[redacted]

1 $\dot{m}_{ein} = 0{,}3\,\frac{kg}{s}$ $T_{ein} = 70°C$

$x_D = 0{,}005$

a) 1HS $0 = \dot{m}_{ein} h_{ein} - \dot{m}_{aus} h_{aus} + \overbrace{100\,kW}^{\dot{Q}_R} - \dot{Q}_{Aus} - \cancel{\dot{W}}$

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

TAB A2

siedend

$h_{ein} = h_f(70°C) = 292{,}98\,\frac{kJ}{kg}$ $\dot{m}_{ein} = 0{,}3\,\frac{kg}{s}$

$h_{aus} = h_f(100°C) = 419{,}04\,\frac{kJ}{kg}$ $\dot{m}_{aus} = 0{,}3\,\frac{kg}{s} = \dot{m}_{ein}$

→ einsetzen $\dot{Q}_{Aus} = \dot{m}(h_{ein} - h_{aus}) + 100\,kW$

$\underline{\dot{Q}_{aus} = 62{,}182\,kW}$

b) Exergiebilanz um Kühlflüssigkeit

$0 = \dot{E}x_{str} + \dot{E}x_{Qj} - \dot{W} - \dot{E}x_{verl}$

c) $T_{KF} = \cancel{288}\,K$ 295K

<u>2HS</u> $0 = \dot{m}\cancel{(s_e - s_a)} + \frac{-\dot{Q}_{aus}}{T_{KF}} + \dot{S}_{erz}$

$$S_{erz} = + \frac{Q_{Aus}}{T_{KF}} = \frac{62{,}182\,kW}{295\,K} = \underline{\underline{0{,}2107\,\frac{kW}{K}}} = \dot{S}_{erz}$$

d) Halboffenes System 1.HS

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

/ $h_{ein} = h_f(T_{ein}) = h_f(20°) =$
$h_{ein} = h_f(20) = \underline{83{,}96 \frac{kJ}{kg}}$
A2

$m_1 = m_{ges}$ $\quad Q = Q_{aus} = 35\,MJ$

$m_2 = m_{ges} + m_s$

$m_{ges_1} = 5755\,kg$

$$(m_g + \Delta m) u_2 - m_g u_1 = \Delta m \cdot h_{ein} + (-Q_{aus})$$

$$m_g u_2 + \Delta m u_2 - m_g u_1 = \Delta m h + (Q)$$

$$\Delta m (u_2 - h_{ein}) = m_g u_1 + (Q)$$

$$\Delta m = \frac{m_{ges} u_1 + Q}{u_2 - h_{ein}}$$

TAB A2

/ $x = 0{,}005$
$u_1 = u_f(100°) + x(u_g(100) + u_f(100))$
$418{,}94 + 0{,}005(419{,}04 - 418{,}94)$
$u_1 = 418{,}9404 \frac{kJ}{kg}$

$$\Delta m = \frac{m_1 u_1 + (-Q)}{u_2 - h_{ein}}$$

A2) $u_2 \doteq u(70°) = u_f(70°) = 292{,}95 \frac{kJ}{kg}$

gesamte Masse siedend

$$= \frac{5755\,kg \cdot 418{,}94 \frac{kJ}{kg} + (-35 \cdot 10^3\,kJ)}{292{,}95 - 83{,}96}$$

$$\Delta m = 11368{,}9\,kg$$

e) halboffen: $m_2 s_2 - m_1 s_1 = \Delta m s_{ein} + \frac{Q_j}{T} + S_{erz}$

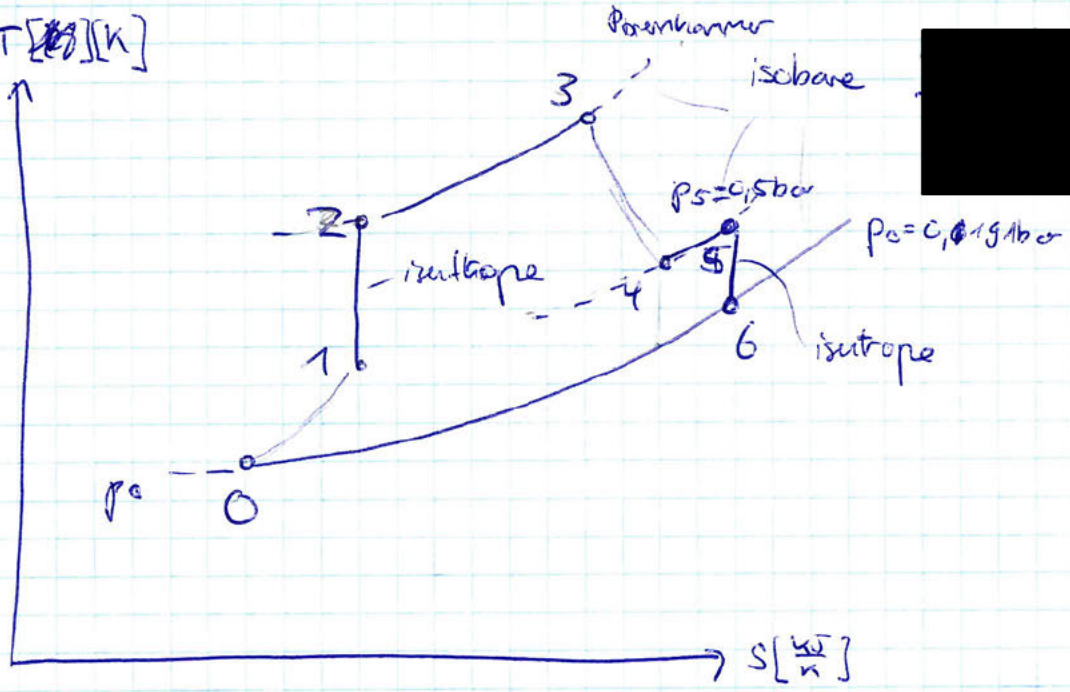
$\Delta m_{12} = 3600$ $\quad m_2 = m_1 + \Delta m = 9355\,kg$

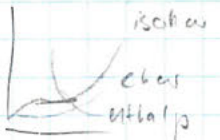
$S_{erz} = m_2 s_2 - m_1 s_1 - \Delta m s_{ein} - \frac{Q_j}{T}$

/ $m_2 = m_1 + \Delta m_{12}$
$m_1 = m_1$
$s_2 = s_f(70) = 0{,}9549 \frac{kJ}{kgK}$ (A2)
$s_1 = s_f(100) + x(s_g(100) - s_f(100))$
A2) $= 1{,}3069 + x(7{,}3549 - 1{,}3069)$
$s_1 = 1{,}33714$
$s_{ein} = s_f(20°) = 0{,}2966$
$Q = 35 \cdot 10^3\,kJ$
$T = 295\,K$

$$\underline{\underline{S_{erz} = 1012{,}428\,kJ}}$$

(2) a)





[redacted]

b) w_6, T_6 1HS um ganze turbine

stat.   adj   gesamte arbeit geht in turbine

$$\cancel{\dot{E}} = \dot{m}_{ges}\left(h_0 - h_6 + \frac{(w_{Luft}^2 - w_6^2)}{2} + \cancel{Q} - \cancel{W}\right)$$

$$0 = h_0 - h_6 + \frac{w_L^2 - w_6^2}{2}$$

$$-\frac{w_L^2 + w_6^2}{2} = h_0 - h_6 \quad \rightarrow \quad 2(h_0 - h_6) = -w_L^2 + w_6^2$$

$$w_6 = \sqrt{2(h_0 - h_6) + w_L^2}$$

$$= \sqrt{2c_p(T_0 - T_6) + w_L^2}$$

// stoffmodell ideales gas $h_0 - h_6 = c_p(T_0 - T_6)$

5 -> 6 adj rev -> $S_{erz} = 0$

-> adj. rev -> isentrop: $\kappa = 1{,}4$

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \quad T_6 = T_5\left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}}$$

/ $T_5 = 431{,}9\,K$
$p_6 = p_0 = 0{,}191\,bar$
$p_5 = 0{,}5\,bar$

$$\boxed{T_6 = 328{,}074\,K}$$

$$w_6 = \sqrt{2c_{pL}(\underbrace{\cancel{T_0 - T_6}}_{T_6 - T_0}) + w_L^2} = \sqrt{2 \cdot 1{,}006\,\frac{kJ}{kgK}\,(+30° + 273{,}15 + 328{,}074) + 200^2\,\frac{m^2}{s^2}}$$

$10^3 J$

$$\boxed{w_6 = 459{,}202\,\frac{m}{s}}$$

c) $\Delta e_{xstr6} - \Delta e_{xstr0}$

$$\Delta \dot{E}_{xstr} = \dot{m}_{ges}\left(h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2}{2}\right) - \dot{m}_{ges}\left(h_0 - h_0 - T_0(s_0 - s_0) + \frac{w_i^2}{2}\right)$$

$$- \dot{m}_{ges}\left(\frac{w_i^2}{2}\right)$$

$$\dot{m}_{ges}\left(h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2}{2} - \frac{w_i^2}{2}\right)$$

// Stoffmodell:

$h_6 - h_0 = c_{pL}(T_6 - T_0)$

$$= \dot{m}_{ges}\left(c_p(T_6 - T_0) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right) + \frac{w_6^2}{2} - \frac{w_i^2}{2}\right)\right)$$

$s_6 - s_0 = c_{pL} \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\cancel{\frac{p_6}{p_0}}\right)$ $\quad \ln(1) = 0$

$$\Delta \dot{e}_{xstr} = \dot{E}_{xstr} / \dot{m}_{ges} = c_p(T_6 - T_0) - T_0\left(c_p \ln\left(\frac{T_6}{T_0}\right)\right) + \frac{w_6^2 - w_i^2}{2}$$

// $c_p = 1{,}006 \frac{kJ}{kgK} \cdot \frac{10^3 J}{kJ}$

$T_6 = 328{,}074\,K$

$T_0 = -30 + 273{,}15\,K$

$T_0 = 243{,}15\,K$

$w_6 = 459{,}202 \frac{m}{s}$

$w_i = 200 \frac{m}{s}$

$$= 1{,}006 \frac{J \cdot 10^3}{kgK}(T_6 - T_0) - 1{,}006 \cdot 10^3 \frac{J}{kg} \cdot T_0 \ln\left(\frac{T_6}{T_0}\right) + \frac{w_6^2 - w_i^2}{2}$$

$$= 97591{,}579 \frac{J}{kg} = 97{,}591 \frac{kJ}{kg} = 97{,}591 \frac{kJ}{kg} = \Delta e_{xstr}$$

d) ~~$0 = \Delta e$~~

~~$0 = \Delta e_{xstr} + \left(1 - \frac{T_0}{T}\right)\dot{Q} - w_t$~~

$$0 = \sum \dot{E}_{xstr} + \sum \dot{E}_{xQj} - \sum W - p_0 \frac{dV}{dt} - E_{xverl} \quad // : \dot{m}$$

$$0 = \Delta e_{xstr} + \left(1 - \frac{T_0}{T_j}\right) q_j - w_t - e_{xverl}$$

$$e_{xverl} = \Delta e_{xstr} + \left(1 - \frac{T_0}{T_j}\right) q_B \, w_t \;?$$

$$e_{xverl} = 97{,}591 \frac{kJ}{kg} + \left(1 - \frac{T_0}{T_B}\right) \cdot q_B =$$

$T_0 = 243{,}15$

$T_B = 1289\,K$

$q_B = 1195 \frac{kJ}{kg}$

$$e_{xverl} = 1067{,}17 \frac{kJ}{kg}$$

③

	$[C°]$	$[C°]$		$[m^3]$
	T_{EW}	T_{Gas}	V_{EW}	V_{Gas}
1	0	500°C		$3{,}14\cdot10^{-3}$
2				

[redacted]

$$V_{Gas} = 3{,}14L \cdot \frac{dm^3}{L} \cdot \frac{m^3}{10^3 dm^3} \Rightarrow V_{gas} = \underline{3{,}14\cdot10^{-3} m^3}$$

$m_{EW} = 0{,}1kg \quad c_V = 0{,}633 \frac{kJ}{kgK} \quad M_g = 50 \frac{kg}{kmol}$

$x_{E1} = 0{,}6$

perfecktes gas: $c_p - c_V = \frac{\bar{R}}{M} \rightarrow c_{pG} = \frac{\bar{R}}{M} + c_V = \frac{8{,}314 \frac{kJ}{kmolK}}{50 \frac{kg}{kmol}} + 0{,}633 \frac{kJ}{kgK}$

$c_p = 0{,}79928 \frac{kJ}{kgK}$, $R = \frac{\bar{R}}{M} = 0{,}166289 \frac{kJ}{kgK}$

$\frac{V_r}{V_1} = \frac{\frac{m^3}{kg}}{m^3} = \frac{1}{kg}$

a) $p_{g1}, m_{g1} \quad p_1 v_1 = RT_1$

$p_1 V_1 = mRT_1 \rightarrow p_1 = \frac{mRT_1}{V_1}$ ~~$= \frac{mRT_1}{V_1} \cdot v_1 = RT_1$~~

$F = \frac{P}{A}$

~~$p_{1g} = \frac{p_{amb} + m_K g + m_{EW} g}{A} = 1bar \cdot 10^5 + 32kg \cdot g + 0{,}1kg \cdot g$~~ ~~$D = 0{,}1m$~~

~~$p_{1g} =$~~

$$p_{1g} = p_{amb} + p_{mK} + p_{EW} = 1bar \cdot 10^5 + \frac{\overset{32kg}{m_K} \cdot g}{0{,}1m^2} + \frac{\overset{m_{EW}}{0{,}1} \cdot g}{0{,}1}$$

$p_{1g} = 103147{,}93\ Pa = 1{,}03147\ bar$

$$m_1 = \frac{p_1 V_1}{RT_1} = \frac{103{,}147kPa \cdot 3{,}14\cdot10^{-3} m^3}{0{,}166289 \frac{kJ}{kgK} \cdot (500K + 273{,}15K)} = 0{,}002519kg = \underline{\underline{2{,}519g}} = m_1$$

b) unsicher ob werte stimmen, nehme $p_{1g} = 1{,}5bar$, & $m_g = 3{,}6g$

x_2 ~~V_{EW} bleibt = $V_2 = 3{,}14\cdot10^{-3}$~~ m^3, sowie masse bleibt gleich $m_{EW1} = m_{EW2}$

Druck auf gas bleibt, ~~$p_{2g} = 1{,}5bar$~~

b) $p_{1g} = 1{,}5\,bar$, $m_g = 3{,}6\,g$

Zustand 2: Wasser inkompressibel $V_{1_w} = V_{2_w}$

Der druck aufs gas ändert sich nicht, immer noch $p_0 + \frac{m_K g}{D} + \frac{m_W g}{D}$

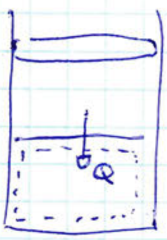
$p_{2g} = p_{1g} = 1{,}5\,bar$ $\qquad pV = mRT$

$T_{2g} = \frac{p_2 V_2}{mR}$ $\qquad V_2$ $\qquad \kappa = \frac{c_p}{c_v} = \frac{0{,}79928}{0{,}633} = 1{,}262$

$$\left(\frac{p_2}{p_1}\right)^{\frac{\kappa-1}{\kappa}} = \left(\frac{V_1}{V_2}\right)^{\kappa-1} \quad // \; p_2 = p_1$$

$$(1)^{\frac{\kappa-1}{\kappa}\cdot\frac{1}{\kappa-1}} = \frac{V_1}{V_2}$$

c) Q_{12}, $T_{2g} = 0{,}003\,°C$, $p_{g1} = 1{,}5\,b$, $m_g = 3{,}6\,g$



1HS $\frac{dE}{dt} = \cancel{\dot m}(h+k+p) + \dot Q - \cancel{\dot W}$ $\quad // \int dt$

$\Delta U_{21} = \bar Q - \cancel{W}$

$m_g(u_2 - u_1) = \bar Q$ $\quad //$ Stoffmodell ig: $u_2 - u_1 = c_v(T_2 - T_1)$

$Q = m_g c_v (T_{2g} - T_{1g}) = 3{,}6\cdot 10^{-3}\,kg \cdot 0{,}633\,\frac{kJ}{kgK}\,(\underbrace{273{,}153}_{T_{2g}} - \underbrace{773{,}15}_{T_{1g}})$

$= -1{,}13939\,kJ$

$$\underline{\underline{|Q_{12}| = 1139{,}39\,J}}$$

3d) x_{Eis_2}

[redacted]

$V_{1EW} = V_{2EW}$

[redacted]

(4) b) 1.HS um Verdichter

$$0 = \dot{m}(h_{2} - h_3) - (-\dot{W}_k)$$

$$\dot{m} = \frac{-\dot{W}_k}{h_2 - h_3} = \quad \Big/ \text{ TAB } \begin{array}{l} h_2 = \\ h_3 = \end{array}$$

	T	p [bar]	V	x	$\dot{W}$ [kW]	s
1						
2				1	-28kW	0
3		8			~~-28kW~~	
4				0		

$s_{23} = 0$ (adj. rev)

a)