^{\,0} - \dot{E}_{x\,ver}$$

$$\dot{Q}_B = \dot{m}_K q_B$$

$$e_{x\,ver} = \frac{\dot{E}_{x\,ver}}{\dot{m}_{ges}}$$

$$e_{x\,ver} = -\Delta e_{x\,str} + \left(1 - \frac{T_0}{\overline{T}}\right) \frac{\dot{m}_K}{\dot{m}_g} q_B = 51{,}127 \frac{kJ}{kg}$$

$\dot{m}_M + \dot{m}_K = \dot{m}_{ges}$

$5{,}293 \dot{m}_K + \dot{m}_K = 6{,}293 \dot{m}_K = \dot{m}_{ges}$

$\frac{1}{6{,}293} = \frac{\dot{m}_K}{\dot{m}_{ges}} \qquad \overline{T} = \overline{T}_B$

[redacted]

Auf. 3

$A_z = 5\,cm^2\,\pi = 0{,}007854\,m^2$

$c_v = 0{,}633\,\frac{kJ}{kgK} = 633\,\frac{J}{kgK}$ $\quad M_g = 50\,\frac{kg}{kmol} = 50\,\frac{g}{mol}$

$R = \frac{\bar{R}}{M_g} = 166{,}28\,\frac{J}{kgK}$

$p_1 V_1 = R T_1$

$p_1 = p_{atm} + \frac{m_K g}{A_z} + \frac{m_{EW} g}{A_z} = 1{,}4009\,bar$

$V_1 = \frac{R T_1}{p_1} = 0{,}9176\,\frac{m^3}{kg}$

$\frac{V_1}{V_1} = m_g = 0{,}0034216\,kg$

$p_1 = p_2$ da es gleichviel gewiegt von aussen hat

V_2

$\Rightarrow$ wird mit $T_2 = 0{,}003°C$ festgefahren

$T_2 = 273{,}18K$

$V_2 = m_g v_1 = \frac{R T_2}{p_2} m_g = 0{,}0011076\,m^3$

$\Delta W_{12} = \Delta V_{p_2} = -284{,}72\,J$

$\Delta E = \Delta U_g = m_g (u_1 - u_2) + \Delta W = \Delta Q_1 = -1{,}3686\,kJ$

$u_1 - u_2 = c_v \Delta T$

back

$p = 1{,}4\,\text{bar}$

$T = 0°C$ alles bei 1,4 bar Tab. 1 $-200{,}09\ \frac{kJ}{kg}$

$u_1 = 0{,}6\,u_{fl}(0°) - 0{,}4\,u_{fest}(0°) = -1{,}3314\ \frac{kJ}{kg}$

$u_2 = u_f(0°) = -0{,}045\ \frac{kJ}{kg}$

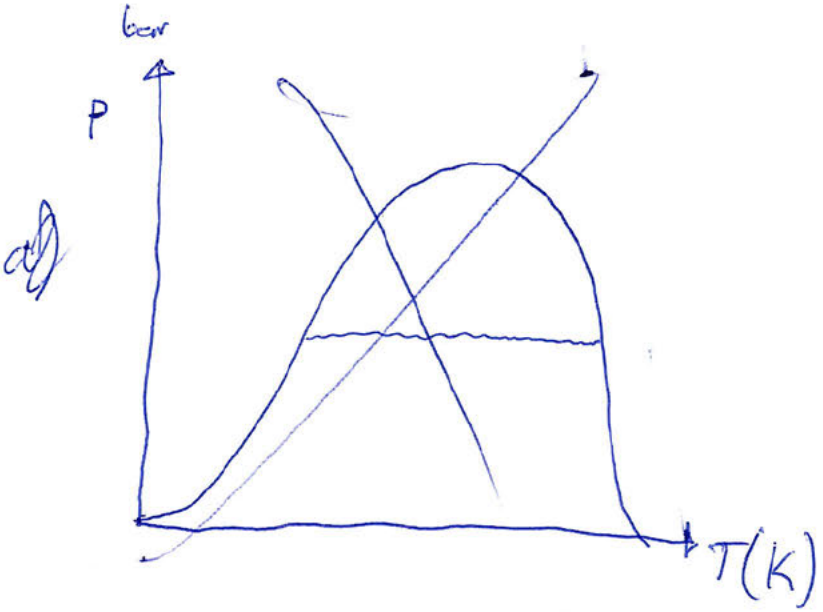
$\Delta E = \Delta U = m_w(u_2 - u_1) = -\Delta Q_1$

$$\frac{-\Delta Q_1 + m_w u_1}{m_w} = u_2 = -1{,}869\ \frac{kJ}{kg}$$

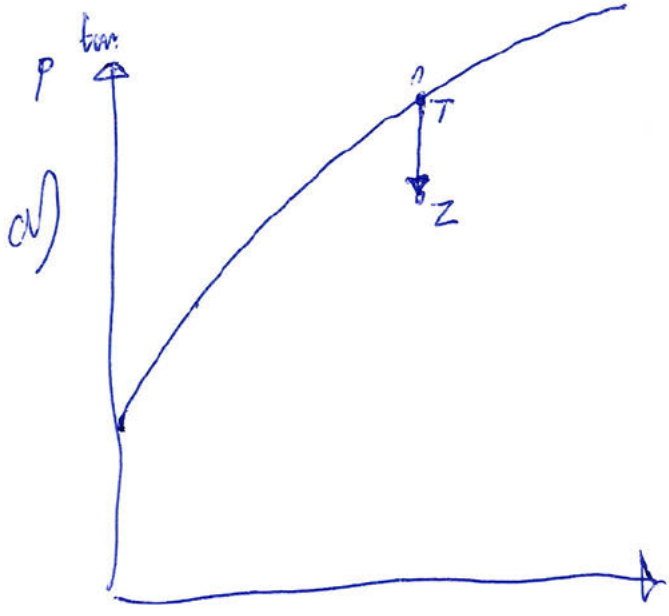
$$\frac{u_2 - u_{fest}}{u_{fl} - u_{fest}} = x_2 = 1{,}5607$$

[redacted]

Aufg. 4



a)



a)

b) $\frac{dE_{CV}}{dt} = \dot{m}_K (h_e - h_a) + \dot{Q}_K$

$\frac{-\dot{Q}_K}{(h_2 - h_4)} = \dot{m}_K$

→ Tab $h_2 =$

$h_4 = h_f(8\,bar) = 93{,}42 \frac{kJ}{kg}$

$h_1 = h_4$ da isenthal (Drossel)

$h_2 = h_g(T_1) = 258{,}36 \frac{kJ}{kg}$

c) $x_1 = \frac{h_1 - h_f}{h_{fg} - h_g}$ bei T_1

d) $T_2 = -20°$

$\varepsilon_K = \frac{Q_K}{W_K}$

back