[redacted]

1. a)

Stat. Fliessprozess mit 1 Massenstrom

$$0 = \dot{m}(h_e - h_a) + \dot{Q} - \cancel{W}^{\,0}$$

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

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

$$\dot{Q}_{A\to} = 0.3\,(h_{ein} - h_{aus}) + 100\,\frac{kJ}{s} = \underline{\underline{62{,}182\,kW}}$$

h_{ein}:

$T = 70\,°C$

$x = 0$

$p = 0.3119$ bar aus A-2

$h_{ein} = h_f = 292{,}98\,\frac{kJ}{kg}$ aus A-2

h_{aus}:

$T_{aus} = 100\,°C$

$x = 0$

$p = 1.014$ aus A-2

$h_{aus} = h_f = 419{,}04\,\frac{kJ}{kg}$ aus A-2

b)

$$\bar{T} = \frac{\int_a^e T\,ds}{s_a - s_e}$$

$$s_a - s_e = \int_{T_{AE}}^{T_A} \frac{c_{if}(T)}{T}\,dT$$

$$\int_a^e T\,ds = Q \quad \text{, weil } p \text{ const.}$$

$$= c_{if}(T) \cdot \left[\ln(T)\right]_{T_E}^{T_A}$$

$$=$$

c) $\bar{T} = 295\,K$ aus Afg.stellung

$$\cancel{0 = \dot{m}(s_e - s_a) + \frac{\dot{Q}_R}{\bar{T}} - \frac{\dot{Q}_{A\to}}{\bar{T}}}$$

$$\cancel{s_e =} \quad 0 = \dot{m}(s_e - s_a) + \frac{\dot{Q}_{Aus}}{\bar{T}} + \ddot{S}_{erz}$$

$$-\ddot{S}_{erz} =$$

1. d) [redacted]

① $T_{R,1} = 100\,°C$

$x_D = 0.005$

$m_1 = 5755\,kg$

② $T_{R,2} = 70\,°C$

$x_2 = 0$

$m_2 = m_1 + \Delta m_{12}$

$\Rightarrow$ halboffenes System

$$\Delta E = m_2 u_2 - m_1 u_1 = \Delta m_{12}(h_{ein}) + Q \cancel{- W}^{\,0}$$

$$(m_1 + \Delta m_{12}) u_2 - m_1 u_1 = \Delta m_{12}(h_e) - Q_{R1,2}$$

$$m_1 u_2 - Q_{R12} - m_1 u_1 = \Delta m_{12}(h_e) - \Delta m_{12} u_2$$

$$m_1 u_2 - Q_{R12} - m_1 u_1 = \Delta m_{12}(h_e - u_2)$$

h_{ein}: $T_{ein} = 20\,°C$

$x = 0$

$p_{ein}: 0.02339$

$h_{ein} = h_f = 83{,}96\,\frac{kJ}{kg}$ } aus A-2

~~$u_1 \cdot kg = 2676{,}1\,\frac{kJ}{kg}$~~

~~$h_f = 419{,}04\,\frac{kJ}{kg}$~~ } ~~aus A-2~~

~~$x = 0.005$~~

~~$u_1 = x \cdot h_g + (1-x) \cdot h_f = 430{,}325\,\frac{kJ}{kg}$~~

u_2: $x_1 = 0.005$

$u_2 = u_f(70\,°C) = \underline{292{,}95}$ aus A-2

$$u_1 = x_1 \cdot u_g(100\,°C) + (1-x_1)\, u_f(100\,°C) =$$

$$= x_1 \cdot \underbrace{\left(2506{,}5\,\frac{kJ}{kg}\right) + (1-x_1)\,(418{,}94)}_{\text{aus A-2}} = \underline{429{,}378\,\frac{kJ}{kg}}$$

$$\Delta m_{12} = \frac{m_1 u_2 + Q_{R12} - m_1 u_1}{h_e - u_2} = \underline{\underline{3589{,}37\,kg}}$$

e)

$\Delta S = S_2 - S_1 \quad m_2 s_2 - m_1 s_1$

$x = 0{,}005$

$s_1 = x \cdot s_g + (1-x) s_f = 1{,}33714 \frac{kJ}{kg\,K}$

$s_g = 7{,}3549 \frac{kJ}{kg\,K}$ – aus A-2

$s_f = 1{,}3069$

$s_2 = s_f (170°C) \qquad x_2 = 0$

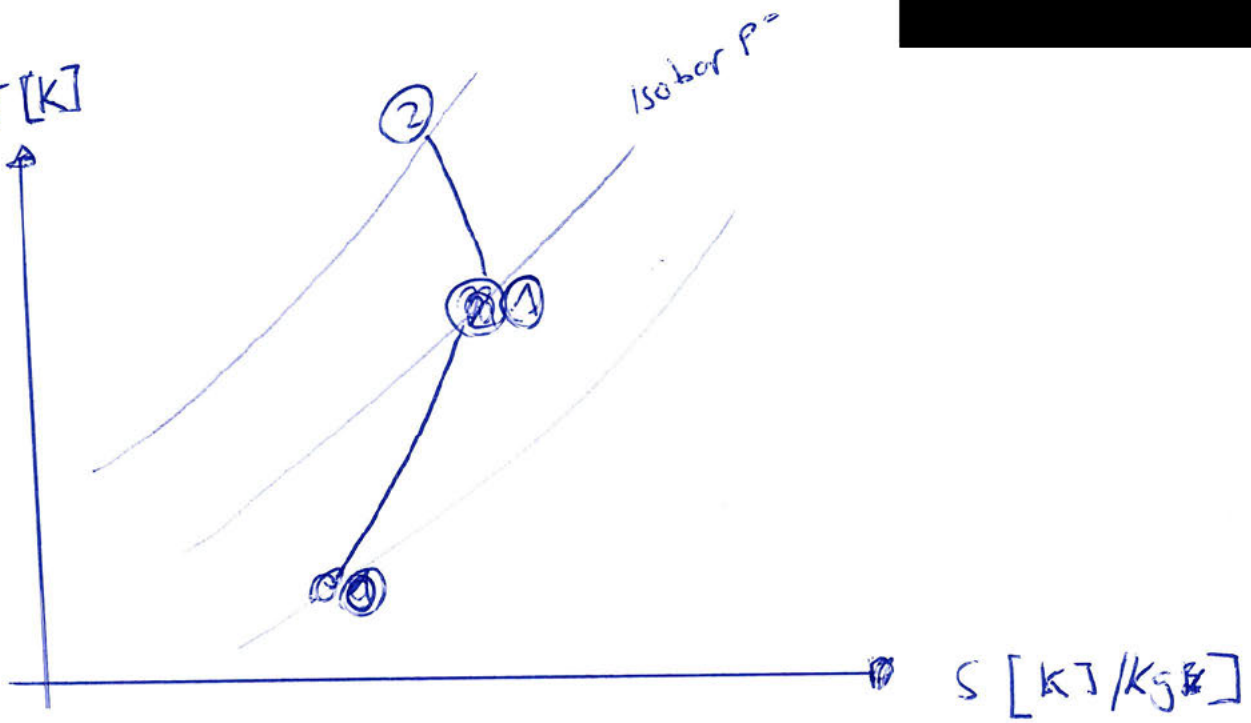
$s_f (70°C) = 0{,}9549 \frac{kJ}{kg\,K}$ aus A-2

$m_2 = 5755\,kg + 3600\,kg = \underline{9355\,kg}$

$\underline{\underline{\Delta S = 1235{,}83\,kJ}}$

2:

a)



b) $w_T = 220 \frac{m}{s}$ $\quad p_6 = p_0$

$p_5 = 0{,}5\,bar$ $\quad T_6 = ?$

$T_5 = 431{,}9\,K$

reversibel & adiabat => polytrope Zustandsänderung

$n = \kappa = 1{,}4$

$c_p = 1{,}006 \frac{kJ}{kgK}$

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 328{,}075\,K$$

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

$$h_5 - h_6 = c_p (T_5 - T_6) = 1{,}006 \cdot (431{,}9 - 328{,}075\,K)$$
$$= 104{,}49 \frac{kJ}{kg}$$

$$\frac{-w_5^2 + w_6^2}{2} = 104{,}49 \frac{kJ}{kg}$$

$$w_6 = \sqrt{104{,}49 \frac{kJ}{kg} \cdot 2 + w_5^2} = 220{,}42\,m/s$$

c) $\Delta ex_{,str} = [h - h_0 - T_0(s - s_0) + ke]$

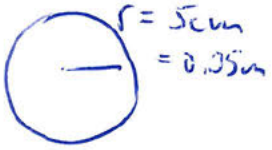
d) $ex_{,vel} = T_0 \cdot \dot{S}_{ez}$

$=$

Aufgabe 3)

a) $R = \frac{\bar{R}}{M} = \frac{\bar{R}}{50\ \frac{g}{mol}} = 0{,}1663\ \frac{J}{gK} = \frac{\frac{kJ}{kg}}{K}$

$= 166{,}29\ \frac{J}{kgK}$



$p_{1,g} = p_{amb} + \frac{mg}{A}$

$m_{total} = m_K + m_{EW} = 32 + 0{,}1 = 32{,}1\,kg$

$A = 0.05m^2 \cdot \pi = 0{,}007854\ m^2$

$p_{g,1} = 1 \cdot 10^5 Pa + 40039{,}9\ Pa =$ ~~1,400839 bar~~

$= 1{,}401 bar$

$m_g = \frac{p_1 V_1}{R T_1} = \frac{1{,}4 \cdot 10^5 \cdot 3.146 \cdot 10^{-3}}{166{,}29 \cdot 773{,}15\,K} = 0{,}003916\,kg$

$m_g = 3{,}92\,g$

b) Solange $x_{Eis,2} > 0$ ist Eis vorhanden, und die Temperatur beträgt 0°C, da sämtliche zugeführte Wärme in den Phasenübergang zu Wasser fliesst und keine Temperaturänderung zur Folge hat. Daher muss die Temperatur beim Schmelzpunkt liegen. $T_{g,2} = T_{EW,2}$ => weil Thermodynamisches Gleichgewicht!

Der Druck $p_{g,2}$ bleibt gleich wie im Zustand 1, also $p_{g,2} = p_{g,1} = 1{,}4$ bar. Das liegt daran, dass sich weder der Aussendruck noch die Masse $(m_K + m_{EW})$ geändert haben.

$T_{g,2} = 0°C$

$p_{g,2} = 1{,}401 bar = p_{g,1}$

3 c)

$Q - \Delta E = \Delta U_G = U_{G,2} - U_{G,1}$

$= c_v (T_2 - T_1) m = 0.635 \frac{kJ}{kgK} \cdot 3{,}42 \cdot 10^{-3} kg \cdot (500K)$

$|Q_{12}| = \underline{1{,}0829\ kJ}$

d) $|Q|_{12} = 1500\,J$ aus Aufg.stellg

$p_{2,EW} = p_{amb} + \frac{mk \cdot g}{A} = \underline{1{,}4\ bar}$

aus Tab. 1

$x_{E,1} = 0.6$

$U_{EW,1} = x \cdot [illegible] \cdot -333{,}458 \frac{kJ}{kg} + (1-x) \cdot [illegible] \left(-0.095 \frac{kJ}{kg}\right)$

$= \underline{-200{,}093 \frac{kJ}{kg}}$ [illegible]

$U_{EW,2} = U_{EW,1} + \Delta U = U_{EW,1} + Q_{12}$

$= -200{,}093 \frac{kJ}{kg} + \frac{1{,}5\,kJ}{0{,}1\,kg} = [illegible] - 185{,}0528$

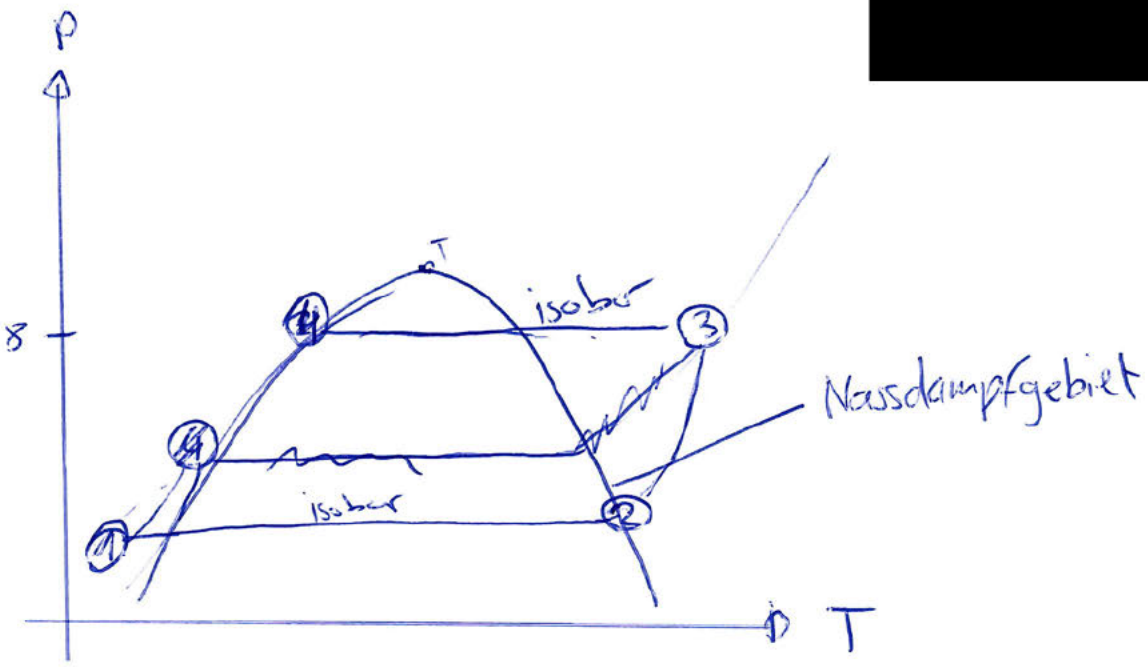
$U_{EW,2} = [illegible] - 185{,}0528 = x_2 [illegible] \cdot -333{,}458 \frac{kJ}{kg}) + (1-x_2) [illegible] \left(-0.095 \frac{kJ}{kg}\right)$

$x_2 = [illegible]$

$0{,}555$

4.

a)



b) $0 = \dot{m}(h_e - h_a) + \dot{Q} - \dot{W}$

c) $x = \frac{m_g}{m_g + m_f}$

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

e)

4e) Die Temperatur wird nicht weiter fallen, weil
Wärme abgeführt wird.