Aufgabe 1 [redacted]

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

stationärer Fließprozess

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

$$= 0{,}3 \frac{kg}{s}\left(292{,}98 \frac{kJ}{kg} - 430{,}12 \frac{kJ}{kg}\right) + 100 kW = \underline{\underline{58{,}86 \, kW}}$$

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

$$x_D = \frac{h_{aus} - h_f}{h_g - h_f} \quad \text{bei } T = 100°C$$

$$\Rightarrow h_{aus} = h_f + x_D(h_g - h_f) \overset{TAB-A2}{=} 419{,}04 \frac{kJ}{kg} + 0{,}005(2635{,}3 - 419{,}04)\frac{kJ}{kg}$$

$$= 430{,}12 \frac{kJ}{kg}$$

b) $\overline{T}_{KF} = \frac{T_{KF,ein} + T_{KF,aus}}{2} = \frac{288{,}15K + 298{,}15K}{2} = \underline{\underline{293{,}15K}}$

c) $\dot{S}_{erz}$

Entropiebilanz:

$$0 = \dot{m}(s_{ein} - s_{aus}) + \frac{\dot{Q}_R}{T_{Reaktor1}} - \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} + \dot{S}_{erz}$$

$$\Rightarrow \dot{S}_{erz} = \frac{\dot{Q}_{aus}}{\overline{T}_{KF}} + \dot{m}(s_{aus} - s_{ein}) - \frac{\dot{Q}_R}{T_{Reaktor1}}$$

$$s_{aus} \overset{TAB-A2}{=} s_f + x_D(s_g - s_f) = 1{,}3069 \frac{kJ}{kgK} + 0{,}005(7{,}3549 - 1{,}3069)\frac{kJ}{kgK}$$

bei $T = 100°C$

$$= 1{,}3371 \frac{kJ}{kgK}$$

$$s_{ein} = s_f(T = 70°C) = 0{,}9549 \frac{kJ}{kgK}$$

$$\Rightarrow \dot{S}_{erz} = \frac{58{,}86\,kW}{293{,}15\,K} + 0{,}3\frac{kg}{s}\left(1{,}3871\frac{kJ}{kgK} - 0{,}9549\frac{kJ}{kgK}\right) - \frac{100\,kW}{373{,}15\,K}$$

$$= \underline{\underline{0{,}046\,\frac{kW}{K}}}$$

d) Energiebilanz halboffenes System

$$0 = \Delta m_{12}\left[h_1 - h_2\right] - Q_{aus,12}$$

$$\Rightarrow \Delta m_{12} = \frac{Q_{aus,12}}{h_1 - h_2} \quad \cancel{= \ldots}$$ Falsch!

$$h_1 = h(20°C) \overset{TAB\text{-}A2}{=} \cancel{\ldots\frac{kJ}{kg}}\ 83{,}96\,\frac{kJ}{kg}$$

$$h_2 \overset{TAB\text{-}A2}{=} h_f(70°C) + x_D\left(h_g(70°C) - h_f(70°C)\right)$$

$$= 292{,}98\frac{kJ}{kg} + 0{,}005\left(2626{,}8\frac{kJ}{kg} - 292{,}98\frac{kJ}{kg}\right) = 304{,}65\frac{kJ}{kg}$$

e) $\Delta S_{12} = S_2 - S_1 = m_2 s_2 - m_1 s_1 = \Delta m_{12}\Delta s_{12}$

(halboffenes System

$$s_1 = s_f(20°C) \overset{TAB\text{-}A2}{=} 0{,}2966\,\frac{kJ}{kgK}$$

$$s_2 \overset{TAB\text{-}A2}{=} s_f(70°C) + x_D\left(s_g(70°C) - s_f(70°C)\right)$$

$$= 0{,}9549\frac{kJ}{kgK} + 0{,}005\left(7{,}7553\frac{kJ}{kgK} - 0{,}9549\frac{kJ}{kgK}\right)$$

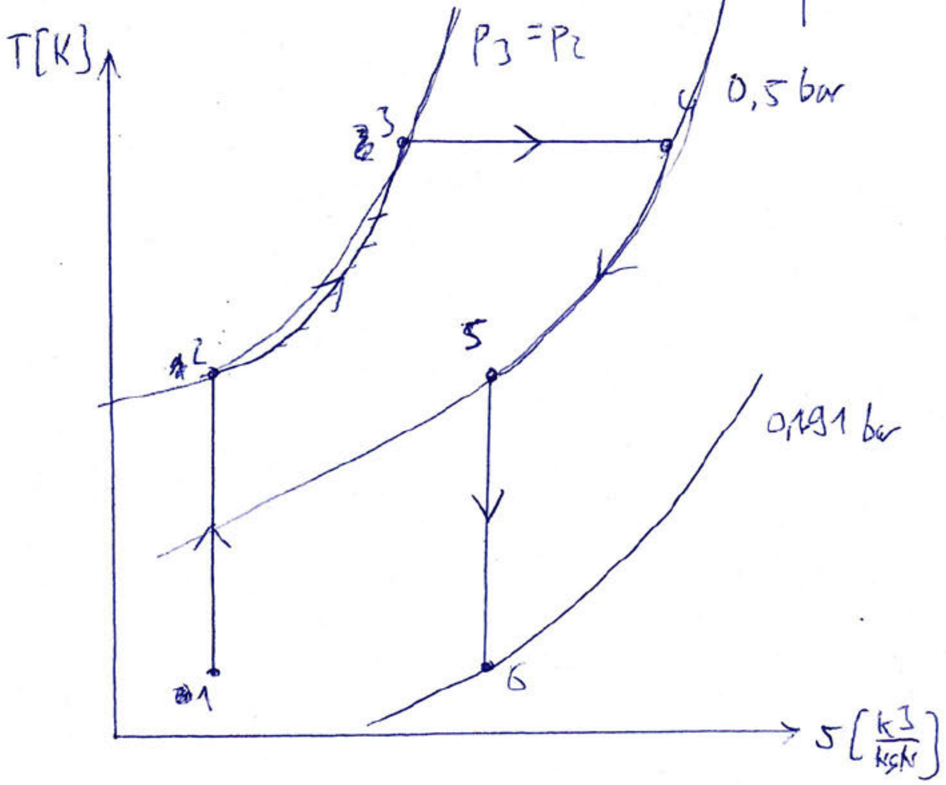
$$= 0{,}9889\,\frac{kJ}{kgK}$$

$$\Delta S_{12} = 3600\,kg \cdot (0{,}9889 - 0{,}2966)\frac{kJ}{kgK} = \underline{\underline{2492{,}29\,\frac{kJ}{K}}}$$

Aufgabe 2 [redacted]

a)

Zustand	p [bar]	T [K]	w [m/s]	s [kJ/kgK]
0	0,191	243,15	200	
1				$s_1 = s_2$
2				$s_2 = s_1$
3				
4	$p_4 = p_5$			
5	0,5	431,9	220	$s_5 = s_6$
6				$s_6 = s_5$



(isobare etwas zu steil skizziert

b) Energiebilanz um die Schubdüse:

$$0 = \dot{m}\left[h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right] \qquad s_5 = s_6 =$$

$$h_5 - h_6 = \cancel{c_p(T_5 - T_6) = 1{,}006\,\frac{kJ}{kgK}(431{,}9\,K - 243{,}15\,K)}$$

$$\cancel{= 188{,}88\,\frac{kJ}{kg}}$$

$$\Rightarrow w_6 = \sqrt{2(h_5 - h_6) + w_5^2} = \cancel{\sqrt{2 \cdot 189{,}88\,\frac{kJ}{kg} + (220\,\tfrac{m}{s})^2} = 220{,}86\,\tfrac{m}{s}}$$

(*) $$= \sqrt{2 \cdot 104{,}45\,\frac{kJ}{kg} + (220\,\tfrac{m}{s})^2} = 220{,}47\,\tfrac{m}{s}$$

c) $\Delta e_{x,str} = \frac{\dot{E}_{x,str}}{\dot{m}_{ges}} = \left[h_6 - h_0 - T_0(s_6 - s_0)\right]$

$=$

$s_6 - s_0 = s^0(T_6) - s^0(T_0) - \underbrace{R \ln\left(\frac{p_6}{p_0}\right)}_{=0}$

$h_6 - h_0 = 189{,}88 \frac{kJ}{kg}$ (aus Teilaufgabe b))

d) $e_{x,verl} = \frac{\dot{E}_{x,verl}}{\dot{m}_{ges}} = T_0 \dot{s}_{erz}$

Entropiebilanz (0-6): $0 = \dot{m}_{ges} s_0 - \dot{m}_M s_6 + \cancel{\frac{\dot{Q}}{T}}^{0} + \dot{S}_{erz}$

$\dot{s}_{erz} = \frac{\dot{m}_M}{\dot{m}_{ges}} - s_0$

$=$

Massenstrombilanz am Vorverdichter: $\dot{m}_{ges}(h_0 - h_{1,s}) = \dot{m}_K(h_0 - h_1)$

$\Longrightarrow \eta_{V,s} = \frac{h_0 - h_{1,s}}{h_0 - h_1} = \frac{\dot{m}_{ges}}{\dot{m}_K}$

---

b) T_6: $\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$ $c_p = 1{,}006 \frac{kJ}{kgK}$

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

$= 328 K$

$\Longrightarrow h_5 - h_6 = c_p(T_5 - T_6) = 104{,}45 \frac{kJ}{kg}$

Aufgabe 3 [redacted]

a) $p_{g,1}$, m_G

$$R_g = \frac{\bar{R}}{M_g} = \frac{8{,}314 \frac{J}{kmol\,K}}{50 \,{}^{g}/_{mol}} = 0{,}166 \frac{J}{g\,K}$$

$$= 166 \frac{J}{kg\,K}$$

$$p_{g1} V_{g1} = R m_g T_{g1} =$$

$$p_{EW1} + p_{G1} = \frac{m_k g}{\pi \frac{D^2}{4}} + p_{amb}$$

b) $T_{g2} = T_{EW2}$

$p_{g2} = p_{EW2}$

~~d)~~

c)

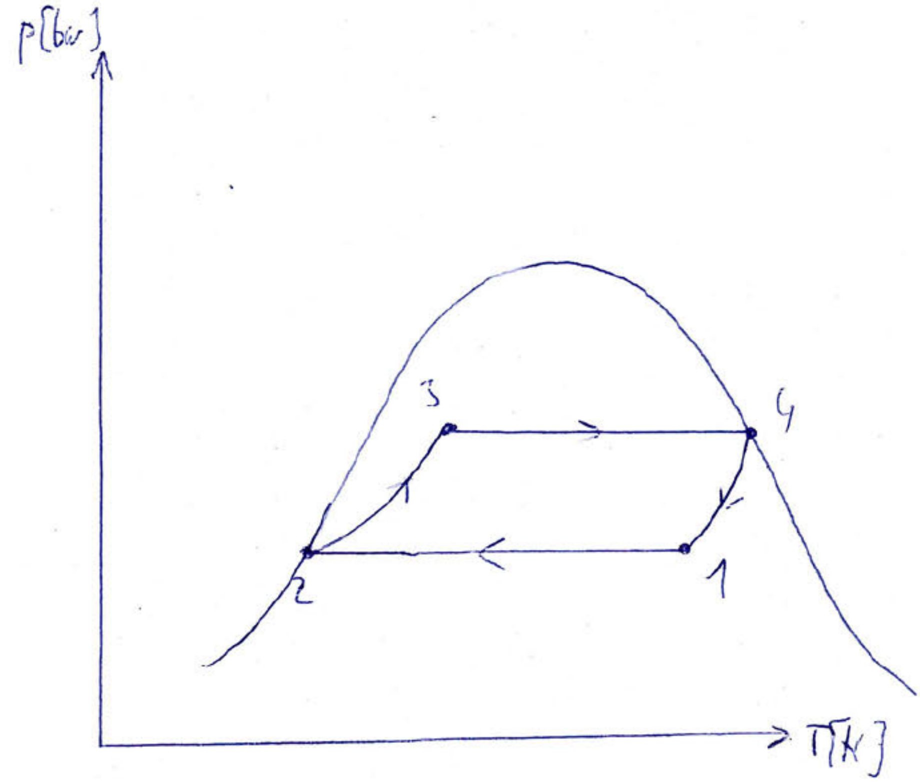
d) $x_{Eis,l} = \dfrac{u - u_{Fe}}{u_{FL} - u_{Fe}}$

[redacted]

Aufgabe 4

Zustand	T[K]	p[bar]	x[ ]
1		$p_1 = p_2$	
2		$p_2 = p_1$	1
3		8	
4		$p_4 = p_3$	0

a)



b) $\dot{m}_{R134,a}$

Energiebilanz um den Verdichter (stationär)

$$0 = \dot{m}_{R134,a}\left(h_2 - h_3\right) + \cancel{\dot{Q}}^{0,\text{adiabat}} + \dot{W}_K$$

$$\Rightarrow \dot{m}_{R134,a} = \frac{\dot{W}_K}{h_3 - h_2}$$

$$h_2 = h_f(-22°C) = 21{,}77 \frac{kJ}{kg}$$

$h_3 =$

c) $\cancel{x_1}$

$$x_1 = \frac{h_1 - h_f}{h_g - h_f}$$

d) $$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{ab}|}{|\dot{Q}_{ab}| - |\dot{Q}_{zu}|} = \frac{\dot{Q}_{ab}}{\dot{Q}_{ab} - \dot{Q}_K + |\dot{W}_K|}$$