Aufgabe 1

a) stationärer Fliessprozess mit $\dot{m}$

$$0 = \dot{m}[h_e - h_a] + \dot{Q} - W$$

$$\dot{Q} = \dot{m}[h_a - h_e]$$

$$\dot{Q}_{Gas} = \dot{m}_{Gas} \cdot c$$

$$\dot{Q}_R + \dot{Q}_{Gas} + \dot{Q}_{ein} = 0$$

$$\dot{Q}_{ein} = \dot{m}[h_a - h_e] = \dot{m}[$$

$\Delta T = 10K$

$$\dot{Q} = \dot{m}[h_a - h_e] = \dot{m}\, c(\Delta T)$$

A1

b) $\bar{T}_{kF}$ ideale Flüssigkeit

$$\bar{T}_{kF} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{\Delta h}{c^{if}\left(\ln\left(\frac{T_2}{T_1}\right)\right)} = \frac{c^{if}(T_2 - T_1)}{c^{if}\ln\left(\frac{T_2}{T_1}\right)}$$

$$= \frac{(T_2 - T_1)}{\ln(T_2/T_1)} = \frac{298.15\,K - 288.15\,K}{\ln\left(\frac{298.15\,K}{288.15\,K}\right)}$$

$$\underline{\bar{T}_{kF} = 293.12\,K}$$

c) $\dot{S}_{erz}$ $\quad \bar{T}_R = \frac{70°C + 100°C}{2} = 85°C$

↖ brauchen wir nicht

~~$0 = \dot{m}[s_e - s_a] + \sum \frac{\dot{Q}_j}{T_j} + \dot{S}_{erz}$~~

$=$

s_e: $s_e(70°C) = 7.7553 \frac{kJ}{kg\,K}$

s_a: $s_a(100°C) = 7.3549 \frac{kJ}{kg\,K}$

TAB - A-Z

TAB A.-Z

~~$\dot{S}_{erz} = \dot{m}[s_a - s_e] =$~~

$$\frac{dS}{dt} = \sum \frac{\dot{Q}}{T} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = -\frac{\dot{Q}}{T} = 0.221 \frac{kW}{K} = \dot{S}_{erz}$$

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

A1

[redacted]

d) Adiabates System

$\Delta E^{\nearrow 0} = \Delta m_i [h_i] + Q \overset{\nearrow 0}{\not\rightarrow}$

$Q = -\Delta m_i [h_i]$

TAB A-2

$h_E = h_f + x(h_g - h_f) = 83.96 \frac{kJ}{kg}$ @ 20°C

$h_A = h_f + x(h_g - h_f) =$ @ 70°C

$h_A = 292.98 \frac{kJ}{kg} + 0.005 \left[2626.8 \frac{kJ}{kg} - 292.98 \frac{kJ}{kg} \right]$

$h_A = 304.649 \frac{kJ}{kg}$

$\Delta m_{12} = \frac{Q_{12}}{h_A - h_E} = \underline{158.50 kg = \Delta m_2}$

e) ich verwende $\Delta m_{12} = 3600 kg$ von Lsg-Vorschlag

$\Delta S_{12} = m_2 s_2 - m_1 s_1$

$m_1 = 5755 kg$

$m_2 = 9355 kg$

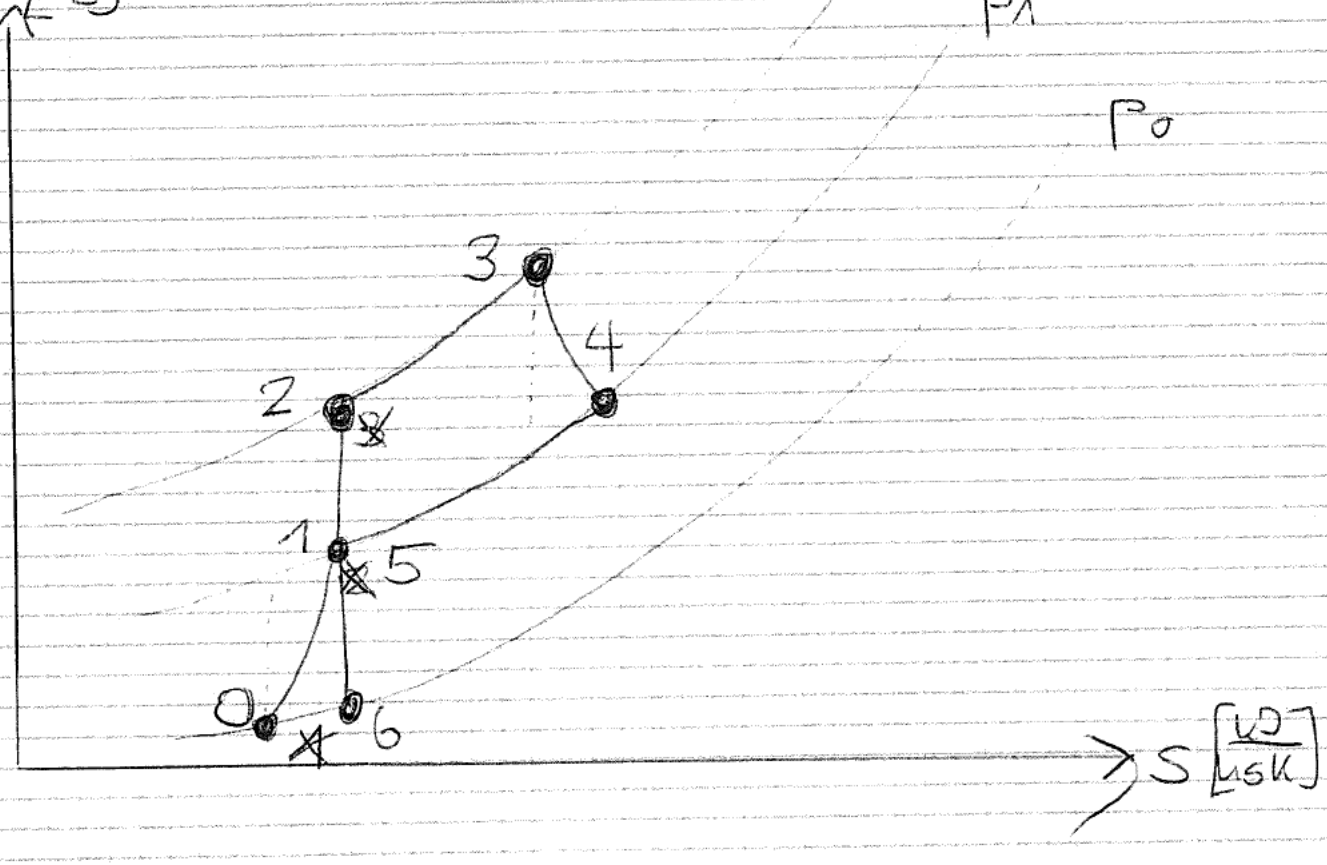
$\underline{\Delta S_{12} = 7226.16 \frac{kJ}{K}}$

$s_1 = 0.2966 \frac{kJ}{kg K}$

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

Aufgabe 2

a)



b) $\dot{w}_5 = 220 \frac{m}{s}$, $p_5 = 0.5\,bar$ $T_5 = 431.9K$

$p_6 = 0.191\,bar$

$-w_6 = 510 \frac{m}{s}$, $T_6 = 340K$

c) $\Delta e_{x,str} = e_{x,str,6} - e_{x,str,0}$

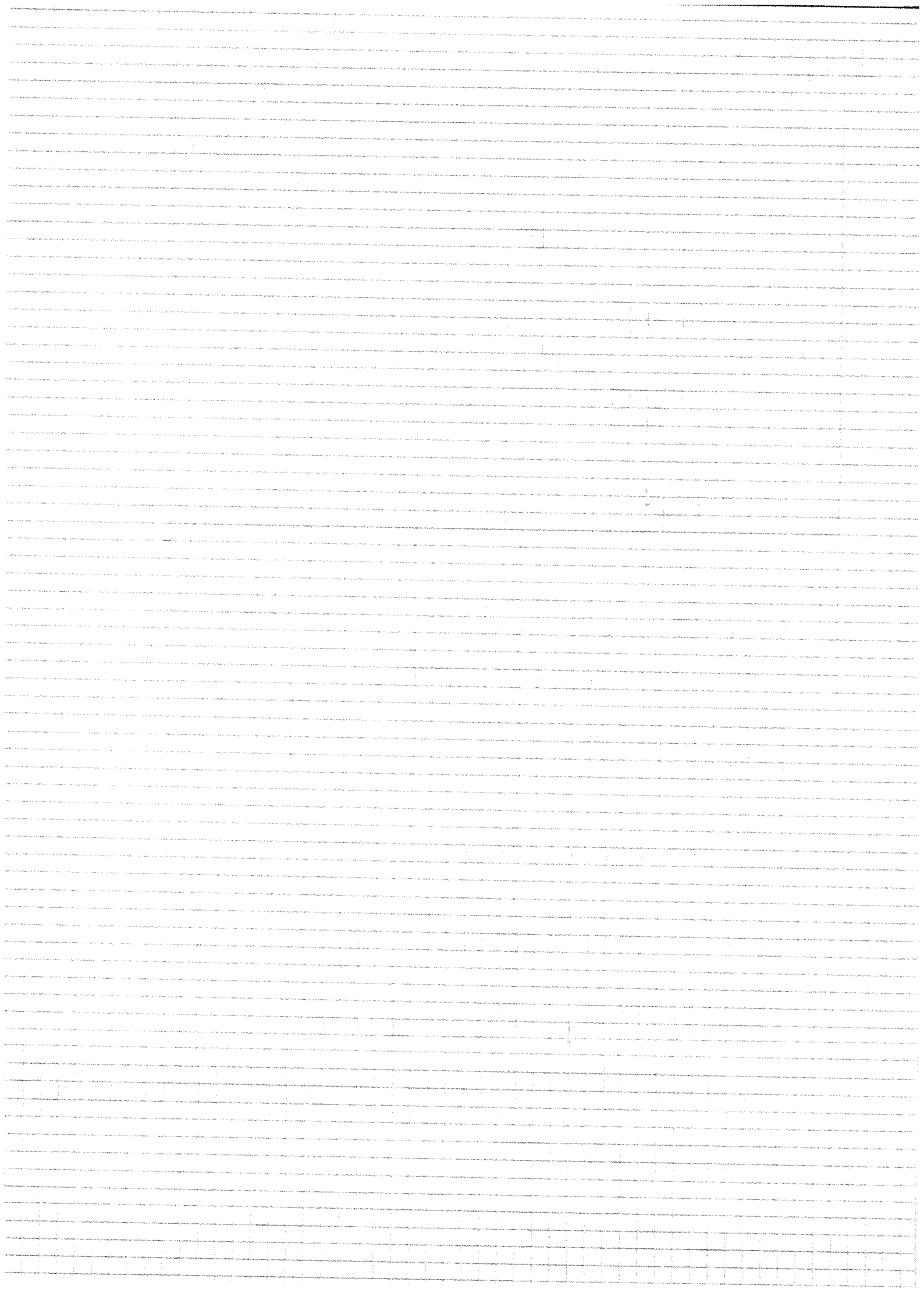
$e_{x,str,6} = [h - h_0 - T_0(s - s_0) + ke]$

$= \left(c_p^{i0}(T_6 - T_0) - T_0(s_6 - s_0) + ke\right)$

$= 1.006 \frac{kJ}{kgK}(340K - \cancel{431.9K}\ 243.15K) - 243.15K\left(4.006 \frac{kJ}{kgK} \ln\left(\frac{340}{243}\right)\right)$

$+ \frac{1}{2} \cdot \left(510 \frac{m}{s}\right)^2$

$e_{x,str,6} = \cancel{270 \frac{kJ}{kg}} = 65.04 kJ/kg$



A2

c) Fortsetzung

$$e_{x,str,0} = \left[c_p^{is}(T_0) - T_0(s_0) + k_c\right]$$

$$= 1.006 \frac{kJ}{kgK}(243.15K) - 243.15K(0) + \frac{1}{2}(200\frac{m}{s})^2$$

$$e_{x,str,0} = -19.755 \frac{kJ}{kg}$$

$$e_{x,str,6} - e_{x,str,0} = 85 \frac{kJ}{kg}$$

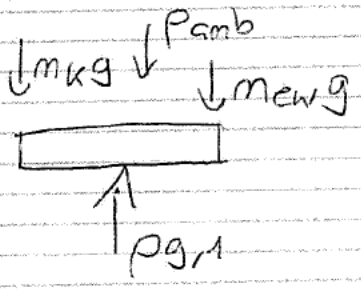
$$\Delta e_{x,str} = 85 \frac{kJ}{kg}$$

[illegible]

Aufgabe 3

a) $p_{g,1}$ & m_g

$$A = \left(\frac{D}{2}\right)^2 \pi_1 = 7.85 \cdot 10^{-3}\ m^2$$



$$= p_{g,1} A = m_{kg} g + m_{EW} g + p_{amb} A$$

$$p_{g,1} = g\left(\frac{m_K + m_{EV}}{A}\right) + p_{amb}$$

$$= 9.81 \frac{m}{s^2}\left(\frac{32kg + 0.1kg}{7.85 \cdot 10^{-3} m^2}\right) + 1bar$$

$$\underline{p_{g,1} = 1.401bar}$$

$$pV = mRT \rightarrow m_g = \frac{p_1 V_1}{R T_1} = \frac{p_1 V_1 M_g}{R T_1} \qquad T_1 = 773.15K$$

$$m_g = \frac{1.4bar \cdot 3.14 \cdot 10^{-3} m^3 \cdot 50 \frac{kg}{kmol}}{8314 \frac{J}{kmol\,K} \cdot 773.15K} = 0.0034kg$$

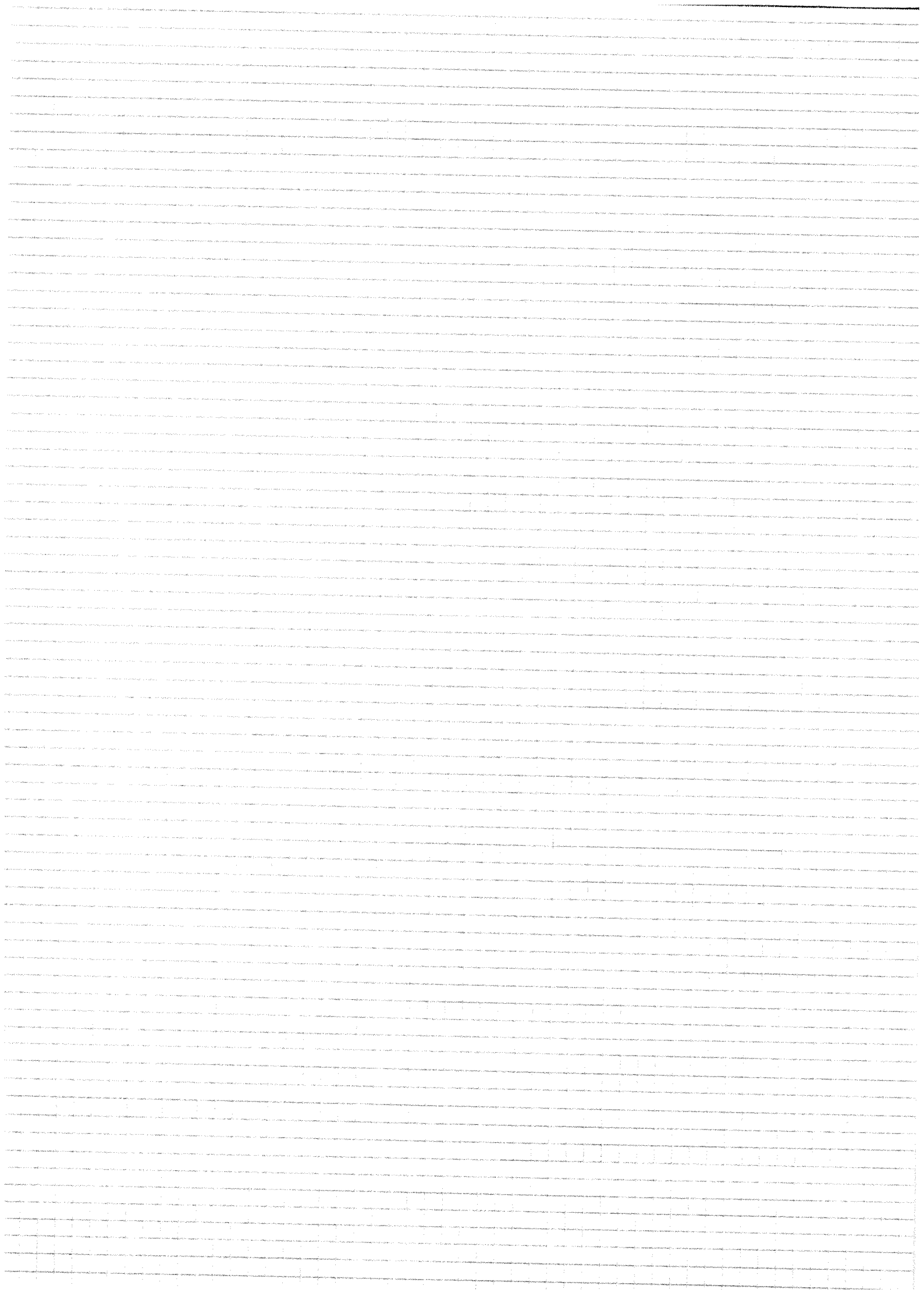
$$\underline{m_g = 3.42g}$$

b) $p_{g,2} = p_{g,1}$ ~~die es druckt~~ die Gleichung von Teilaufgabe a) gilt immer noch $p_{g,1} A = m_{kg} + m_{EW} g + p_{amb} A$

$$\underline{p_{g,2} = 1.401bar}$$

$$\underline{T_{g,2} = T_{EW_2} = 0°C}$$

$x_{Eis,2} > 0$, d.h. dass die Temperatur des EW-Gemisches noch nicht gestiegen ist.



A3

c) $T_{g,1} = 500°C = 773.15K$
$T_{g,2} = 0°C = 273.15K$
$\Rightarrow \Delta T = 500K$

$$\Rightarrow V_2 = \frac{mRT_2}{M p_2} = \frac{3.425 \cdot 8314 \frac{J}{kmol\,K} \cdot 273.15K}{50 \frac{kg}{kmol} \cdot 1.401 bar}$$

$V_2 = 0.0011 \Rightarrow V_2 = 1.108L$

$$W_{12} = \int_1^2 p\,dV = 1.401 bar (V_2 - V_1)$$

$$Q_{12} = c_v \cdot m \cdot \Delta T = 0.633 \frac{kJ}{kg\,K} \cdot 3.425 \cdot 500K$$

$$\underline{Q_{12} = 1.08 kJ}$$

d) $u = u_s + x(u_f - u_s)$ ← TAB. 1. S. 7 Entwurfsbogen

$$x = \frac{u - u_s}{u_f - u_s} \Rightarrow x = \frac{(-315.789 + 333.458)\frac{kJ}{kg}}{(-0.045 + 333.458)\frac{kJ}{kg}}$$

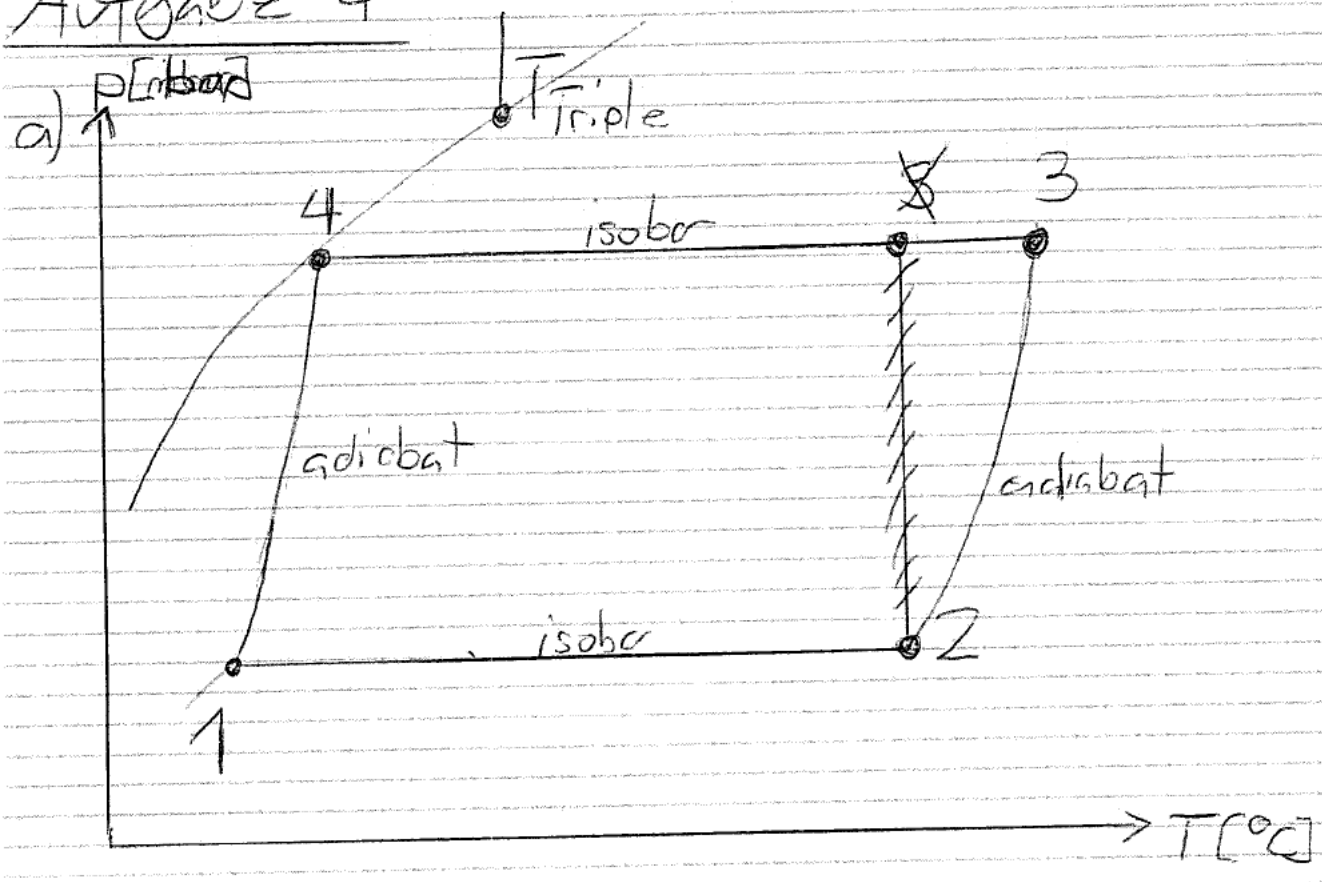
$$u = \frac{-Q_{12}}{m_g} = -315.789 \frac{kJ}{kg}$$

$x = 0.0529 \Rightarrow x_{Eis,1} = 5.3\%$

$$\underline{x_{Eis,2} = 5.29\%}$$

Aufgabe 4

a)



b) $\dot{m}_{R134a}$ Stationärer Fliessprozess mit $\dot{m}$

$$0 = \dot{m}[h_2 - h_3] + \dot{Q} - \dot{W} \qquad 2 \to 3$$

$$\dot{m} = \frac{\dot{W}_k}{h_2 - h_3} = \frac{\dot{W}_k}{h_2 - h_3}$$

TAB A-12

Saturated
h_3(8bar) = 264.15 $\frac{kJ}{kg}$

Saturated
h_2(~~251~~. 1bar) = 231.35 $\frac{kJ}{kg}$

$\dot{m}$ =

A4

c) $\dot{m} = 4 \frac{kg}{h}$

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