[redacted]

Aufgabe 1

a) $\frac{d\cancel{E}^{0\,\text{stat. TP}}}{dt} = \dot{m}_i \left[h_i + \cancel{\text{pot+kin}}^{0} \right] + \sum_j \dot{Q}_j - \cancel{\sum_n \dot{W}_n}^{0}$

$$0 = \dot{m}\left[h_{ein} - h_{aus}\right] - \dot{Q}_{aus} + \dot{Q}_R$$

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

$h_{ein} = h_f(70°C) + x\,(h_g(70°C) - h_f(70°C))$ aus TAB A-2

$= \underline{304{,}65\ \frac{kJ}{kg}}$

$h_{aus} = h_f(100°C) + x\,(h_g(100°C) - h_f(100°C))$ aus TAB A-2

$= \underline{430{,}33\ \frac{kJ}{kg}}$

$\dot{Q}_{aus} = \underline{\underline{62{,}296\ kW}}$

b) ideale Flüssigkeit

Entropiebilanz

$\frac{d\cancel{S}^{0,\,\text{stat. TP}}}{dt} = \sum_i \dot{m}_i s_i + \sum_j \frac{\dot{Q}_j}{T_j} + \cancel{\dot{S}_{erz}}$ reversibel, kein Druckverlust und adiabat

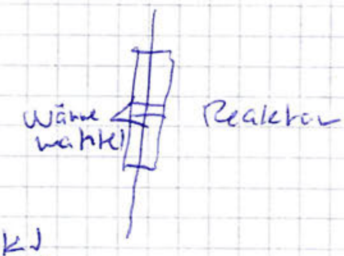
~~$0 = \dot{m}(s_{ein} - s_{aus}) + \frac{\dot{Q}_{aus}}{\bar{T}_{KF}}$~~

~~$s_{ein} - s_{aus} = \int_{T_{aus}}^{T_{ein}} \frac{c^{if}}{T}\,dT = c^{if} \cdot \ln\left(\frac{T_{ein}}{T_{aus}}\right)$~~ ?

$\rightarrow$ andere Formel: $\bar{T} = \frac{\int_e^a T\,ds}{s_a - s_e}$

$= \frac{?}{\int_{T_e}^{T_a} \frac{c^{if}}{T}\,dT} = \boxed{\frac{?}{c^{if} \cdot \ln\left(\frac{T_a}{T_e}\right)}}$

c) mit $\overline{T}_{KF} = 295\,K$



$$\overset{0\ \text{stat. FP}}{\frac{dS}{dt}} = \sum_i \cancel{\dot{m}_i}^{\,0\ \text{keine Masse}}\, s_i + \sum_j \frac{\dot{Q}_j}{T_j} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = -\frac{\dot{Q}_{aus}}{T_{KF}} = \frac{62{,}3\,kW}{295\,K} = \underline{\underline{0{,}21\,\frac{kJ}{K}}}$$

d)

e) geschlossenes System

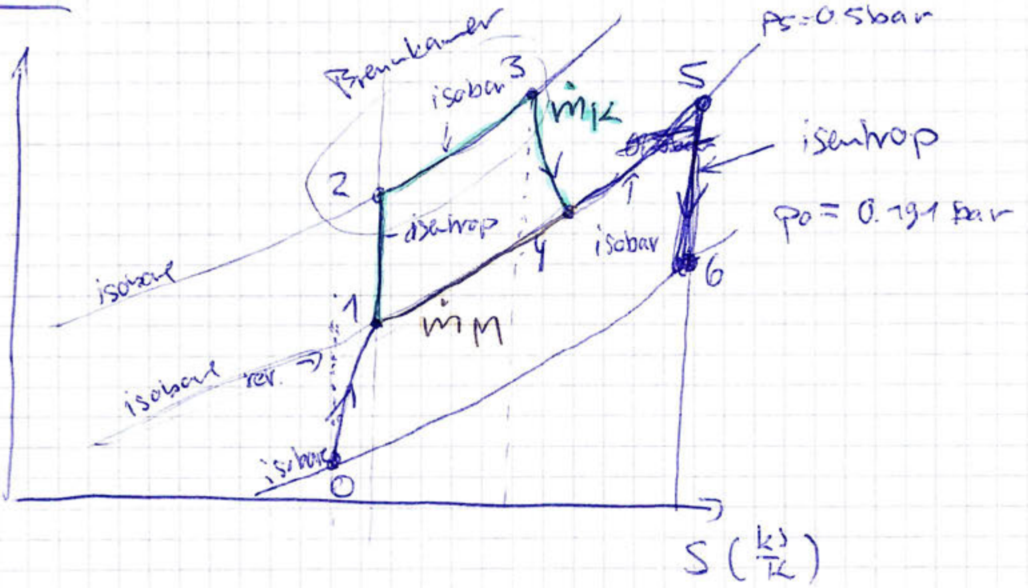
$$\Delta S = S_2 - S_1 = m(s_2 - s_1)$$

$$\boxed{\Delta S_{12} = \delta m_{12} \cdot (s_2 - s_1)}$$

[redacted]

Aufgabe 2

a)



b) 5 → 6 adiabat, reversibel

$$\frac{d\cancel{E}}{dt} = \dot{m}_{Ges}\left[h_5 - h_6 + \frac{(w_5^2 - w_6^2)}{2}\right] + \cancel{\sum \dot{Q}_j} - \sum_n \dot{W}_{t,n}$$

0, stat. FP; 0, adiabat

$$0 = \dot{m}_{Ges}\left[h_5 - h_6 + \frac{(w_5^2 - w_6^2)}{2}\right] - \dot{W}_V \qquad \boxed{\text{ideales Gas}}$$

$$h_5 - h_6 = \int_{T_5}^{T_6} c_p^{ig}\, dT = c_{p,Luft}^{ig} \cdot (T_6 - T_5) \qquad T_6 = ?$$

stat. FP; adiabat; adiabat, rev.

$$\frac{d\cancel{S}}{dt} = \sum \dot{m}_i s_i + \cancel{\sum \frac{\dot{Q}_j}{T_j}} + \cancel{\dot{S}_{erz}}$$

$$0 = m[s_5 - s_6] \rightarrow s_5 = s_6 \quad \text{isentrop}$$

0 stat. FP; 0 adiabat; 0

$$\frac{d\cancel{Ex}}{dt} = \sum_i \dot{E}_{xStr,i} + \cancel{\sum_j \dot{E}_{x,Q,j}} - \sum_n [\dot{W}_n] - \cancel{\dot{E}_{x,verl}}$$

$$0 = \dot{m}_{Ges} \cdot [h_6 - h_5 - T_0(s_6 - s_5) + ke] - \dot{W}_V$$

c)

d) $$\overset{0\ \text{stat FP}}{\cancel{\frac{dE_x}{dt}}} = \sum_i \dot{E}_{x,str,i} + \sum_j \overset{0\ \cancel{\text{adiabat}}}{\cancel{\dot{E}_{x,Q,j}}} - \sum_n \overset{0}{\cancel{\dot{W}_n}} - \dot{E}_{x,verl.}$$

$$0 = \sum_i \dot{E}_{x,str,i} + \dot{E}_{x,Q_B} - \dot{E}_{x,verl.}$$

$$\boxed{\dot{e}_{x,verl} = h_6 - h_0 - T_0(s_6 - s_0) + ke + \left(1 - \frac{T_0}{T_B}\right) q_B}$$

$$\dot{e}_{x,verl} = \underbrace{\Delta e_{x,str}}_{100\,\frac{kJ}{kg}} + \left(1 - \frac{\overset{-30°C}{T_0}}{\underset{1289K}{T_B}}\right) q_B$$

~~Tkaa?~~

$$\dot{e}_{x,verl} = 100\,\frac{kJ}{kg} + \left(1 - \frac{273{,}15 - 30}{1289}\right) 1195 = \underline{\underline{1069{,}58}}\ kJ$$

Aufgabe 3 [redacted]

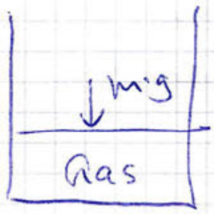
a) $T_{g,1} = 500°C$ $V_{g,1} = 3.14 L$ ~~$v_{g,1} = \frac{V_{g,1}}{M_g} = 0,0000628 \frac{m^3}{kg}$~~

$p_1 v_1 = R T_1$

$p_{g1} = \frac{\frac{\bar{R}}{M_g} \cdot T_{g,1}}{v_{1,g}} =$

$v_{g,1} = \frac{V_{g,1}}{m_{g,1}}$

$m_{g1} = ?$



$F = mg = 32.1 \cdot 9.81$

$A = \pi (5cm)^2$

$p = \frac{F}{A} = \frac{32,1 \cdot 9,81}{\pi (5cm)^2} = 40094.44 Pa = \underline{\underline{0,4 bar}}$

$m_g = \frac{p_1 V_1}{R T_1} = 0,9769 kg = \underline{\underline{0,98 kg}}$

↗ $\frac{\bar{R}}{M}$

b) thermodynamisches gleichgewicht in Zustand 2

→ $\boxed{T_{g,2} = T_{EW,2}}$

da die Temperatur im Fest-Flüssig Bereich gleich bleibt

→ $\boxed{T_{EW,2} = T_{EW,1}}$ → somit $\boxed{T_{g,2} = T_{EW,1} = 0°C}$

$\boxed{p_{g2} = p_{g1}} = \underline{0,4 bar}$

Weil keine Masse verloren geht und die Fläche gleich bleibt.

→ Somit presst immernoch die gleiche Masse auf die Gleiche Fläche

c) $\frac{d\cancel{E}^{\,\Delta U}}{dt} = \cancel{\dot{m}_i \left[h_i + \ldots \right]}^{\,0} + \sum_j \dot{Q}_j - \sum_n \dot{W}_n$

$\Delta U = \dot{Q}_{12} - \dot{W}_{12}$

$U_2 - U_1 = Q_{12} - W_{12}$

$\left.\right\}$ massen bleiben gleich

$u_2 - u_1 = q_{12} - w_{12}$

$Q_{12} = U_2 - U_1 + W_{12}$ ← nur vom gas (Volumenarbeit) ~~mit Umgebung~~

$= m_{EW} \cdot (u_{2EW} - u_{1EW}) + m_g (u_{2g} - u_{1g}) + \int_1^2 p \, dV$ ← konst

$p \int_1^2 dV = \cancel{0{,}1\,\text{bar}}\ 9{,}4\,\text{bar} \cdot (V_2 - V_1)$

isentropen Gleichung

$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2} \right)^{n-1}$ $\qquad n = k = \frac{\frac{\bar{R}}{M} + c_v}{c_v} = 1{,}2627$

$\frac{V_1}{V_2} = \left(\frac{T_2}{T_1} \right)^{\frac{1}{n-1}}$

$v_2 = v_1 \cdot \frac{1}{\left(\frac{T_2}{T_1} \right)^{\frac{1}{n-1}}} = \frac{V_1}{m_g} \cdot \frac{1}{\left(\frac{273.15}{500+273.15} \right)^{\frac{1}{n-1}}} = \underline{0{,}1682}$

$\boxed{V_2 = m_g \cdot v_2}$

$p \int_1^2 dV = 0{,}06467$

[redacted]

Aufgabe 3

d) $x = \frac{u_2 - u_f}{u_g - u_f}$ bei $\boxed{0°C}$

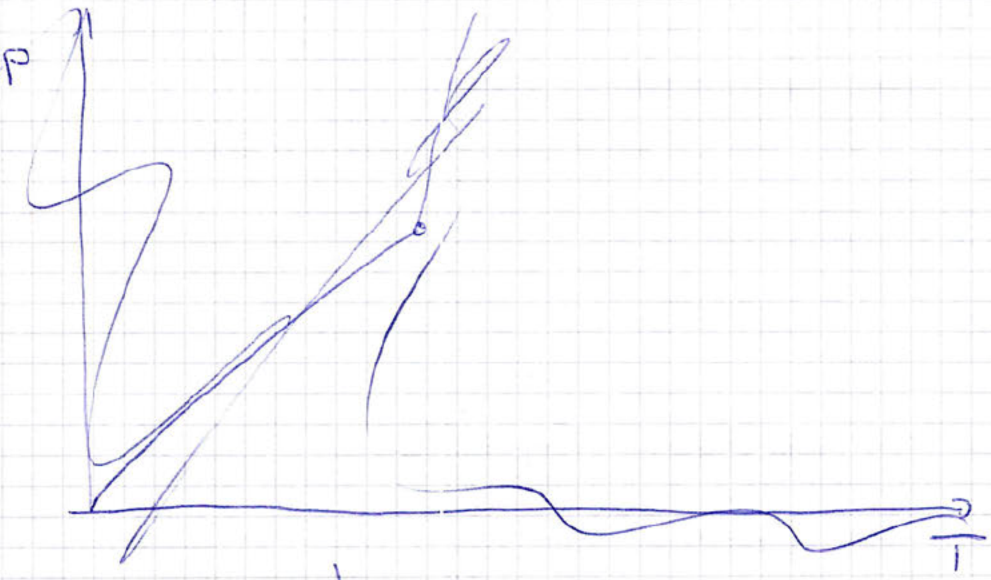
$u_2 = \frac{U_2}{m_{EW}}$

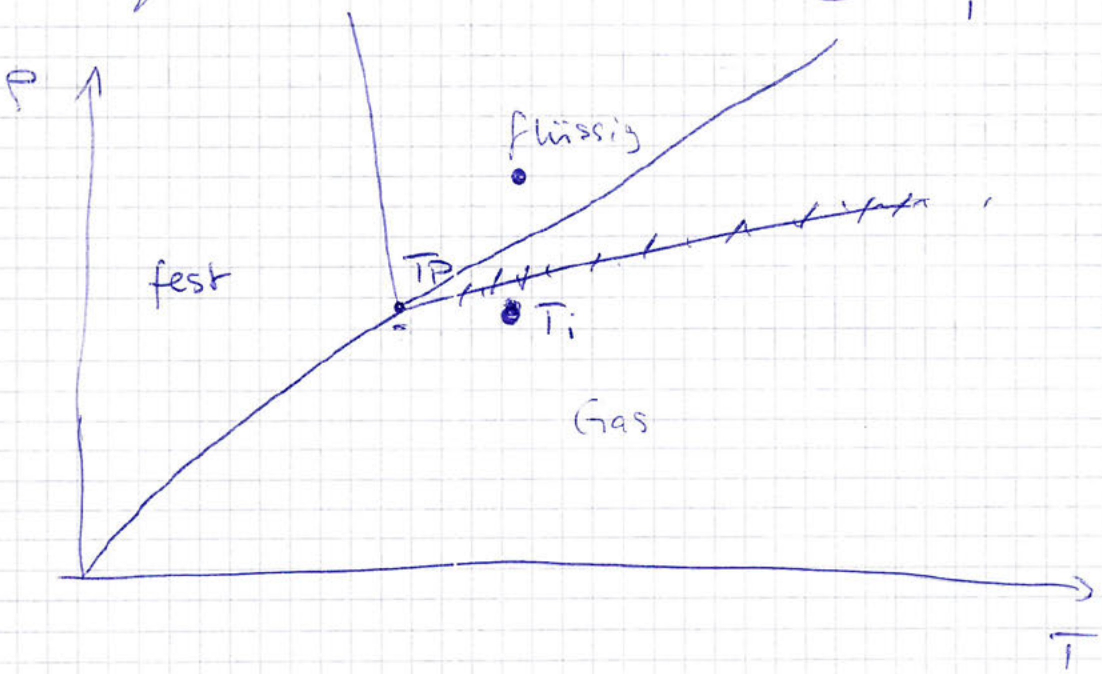
$U_2 =$

[redacted]

Aufgabe 4

a)





b) $2 \to 3$ ← isentrop

0, stat. FP   ü adiabat

$$\frac{d\cancel{E}}{dt} = \dot{m}_i [h_i] + \cancel{\sum_j \dot{Q}_j} - \sum_n \dot{W}_n$$

weil Arbeit am System verrichtet wird

$$0 = \dot{m}_{R134a} \cdot [h_2 - h_3] + \dot{W}_K$$

$$\dot{m}_{R134a} = \frac{\dot{W}_K}{h_2 - h_3}$$

$h_2 = h_g(T_2)$ $T_2 = ?$

$h_3 = h_f(8\,bar) + x\,(h_g(8\,bar) - h_f(8\,bar))$; $x = ?$

isentrop ⇒ $s_2 = s_3$ $s_2 = s_g(T_2)$

$$x_3 = \frac{s_3 - s_f}{s_g - s_f}$$ (bei 8bar) $s_3 = s_2$ $s_2 = s_g(T_2)$

$T_2 = ?$

brauche T_2, aber wie mach ich das?

c) $p_4 = p_3 = 8\,bar$

adiabate Drossel → isotherm $T_q = T_4$

$x_4 = 0$ → gesättigt bei 8 bar

$\underline{T_4 = 31{,}33°C}$ TABA-11 $\boxed{\text{liquid-vapor at 8bar}}$

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

=