Aufgabe 1 [redacted]

E-Bilanz Reaktor: (stationär) (siedendes Wasser)

a)

$\cancel{0 = \dot{m}_{ges}} \quad \cancel{0 = \dot{m}_{ein}(h_{ein}) + \dot{Q}_R + \dot{Q}_{aus}}$

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

Tab A-2:

$h_{ein} = h_f(70°C) = 292.98$

siedende Flüssigkeit

$h_{aus} = h_f(100°C) = 419.04$

$\dot{Q}_{aus} = \dot{m}_{ein}(h_{aus} - h_{ein}) + \dot{Q}_R = \underline{137.818 \text{ kW}}$

~~b) Entropiebilanz Kühlf.:~~

$\cancel{0 = \dot{m}_{KF}(s_{ein} - s_{aus}) + \frac{\dot{Q}_{aus}}{T} + \dot{S}_{erz}}$ ~~von KF~~ ~~0, da Druck sich nicht ändert → reversibel~~

~~E-Bilanz KF: von KF~~

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

$\cancel{\dot{m}_{KF} = \frac{\dot{Q}_{aus}}{h_{aus} - h_{ein}}}$

b)

druck ändert sich nicht → reversibel

$s_2 = s_{KF,aus}$

$s_1 = s_{KF,ein}$

$$\bar{T} = \frac{\int_{KF,ein}^{KF,aus} T\,ds}{s_{KF,aus} - s_{KF,ein}} = \frac{q^{rev}}{s_2 - s_1} = \frac{h_2 - h_1}{s_2 - s_1}$$

$$h_2 - h_1 = c(T_2 - T_1) + \cancel{v(p_2 - p_1)} \quad p_2 = p_1 \qquad | \; c = \text{Wärmekapazität des KF}$$

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

$$\bar{T} = \frac{\cancel{c}(T_2 - T_1)}{\cancel{c} \cdot \ln\left(\frac{T_2}{T_1}\right)} = \frac{T_2 - T_1}{\ln\left(\frac{T_2}{T_1}\right)} = \underline{293.12 \text{ K}} \qquad \left| \; \begin{array}{l} T_1 = T_{KF,ein} \\ T_2 = T_{KF,aus} \end{array} \right.$$

Rückseite! aufgabe c auf separatem Blatt

d) E-Bilanz: $\Delta E = \Delta U$; $Q_{R,12} = -35\ MJ$

$$\Rightarrow U_2 - U_1 = \Delta m_{12} \cdot h(20°C) + Q_{R,12}$$

$$m_{ges,1} = 5755\ kg = m_1$$

$$m_{ges,2} = m_{ges,1} + \Delta m_{12} = m_2$$

$$\Rightarrow m_2 u_2 - m_1 u_1 = \Delta m_{12} \cdot h(20°C) + Q_{R,12}$$

$$\Delta m_{12}\left(u_2 - h(20°C)\right) = m_1(u_1 - u_2) + Q_{R,12}$$

$$\Delta m_{12} = \frac{m_1(u_1 - u_2) + Q_{R,12}}{u_2 - h(20°C)}$$

Tab A-2:

$h(20°C) = h_f(20°C) = 83.96$

siedende flüssigkeit

$u_2 = u_f(70°C) = 292.95$

~~$u_2 = u_f(20°C) = 83.96$ 83.95~~

$u_1 = u_f(100°C) = 418.94$

~~$\Rightarrow \Delta m_{12}$~~

$$\Rightarrow \Delta m_{12} = 3302\ kg$$

e) S-Bilanz:

~~$\Delta S_{12} = \Delta m_{12}(s(20°C)) + \frac{Q_{R,12}}{T} + S_{erz}$ | $T = 295\ K$~~

~~Tab A-2: $T = 295\ K$~~

~~$s(20°C) = s_f(20°C) = 0.2966$~~

$\Delta S_{12} = m_2 \cdot s_2 - m_1 \cdot s_1$ | $m_2 = m_1 + \Delta m_{12} = 9056\ kg$

Tab A-2:

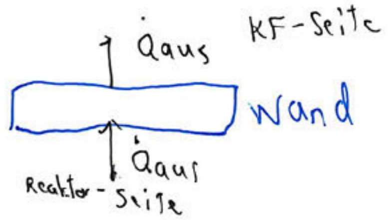
$s_2 = s_f(70°C) = 0.9549$ $\Rightarrow \Delta S_{12} = 1126.36\ kJ/K$

$s_1 = s_f(100°C) = 1.3069$

Aufgabe 1 [redacted]

c) S-Bilanz Kühlwand:

$$0 = \frac{|\dot{Q}_{aus}|}{T_{Reaktor,1}} - \frac{\dot{Q}_{aus}}{\overline{T}} + \dot{S}_{erz}$$



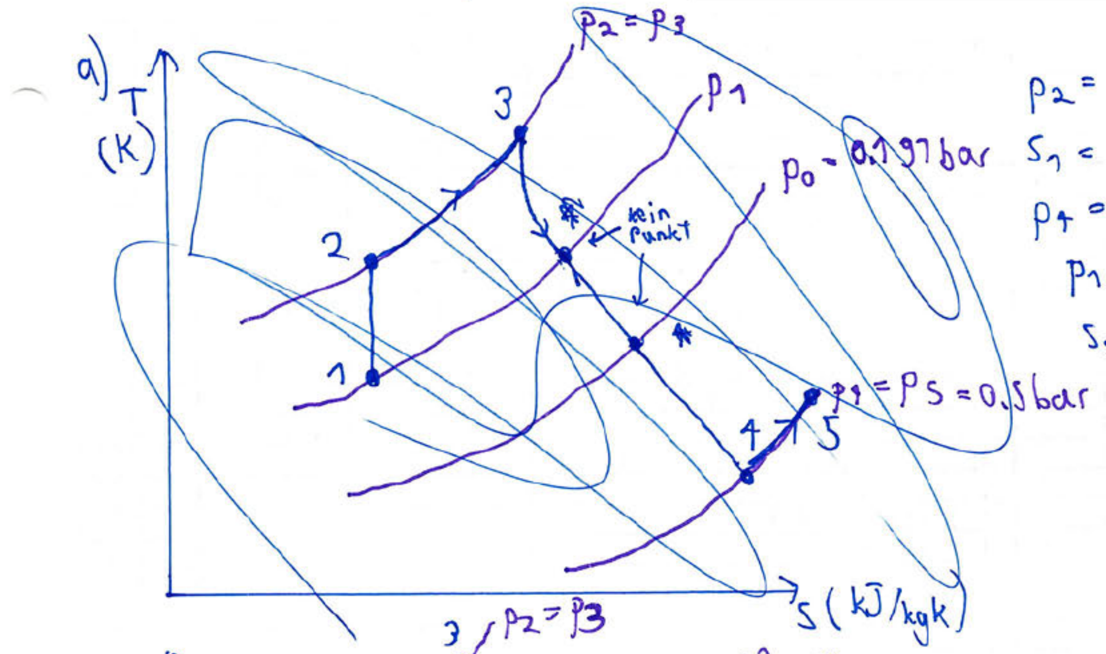
$$\Rightarrow \dot{S}_{erz} = \dot{Q}_{aus}\left(\frac{1}{\overline{T}} - \frac{1}{T_{Reaktor,1}}\right)$$

| $\dot{Q}_{aus} = 137.818$ kW

$$\Rightarrow \dot{S}_{erz} = 0.1008 \text{ kW/K}$$

Aufgabe 2 [redacted]

a)



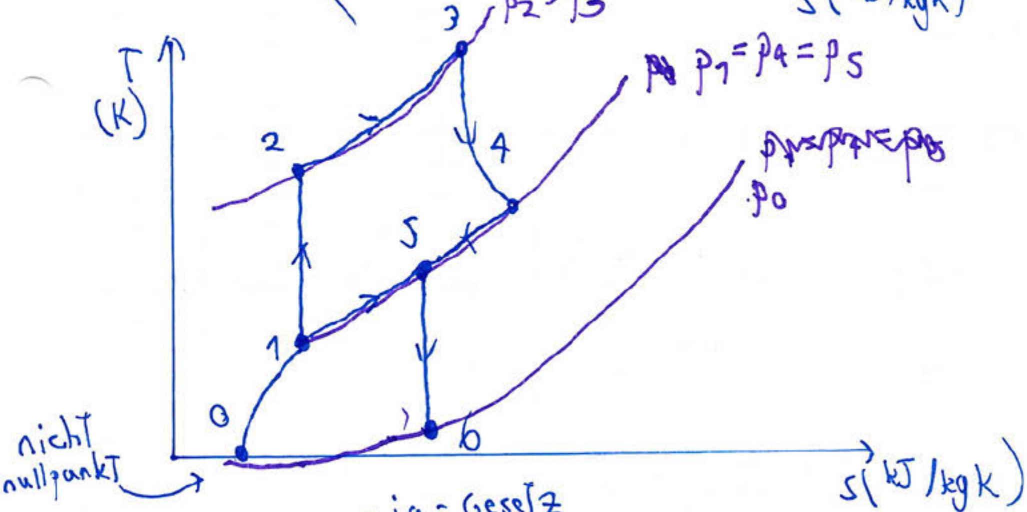
$p_2 = p_3$

$s_1 = s_2$

$p_4 = p_5 = 0.5$ bar

$p_1 = 0.5$ bar

$s_5 = s_6$



b)

ig - Gesetz

$h_5 = c_p \cdot T_5 = 434.49$ kJ/kg

E-Bilanz Schubdüse: adiabat $\dot{Q} = 0$; stationär

$0 = \dot{m}_{ges} \left(h_5 - h_6 + \frac{1}{2} w_5^2 - \frac{1}{2} w_6^2 \right)$

$\Rightarrow h_6 = h_5 + \frac{1}{2} \left(w_5^2 - w_6^2 \right)$

T_6: 5→6 isentrop → $n = k$ $\quad p_6 = p_0$

polytropes T-verhältnis:

$T_6 = T_5 \cdot \left(\frac{p_0}{p_5} \right)^{\frac{k-1}{k}} = 293.9$ K $\quad | \ h_6 = c_p \cdot T_6$

$\Rightarrow w_6 = \left(2 \cdot (h_5 - h_6) + w_5^2 \right)^{1/2} = \underline{571 \text{ m/s}}$

Rückseite!

c)
$$\Delta e_{x,str} = h_6 - h_0 - T_0 (s_6 - s_0) + p_0 (v_6 - v_0)$$

$$h_6 - h_0 = c_p (T_6 - T_0) = 57.05 \text{ kJ/kg}$$

$$s_6 - s_0 = c_p \cdot \ln\left(\frac{T_6}{T_0}\right) - \cancel{R \cdot \ln\left(\frac{p_6}{p_0}\right)}^{p_6 = p_0} = 0.791 \text{ kJ/kgK}$$

$$R = c_p - \frac{c_p}{k} = 0.287 \text{ kJ/kgK}$$

ig-Gesetz

$$v_6 = \frac{R T_6}{p_6} = 4.416 \text{ m}^3/\text{kg}$$

$$v_0 = \frac{R T_0}{p_0} = 3.653 \text{ m}^3/\text{kg}$$

$$\Delta e_{x,str} = \underline{79.78 \text{ kJ/kg}}$$

d) keine Arbeit wird zugeführt nur die Ströme und Wärme q_B

Exergie-Bilanz Gesamtsystem: (stationär)

$$0 = \dot{m}_{ges}(-\Delta e_{x,str}) + \dot{E}_{x,Q_B} - \dot{E}_{x,verl}$$

$$\dot{E}_{x,Q_B} = \left(1 - \frac{T_0}{T_B}\right) \cdot \dot{Q}_B = \dot{m}_K \left(1 - \frac{T_0}{T_B}\right) \cdot q_B$$

$$\dot{m}_{Ges} = \dot{m}_K + \dot{m}_M = \dot{m}_K + 5.293 \cdot \dot{m}_K = 6.293\, \dot{m}_K$$

$$\Rightarrow \dot{m}_K = \frac{\dot{m}_{Ges}}{6.293}$$

$$\Rightarrow 0 = -\Delta e_{x,str} + \frac{1}{6.293}\left(1 - \frac{T_0}{T_B}\right) \cdot q_B - e_{x,verl}$$

$$e_{x,verl} = \frac{1}{6.293}\left(1 - \frac{T_0}{T_B}\right) q_B - \Delta e_{x,str} = \underline{134.89 \text{ kJ/kg}}$$

$$\mid \Delta e_{x,str} = 79.78 \text{ kJ/kg}$$

Aufgabe 3 [redacted]

a) $R_g = \frac{\bar{R}}{M_g} = 166.28\ J/kgK$ | $A = \frac{\pi D^2}{4} = 0.0078\ m^2$

Kräfte-GGW

$p_{g,1} \cdot A = m_K \cdot g + p_{amb} \cdot A + m_{EW} \cdot g$

~~$p_{g,1} = \frac{m_K g + m_{EW}}{A} + p_{amb} = 1.38\ 1.4\ bar$~~ ~~1.3998~~ $p_{g,1} = \frac{(m_K + m_{EW}) g}{A} + p_{Amb} = 1.4\ bar$

$m_g = \frac{p_{g,1} \cdot V_{g,1}}{R T_{g,1}} = 3.42\ g$

b) $p_{g,2} \overset{!}{=} p_{g,1} = 1.4\ bar$, da immer noch der gleiche druck durch atmosphäre und Gewicht wirkt.

~~reibungsfrei →~~ reibungsfrei und adiabat ~~→ reversibel → n = k~~

~~$k = \frac{R + c_v}{c_v} = 1.263$~~

~~polytropes T-Verhältnis $\Rightarrow T_{g,2} = T_{g,1} \left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} = 773.15\ K$~~

c) ~~$T_{g,2} = 0.003\ °C$~~

Rückseite!

c) $T_{g,2} = 0.003°C$

E-Bilanz Gas:

$$U_2 - U_1 = Q_{12} - \int_1^2 p\,dV \overset{\text{isobar}}{=} Q_{12} - p_1(V_2 - V_1)$$

$$V_2 = \frac{mRT_2}{p_2} = 0.0011\,m^3$$

$$u_2 - u_1 = c_v(T_2 - T_1) = -316.498\,kJ/kg$$

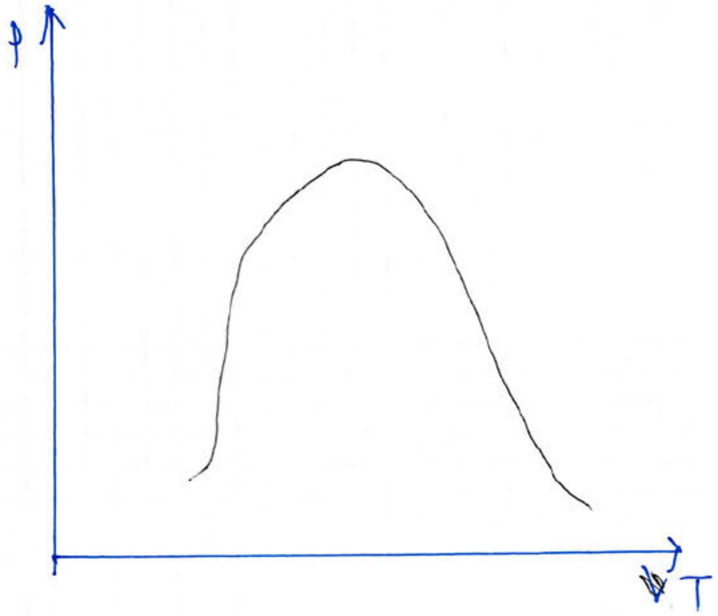
$$Q_{12} = m_g(u_2 - u_1) + p_1(V_2 - V_1) = \cancel{-286.68\,kJ}\ -1398.9\,kJ = -1400\,kJ$$

d)

$$x_{Eis,2} = \frac{u_{2,eis} - u_f}{u_{Fest} - u_f}$$

Aufgabe 4 [redacted]

a)



$h_1 = h_4$
$p_1 = p_2$
$p_3 = p_4 = 8\,bar$
$s_2 = s_3$

b) Tab A-11

$h_4 = h_f(8\,bar) = 93.42\ kJ/kg$

$h_1 = h_4$, da isenthalpe drossel