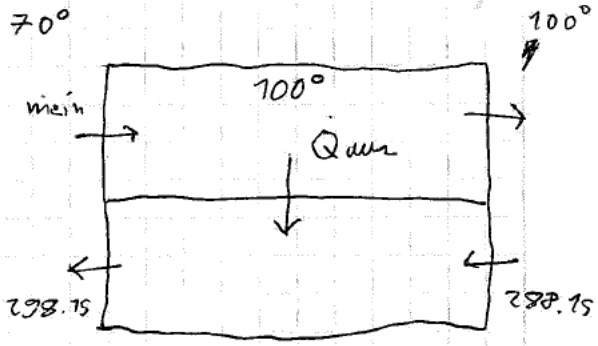
22-939-939

A1

a)



Stationäre KF:

$$0 = \dot{m}_{KF}\,[h_{ein} - h_{aus}] + \dot{Q}_{aus}$$

$$\dot{Q}_{aus} = \dot{m}_{KF}\,[h_{aus} - h_{ein}]$$

$$\dot{Q}_{aus} = \dot{m}_{KF}\, c\, (T_{aus} - T_{ein})$$

$$0 = \dot{m}_{ein}\,[h_{ein} - h_{aus}] + \dot{Q}_R - \dot{Q}_{aus}$$

$$\dot{Q}_{aus} = \dot{m}_{ein}\,[h_e - h_{aus}] + \dot{Q}_R$$

$h_{aus} = h_f(100°C) = 419.04$

$h_e = h_f(70°C) + x \cdot (h_g(70°) - h_f(70°)) =$

b) $$\overline{T} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{h_a - h_e}{s_a - s_e} = \frac{c\,(T_a - T_e)}{c\,\ln\left(\frac{T_a}{T_e}\right)}$$

$$\int_e^a T\,ds = q$$

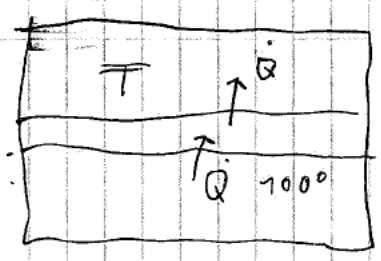
$$= \frac{298.15\,K - 288.15\,K}{\ln\left(\frac{298.15\,K}{288.15\,K}\right)}$$

1HS: $q = h_a - h_e$

$$= 293.12\,K$$

22-934-939

A7



c) 2. HS:

$$0 = \frac{\dot{Q}_{aus}}{T} - \frac{\dot{Q}_{ein}}{\overline{T}} + \dot{S}_{erz}$$

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

$$= \frac{65kW}{293.72k} - \frac{65kW}{373.75K} = 47.5 \frac{J}{kgK} //$$

d) ~~[illegible]~~

1. HS halboffen

$$\Delta U = m_2 u_2 - m_1 u_1 = \Delta m\,[h_{ein}] - Q_{R12}$$

$$h_{ein} = h_f(20°) = 83.96 \frac{kJ}{kg}$$

$$Q_{R12} = 35 \cdot 10^6 J$$

$$m_2 = \Delta m + m_{ges,1}$$

$$m_1 = m_{ges,1}$$

$$\Delta m u_2 + m_{ges} u_2 - m_{ges} u_1 = \Delta m h_{ein} - Q_{R12}$$

$$\Delta m (u_2 - h_{ein}) = m_{ges}(u_1 - u_2) - Q_{R12}$$

$$\Delta m = \frac{m_{ges}(u_1 - u_2) - Q_{R12}}{u_2 - h_{ein}} = 3302 kg //$$

$$u_2 = u_f(70°) = 292.95 \frac{kJ}{kg}$$

$$u_1 = u_f(100°) = 418.94 \frac{kJ}{kg}$$

e) $\Delta S = m_2 s_2 - m_1 s_1 = 1127.3 \frac{kJ}{kgK}$ //

$$m_2 = m_g + \Delta m = 3302kg + 5755kg = 9056.9 kg$$

$$m_1 = 5755kg$$

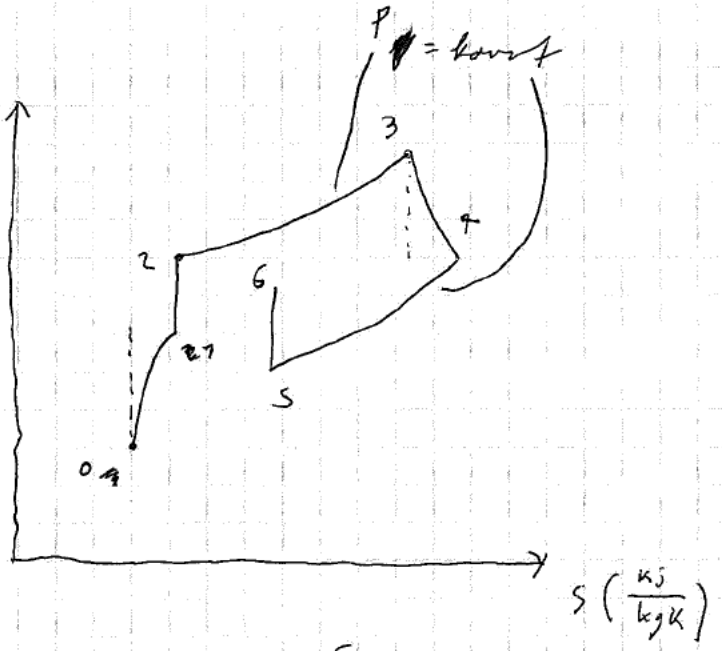
$$s_2 = s_f(70°) = 0.9549$$

$$s_1 = s_f(100°) = 1.3069$$

22-934-9389

A2

a)



	0	1	2	3	4	5	6
p	0.197		=		=		
T	-30						

b) 1. HS stationär:

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

$$0 = h_5 - h_6 + \frac{w_5^2}{2} - \frac{w_6^2}{2}$$

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

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

$$T_6 = \frac{T_5}{\left(\frac{p_5}{p_6}\right)^{\frac{\kappa-1}{\kappa}}} = \frac{437.9\,K}{\left(\frac{0.5\,bar}{0.197\,bar}\right)^{\frac{0.4}{1}}} = 328\,K$$

$$w_6 = \sqrt{2 \cdot 1.006 \frac{kJ}{kgK}\,(437.9K - 328K) + 220^2 \frac{m}{s}}$$

$$= 220.4 \frac{m}{s}$$

c) $e_{x,ser,6} = [h_6 - h_0 - T_0(s_6 - s_0) + \frac{1}{2}w_6^2]$

$h_6 - h_0 = c_p(T_6 - T_0) = 97.9 \frac{kJ}{kg}$

$s_6 - s_0 = c_p \ln\left(\frac{T_6}{T_0}\right) = 0.3373 \frac{kJ}{kgK}$

$e_{x,ser,6} = c_p(340K - 243.15K) = 97.9 \frac{kJ}{kg}$

$e_{x\,ser,6} = 97.9 \frac{kJ}{kg} - 243.15K \cdot 0.3373 \frac{kJ}{kgK} + \frac{1}{2} 510 \frac{m^2}{s^2}$

$= 130 \frac{MJ}{kg}$

$e_{x\,ser,0} = \frac{1}{2} 200 \frac{m^2}{s^2} = 20 \frac{MJ}{kg}$

$e_{x,ser} = 130 \frac{MJ}{kg} - 20 \frac{MJ}{kg} = 110 \frac{MJ}{kg}$

d) $0 = \dot{m}[s_0 - s_6] + \frac{\dot{Q}_0}{T_0} + \dot{S}_{erz}$

$\dot{S}_{erz} = s_6 - s_0 - \frac{q_0}{T_0}$

$= c_p \ln\left(\frac{T_6}{T_0}\right) - \frac{77.5 \frac{kJ}{kg}}{77.89K} = -0.56 \frac{kJ}{kgK}$

$T_6 = 340K$

$T_0 = 243.15K$

22-934-9389

A3

a) $A = 5\,cm^2 \cdot \pi = 0.00785\,m^3$

$F = mg = 314.9\,N$

$p_F = \frac{314.9\,N}{7.85 \cdot 10^{-3}\,m^3} = 0.4\,bar$

$p = 1\,bar + 0.4\,bar = 1.4\,bar$

$M = 50\,\frac{kg}{kmol}$

$m = \frac{pV}{RT} = 0.0034\,kg = 3.4\,g$

$T = 273.15\,K$

$p = 1.4 \cdot 10^5\,Pa$

$R = \frac{\bar{R}}{M} = \frac{8.314\,\frac{J}{kmol\,K} \cdot 10^3}{50\,\frac{kg}{kmol}} = 166.28\,\frac{J}{kg\,K}$

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

b) $p = \frac{mRT_2}{V_2}$

$T_2 = T_{Eis} = 0°$ da thermodynamischer Nullpunkt

$p = \frac{3.4 \cdot 10^{-3}\,kg \cdot R_L \cdot 273.15\,K}{V_2}$

$p_2 = p_1 = 1.4\,bar$, da p immer gleich Aussendruck + Gewicht

22-934-939

A3

c) 1. HS: $\Delta U = Q - W$

$\Delta U = m_g (u_2 - u_1)$

$c_v (T_2 - T_1) = 0.633 (273.15 - 773.15)$

$= -316.5\,kJ$

$W = p (V_{a2} - V_{a1}) = 285\,J$

$V_2 = \frac{m R T_2}{p_2} = \frac{3.9 \cdot 10^{-3}\,kg \cdot R \cdot 273.15\,K}{1.9 \cdot 10^5\,Pa} = 0.0077\,m^3$

$Q = \Delta U + W = -316.5 \cdot 10^3\,J + 285\,J = -316.3\,kJ$

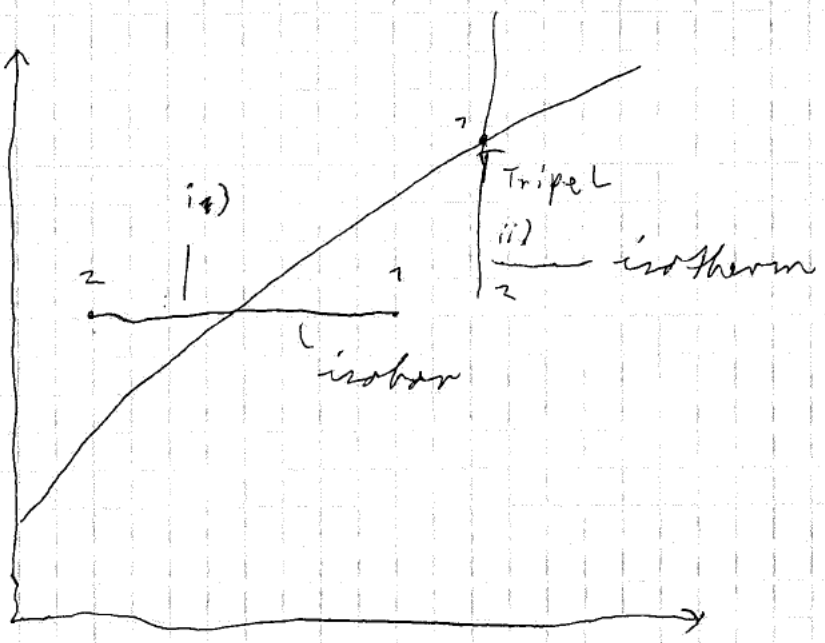
d)

22-934-939

[redacted]

A4

a)



	1	2	3	4
p	=		8 = 8	
T				

b) TH S: $0 = \dot{m}[h_2 - h_3] - \dot{W}_K$

$h_2 = h_g$ $\Rightarrow T_1 = -10° = 263.15°$

c) $\varphi_1 = \varphi_2$

e) T_1 würde sinken, da der sublimierte Wasser Wärme abgeben würde