Aufgabe 1)

[redacted]

a) ges.: $\dot{Q}_{aus}$

Stationärer Fließprozess:

$$0 = \dot{m}\left(h_e - h_a + \cancel{\frac{w_e^2 - w_a^2}{2}}^{0} + \cancel{g(z_e - z_a)}^{0}\right) + \sum_j \dot{Q}_j - \cancel{\sum_n \dot{W}_{t,n}}^{0}$$

$$\Leftrightarrow 0 = \dot{m}(h_e - h_a) + \sum_j \dot{Q}_j$$

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

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

$$= \dot{m}_{ein}\left(292{,}98\,\frac{kJ}{kg} - 419{,}04\,\frac{kJ}{kg}\right) + \dot{Q}_R$$

$$= 0{,}3\,\frac{kg}{s}\left(292{,}98\,\frac{kJ}{kg} - 419{,}04\,\frac{kJ}{kg}\right) + 100\,kW =$$

$$= 62{,}182\,\frac{kJ}{s} = \underline{\underline{62{,}182\,kW}}$$

Werte für h_f kommen aus Tabelle 42 !

b)

$$\overline{T} = \int_e^a T\,ds \cdot \frac{1}{s_a - s_e}$$

$$= \frac{T_{KF,aus} \cdot s_{aus} - T_{KF,ein} \cdot s_{ein}}{s_{aus} - s_{ein}}$$

c) (Mit Ersatzergebnis $\bar{T}_{KF} = 295\,K$)

$$0 = \dot{m}\,(s_e - s_a) + \sum_j \left(\frac{\dot{Q}_j}{\bar{T}_j}\right) + \dot{S}_{erz}$$

$$\left.\begin{aligned} s_e &= 0{,}9549\ \frac{kJ}{kg\cdot K} \\ s_a &= 1{,}3069\ \frac{kJ}{kg\cdot K} \end{aligned}\right\}\ \text{Tabelle A-2}$$

$$\Leftrightarrow\ \dot{S}_{erz} = \dot{m}\,(s_a - s_e) + \dot{Q}_{aus} \cdot \frac{1}{\bar{T}_{KF}} =$$

$$= 0{,}3\ \frac{kg}{s}\left(1{,}3069\ \frac{kJ}{kg\cdot K} - 0{,}9549\ \frac{kJ}{kg\cdot K}\right) + \frac{62{,}182\ kW}{295\ K}$$

$$= 0{,}316\ \frac{kJ}{K\cdot s}$$

d) Energiebilanz:

$$\frac{dE}{dt} = \sum_i \dot{m}_i(t)\left[h_i(t) + \cancelto{0}{ke_i} + \cancelto{0}{pe_i(t)}\right] + \sum_j \dot{Q}(t) - \cancelto{0}{\sum \dot{W}_n(t)}$$

$$Q_{R,12} = \Delta m_{12}\,(h_{20^\circ C} - h_{70^\circ C}) + m_{ges,1}\,(h_e - h_{70^\circ C})$$

$$, \text{wobei}\quad h_{20^\circ C} = 83{,}96\ \frac{kJ}{kg}$$

$$h_{70^\circ C} = 292{,}98\ \frac{kJ}{kg} \qquad \text{Tabelle A2}$$

$$h_e = (419{,}04 + x_D \cdot 2257)\ \frac{kJ}{kg}$$

$$= 430{,}325\ \frac{kJ}{kg}$$

[redacted]

Fortführung 1c)

$$\Delta m_{12} = \frac{Q_{R,12} - m_{ges,1}(h_{e} - h_{70°C})}{h_{20°C} - h_{70°C}} =$$

$$\underline{\underline{= 3614,11\ kg}}$$

e) $$\frac{dS}{dt} = \sum_i \dot{m}_i(t) s_i(t) + \int_G \frac{\partial \dot{Q}}{T_G} + \dot{S}_{erz.}$$

$$\Rightarrow \Delta S = \sum_i \Delta m_i \cdot s_i + \int_G \frac{Q}{T_G} + S_{erz}$$

$$\Rightarrow \Delta S = \Delta m_{12}(s_{20°C} - s_{70°C}) + m_{ges,1}(s_{100°C} - s_{70°C}) + S_{erz}$$

$$\Rightarrow s_{20°C} = 0{,}2966\ \frac{kJ}{kg \cdot K}$$

$$s_{70°C} = 0{,}9549\ \frac{kJ}{kg \cdot K}$$

$$s_{100°C} = (1{,}3069 + x_D(7{,}3549 - 1{,}3069))\ \frac{kJ}{kg \cdot K}$$

$$= 1{,}33714$$

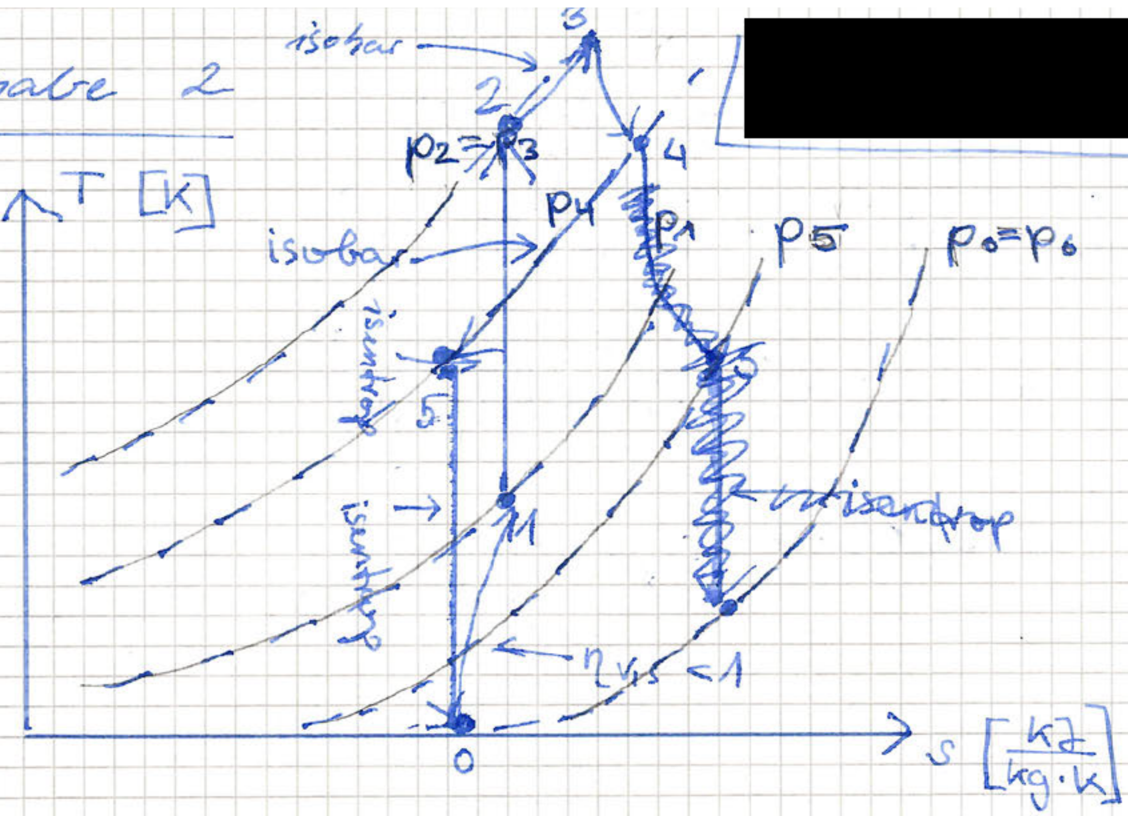
$$S_{erz} = 0 \quad (\text{adiabat})$$

~~KS~~ = Tabelle A-2

Aufgabe 2

[redacted]

a)



b)

w_5, p_5, T_5, p_6 gegeben

Schubdüse adiabat reversibel (isentrop)

$$\Rightarrow T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 431{,}9\,K \cdot \left(\frac{0{,}191\,bar}{0{,}5\,bar}\right)^{\frac{0{,}4}{1{,}4}} =$$

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

$$0 = \dot{m}\left(h_e - h_a + \frac{w_e^2 - w_a^2}{2} + \cancel{g(z_e - z_a)}^{0}\right) + \cancel{\sum_i \dot{Q}_i}^{0} - \cancel{\sum_n \dot{W}_n}^{0}$$

$$0 = \dot{m}\left(h_e - h_a + \frac{w_e^2 - w_a^2}{2}\right)$$

$$(h_e - h_a) = c_p^{ig}(T_5 - T_6)$$

$$w_e = w_5$$

$$-2\left(h_e - h_a\right) = \omega_e^2 - \omega_a^2$$

$$\omega_a^2 = \omega_5^2 + 2 \cdot c_{p,Luft}^{ig}\left(T_5 - T_6\right)$$

$$\omega_a = \sqrt{\omega_5^2 + 2\, c_{p,Luft}^{ig}\left(T_5 - T_6\right)}$$

$$= 220{,}47\ \frac{m}{s}$$

c)

Aufgabe 3

[redacted]

a)

$$R = \frac{\bar{R}}{M_g} = \frac{8,314 \frac{J}{mol \cdot K}}{50 \frac{kg}{kmol}} = 0,1663 \frac{kJ}{\cancel{mol}\, kg \cdot K}$$

$$V_{g,1} = 3,14L = 3,14 \cdot 10^{-3} m^3$$

$$p_{g,1} \cdot V_{g,1} = R \cdot T_{g,1} \cdot m_{g,1}$$

$$\Rightarrow p_{g,1} = \cancel{\frac{0,1663 \frac{kJ}{kg \cdot K} \cdot (500 + 273,15)K}{3,14 \cdot 10^{-3} m^3}} =$$

$$\cancel{= 28636\ kPa}$$

$$p_{1,g} \cdot \pi D^2 = g(m_K + m_{EW}) + p_{amb}$$

$$p_{1,g} = \frac{9,81 \frac{m}{s^2}(0,1kg + 32kg)}{\pi \cdot (0,1m)^2} = \cancel{10023,61\ Pa}$$

$$111348,6101\ Pa$$

$$m_{g,1} = \frac{p_{g,1} \cdot V_{g,1}}{R \cdot T_{g,1}} \approx \cancel{2,45 \cdot 10^{-4} kg}$$

$$2,72 \cdot 10^{-3}$$

b) $p_{,G2}$ ist unverändert, weil der durch das Schmelzen verursachte Temperaturunterschied ausgeglichen wird, indem sich das Volumen verändert. Von oben drückt ja unverändert die gleiche Gewichtskraft

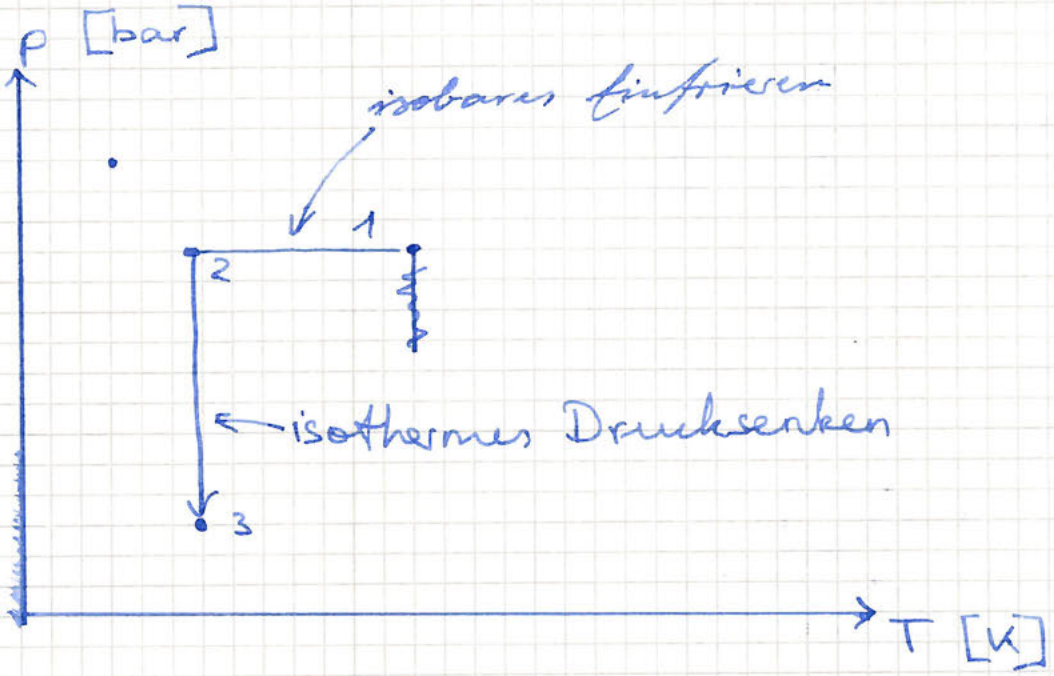
c) $|\overline{\overline{Q}}|_{12} = {}^{+}W_v = \pm m_{Gas} \cdot p_{Gas} (V_2 - V_1)$

d)

Aufgabe 4)

[redacted]

a)



b) ~~Von 3 → 4:~~

= Von 2 → 3

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

$h_2 =$

$h_3 = 264{,}15\ \frac{kJ}{kg}$ Tabelle A11

$T_2 = T_i - 6K$

$$\rightarrow \dot{m} = \frac{\dot{W}_K}{h_2 - h_3}$$

c) $$\phi = \phi_f + x_1 (\phi_g - \phi_f)$$

$$\Rightarrow x_1 = \frac{\phi - \phi_f}{\phi_g - \phi_f}$$

d) $$\varepsilon_K = \frac{|\dot{Q}_{ab}|}{|\dot{W}_t|} =$$

e) Kälter