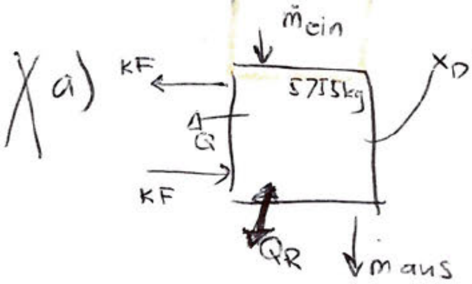
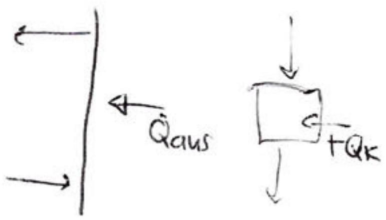
Aufgabe 1 stationär

[redacted]

a)



$x_D = \frac{m_D}{m_{ges}} = 0.005$



$$\overbrace{\frac{dE}{dt}}^{=0 \text{ stat}} = \dot m_{ein} h_1 - \dot m_{aus} h_2 + \dot Q - \overbrace{\dot W_t}^{=0}$$

$$0 = \dot m (h_1 - h_2) + \dot Q \cancel{+ \dot Q_{R}} + \dot Q_K$$

$$\dot Q = \dot m (h_2 - h_1) = 0.3 \frac{kg}{s} (419.04 - 292.98)$$

$$= 37.818 \text{ kW} + \underbrace{\dot Q_K}_{100 \text{ kW}} = \underline{100037.818 \text{ W}}$$

Siedende Flüssigkeit

$$h_2(100°C, x_2 = 0) = h_f(100°C) \overset{\text{TAB A2}}{=} 419.04 \frac{kJ}{kg}$$

$$h_1(70°C, x_1 = 0) \underset{\text{TAB A2}}{=} 292.98 \frac{kJ}{kg}$$

b) $$\bar T_{KF} = \frac{\int_e^a T\, ds}{s_a - s_e} = \frac{\overset{h_a - h_e}{\dot Q}}{c_{if} \cdot \ln\left(\frac{T_2}{T_1}\right)} = \frac{c_{if}(T_2 - T_1)}{c_{if} \ln\left(\frac{T_2}{T_1}\right)} = \frac{T_2 - T_1}{\ln\left(\frac{T_2}{T_1}\right)} = \underline{\underline{293.1216 \text{ K}}}$$

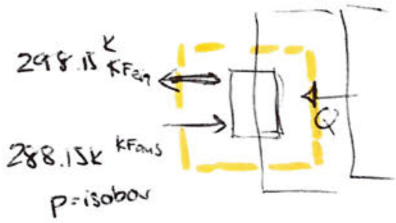
ideale Flüssigkeit

$T_2 = 288.15$ K

$T_1 = 298.15$ K

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

$$\underbrace{\cancel{\frac{dS}{dt}}}_{=0 \text{ stat}} = \dot{m}_{KF}(h_e - h_a) + \frac{\dot{Q}_{aus}}{T_{KF}} + \dot{S}_{erz}$$



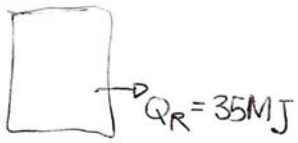
$$\dot{S}_{erz} = \dot{m}(h_a - h_e) - \frac{\dot{Q}_{aus}}{T_{KF}}$$

$\dot{Q}_{aus} = 65\,kW$

$T_{KF} = 295\,K$

$$\left.\begin{aligned} h_a(298.15\,K) &= h_f(T_2) + v^{if}(p - p_{sat}(T)) \\ h_e(288.15\,K) &= h_f(T_1) + v_{if}(p - p_{sat}(T)) \end{aligned}\right\} \Delta h = h_f(T_2) - h_f(T_1) = c_{if} \cdot (T_2 - T_1)$$

d) $\Delta E = Q - \cancel{W_v}^{\,v=const \to p=const} = m_2 u_2 - m_1 u_1$



$$m_2 u_2 - m_1 u_1 = \Delta m \cdot h_f(20°C) + Q_R$$

$$m_2 = m_1 + \Delta m$$

@ 2, $x_2 = 0$ & 70°C $\rightarrow u_f(70°C) = 292.95 \frac{kJ}{kg}$ (TAB A2)

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e) $\Delta S = S_2 - S_1 = m_2 s_2 - m_1 s_1 = \Delta m\, s(20°C) + \frac{Q}{T_J} + S_{erz}$

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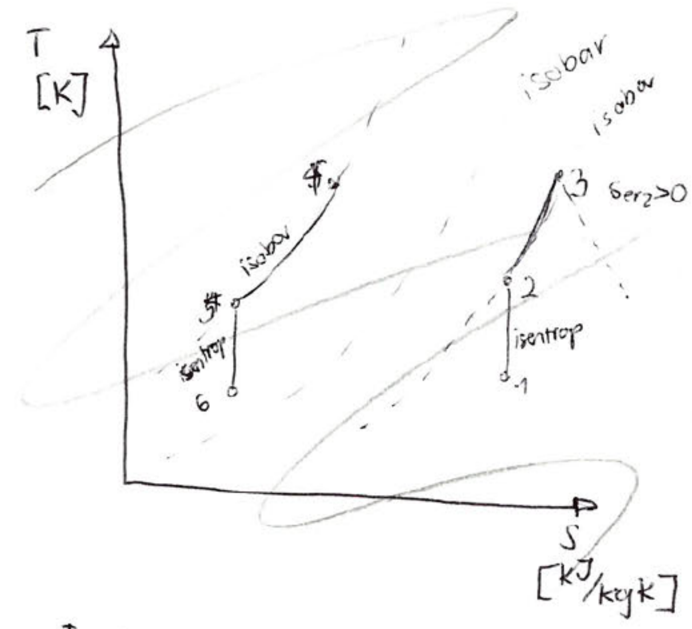
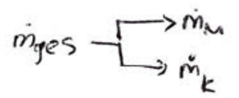
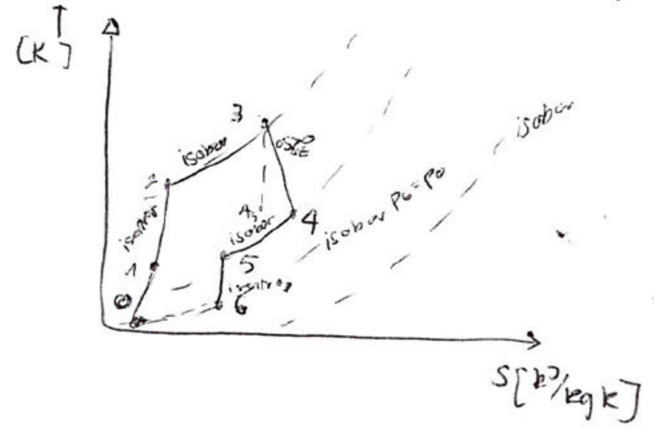
Aufgabe 2

a)

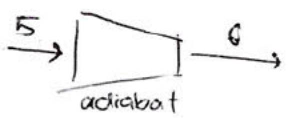


	p	T	v	
0	0.191	-30°C		
1				$s_1 = s_2$
2	$p_2 = p_3$			
3				
4	0.5 $p_4 = p_5$			
5	0.5	431.9	$w_5 = 220\ m/s$	$s_5 = s_6$
6	0.191			





b) $w_6 = ?$, $T_6 = ?$



$s_5 = s_6$

$$\underbrace{\frac{dE}{dt}}_{=0 \text{ stat}} = \dot m_{ges}\Big(\underbrace{h_5 - h_6}_{\substack{\text{i.g.}\\ c_p \cdot (T_5 - T_6)}} + \frac{w_5^2}{2} - \frac{w_6^2}{2}\Big) + \cancel{\dot Q}^{\,\text{adiab.} = 0} - \cancel{\dot W_t}^{\,=0}$$

$(s_6 = s_5)$

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = \cancel{431} = \underline{\underline{328.075\,K}}$$

$n = 1.4$

$$\rightarrow \cancel{c_p(T_6 - T_5) - w}$$

$$\underbrace{c_p}_{1.006 \frac{kJ}{kg K}}(T_5 - T_6) + \frac{\overbrace{w_5}^{220\ m/s}{}^2}{2} = \frac{w_6^2}{2} = 128647.95$$

$$\rightarrow w_6 = \underline{\underline{507.24 \frac{m}{s}}}$$

c) 

$$\Delta \mathring{E}x_{str\,0,6} = \mathring{m}\left[h_6 - h_0 - \overset{243.15K}{T_0}(s_6 - s_0) + \frac{w_6^2}{2}\right] \quad \Big| \div \dot{m}_{ges}$$

$$\Delta \mathring{e}x_{str} = 12.1586\,\frac{kJ}{kg} + \frac{w_6^2}{2}$$

$$= \underline{\underline{116.487}}\ \frac{kJ}{kg}$$

$$h_6 - h_0 = c^{if}(T_6 - T_0) + \underbrace{v^{if}(p_6 - p_0)}_{=0}$$
$$= 85.434\,\frac{kJ}{kg}$$

$T_6 = 328.075\,K$

$T_0 = -30 + 273.15 = 243.15\,K$

$$s_6 - s_0 = c^{if}\ln\left(\frac{T_6}{T_0}\right) = 0.3014\,\frac{kJ}{kgK}$$

$w_6 = 507.24\,\frac{m}{s}$

$$\frac{w_6^2}{2} = 128646$$

d) $e_{x,verl} = ?$

$e_{xQ} = 0$
$w_t = 0$

adiabat

$$\frac{dE_x^{\,\to 0\ stat}}{dt} = \Delta E_{x,str} - e_{x,verl}$$

$$e_{x,verl} = \Delta e_{x,str} = 116.487\,\frac{kJ}{kg}$$

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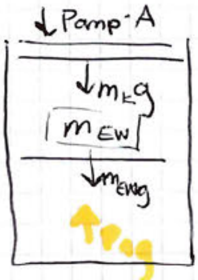
Aufgabe 3

a)



$A = \pi \cdot \frac{D^2}{4} = 25\pi = 78.54\,cm^2$

$= \pi \cdot \frac{0.1^2 m^2}{4} = 0.00785\ m^3$

$$p_{1,g} = \underbrace{p_{amp}}_{10^5\,Pa} + \frac{m_K}{A} \overset{(9.806\frac{m}{s^2})}{g} + \frac{m_{EW}}{A} g$$

$\hat{=}\ 140078.09\ Pa$

$= \underline{1.4\ bar}$

$V_{g_1} = v_g \cdot m_g$

~~b)~~ $\rightarrow m = \frac{p_1 V_1}{R T_1} = \frac{140094 \cdot V_1}{R \cdot T_1} = 0.003432\ kg = \underline{\underline{3.4\,g}}$

$R = c_v(\overset{?}{k} - 1) = \frac{\bar{R}}{M} = \frac{8.314\ J/mol\,K}{50\ kg/kmol} = 166.28$

$\uparrow 0.633 \frac{kJ}{kg}$

$V_1 = 3.14\ L = 3.14 \cdot 10^{-3}\,m^3$

$T_{g,1} = 500 + 273.15$

b) $p_{g,2} = p_{g,1} = 1.4\,bar$, weil in der zustandsänderung hat es keine zusätzliche masse gegeben, die p_g entgegen wirken muss (da EW konstante Masse & Kolben auch)

T von Eis ist auch konst weil agregatzustand ändert (bei konst p & T)

$T_{g,2}$

$T = \frac{pV}{mRT}$ (weil $V\downarrow$ ist auch $T\downarrow$)
& rest konstant

c) @ Zustand 2 GGW $\rightsquigarrow \Delta U = 0$ i.g.

$$\Delta U = \underbrace{\Delta U_{gas}}_{c_v (T_{2g} - T_{1g})} + \underbrace{\Delta U_{EW}}_{c_{if} (T_{2w} - T_{1w})}$$

$T_{2g} = T_{2w} = 0.003°C$

$=$

$R = c_v(k-1)$

$\frac{R}{c_v} + 1 = k$

$\Delta E = Q - W_v = 0$

$Q = W_v \Rightarrow \quad q = w_v = \frac{R(T_2 - T_1)}{1-n}$

geschlossenes System:

$\cancel{\Delta E}$ $\quad \underbrace{m(u_2 - u_1)}_{c_v(T_2 - T_1)} = Q$

d) $x_{Eis,2}$ $\quad \cancel{\Delta U = Q}$

$T_{Eis} = 0.003°C$ $\quad p_2 = p_{amb} + m_K\, u$

$x_{Eis,1} = \frac{m_{Eis}}{m_{EW}} = 0.6 \longrightarrow m_{Eis} = 0.6 \cdot 0.1 kg$

@ $0°C = T_{1EW}$

zB.

$u_2 = -334.5$

$u_2 - u_1 = c^{if} (T_2 - T_1)$

$\Rightarrow u_2 = c^{if}(T_2 - T_1) + u_1$

$\rightsquigarrow$ interpolieren

$\rightarrow$ @ $p = 1 bar$, $T = 0.003$

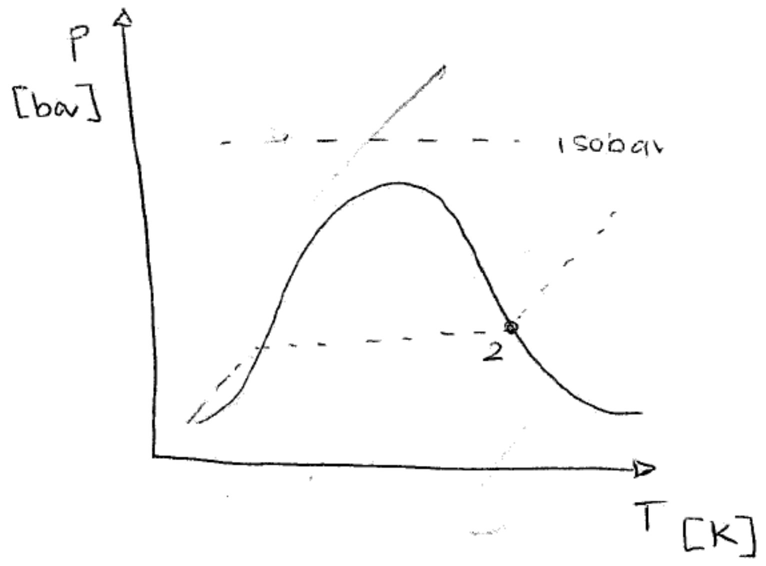
interpoliere für x

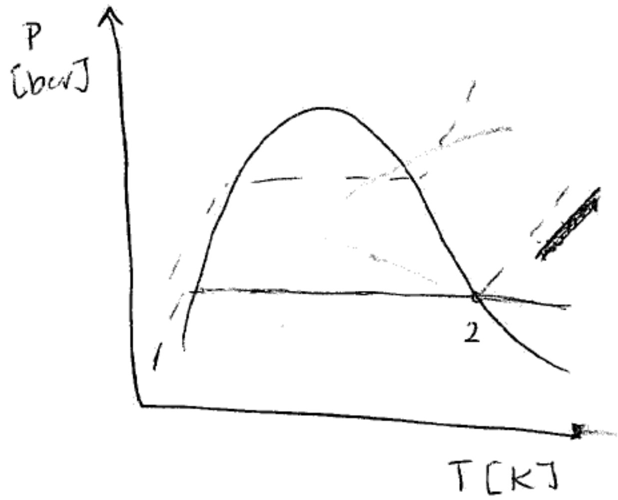
$x = \frac{u_2 - u_f}{u_g - u_f} =$

[redacted]

Aufgabe 4

a)





	p	T	v
1	p_u		
2	8bar	$-22^\circ C$	
3	8 bar		
4	8bar		

$q_{41} = 0$

$p_u = -5\,mbar + p_{TP}$

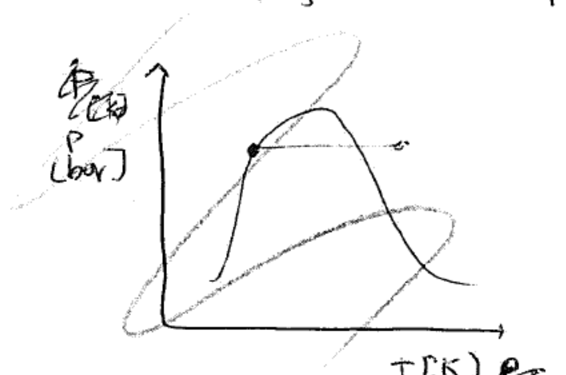
$T_i - 10K = T_{Sublimationspunkt}$

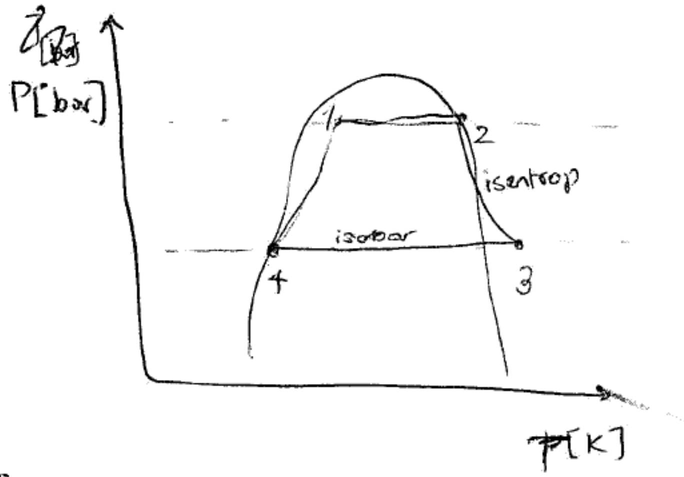
$x_2 = 1$

$x_3 = 1 \qquad s_3 = s_2$

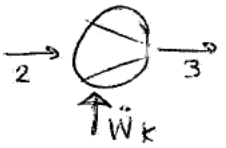
$x_4 = 0$

$T_i - T_3 = 6K$





b) $\dot{m}_{R134a} = ?$



1HS. $\cancel{\frac{dE}{dt}}^{stat=0} = \dot{m}_R(h_2 - h_3) + \cancel{\dot{Q}}^{adiabat=0} - \dot{W}_K$

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

$h_2(8bar, x_2 = 1) = h_g(8bar) \overset{TAB\,A11}{=} 264.15 \frac{kJ}{kg}$

$h_3(8bar, s_2) \Rightarrow$ interpolieren @ 8bar mit s_2 : $h_3 = \frac{h(s_x) - h(s_y)}{s_x - s_y}(s_2 - s_y) + h(s_y)$

$s_2(8bar, x = 1) \overset{Tab\,A11}{=} 0.9066 \frac{kJ}{kg\,K} = s_3$

c) Drossel ~ isenthalp, isotherm

$x_4 = 0 \quad p_4 = 8\,bar \quad \rightsquigarrow h_4 = 93.42 \frac{kJ}{kg}$

TAB A11

$T_4 = 31.33$

$h_1 = 92.42\,, \quad p_u = 6\,bar$

→ interpolieren @TAB A12

$$h = \frac{\phi(P_1) - \phi(P_2)}{P_1 - P_2}(P - P_2) + \phi(P_2)$$

will das also umformen für

$$P = \frac{h - \phi(P_2)}{\phi(P_1) - \phi(P_2)}(P_1 - P_2) + P_2$$

d)

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

e) $Q = cm(T_2 - T_1)$ → die Temp würde Abnehmen

Phase veränderung