1a)

$$0 = \dot{m}_{ein}\left(h_1 - h_2\right) - \dot{Q}_{aus} + \dot{Q}_R$$

$$\dot{Q}_{aus} = \dot{m}_{ein}\left(h_1 - h_2\right) + \dot{Q}_R$$

$$= 62.18\ kW$$

$h_1 \overset{\wedge -7}{=} 292.38 \frac{kJ}{kg}$

$h_2 \overset{\wedge -2}{=} 419.04 \frac{kJ}{kg}$

1b)

$$\bar{T} = \frac{\int_e^2 T\,ds}{s_2 - s_e} = \frac{T_2 s_2 - T_e s_e}{s_2 - s_e}$$

$s_2 =$

$s_e =$

c)

$$0 = \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = -\frac{\dot{Q}_{aus}}{\bar{T}}$$

d)

$$\Delta E = m_{ges,2} u_2 - m_{ges,1} u_1$$

$$= \left(m_{ges,1} + \Delta m_{12}\right) u_2 - \left(m_{ges,1} u_1\right) = \Delta m_{12}\, h_{Wasser\,@\,20°C} + \cancel{Q_{12}}^{0}$$

$h_{W\,@\,20°C} \overset{\wedge -7}{=} 83.96 \frac{kJ}{kg}$, $u_2 = 292.95 \frac{kJ}{kg}$

$u_1 = 0.995\, u_f + 0.005\, u_g$

$\overset{\wedge 2}{=} 429.38 \frac{kJ}{kg}$

1d) (continued)

$$m_{gas,1}(u_2 - u_1) + \Delta m_{w2}(u_2 - h_{w@20°C}) = 0$$

$$\Delta m_{w2} = -m_{gas,1}\frac{(u_2 - u_1)}{u_2 - h_{w@20°C}} = 3756.84\ kg$$

e) ΔS $\quad \Delta S_{12} = (m_{gas,1} + \Delta m_{w2})\, s_2 - m_{gas,1}\, s_1$

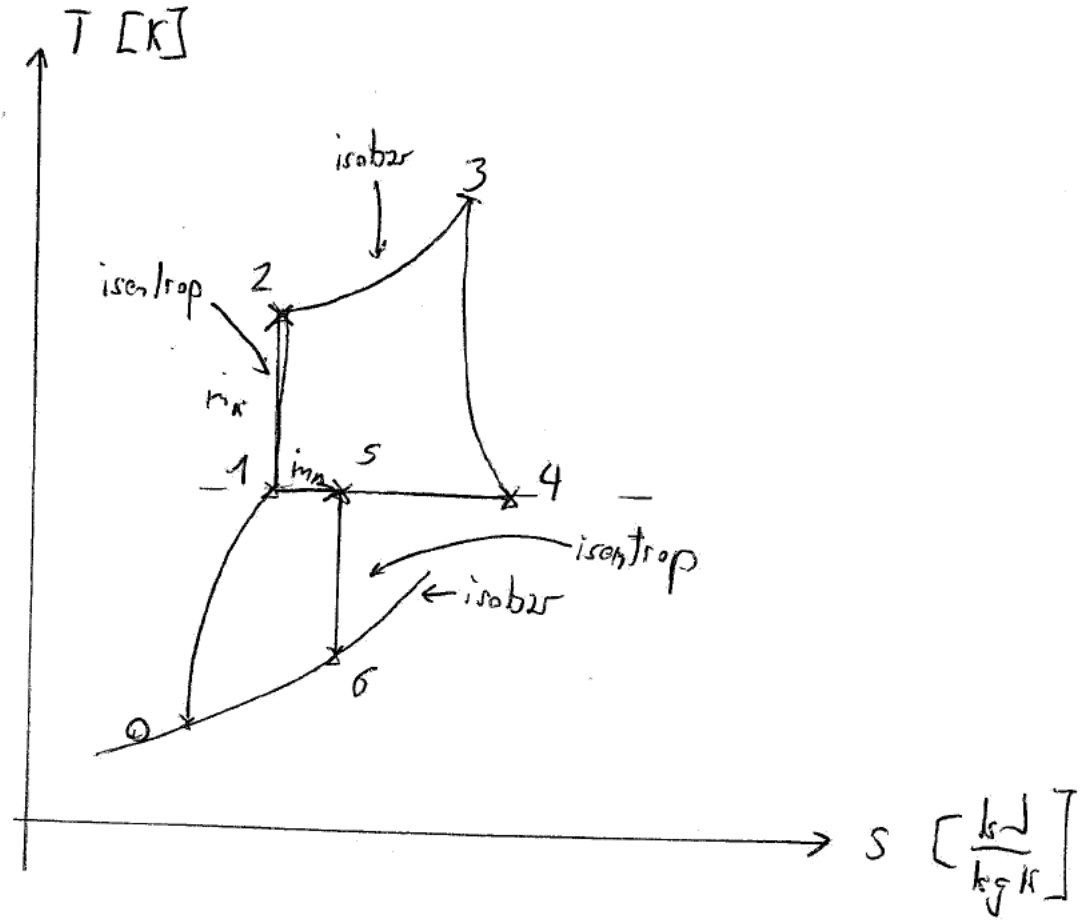
$$s_1 = 0.995 \cdot s_L + 0.005 \cdot s_g \quad \Big| \text{at } 100°C$$

$$s_1 = 1.337 \frac{kJ}{kg\,K}$$

$$s_2 = 0.9549 \frac{kJ}{kg\,K}$$

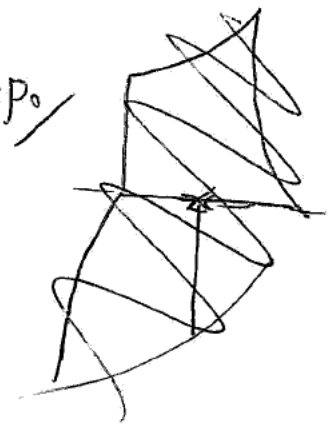
$$= 1388.42 \frac{kJ}{K}$$

32)



b) $T_6 = T_5 \cdot \left(\frac{p_6}{p_5}\right)^{\frac{0.4}{1.4}} = 328.07\,K$ //

$p_6 = p_0$ //



$0 = \dot{m}_{ges}\left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right)$

$h_5 - h_6 = c_p(T_5 - T_6) = 104.45\,\frac{kJ}{kg}$

$\frac{w_6^2}{2} = c_p(T_5 - T_6) + \frac{w_5^2}{2} = 128.65\,\frac{kJ}{kg}$

$w_6 = \sqrt{2 \cdot 128.65\,\frac{kJ}{kg}} = 507.25\,m/s$ //

(2) Aufg. 2

c) $e_{x,str} = h_6 - h_0 - T_0 (s - s_0) +$ [redacted]

$+ \Delta ke \qquad \Delta ke$

$T_0 = 243.75\,K \quad \Big| = -\frac{w_0^2}{2} + \frac{w_6^2}{2}$

$h_6 - h_0 = c_p (T_6 - T_0) = 85.429 \frac{kJ}{kg}$

$s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right)$

$= 0.301 \frac{kJ}{kg\,K}$

$e_{x,str} = 12.157 \frac{kJ}{kg} + \Delta ke$

$= 96.49 \frac{kJ}{kg}$ //

d) $e_{6,verl} = T_0 \, s_{erz}$

$s_{erz} = -(s_0 - s_6)$

$= s_6 - s_0 = 0.301 \frac{kJ}{kg\,K}$

$= 73.788 \frac{kJ}{kg}$ //

[redacted]

3a) $R = \frac{\bar{R}}{M_g} = 166.28 \frac{J}{kgK} = 0.166 \frac{J}{gK}$ /

$p_{1,G} = \frac{m_{EW} \cdot 4}{D^2 \pi} \cdot g + p_0 + \frac{m_K \cdot 4}{D^2 \pi} \cdot g$ | $pA = F$

$= 1.4 bar$ //

~~$p_{g,1} V_{g,1}$~~ $p_{g,1} V_{g,1} = m_{g,1} \bar{R} T \Rightarrow m_g = \frac{p_{g,1} V_{g,1}}{\bar{R} T_{g,1}} =$ ~~3.493g~~

3.427 g //

b) ~~$0 = Ch_g$~~ $0 = C h_g - h_{EW})$

$p_{2,g} = p_{g,1} = 1.4 bar$ /, da das Gewicht (F_g) immer konstant ist, das drückt //

$T_2 \approx T_{EW,1}$ ~~weil~~

$= 0°C$, da ~~es noch Wasser~~

~~die Wärmekapazität & Masse von Wasser wesentlich grösser ist & die Schmelzenthalpie~~

es noch Eis hat, somit muss ~~T_2~~ $\approx T_{2,EW} = T_{1,EW}$ sein //

[redacted]

a) $\Delta E = E_{2,g} - E_{1,g} = -Q_{12}$

3c) (zu Eis ist pos.)

$$E_{2,g} - E_{1,g} = U_2 - U_1 = m_g (u_2 - u_1) = m_g c_v (T_{2g} - T_{1g})$$

$$= 1085\,J$$

(pos. zu Eis)

d) 3c) da p = const

$$Q_{12} = c_p m_g (T_{2,g} - T_{1,g}) \quad \Big| \; c_p = R + c_v = 0.799 \frac{J}{gK}$$

$$= 1369.3\,J$$

d) $U_{2,EW} - U_{1,EW} = Q_{12} = m_{EW} \big(x_1 u_{flüssig} + (1 - x_1) u_{fest} \big) - \big(x_2 u_{flüssig} + (1 - x_2) u_{fest} \big) \big)$

$$\frac{Q_{12}}{m_{EW}} = x_1 (u_{flüssig} - u_{fest}) + u_{fest} - u_{fest} - (x_2 (u_{flüssig} - u_{fest}))$$

$$= (x_1 - x_2)(u_{flüssig} - u_{fest})$$

$$x_2 = \frac{Q_{12}}{m_{EW}(u_{fest} - u_{flüssig})} + x_1$$

=

u_{fest}, $u_{flüssig}$ } at 0°C

3d) $u_{fest} = u_S$, $u_{flüssig} = u_L$ 2) 0,000 °C

$$U_{2,FW} - U_{1,FW} = -Q_{12} = m_{tol}\left(\left(x_2 u_L + (1-x_2)u_S\right) - \left(x_1 u_L + (1-x_1)u_S\right)\right) \qquad m_{tol} = 100\,g$$

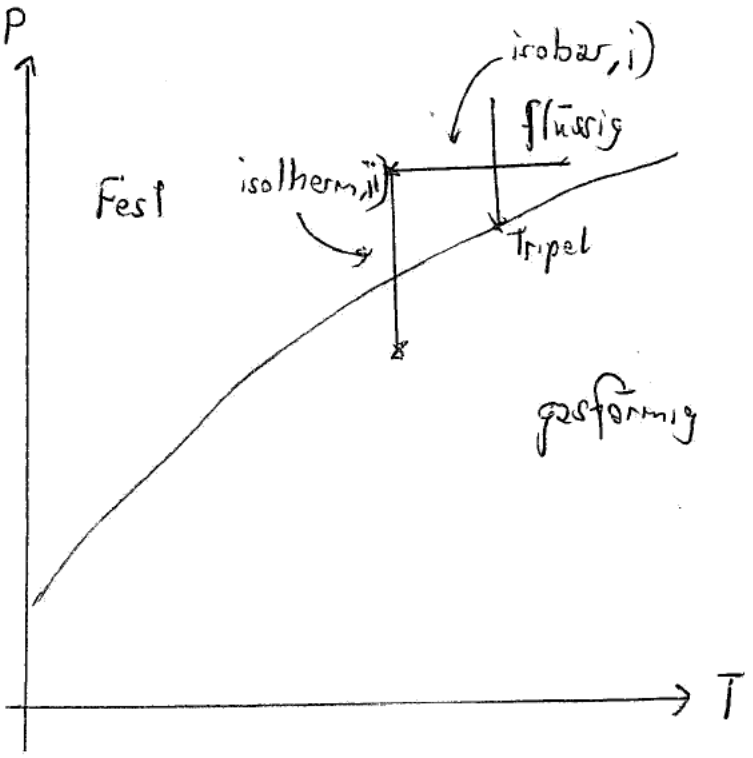
$$\frac{-Q_{12}}{m_{tol}} = x_2(u_L - u_S) + u_S - \left(x_1(u_L - u_S) + u_S\right)$$

$$= (x_2 - x_1)(u_L - u_S)$$

$$x_2 = \frac{-Q_{12}}{m_{tol}(u_L - u_S)} + x_1 = 0,574$$

(14:30)

4a)



b) $s_2 = s_3$, $T_i = -10\,°C$ (Abb. S)

$T_{ver} = -16\,°C$ / $= T_2$

$h_2 = 237.74 \frac{kJ}{kg}$ / (A-10)

$s_2 = s_3 = 0.9298 \frac{kJ}{kg\,K}$ / (A-10)

~~korrekt~~

$$h_3 = \frac{(273.66 - 264.15)\frac{kJ}{kg}}{(0.9374 - 0.9066)\frac{kJ}{kg\,K}} (0.9298 - 0.9066)\frac{kJ}{kg\,K} + 264.15\frac{kJ}{kg}$$

$= 271.31 \frac{kJ}{kg}$ /

$$0 = \dot{m}_{R134a}(h_2 - h_3) + \dot{W}_{II} \Rightarrow \dot{m}_{R134a} = \frac{-\dot{W}_{II}}{h_2 - h_3} = 3.00\frac{kg}{h}$$ //

4b)

4e) Die Temperatur wurde abnehmen, da durch den abgeführten Wärmestrom Energie dem System entzogen wird. (Bei konstantem Volumen)

4c) $h_4 \overset{x=1}{=} 93.42 \frac{kJ}{kg}$

(gesättigt. at $-76°C$)

$p_1 = p_2 = 1.5748 bar$

$0 = \dot{m}_{1234} (h_4 - h_1)$ (adiabat)

$\Rightarrow h_1 = h_4 = 93.42 \frac{kJ}{kg}$

h_f at $-76°C$, h_g at $-76°C$

$h_1 = (1-x) h_f + x h_g \Rightarrow h_f - x h_f + x h_g$

$\Rightarrow x(-h_f + h_g) = h_1 - h_f \Rightarrow x = \frac{h_1 - h_f}{-h_f + h_g} = 0.308$ //

4d) $0 = \dot{m}_{R134a}(h_1 - h_2) + \dot{Q}_K$

$\dot{Q}_K = -\dot{m}_{R134a}(h_1 - h_2) = 0.[illegible] \cdot 144.3 \frac{kJ}{h} = [illegible]$

$= 120.3\,W$

$\varepsilon_K = \frac{|\dot{Q}_K|}{|\dot{W}_A|} = 4.3$