Aufgabe 1

a) ~~Energiebilanz an der Reaktorwand:~~

$T_{ein} = 288{,}15\,K \quad T_{aus} = 298{,}15\,K$

$$0 = \dot{M}_{ein} \cdot (h_e - h_a) + \dot{Q}_{aus} + \dot{Q}_Z$$

$h(70°) - h(100°)$

$$\Delta U = Q$$

b) $$\overline{T} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{\Delta U}{c_{if} \ln\left(\frac{T_a}{T_e}\right)} = \frac{c_{if} \cdot (T_{aus} - T_{ein})}{c_{if} \cdot \ln\left(\frac{T_{aus}}{T_{ein}}\right)}$$

$$\overline{T} = \frac{298{,}15\,K - 288{,}15\,K}{\ln\left(\frac{298{,}15\,K}{288{,}15\,K}\right)} = \underline{\underline{293{,}12\,K}}$$

c) $$\Delta S^{\circ} = \sum_i \frac{Q_i}{\overline{T}_i} + S_{erz} \rightarrow S_{erz} = -\frac{-\dot{Q}_{aus}}{\overline{T}} = -\frac{-65\,kW}{293{,}12\,K} = 0{,}222$$

d) Energiebilanz:

$$0 = \dot{M}(h_e - h_a) + \sum \dot{Q}_j \Rightarrow 0 = \dot{M}(h_e - h_a) + \dot{Q}_{12}$$

$$\dot{M} = \frac{-\dot{Q}_{12}}{h_e - h_a}$$

$h_e = h(20°) \overset{\text{TAB-A2}}{=} 83{,}69 \frac{kJ}{kg}$

$h_a = h(70°) = 292{,}98 \frac{kJ}{kg}$

TAB-A2

$h_e = h(20°)$ $83{,}69 \frac{kJ}{kg}$

Halb offen: ~~Q~~ $M_2 u_2 - M_1 u_1 = \Delta M_i (h_i) + Q_{12} - \sum W^{\circ}$

$M_2 u_2 - M_1 u_1 = \Delta M_{12} \cdot h_e + Q_{12}$

$M_1 = 5755 kg$ $M_2 = M_1 + \Delta M$

$u_1 = u_f + x(u_g - u_f)$ (TAB A2)

(100°) $u_1 = 418{,}94 \frac{kJ}{kg} + 0{,}005\,(2506{,}5 - 418{,}94) \frac{kJ}{kg} = 429{,}378 \frac{kJ}{kg}$

(70°) $u_2 = 292.95 \frac{kJ}{kg} + 0{,}005(2463{,}6 - 292{,}95) \frac{kJ}{kg} = 303{,}835 \frac{kJ}{kg}$

$\Rightarrow M_1 u_2 + \Delta M u_2 - M_1 u_1 - Q_{12} - \Delta M_{12} \cdot h_e$

$\Delta M (h_e - u_2) = M_1 u_2 - M_1 u_1 - Q_{12}$

$$\Delta M = \frac{M_1 (u_2 - u_1) - Q_{12}}{h_e - u_2} = \frac{5755 kg (303{,}835 \frac{kJ}{kg} - 429{,}378 \frac{kJ}{kg}) - 35 \cdot 10^3 kJ}{83{,}69 \frac{kJ}{kg} - 303{,}835 \frac{kJ}{kg}}$$

$\underline{\Delta M = 3440{,}92 kg}$

TABA2

e) $\Delta S_{12} = M_2 s_2 - M_1 s_1$ (100°) $s_1 = s_f + x(s_g - s_f) = 1{,}33719 \frac{kJ}{kgK}$

(70°) $s_2 = s_f + x(s_g - s_f) = 0{,}9899 \frac{kJ}{kgK}$

$M_2 = 5755 kg + 3440{,}92 kg$

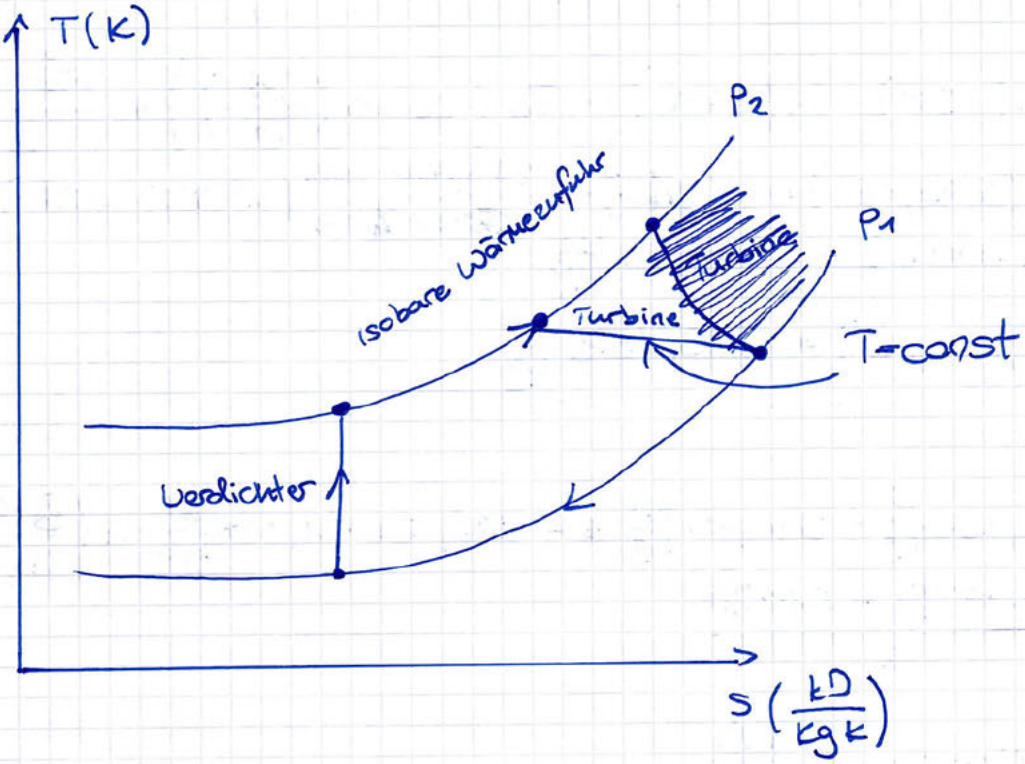
$= 9195.919 kg$

$M_1 = 5755 kg$

$\Delta S_{12} = M_2 s_2 - M_1 s_1 = \underline{1398{,}6 \frac{kJ}{K}}$

Aufgabe 2

a)



b) Fließprozess stationär:

$$0 = \dot{m}\left(h_e - h_a + \frac{(w_e^2 - w_a^2)}{2}\right) + \sum_i Q_i - \sum w^0$$

$$\frac{-Q_B}{\dot{m}} = h_e(T_5) - h_a(T_6) + \frac{w_e^2 - w_a^2}{2}$$

$T_5 = 431{,}9\,K$

$$T_6 : \frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \Rightarrow T_6 = 431{,}9\,K \cdot \left(\frac{0{,}191\,bar}{0{,}5\,bar}\right)^{\frac{1{,}4-1}{1{,}4}}$$

$T_6 = 328{,}0747\,K = 328{,}08\,K$

$$h_e(T_5) \overset{\text{TAB-A22}}{=} h(440) + \frac{431{,}9\,K - 430\,K}{440\,K - 430\,K}\left(h(440) - h(430)\right) = 433{,}364\,\frac{kJ}{kg}$$

$$h_a(T_6) = h(330) + \frac{328{,}08\,K - 325\,K}{330\,K - 325\,K}\left(h(330) - h(325)\right) = 328{,}38\,\frac{kJ}{kg}$$

$$w_a = w_6^2 = \left(h_e(T_5) - h_a(T_6)\right) + \frac{Q_B}{\dot{m}} + w_e^2 \qquad \dot{m} = ?$$

c) $-\Delta E_{x,str} = \dot{M}\left(h_e - h_a - T_0(s_e - s_a) + \frac{w_e^2 - w_a^2}{2}\right)$

$$\frac{-\Delta E_{x\,str}}{\dot{M}} = h(-30°) - h(340K) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right)\right) + \frac{w_e^2 - w_a^2}{2}$$

$$h(243{,}15) = h(240) + \frac{243{,}15K - 240K}{250K - 240K}\left(h(250) - h(240)\right)$$

$h(340K) = 340{,}42 \frac{kJ}{kg}$

$\rightarrow h(243{,}15) = 243{,}159 \frac{kJ}{kg}$

$$\frac{-\Delta E_{x\,str}}{\dot{M}} = 243{,}159\frac{kJ}{kg} - 340{,}42\frac{kJ}{kg} - 243{,}15K \cdot \left(1{,}006\frac{kJ}{kgK} \cdot \ln\left(\frac{340K}{243{,}15K}\right)\right) + \frac{200^2\frac{m^2}{s^2} - 510^2\frac{m^2}{s^2}}{2}$$

$$\frac{\Delta E_{x\,str}}{\dot{M}} = \underline{11'0229{,}27\frac{kJ}{kg}}$$

d) $\dot{E}_{x,verl} = T_0 \cdot \dot{S}_{erz}$

$S_{erz} = \dot{M}(S_2 - S_1) = M\left(\ln\left(\frac{T_2}{T_1}\right)c_p\right)$

$$\frac{\dot{E}_{x\,verl}}{\dot{M}} = T_0 \cdot c_p \cdot \ln\left(\frac{T_6}{T_0}\right) = 243{,}15K \cdot 1{,}006\frac{kJ}{kgK} \cdot \ln\left(\frac{340K}{243{,}15K}\right)$$

$$= \underline{82{,}01\frac{kJ}{kg}}$$

Aufgabe 3

a) p_{g1} , M_g $\qquad A = \pi \cdot r^2 = 0{,}031415\,m^2$

32kg
0,1kg
$T_1 = 500°C$
3,14L

$p = F \cdot A$

$p_g = A \cdot ((0{,}1kg + 32kg) \cdot g) + 1bar$

$= 0{,}031415\,m^2 \cdot (32{,}1kg) \cdot 9{,}81\,m/s^2 + 10^5 Pa$

$= \underline{100809{,}89Pa}$

$M_g = 50\,\frac{kg}{kmol}$ $\qquad V = 3.14L = 3.14 \cdot 10^{-3}\,m^3$ $\qquad T = 500°C = 773.15K$

$p_{g1} \cdot V_{g1} = M \frac{\overline{R}}{M} \cdot T$

$\frac{p_{g1} \cdot V_{g1} \cdot M_g}{\overline{R} \cdot T} = M = \frac{100'009{,}89Pa \cdot 3{,}14 \cdot 10^{-3} m^3 \cdot 50\,\frac{kg}{kmol}}{8.314\,\frac{J}{kmol\,K} \cdot 773{,}15K} = \underline{2.44g}$

b) $pV = M \cdot \frac{\overline{R}}{M} \cdot T$

c) ~~[illegible]~~

~~[illegible]~~

1Hs $\Delta U = Q$

$0{,}1\,kg \cdot \left(u(0{,}003°C) - u(0°C)\right) = Q$

$0{,}1\,kg \left(-333{,}442\,\frac{kJ}{kg} + 333{,}458\,\frac{kJ}{kg}\right) = Q = 0{,}0043\,kJ$

$= 0{,}43\,J$

d) $u = u_f + x(u_s - u_f)$

$\frac{u - u_f}{u_s - u_f} = x_2$ $\qquad u_s = -333{,}442\,\frac{kJ}{kg}$

$u_f = -0{,}033\,\frac{kJ}{kg}$

$|Q_{12}| = \Delta U \Rightarrow \Delta U = m \cdot (u_2 - u_1)$ $\quad (u_2 = u)$

$u_1 = u(0°C)$

$\frac{Q_{12}}{m} + u_1 = u_2$

$u_1 = u_f + x_i(u_s - u_f)$

$u_1 = -0{,}045 + 0{,}6 \cdot (-333{,}458 + 0{,}045)$

$u_1 = -200{,}0928\,\frac{kJ}{kg}$

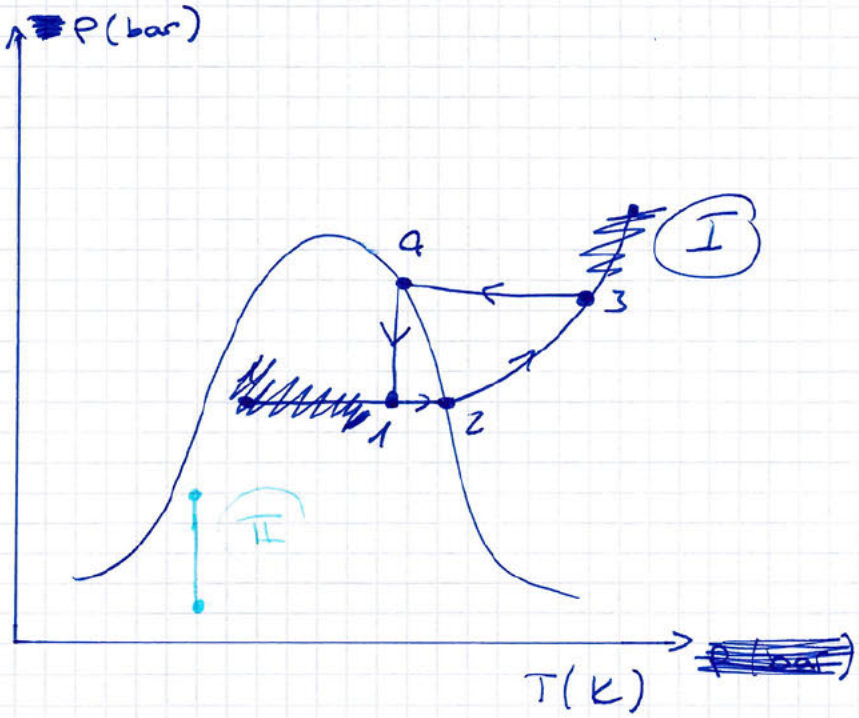
$\frac{1{,}5\,kJ}{0{,}1\,kg} - 200{,}0928\,\frac{kJ}{kg}$

$= -185{,}0928\,\frac{kJ}{kg}$

$x_2 = \frac{-185{,}0928\,\frac{kJ}{kg} + 0{,}033\,\frac{kJ}{kg}}{-333{,}442\,\frac{kJ}{kg} + 0{,}033\,\frac{kJ}{kg}} = \underline{0{,}555}$

Aufgabe 4

a)



b) Energiebilanz über den Verdichter

$T_i = -18°C$

$$\dot{W}_K = \dot{m}_{Kälte}(h_e - h_a)$$

$$h_e = h_2 = h(T_2) = h(-18°C) = 236{,}53 \frac{kJ}{kg}$$

$$h_a = h(p = 8\,bar) = 264{,}15 \frac{kJ}{kg}$$

$$T_2 = T_i - 6K$$

$$\frac{\dot{W}_K}{h(T_2) - h(p = 8bar)} = \frac{0{,}028\,kW}{(236{,}53 - 264{,}15)\frac{kJ}{kg}} = \underline{10{,}00101\,\frac{kg}{s}}$$

c) $x = \frac{h - h_f}{h_g - h_f}$

h

d) $\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|W_{+}|}$

$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{\dot{W}_+}$ $\quad \dot{W}_+ = 28\,W$

e) Das Wasser würde wieder gefrieren und weiter abkühlen