

Thermo I 2024

Aufgabe 1

a) \dot{Q}_{aus} ?

1. HS: $0 = \dot{m}(h_e - h_a) + \dot{S}_{\text{Q}} - \dot{S}_{\text{gen}}$

$$\dot{Q}_{\text{aus}} = \dot{m}(h_a - h_e) \stackrel{!}{=} \dot{Q}_{\text{R}}$$

$$\begin{aligned} h_e &= h_f(70^\circ\text{C}, x=0) = 292,98 \text{ kJ/kg} \\ h_a &= h_f(100^\circ\text{C}, x=0) = 419,04 \text{ kJ/kg} \end{aligned} \quad \left. \begin{array}{l} \text{Sieded} \\ \text{Tab. A-2} \end{array} \right\}$$

$$\begin{aligned} \dot{Q}_{\text{aus}} &= 0,3 \text{ kg/s} (419,04 - 292,98) \text{ kJ} - 100 \frac{\text{kJ}}{\text{s}} \\ &= -62,18 \frac{\text{kJ}}{\text{s}} \text{ (kW)} \end{aligned}$$

b) $\bar{T}_{\text{KF}} = \frac{\int_e^a T \, ds}{s_a - s_e} \quad \int_e^a T \, ds = h_a - h_e \quad (1. \text{ HS})$

$$= \frac{h_a - h_e}{s_a - s_e} \rightarrow \text{KF} = \text{ideale Flüssigkeit?}$$

$$h_a - h_e = c_{\text{KF}} (T_2 - T_1)$$

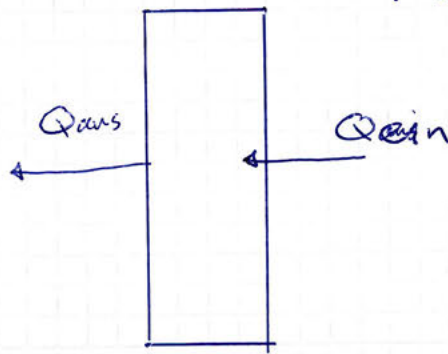
$$s_a - s_e = c_{\text{KF}} \cdot \ln\left(\frac{T_2}{T_1}\right)$$

$$\begin{aligned} \bar{T}_{\text{KF}} &= \frac{c_{\text{KF}} (T_2 - T_1)}{c_{\text{KF}} \ln\left(\frac{T_2}{T_1}\right)} = \frac{(298,15 \text{ K} - 288,15 \text{ K})}{\ln\left(\frac{298,15}{288,15}\right)} \\ &= \underline{\underline{293,12 \text{ K}}} \end{aligned}$$

c Serz

Wärmeübertragung über Kühlwand!

adiabert



$$0 = \sum \cancel{m_i s_i} + \sum \frac{Q_i}{T_i} + \dot{S}_{\text{Serz}} \quad \underline{Q_{\text{aus}} = Q_{\text{ein}} = 65 \text{ kW}}$$

$$\begin{aligned} T_{\text{min reaktor}} &= 100^\circ\text{C} = 373,15 \text{ K} \\ T_{\text{KF}} &= 293,12 \text{ K} \end{aligned}$$

$$\begin{aligned} \dot{S}_{\text{Serz}} &= \frac{Q_{\text{aus}}}{T_{\text{KF}}} - \frac{Q_{\text{ein}}}{T_{\text{reaktor}}} = 65 \text{ kW} \left(\frac{1}{293,12 \text{ K}} - \frac{1}{373,15 \text{ K}} \right) \\ &= \underline{\underline{0,04 \text{ kJ/K}\cdot\text{s}}} \end{aligned}$$

a

$$\begin{aligned} 1: & 5755 \text{ kg} / 0,005 / 100^\circ\text{C} \\ 2: & 70^\circ\text{C} / x=0 \end{aligned} \quad \left. \begin{array}{l} \Delta m_{12} = 20^\circ\text{C} / x=0 \\ Q_{\text{aus},12} = 35 \text{ MJ} \end{array} \right\}$$

Halb offenes System:

$$\Delta E = m_2 u_2 - m_1 u_1 = \Delta m_i h_i + Q_j - \cancel{W_n}$$

$$m_2 = m_1 + \Delta m$$

$$u_2 = u(70^\circ\text{C}, x=0) = 292,95 \text{ kJ/kg} \quad [\text{TAB A2}]$$

$$m_1 = 5755 \text{ kg}$$

$$\begin{aligned} u_1 &= u(100^\circ\text{C}, x=0,005) = \cancel{u_f} u_f + x(u_g - u_f) \\ &= 418,96 \text{ kJ/kg} + 0,005 \cdot (2506,5 - 418,94) \\ &= \underline{\underline{429,3728 \text{ kJ/kg}}} \quad [\text{TAB A2}] \end{aligned}$$

$$h_i = h(20^\circ\text{C}, x=0) = h_f = 83,96 \text{ kJ/kg}$$

$$\sum Q_j = Q_{R12} - Q_{\text{aus},12} = 0$$

next page

d continuous

$$(m_1 + \Delta m) u_2 - \Delta m h_i = m_1 u_1$$

$$m_1 u_2 + \Delta m u_2 - \Delta m h_i = m_1 u_1$$

$$\Delta m = \frac{m_1 u_1 - m_1 u_2}{u_2 - h_i}$$

$$= \frac{5755 \text{ kg} (429,3778 - 292,95 \text{ kJ/kg})}{292,95 - 83,96 \text{ kJ/kg}}$$

$$= \underline{\underline{3765,1 \text{ kg}}}$$

e,halb offe ΔS

$$\Delta S_{12} = m_2 s_2 - m_1 s_1 \quad \rightarrow \Delta m_2 = 3600 \text{ kg}$$

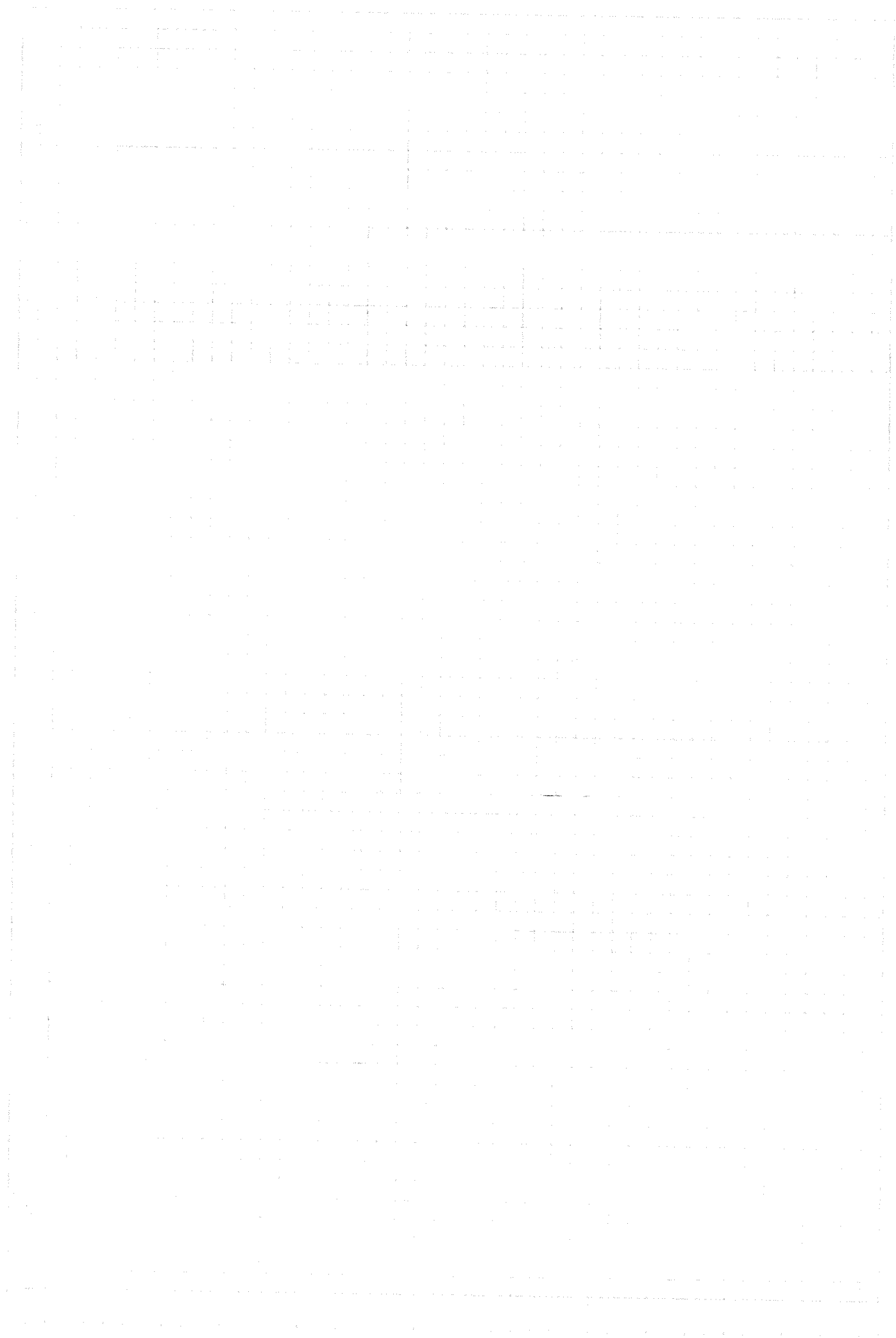
$$m_2 = 9355 \text{ kg}$$

$$m_1 = 5755 \text{ kg}$$

$$s_2 = s(70^\circ\text{C}, x=0) = 0,9549 \text{ kJ/kg}\cdot\text{K}$$

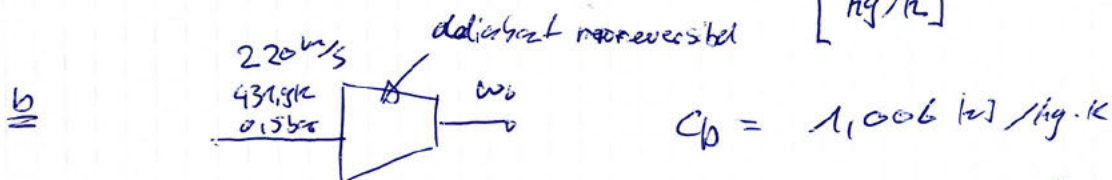
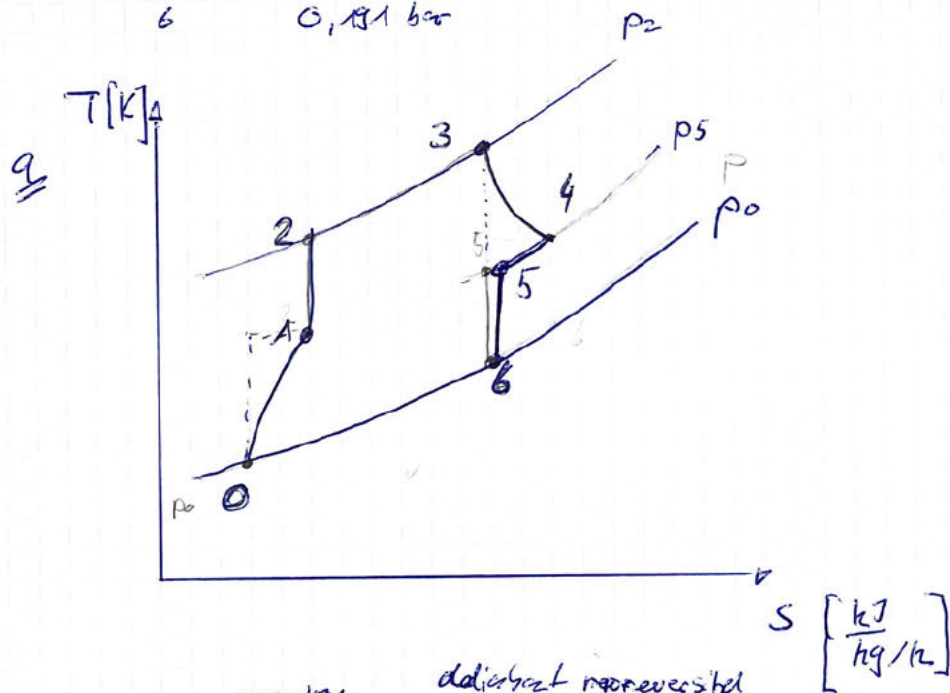
$$\begin{aligned} s_1 &= s(100^\circ\text{C}, x=0,005) = s_f + x(s_g - s_f) \\ &= 1,3069 \frac{\text{kJ}}{\text{kg}\cdot\text{K}} + 0,005(7,3549 - 1,3069) \\ &= \underline{\underline{1,337 \text{ kJ/kg}\cdot\text{K}}} \end{aligned}$$

$$\begin{aligned} \Delta S_{12} &= 9355 \text{ kg} \cdot 0,9549 \text{ kJ/kg}\cdot\text{K} - 5755 \text{ kg} \cdot 1,337 \text{ kJ/kg}\cdot\text{K} \\ &= \underline{\underline{2984,146 \text{ kJ/K}}} \\ &= \underline{\underline{1238,65 \text{ kJ/K}}} \end{aligned}$$



Aufgabe 2 (ideales Gas, Luft)

<u>a</u>	0	0,191 bar	-30 °C	
	1			$s_1 = s_2$
q_B	2	$p_2 = p_3$		$s_2 = s_1$
	3	$p_3 = p_2$		
	4			
	5	0,5 bar	431,9 K	
	6	0,191 bar		



Ans: $0 = m(h_e - h_a + \frac{w_e^2 - w_a^2}{2}) + \dot{Q}_i - \dot{E}_{w0}$

$$w_a^2 = h_e - h_a + \frac{w_e^2}{2}$$

$$w_a = \sqrt{h_5 - h_0 + \frac{w_e^2}{2}} = \sqrt{c_p (T_5 - T_0) + \frac{w_e^2}{2}}$$

$$\frac{T_0}{T_5} = \left(\frac{p_0}{p_5} \right)^{\frac{\gamma-1}{\gamma \cdot T_5}} = \left(\frac{p_0}{p_5} \right)^{\frac{\gamma-1}{\gamma \cdot T_5}} = \left(\frac{0,191}{0,5} \right)^{\frac{0,4}{1,4}} \cdot 431,9 \text{ K}$$

$$= \underline{\underline{328,07 \text{ K}}}$$

$$w_a = \sqrt{1,006 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} (431,9 - 328,07) + \frac{220^2 \text{ m}^2/\text{s}^2}{2}} = \underline{\underline{682,79 \text{ m/s}}}$$



c// ΔE_{xst}

$$0 = \dot{m} (h_e - h_a - T_0 (s_e - s_a)) + \frac{W_e^2}{2} - \frac{W_a^2}{2} = -\Delta E_{xst}$$

$$T_0 = 243,15 \text{ K}, T_6 = 340 \text{ K}, \cancel{E}$$

$$\cancel{h_a} h_0 - h_6 = c_p (T_0 - T_6) = 1,006 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} (243,15 \text{ K} - 340 \text{ K}) = -97,43 \frac{\text{kJ}}{\text{kg}}$$

$$(s_e - s_a) = c_p \cdot \ln \left(\frac{T_0}{T_6} \right) - R \ln \left(\frac{p_e}{p_0} \right)$$

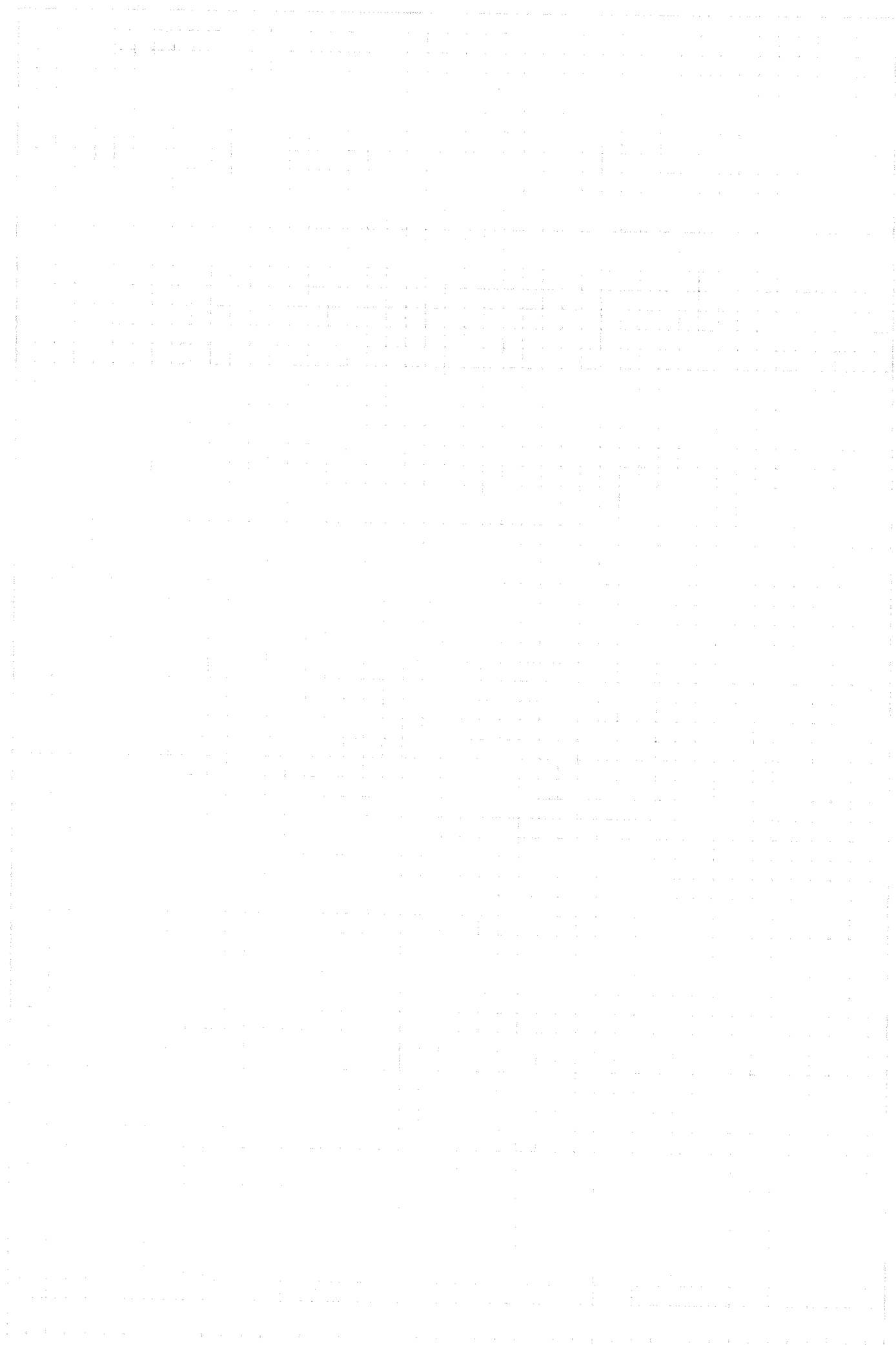
$$= c_p \cdot \ln \left(\frac{T_0}{T_6} \right) = 1,006 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} \cdot \ln \left(\frac{243,15}{340} \right) = -0,33$$

$$\Delta E_{xst} = -\dot{m} \left(c_p (h_0 - h_6) - T_0 \left(c_p \ln \left(\frac{T_0}{T_6} \right) + \frac{W_e^2}{2} - \frac{W_a^2}{2} \right) \right)$$

d// Ex verl:

$$0 = \underbrace{\dot{m} (-\Delta E_x)}_{100 \text{ kJ/kg} \rightarrow \text{Aufgabe c}} + \frac{1 - T_0}{T_0} \dot{Q}_J - \dot{E}_{x \text{ verl}}$$

$$\begin{aligned} \dot{E}_{x \text{ verl}} &= 100 \text{ kJ/kg} + \left(1 - \frac{243,15 \text{ K}}{1289 \text{ K}} \right) 1195 \frac{\text{kJ}}{\text{kg}} \\ &= \underline{\underline{1069,58 \text{ kJ/kg}}} \end{aligned}$$



Aufgabe 3

a $F_1 = m_K \cdot g + m_{ew} \cdot g + p_0$
 $= 32 \text{ kg} \cdot 9,81 \text{ m/s}^2 + 0,1 \text{ kg} \cdot 9,81 \text{ m/s}^2$
 $= 314,901 \frac{\text{kg} \cdot \text{m}}{\text{s}^2} + 1 \cdot 10^{-5} \text{ Pa}$

$$p_g \cdot A = F_1 \quad A = r^2 \pi = 0,05 \text{ m}^2 \pi = \underline{0,007854 \text{ m}^2}$$
$$p_g = \frac{314,901 + 1 \cdot 10^{-5} \text{ Pa}}{A} = \underline{1,4 \text{ bar}}$$

$$m_g = \frac{pV}{RT}$$
$$= \frac{1,5 \cdot 10^5 \cdot 3,14 \cdot 10^{-3}}{16628 \cdot 773 \text{ K}}$$

$$= \underline{3,664 \text{ g}}$$

$$p_g = 1,5 \text{ bar}$$

$$T = 773 \text{ K}$$

$$V = 0,314 \cdot 10^{-3} \text{ m}^3$$

$$R = \frac{pV}{nT} = R = \cancel{cp - cv}$$

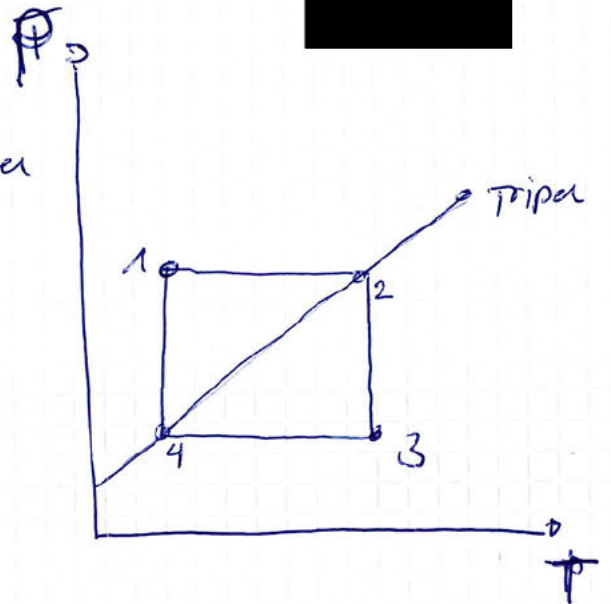
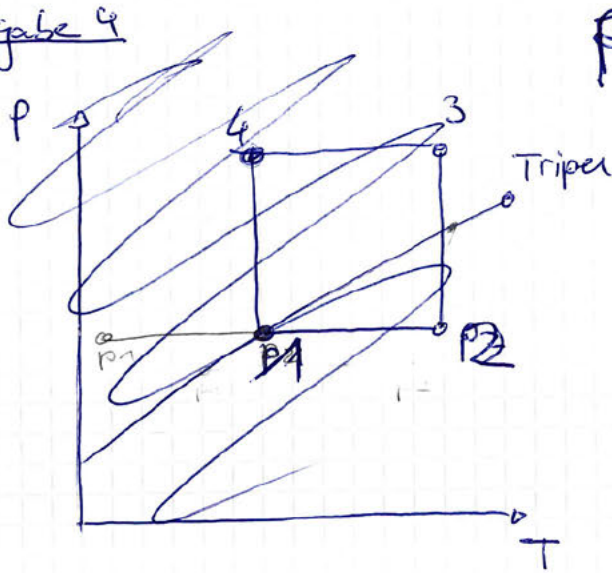
$$= \frac{R}{M} = \frac{8,314 \text{ kJ/kmol}}{50 \frac{\text{kg}}{\text{kmol}}} = \underline{166,28 \text{ J/mol}}$$

b

Handwritten text on lined paper, mostly illegible due to extreme fading. The text appears to be organized into several paragraphs or sections, with some lines being more prominent than others. The handwriting is cursive and somewhat slanted. There are some faint markings that could be interpreted as numbers or small symbols, but they are not clear enough to transcribe accurately. The overall appearance is that of a very old or poorly preserved document.

Aufgabe 4

a //



$$T_1 = 5^\circ\text{C}$$

1	$p_2 = p_1$		
2	$p_2 = p_1$	$x_2 = 1$	
3	sber		$w = 28 \text{ W}$
4	sber	$x = 0$	

b m

$$c \quad x_1 = \frac{m_D}{m_D + m_F}$$

$$d \quad \epsilon_k = \frac{|\dot{Q}_{zu}|}{\dot{W}_k} = \frac{|\dot{Q}_k|}{\dot{W}_k}$$

