① $\dot{Q}_{aus}$

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

Wasser

h_{ein} 70°C siedend → Nassdampf

A-2 @ 70°C mit $x_0 = 0{,}005$

$$h_e = h_f(70°C) + x_0(h_g(70°C) - h_f(70°C))$$
$$= 292{,}98\frac{kJ}{kg} + 0{,}005\left(2626{,}8\frac{kJ}{kg} - 292{,}98\frac{kJ}{kg}\right)$$
$$= \underline{309{,}65\frac{kJ}{kg}}$$

$$h_a = h_f(100°C) + x_0(h_g(100°C) - h_f(100°C))$$
$$= 419{,}04\frac{kJ}{kg} + 0{,}005\left(2676{,}1\frac{kJ}{kg} - 419{,}04\frac{kJ}{kg}\right)$$
$$= 430{,}33\frac{kJ}{kg}$$

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

$$0{,}3\frac{kg}{s}\left(309{,}65\frac{kJ}{kg} - 430{,}33\frac{kJ}{kg}\right) + 100kW + \dot{Q}_{aus} = 0$$

$$\dot{Q}_{aus} = \underline{\underline{-62{,}296\,kW}}$$

Wenn Pfeil anders herum zeigt

→ 62,30kW fliesst heraus

$= \dot{Q}_{aus}$

In der ganzen Aufgabe habe ich für den Begriff siedend mit einem dampfanteil x von 0,005 gerechnet

b) $\overline{T}_{KF} = \frac{\int_1^2 T\,ds}{s_a - s_e} = \frac{q_{12}}{s_2 - s_1} = \frac{h_2 - h_1}{s_2 - s_1}$

da ideale Flüssigkeit und isobar

$\rightarrow$

$h_2 - h_1 = c\,(T_2 - T_1)$

$s_2 - s_1 = c \ln\left(\frac{T_2}{T_1}\right)$

$\overline{T}_{KF} = \frac{c\,(T_2 - T_1)}{c \ln\left(\frac{T_2}{T_1}\right)}$

$T_2 = 298{,}15\,K$

$T_1 = 288{,}15\,K$

$= \frac{298{,}15\,K - 288{,}15\,K}{\ln\left(\frac{298{,}15}{288{,}15}\right)} = \underline{\underline{293{,}12\,K}}$

c) $\frac{\dot{Q}_{ab}}{\overline{T}_{KF}} + \dot{S}_{erz} - \frac{\dot{Q}_{ab}}{\overline{T}_R} = 0$

$\dot{S}_{erz} = \dot{Q}_{ab}\left(-\frac{1}{\overline{T}_{KF}} + \frac{1}{\overline{T}_R}\right)$

$= 62{,}33\,kW\left(-\frac{1}{293{,}12\,K} + \frac{1}{373{,}13\,K}\right) =$

$\underline{\underline{\dot{S}_{erz} = 46\,J}}$

d halboffen

① $m_1 = 5755\,kg$ $\quad m_2 = m_1 + \Delta m$

$x_1 = 0{,}005$ $\quad \Delta m$ $\quad T_2 = 70°C$

$T_1 = 100°C$

$T_{ein} = 20°C$

$m_2 u_2 - m_1 u_1 = \Delta m h_{ein} + Q_{aus\,12}$

A-2 @ 100°C

$u_1 = u_f(100°C) + x_0 (u_g(100°C) - u_f(100°C))$

$= 292{,}95 + 0{,}005 (2469{,}6 - 292{,}95)$

@ 70°C

$u_2 = 418{,}94 \frac{kJ}{kg} + 0{,}005 (2506{,}5 \frac{kJ}{kg} - 418{,}94 \frac{kJ}{kg})$

$= 429{,}38 \frac{kJ}{kg}$

@ 70°C

$u_2 = 292{,}95 \frac{kJ}{kg} + 0{,}005 (2469{,}6 \frac{kJ}{kg} - 292{,}95 \frac{kJ}{kg})$

$= 303{,}83 \frac{kJ}{kg}$

hein @ 20°C

$h_{ein} = h_f(20°C) + x_0 (h_g(20°C) - h_f(20°C))$

$= 79{,}77 \frac{kJ}{kg} + 0{,}005 (2536{,}2 \frac{kJ}{kg} - 79{,}77 \frac{kJ}{kg})$

$= 87{,}08 \frac{kJ}{kg}$

$m_1 u_2 - m_1 u_1 + \Delta m u_2 - \Delta m h_e = Q_{aus}$

$\Delta m = \frac{Q_{aus} + (m_1 (u_1 - u_2))}{u_2 - h_e}$

$= 3495\,kg$

e

$$\Delta S_{12} = m_2 s_2 - m_1 s_1 = \Delta m s_e + \frac{Q_R}{T} + S_{erz}$$

②	p [bar]	T [K]	w [m/s]	$\dot{m}$	
1				$\dot{m}_{ges}$	
2				$\dot{m}_K$	
3	p_2			$\dot{m}_K$	isentrop
4				$\dot{m}_K$	
5	0,5	431,9	220 m/s	$\dot{m}_{ges}$	
6	0,191				
0	0,191	243,15	200 m/s		

$c_p = 1{,}006 \frac{kJ}{kg\,K}$ $\quad \kappa = \frac{c_p}{c_v} = 1{,}4$

$c_v = \frac{1{,}006 \frac{kJ}{kg\,K}}{1{,}4} = 0{,}719 \frac{kJ}{kg\,K}$

$R = c_p - c_v = 0{,}287 \frac{kJ}{kg\,K}$

6 w_6^2.

5 → 6 isentrop $s_5 = s_6$

$$w_{rev} = -\int_1^2 v\,dp + \Delta ke \qquad \Delta ke = \frac{w_6^2}{2} - \frac{w_5^2}{2}$$

polytrop $n \neq 1$

$$-\int_1^2 v\,dp = n\int_1^2 p\,dv \qquad -v\int_1^2 v\,dp = n\int_1^2 p\,dv$$

$$w_{rev} = \frac{\dot{W}_{rev}}{\dot{m}}$$

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

$$w_{rev} = \int_1^2 p\,dv = \frac{R(T_6 - T_5)}{1-n} =$$

$$T_6 = T_5\left(\frac{p_6}{p_5}\right)^{\frac{1,4-1}{1,4}} = 431,9\,K \cdot \left(\frac{0,1916\,bar}{0,5}\right)^{\frac{0,4}{1,4}}$$

$$= 328,1\,K$$

$$\frac{0,287\,\frac{kJ}{kgK}\,(328,1\,K - 931,9\,K)}{1 - 1,4} = 79,5\,kW$$

$$w_{rev}\,\dot{m} = \dot{W}_{rev}$$

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

$$\dot{m}\left(c(T_5 - T_6) + \frac{w_5^2 - w_6^2}{2} - w_{rev}\right) = 0$$

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$$1{,}006\,\frac{kJ}{kg}\,(431{,}9\,K - 328{,}1\,K) - 74{,}5\,kW + \frac{220^2}{2} = \frac{w_6^2}{2}$$

$$\frac{w_6^2}{2} = 54122{,}8$$

$$w_6 = 329\,\frac{m}{s}$$

c)

$$-\Delta \dot{E}_{xstr} = \dot{E}_{xstr,0} - \dot{E}_{xstr,6} =$$

$$\dot{m}(h_0 - h_6 - T_0(s_0 - s_6) + \Delta ke)$$

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

$$= c_p(T_0 - T_6) - T_0\left(\ln\frac{T_0}{T_6} - R\ln\left(\frac{p_0}{p_6}\right)\right) + \frac{w_0^2 - w_6^2}{2}$$

$$= 1{,}006\,\frac{kJ}{kgK}(243{,}15\,K - 328{,}1\,K) - 243{,}15\,K\left(\ln\frac{243{,}15\,K}{328{,}1\,K}\right) - 0{,}287\,\frac{kJ}{kg}\underbrace{\left(\ln(1)\right)}_{=0}$$

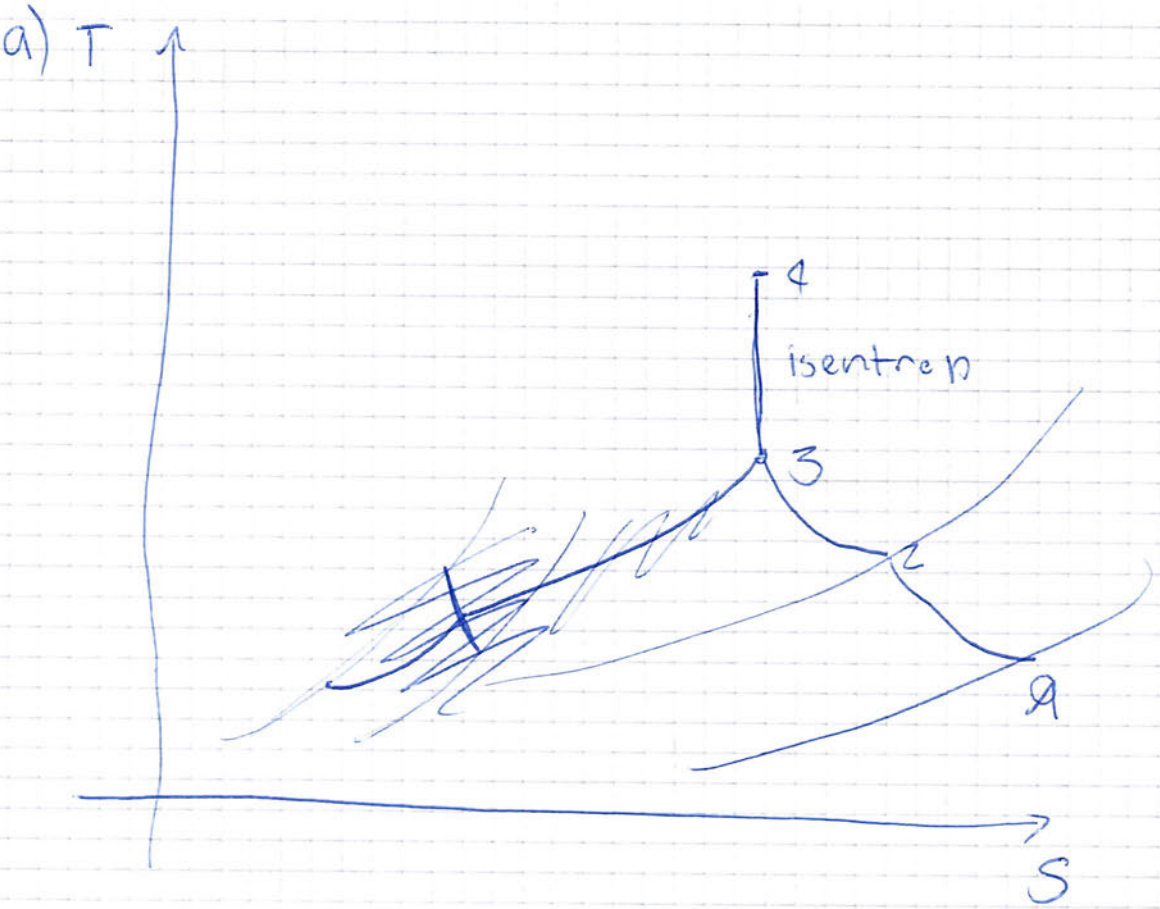
$$+ \frac{200^2\,\frac{m^2}{s^2}}{2} - \frac{329^2\,\frac{m^2}{s^2}}{2}$$

$$\Delta e_{xstr} = 119{,}5\,\frac{kJ}{kg}$$

d) $\dot{E}_{x,verl} = e_{x,verl}\,\dot{m}_{Ges}$

$$0 = -\Delta e_{x,str} + e_{x,Q_j} - w_{t,n} - e_{x,verl}$$

$$e_{x,a} = \frac{\left(1 - \frac{T_0}{T_B}\right)\dot{Q}}{\dot{m}}$$

a) 

(3)

a) $p_{g,1}$ m_g

$M_g = 50 \frac{kg}{kmol}$

$R = \frac{\bar{R}}{M_g} = \frac{8{,}314 \frac{J}{molK}}{50 \frac{kg}{kmol}} = 0{,}16 \frac{kJ}{kgK}$

$p_1 V_1 = m_1 R T$

damit GGW (1)

$p_{amb} A \downarrow \; \downarrow m_{kg}$

$\uparrow p_g A$

$p_{amb} A + m_{kg} = p_g A$

$A = \frac{(0{,}1\,m)^2 \pi}{} = 0{,}0314\,m^2$

$p_{g1} = 10^5 Pa + \frac{32kg \cdot 9{,}81 \frac{m}{s^2}}{0{,}0314\,m^2}$

$= 1{,}1\,bar$

$m_1 = \frac{p_1 V}{R T_1} = \frac{1{,}09 \cdot 10^5 Pa \cdot 3{,}14 \cdot 10^{-3} m^3}{0{,}16 \cdot 10^3 \frac{kJ}{kgK} \cdot 773{,}15K} = 2{,}77g$

c) $m(u_{2G} - u_{1G}) + Q_{12} = 0$

$m_G (c_v (T_{G2} - T_{G1})) = Q_{12}$

$c_v = 0{,}633 \frac{kJ}{kgK}$

$= Q_{12}$

$0{,}0277kg \cdot 0{,}633 \frac{kJ}{kgK} (-499{,}997K) = Q_{12}$

$-7{,}21kJ = Q_{12}$

→ 7,21 kJ Wärme von Gas zu EW

d ~~8~~ qGW

$\Rightarrow$ ~~$\frac{}{}$~~ $u_{zG} - u_{zEW} = 0$

$m_g u_{zG} - m_{EW} u_{zEW} = 0$

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EW

AZ 0°C $m(u_2 - u_1) = Q_{ZU}$

$u_1 =$

b) $p_{2G} = p_{2EW}$

$p_2 V = mRT_2$

Gleichgewicht

$u_{2EW} - u_{2G} = C$

$c_v = 0{,}633 \frac{kJ}{kg\,K}$

$c_p =$

d)

$$x_{Eis} = \frac{u_{ZEis} - u_{Flüssig}}{u_{Fest} - u_{Flüssig}}$$

④

	p [bar]	T	x
1			
2	p_1	T_1	1
3	8		
4	8 bar		0

isobar

isentrop

isenthalp

~~1/4~~ T_i

$$\dot{m}(h_2 - h_3) - \dot{W}_K = 0$$

$$T_2 = T_1 = T_i - 6K = -16°C = 257{,}15K$$

$$T_i = -10°C$$

h_2 A10 @ $-16°C$ $x = 1$ $h_2 = h_g(-16°C)$

$h_2 = 237{,}74 \frac{kJ}{kg}$ $s_2 = 0{,}9298 \frac{kJ}{kgK}$

A-11 @ 8bar

$$h_3 = h_f(8bar) + \frac{s_2 - s_f(8bar)}{s_g(8bar) - s_f(8bar)} \left(h_g(8bar) - h_f(8bar)\right)$$

$$= 93{,}42\frac{kJ}{kg} + \frac{0{,}9298 - 0{,}3459}{0{,}902 - 0{,}3459}\left(269{,}15\frac{kJ}{kg} - 93{,}42\frac{kJ}{kg}\right)$$

$= 26$

A12 @ 8bar

$$h_3 = h(sat) + \frac{s_2 - s(sat)}{s(40°C) - s(sat)}\left(h(40°C) - h(sat)\right)$$

$$= 269{,}15\frac{kJ}{kg} + \frac{0{,}9298 - 0{,}9066}{0{,}9379 - 0{,}9066}\left(273{,}66\frac{kJ}{kg} - 269{,}15\frac{kJ}{kg}\right) = 271{,}31\frac{kJ}{kg}$$

$$\dot{m} = \frac{\dot{W}_K}{h_2 - h_3} = \frac{-28W}{237{,}74\frac{kJ}{kg} - 271{,}31\frac{kJ}{kg}} = 0{,}00083\frac{kg}{s}$$

c

$h_1 = h_4$

h_4 @ A11 @ 8 bar $x = 0$

$= h_f(8\,bar) = 93{,}42\frac{kJ}{kg}$

d

$$\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_H|} = 28W$$

$\dot{Q}_{zu} = \dot{Q}_K$

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

$0{,}00083\frac{kg}{s}\left(93{,}42\frac{kJ}{kg} - 237{,}74\frac{kJ}{kg}\right) + \dot{Q}_K = 0$

$\dot{Q}_K = 119{,}8\,W$

$\varepsilon_K = 4{,}27$

$T_1 = -16°C$ A10 @ $-16°C$

$h_1 = h_f(-16°C) + x_1(h_g(-16°C) - h_f(-16°C))$

$$\frac{93{,}42\frac{kJ}{kg} - 29{,}3\frac{kJ}{kg}}{237{,}79\frac{kJ}{kg} - 29{,}3\frac{kJ}{kg}} = x_1 = 0{,}31$$

$T_1 = T_2$