6)

z	p	T
1		
2		
3	8	
4	8	

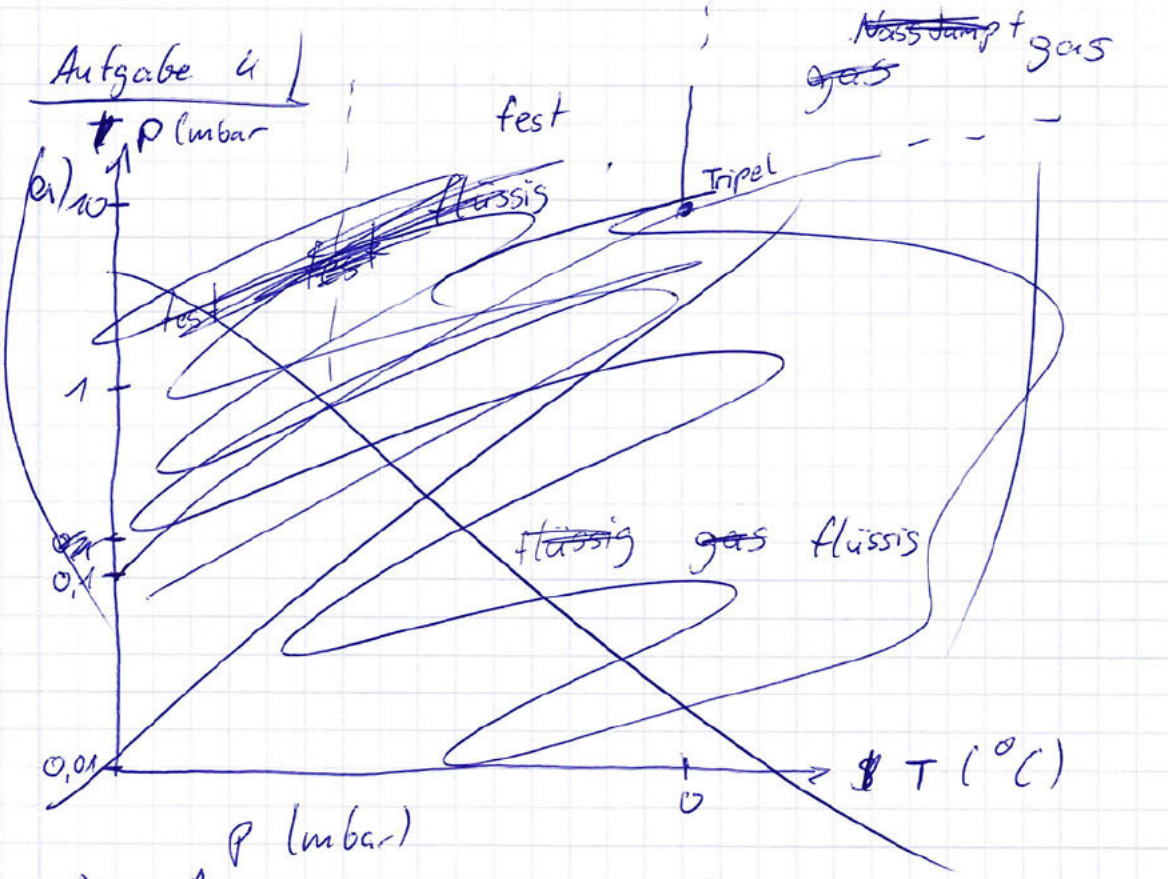
$0 = \dot{m}_{R134} (h_1 - h_2) + \dot{Q}_K$

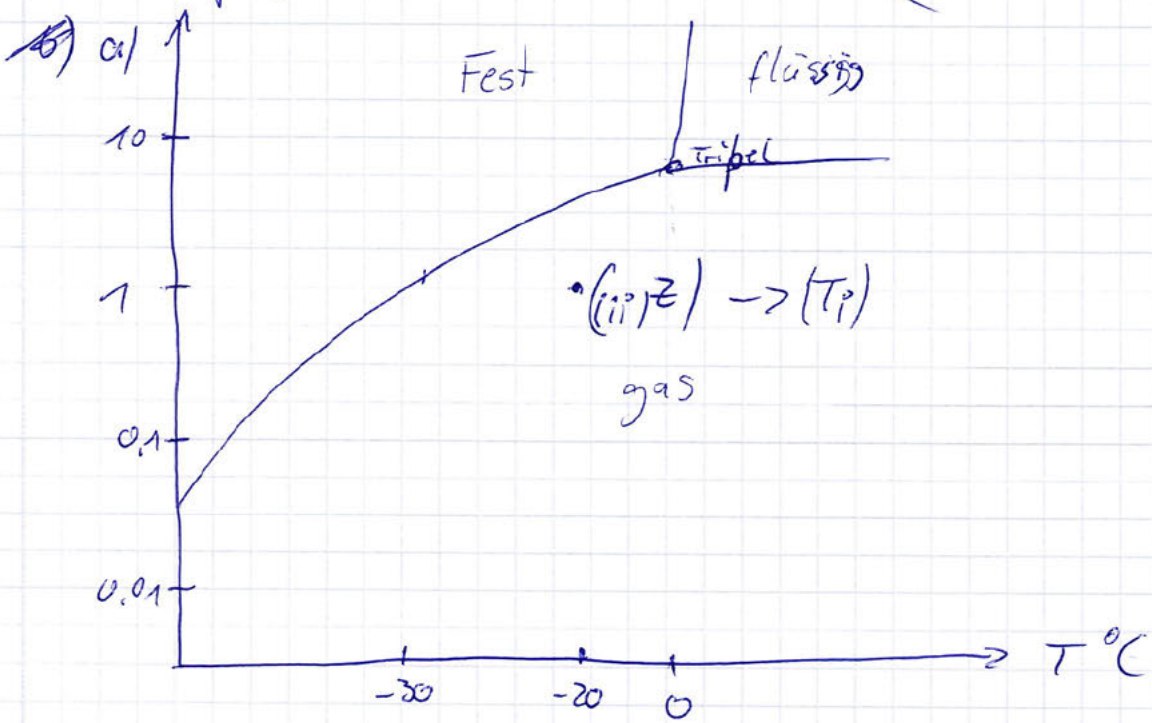
$\dot{m}_R = \frac{\dot{Q}_K}{h_2 - h_1}$

$h_2 = h_g$ (

8

Aufgabe 4


p (mbar)
fest
Tripel
flüssig
flüssig
T (°C)
10
1
0,1
0,01
0


p (mbar)
Fest
flüssig
Tripel
gas
T °C
10
1
0,1
0,01
-30
-20
0

~~zu b)~~

$p = p_2$

$(T_2 = 0{,}003\,°C$!$)$

$c_p = 0{,}633$

$\kappa_V = c_p - R$

$c_V = 0{,}46672$

a) $m(u_2 - u_1) = Q$

$m c_V (T_2 - T_1) = Q$

$Q_{12} = -1103\,J$

d)

$\Delta U = \Sigma Q$

$m_{Eis}(u_2 - u_1) = -Q_{12}$

$u_2 m_{EW} - u_1 m_{EW} = -Q_{12}$

$u_2 = \frac{-Q_{12} + u_1 m_{EW}}{m_{EW}}$

$u_2 = -18{,}9238$

$u_1 = -200{,}0928$ (siehe letzte Seite)

$u_{flüssig} = 0{,}045$

$u_{fest} = -333{,}458$

$u_2 = u_{flüss} + x_2 (u_{fest} - u_{flüssig})$

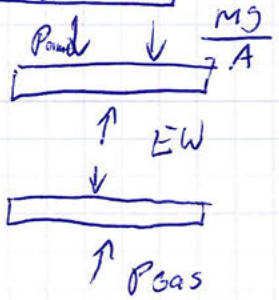
$x_2 = \frac{(u_2 - u_{flüssig})}{u_{fest} - u_{flüssig}}$

$x_2 = 0{,}05662$

$x_2 = 5{,}662\,\%$

Aufgabe 3

a)



$p_{amb} = 1\,bar$

$m = 32\,kg$

$$p_{Gas} = p_{amb} + \frac{mg}{A} \qquad A = \frac{D^2}{4}\pi$$

$$p_{Gas} = 1{,}399\,bar \approx \underline{1{,}4\,bar}$$

* Perfektes Gas

$$p_{Gas} V_G = mRT$$

$$m_{Gas} = \frac{p_{Gas} \cdot V_G}{RT}$$

$$m_{Gas} = \underline{3{,}42\,g}$$

$V_G = \underline{3{,}14\,L}$

$$R = \frac{\bar{R}}{M} = \frac{\cancel{166}}{166{,}28} \frac{J}{kg\,K}$$

b) $x_{Eis,2} > 0$

$x_{Eis,1} = 0{,}6$

$m_{EW} = 0{,}1\,kg$

$T_{EW} = 0\,^\circ C$

$T_{g,2}$???

Temperatur vom Gas wird kleiner, da Wärme in das EW fließt. Der Druck bleibt jedoch konstant, da das Equillibrium vom Außendruck abhängt.

↳ Das Equillibrium ist nun an einem anderen Punkt

$$p_{g,2} = p_{g,1} = \underline{1{,}399\,bar}$$

d) Geschlossenes System

$\Delta E = EQ - EW$

$\Delta U = EQ$

$m_2 (u_2 - u_1) = Q$

a)

(bei $p = 1{,}4\,bar$ (Tabelle 1))

$u_1 = u_{flüssig} + x_1 (u_{Fest} - u_{flüssig})$

$u_1 = \underline{-200{,}0928}$

($u_{flüssig} = -0{,}045$; $u_{Fest} = -333{,}458$)

$u_2 = u_{flüssig} + x_2 (u_{Fest} - u_{flüssig})$

(x_2 ???)

zu (d)

zu Aufgabe (3d)

b) st. Fließgr.

$$0 = \dot{m}\left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right) + \cancel{\dot{Q}}^{\,0} - \cancel{W}^{\,0} \qquad (p_4 = p_5 = p_1 \text{ !})$$

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

$$h_5 - h_6 = (T_5 - T_6)\, c_p \qquad \left[T_6 = T_5 \left(\frac{p_0}{p_5}\right)^{\frac{n-1}{n}}\right]$$

$$\dot{m}_{ges} = \dot{m}_K + \dot{m}_M \qquad \dot{m}_M = 5{,}293\, \dot{m}_K \qquad T_6 = \underline{328{,}07\ K}$$

$$\cancel{\dot{m}_K}\ \frac{\dot{Q}_B}{\dot{m}_K} = q_B = 1155\ \frac{kJ}{kg}$$

$p_1 = 0{,}56$ bar

$$T_1 = T_0\left(\frac{p_1}{p_0}\right)^{\frac{n-1}{n}} = \underline{320{,}055\ K}$$

$$0 = \dot{m}_{ges}\,(\ldots)$$

$$\left(\dot{m}_K h_4 + \dot{m}_M h_1 - \dot{m}_{ges} h_5 = 0\right)$$

Ansatz: $\cancel{0} = \dot{m}_{ges} h_5 - \dot{m}_{ges} h_6 + \frac{w_5^2}{2}\cancel{\dot{m}_{ges}} = \frac{w_6^2}{2}$

$$w_6^2 = 2(h_5 - h_6) + w_5^2$$

$$w_6 = \sqrt{2(h_5 - h_6) + w_5^2}$$

$$w_6 = \sqrt{2 c_p (T_5 - T_6) + w_5^2}$$

$$= \underline{220{,}474\ \frac{m}{s}}$$

c)

$$\Delta e_x = e_{x,6} - e_{x,0}$$

$$\Delta e_x = h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2}{2} - \left(h_0 - h_0 - T_0(s_0 - s_0) + \frac{w_0^2}{2}\right)$$

$h_6 - h_0 = c_p (T_6 - T_0)$

$= 85{,}429$

$s_6 - s_0 = \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)$

$= \underline{0{,}2995}$

↳ setze für $w_6 =$ ~~220,474~~ 510 $\frac{m}{s}$ ein!

Δe_x [alles eingesetzt]

$$\Delta e_x = \underline{130\ \frac{kJ}{kg}}$$

4

Aufgabe 2)

$w_{Luft} = 200 \frac{m}{s}$

$p_0 = 0{,}191$ bar

$T_0 = -30°C$

$q_B = \frac{\dot{Q}_B}{\dot{m}_K}$

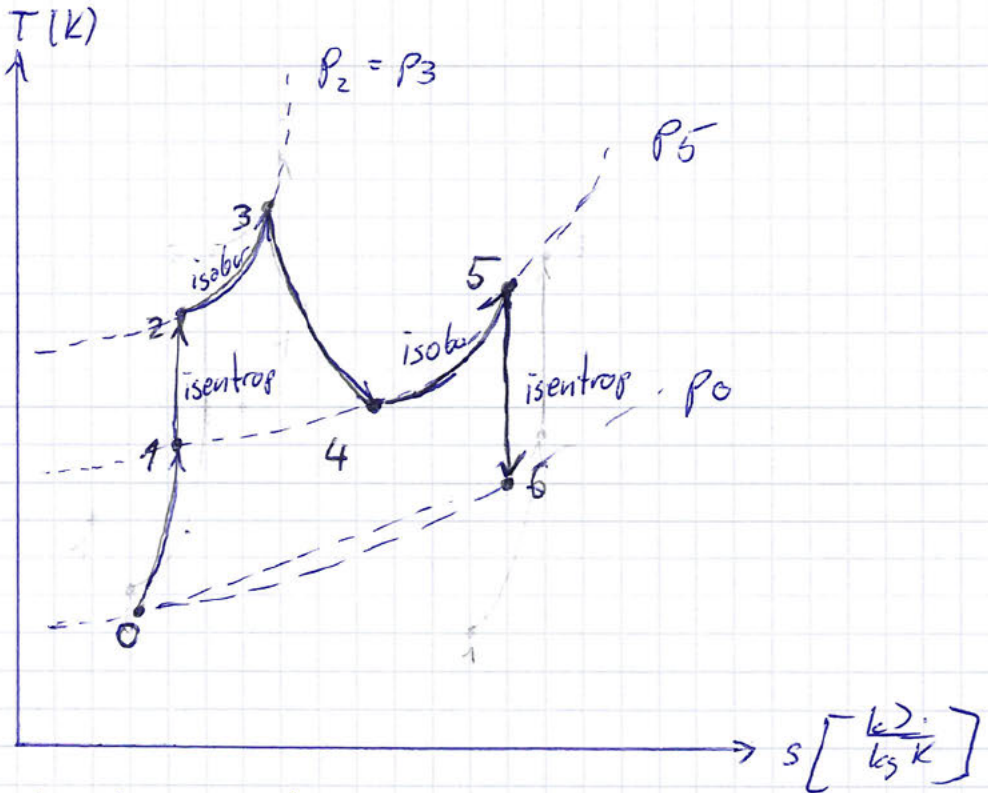
$c_{pL}^{ig} = c_{pL} = 1{,}006 \frac{kJ}{kg\,K}$

$n = 1{,}4$

$\dot{m}_{ges} = \dot{m}_K + \dot{m}_M$

$\frac{\dot{m}_M}{\dot{m}_L} = \underline{\underline{5{,}293}}$

a)



0 → 1 $\eta_{V,S} < 1$

1 → 2 isentrop

2 → 3 isobar ($\uparrow\uparrow T$)

3 → 4 $\eta_{T,S} < 1$

4 → 5 isobar $p_1 = p_4 = p_5 = 0{,}5$ bar

5 → 6 isentrop

Halboffen!

$$\Delta E = m_2 u_2 - m_1 u_1 = \Delta m_{12} h_{ein} + \Sigma Q \qquad \rightarrow \Sigma Q = -Q_{aus}$$

$$\Delta m_{12} + m_1 u_2 - m_1 u_1 = \Delta m_{12} h_{ein} + \Sigma Q$$

$$\Delta m_{12} u_2 + m_1 u_2 - m_1 u_1 = \Delta m_{12} h_{ein} + \Sigma Q$$

$$\Delta m_{12} = \frac{m_2 u_2 - m_1 u_1 - \Sigma Q}{h_{ein}}$$

$$h_{ein} = h_g(20°C) = 2538{,}1 \frac{kJ}{kg}$$

$$\Delta m_{12} = \frac{(\Delta m_{12} + m_1) u_2 - m_1 u_1 - \Sigma Q}{h_{ein}} \qquad m_1 = 5755\,kg$$

$$m_2 = \Delta m_{12} + m_1$$

$$\Sigma Q = -35MJ = -Q_{aus,12}$$

$$\Delta m_{12} = \frac{u_2 + m_1 u_2 - m_1 u_1 + Q_{aus}}{h_{ein} - u_2}$$

$$u_2 = u_g(70°C) = 2469{,}6 \qquad \text{Tab. (T+Z)}$$

$$u_1 = u_f + x(u_g - u_f) \quad \text{bei } 100°C$$

$$u_f = 418{,}94 \qquad u_g = 2506{,}5$$

$$u_1 = 429{,}38$$

$$\Delta m_{12} = 17{,}1955\,kg \quad (??)$$

2

Aufgabe 1

a)

$\dot{m}_{ein} = \dot{m}_{aus} = 0{,}3 \frac{kg}{s}$

stationärer Fließpr.

$\Sigma \dot{Q} = \dot{Q}_R - \dot{Q}_{aus}$

($\dot{Q}_{aus}$ ist negativ definiert!)

$0 = \dot{m}_{ein} (h_{ein} - h_{aus}) + \Sigma \dot{Q}$

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

$h_{ein} = h_g (70°C) = 2626{,}8 \frac{kJ}{kg}$

$h_{aus} = h_g (100°C) = 2676{,}1 \frac{kJ}{kg}$ (Tab A-2)

$\dot{Q}_{aus} = 85{,}21\ kW$

b) $\bar{T} = \frac{\int_e^a T\, ds}{s_a - s_e}$ ideales Fluid

$\bar{T} \approx \frac{T_{ein} + T_{aus}}{2} \approx 293{,}15\ K$

c) $0 = \dot{m} (s_e - s_a) + \frac{-\dot{Q}}{\bar{T}_V} + \dot{s}_{erz}$ (zwischen Wasser und Kühlmittel ≠ Gesamtentropie ?)

$\dot{s}_{erz} = \dot{m}_{ein} (s_{aw} - s_{ew}) + \frac{\dot{Q}}{\bar{T}}$ kW

$s_{aw} = s_g (70°C) = 7{,}7553 \frac{kJ}{kg\,K}$

$s_{ew} = 7{,}3549 \frac{kJ}{kg\,K}$ (Tab A3)

$\dot{s}_{erz} = 0{,}41 \frac{kW}{K}$

d) $\dot{m} = 0$ $T_{1r} = 100°C$

$T_{2r} = 20°C$

ΔM_{12} $T_{ein,12} = 20°C$

$Q_{R,12} = 35\ MJ$