[redacted]

1) a) Energiebilanz um Reaktor:
- stationär, ein Massenstrom:

~~$d=$~~

$$0 = \dot m_{ein}[h_e - h_a] + \dot Q_R + \dot Q_{aus} - \overset{0}{\cancel{\dot W_t}}$$

$$\dot Q_{aus} = \dot m_{ein}[h_a - h_e] - \dot Q_R$$
$$= -62.297 \text{ kW}$$

$h_e = h_f + x_D(h_g - h_f) \mid @ 70°C$
$= 304.65 \frac{kJ}{kg}$

$h_a = h_f + x_D(h_g - h_f) \mid @ 100°C$
$= 430.325 \frac{kJ}{kg}$

b) $\bar T_{KF}$: Entropiebilanz um KF:

$p_{KF_{aus}} = p_{KF_{ein}} \Rightarrow$ isobar $\Rightarrow$ reversibel $\rightarrow$ TAB A-2

$\rightarrow \dot S_{erz} = 0$

$$0 = \dot m_{KF}(s_e - s_a) + \frac{-\dot Q_{aus}}{\bar T_{KF}} = \dot m_{KF} \cdot c_{KF}^{if} \ln\left(\frac{T_e}{T_a}\right) \frac{-\dot Q_{aus}}{\bar T_{KF}}$$

$\rightarrow \dot m_{KF}$: Energiebilanz um KF:

$$0 = \dot m_{KF}(h_e - h_a) - \dot Q_{aus}$$

$$\Rightarrow \dot m_{KF} = \frac{\dot Q_{aus}}{h_e - h_a} = \frac{\dot Q_{aus}}{c_{KF}^{if}(T_e - T_a)} \quad \Big| \; p_{KF} = const$$

$$0 = \frac{\dot Q_{aus}}{\cancel{c_{KF}^{if}}(T_e - T_a)} \cdot \cancel{c_{KF}^{if}} \ln\left(\frac{T_e}{T_a}\right) - \frac{\dot Q_{aus}}{\bar T_{KF}}$$

$$\cancel{\dot Q_R - \frac{\dot Q_R}{T_e - T_a} \ln\left(\frac{T_e}{T_a}\right)}$$

$$\frac{\dot Q_{aus}}{\frac{\dot Q_R}{T_e - T_a} \cdot \ln\left(\frac{T_e}{T_a}\right)} = \bar T_{KF} = 293.12 \text{ K}$$

1 c) ~~A~~

$\dot{S}_{erz,ges} \overset{!}{=} \dot{S}_{erz,Reaktor}$, da $\dot{S}_{erz,UW} \overset{!}{=} 0$ [redacted]

Entropie-bilanz um Reaktor

~~Setze~~ ↳ mit 1 massenstrom & stationär

$0 = \dot{m}_{ein}(s_e - s_a) + \frac{\dot{Q}_R + \dot{Q}_{aus}}{\bar{T}_{KF}} + \dot{S}_{erz}$

$\dot{S}_{erz} = -0.0241$ | kann nicht sein?

@ 70°C:
$s_e = s_f + x_D(s_g - s_f)$ ~~[illegible]~~
@ 100°C:
$s_a = s_f + x_D(s_g - s_f) =$
$s_e = 0.988902 \frac{kJ}{kg\,K}$
$s_a = 1.3314 \frac{kJ}{kg\,K}$

d)

$+ \Delta m_{12}$

Energiebilanz um Wasser: ~~geschlossenes~~ halboffenes system:

~~halboffen~~

~~$E_2 - E_1 = Q_{12} - W_{v,21}$~~

$m_2 u_2 - m_1 u_1$ ~~$+ \Delta$~~ $= \Delta m_{12}[h_{ein}] + Q_{12} - W_{12}$

$u_1 =$

Ideales Gas, Luft:

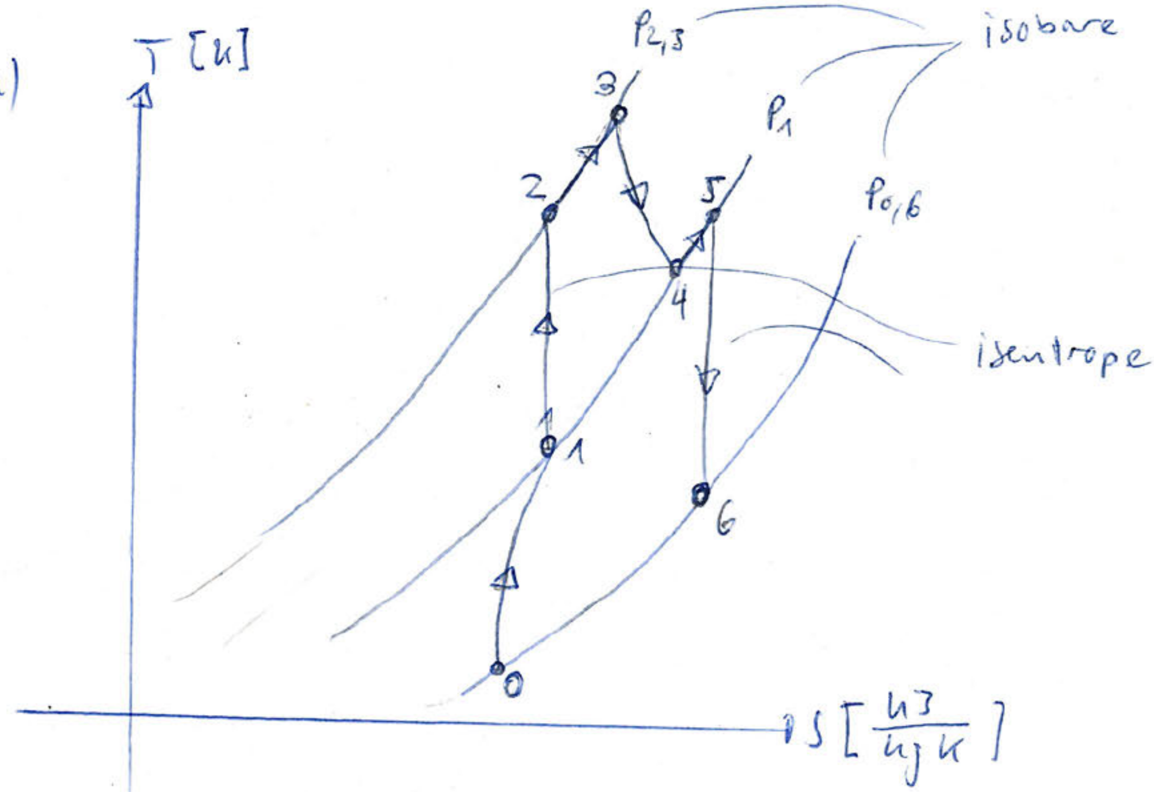
[redacted]

2)

	P[bar]	T[°C]	T[K]					
0	0.191	-30						
1								
2								
3								
4								
5								
6			328.07					

0–1: } $\Delta Q = 0$, isentrop $\eta_g < 1$ komprimiert
1–2: } isentrop = adiabat rev.
2–3: } isobar
3–4: } adiabat
4–5: } isobar, $p_4 = p_1 = p_5$
5–6: } isentrop = rev / adiabat

a)



b) ~~Energiebilanz~~ $\Rightarrow$ isentrop, da reversibel & $\Delta Q = 0$

$\hookrightarrow n = k = \frac{c_p}{c_v} = 1.4$ ~~$k =$~~

~~$\Rightarrow c_v = \frac{R}{M_L} + c_p$~~

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

$$= \underline{\underline{328.07\ K}}$$

w_6: Energiebilanz um Schubdüse, stationär, ein Massenstrom:

$$0 = \dot{m}_{ges}\left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right) + \underbrace{\cancel{\dot{Q}_{56}}}_{0,\ \text{adiabat}} - \dot{W}_{t,56}$$

& $p_e = 0$

$$\dot{W}_{t56} = \dot{W}_{t56}^{rev} = \dot{m}_{ges}\,\cdot$$

[redacted]

2)

c) $w_0 = 510 \frac{m}{s}$, $T_6 = 340\ K$

Exergiebilanz um ~~Turbine~~ alles im Triebwerk, stationär, 1 massenstrom:

$$\Delta e_{x,str} = -\left[h_0 - h_6 - T_0(s_0 - s_6) + \Delta ke + \Delta pe^{\nearrow 0}\right] \quad \Big| \quad \Delta ke = \frac{w_0^2 - w_6^2}{2}$$

~~KKM~~ $h_0 - h_6 = c_p \cdot (T_0 - T_6) = -97.4311 \frac{kJ}{kg}$

$s_0 - s_6 = c_p \cdot \ln\left(\frac{T_0}{T_6}\right) = -0.57727 \frac{kJ}{kg\,K}$

$\frac{w_0^2 - w_6^2}{2} = -110'050 \frac{J}{kg}$

~~$\Delta e_{x,str} = 207.878 \frac{kJ}{kg}$~~ $\Delta e_{x,str} = 115.747 \frac{kJ}{kg}$

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

Entropiebilanz um ~~Turbine~~ alles im Triebwerk:

$$0 = \dot{m}(s_0 - s_6) + \frac{\dot{Q}_{06}}{\overline{T}_{06}} + \dot{S}_{erz}$$

$\Rightarrow$ alles adiabat außer Brennkammer

$\frac{\dot{Q}_{06}}{\dot{m}} = -q_B = -1195 \frac{kJ}{kg}$

$\overline{T}_{06} = \overline{T}_B = 1289\ K$

$$\Rightarrow \frac{\dot{S}_{erz}}{\dot{m}} = s_6 - s_0 - \frac{-q_B}{\overline{T}_B} = 1.304 \frac{kJ}{kg\,K}$$

$e_{x,verl} = 317.15 \frac{kJ}{kg}$

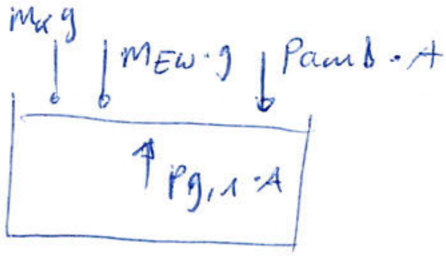
[redacted]

3

a) $p_{g,1} = ?$ → perfektes Gas

$m_g = ?$

$$p_{g,1} = \frac{m_g R T_{g,1}}{V_{g,1}}$$



$$p_{g,1} = \frac{m_K g}{A} + \frac{m_{EW} g}{A} + p_{amb}$$ | $A = \pi \left(\frac{D}{2}\right)^2 = 7.854 \cdot 10^{-3} m^2$

$p_{g,1} = 40.0948$ ~~bar~~ $\frac{N}{m^2} + 1 bar$

$= \cancel{1{,}0004 bar}$ 1.401

$$m_g = \frac{p_{g,1} V_{g,1}}{R T_{g,1}}$$ | $R = \frac{\bar{R}}{M_g} = 166.28 \frac{kJ}{kg K}$

$= \underline{2.4512 \cdot 10^{-3} kg}$

b)

⇒ Thermodynamisches Glgw ⇒ $T_{EW,2} = T_{G,2}$

Energiebilanz um EW + Gas:

Geschlossenes sys. am Kolben:

$m_{ew}(u_2^{ew} - u_1^{ew}) + m_g(u_2^g - u_1^g) = \cancel{Q}^0 - W_V$ | nur gasvolumen ändert sich!

$m_{ew}(u_2^{ew} - u_1^{ew}) + m_g c_v (T_{2,g} - T_{1g}) = -W_V = \frac{R(T_{2g} - T_{1g})}{1-n}$

[redacted]

3

c) $T_{g,2} = 0.003\,°C$

Energiebilanz um gas: Geschlossen, an Kolben

~~$p_{Ref} = const.$~~

$m_g(u_2 - u_1) = Q_{12} - W_v \quad \Big| \; W_v = \frac{R(T_{2g} - T_{1g})}{1-n}$

$m_g c_v (T_{2,g} - T_{1,g}) + W_v = Q_{12} \qquad n = \frac{c_p}{c_v} = 1.2626$

$c_p = \frac{R}{M_L} + c_v = 0.79228$

d) $|Q_{12}| = 1500\,J \Rightarrow Q_{12}^{eis} = 1500\,J$

$x_{eis,2}$:

$u_2^{eis} = u_f + x_{eis,2}(u_g - u_f) \quad @\, p_{eis} \quad \Big| \; p_{eis} = 1\,bar + \frac{m_K \cdot g}{A} = 1.39969\,bar \approx 1.4\,bar$

u_2^{eis} : Energiebilanz um EW:

$m_{eis}(u_2 - u_1) + Q_{12}^{eis} - \underbrace{\cancel{W_v^{eis}}}_{0,\ \text{inkompressibel}} = 0$

$u_2^{eis} = \frac{-Q_{12}^{eis}}{m_{EW}} + u_1 \quad \Big| \; u_1 = u_{fest} + x_{eis}(u_{flüssig} - u_{fest}) \;\Big|\; @\, 1.4\,bar$

flüssig eis/fest

$= -200.0328\,\frac{kJ}{kg}$

~~$u_2^{eis} = -215.0928\,\frac{kJ}{kg}$~~ $\quad u_2^{eis} = -215.0928\,\frac{kJ}{kg}$

$x_{eis,2} = \frac{u_2^{eis} - u_{fest}}{u_{flüssig} - u_{fest}} = \underline{\underline{0.355}}$