Aufgabe 1 [redacted]

a) ges: $\dot{Q}_{aus}$ (approx +65 kW)

Energie Bilanz:

$$\frac{dE}{dt} = \sum \dot{m}_i(t)[h_i(t) + ke_i(t) + pe_i(t)] + \sum \dot{Q}_j(t) - \sum \dot{W}_n(t)$$

~~$\dot{m}_{KF} = 0$, $\dot{W}_{KF} = 0$ ⇒ $\frac{dE}{dt} = \sum \dot{Q}_j$~~

ges: $\dot{m} = 0.3$ kg/s, $\dot{Q}_R = 100$ kW, $\dot{Q}_{aus} = ?$

dastationär: $\frac{dE}{dt} = 0$

$$0 = \dot{m}[h_{ein} - h_{aus}] + 100\,kW - \dot{Q}_{aus}$$

$$\Rightarrow \dot{Q}_{aus} = 0.3[h_{ein} - h_{aus}] + 100 \cdot 10^3$$

h_{ein}: reines Wasser; 70°C $x_D = 0.005$ // h_{aus}: 100°C

Tab A2: $h_f = 292.98$ $h_g = 2626.8$ (70°C

$h_{ein} = 292.98 + 0.005(2626.8 - 292.98) = 304.65$

Tab A2: $h_f = 419.04$ $h_g = 2676.1$

$h_{aus} = 419.98 + 0.005(2676.1 - 419.98) = 431.26$

$$\Rightarrow \dot{Q}_{aus} = 0.3[304.65 - 431.26] + 100 \cdot 10^3 = -55967.07\ J/s$$
$$= 99.96\ kJ/s$$

b) $\bar{T}_{KF} = \frac{\int_e^a T ds}{s_a - s_e} = \frac{\int}{\quad}$

$$s_a - s_e = \int_{T_1}^{T_2} \frac{c^{if}(T)}{T} dT \Rightarrow \frac{\int_e^a T ds}{\int_{T_1}^{T_2} \frac{c^{if}(T)}{T} dT} = \bar{T}_{KF} = \frac{\int_e^a T ds}{c^{if} \int_{T_1}^{T_2} \frac{1}{T} dT}$$

$T_1 = 288.15K$ $T_2 = 298.15K$

$$\Rightarrow \int_{T_1}^{T_2} \frac{1}{T} dT = \ln\left(\frac{T_2}{T_1}\right) = \ln\left(\frac{298.15}{288.15}\right) = 0.0341$$

Tabelle A2: $s_e(15°C) = 0.2245$
$s_a(25°C) = 0.3674$

$$\Rightarrow \bar{T}_{KF} = \frac{\int_e^a T ds}{0.3674 - 0.2245} = \frac{\int_e^a T ds}{0.1429} = \frac{T_a s_a - T_e s_e}{0.1429} = 313.86\,K$$

c) Entropiebilanz

$0 = \dot{m}[s_e - s_a] + \sum \frac{\dot{Q}_j}{T_j} + \dot{S}_{erz}$

$\Rightarrow -\dot{S}_{erz} = \frac{\dot{Q}_j}{T_j} = \frac{99.96}{295} = 0.3388 \, kJ/K\cdot s = 0.3388 \, \frac{kW}{K}$

d) Energiebilanz:

$m_{12} \Rightarrow T_{ein,12} = 20°C$

$T_{Rückfluss} = 70°C$

$Q_R = 35 MJ$

$\frac{dE}{dt} = m_{12}[h_{12}] + Q_R = E_{100°C} - E_{70°C} = m(u_{100} - u_{70})$

$E_{100°C} = U_{100} + KE + PE = U = m u_{100}$

$E_{70°C} = U_{70} = m u_{70°C}$

$\Rightarrow m_{12}[h_{12}] + Q_R = 5755(1.337 - 0.589) = 2004.1 \cdot 10^3$

$s_{100} = 1.3069 + 0.005(7.3545 - 1.3069) = 1.33714$ (TAB A2)

$s_{70} = 0.5545 + 0.005(7.7553 - 0.5545) = 0.5885$

~~$2004.1\cdot 10^3 / 83.96 = 440.73$ kg~~

~~Entropiebilanz~~

$\Rightarrow \frac{Q_R - 2004 \cdot 10^3}{83.96 \times 10^3} = m_{12} = 4680 \, kg$

~~c) $S_2 = 4680 \cdot 0.2966 + 5755(0.5545$~~

$u_{100} = 418.94 + 0.005(2506 - 418.94) = 425.3$

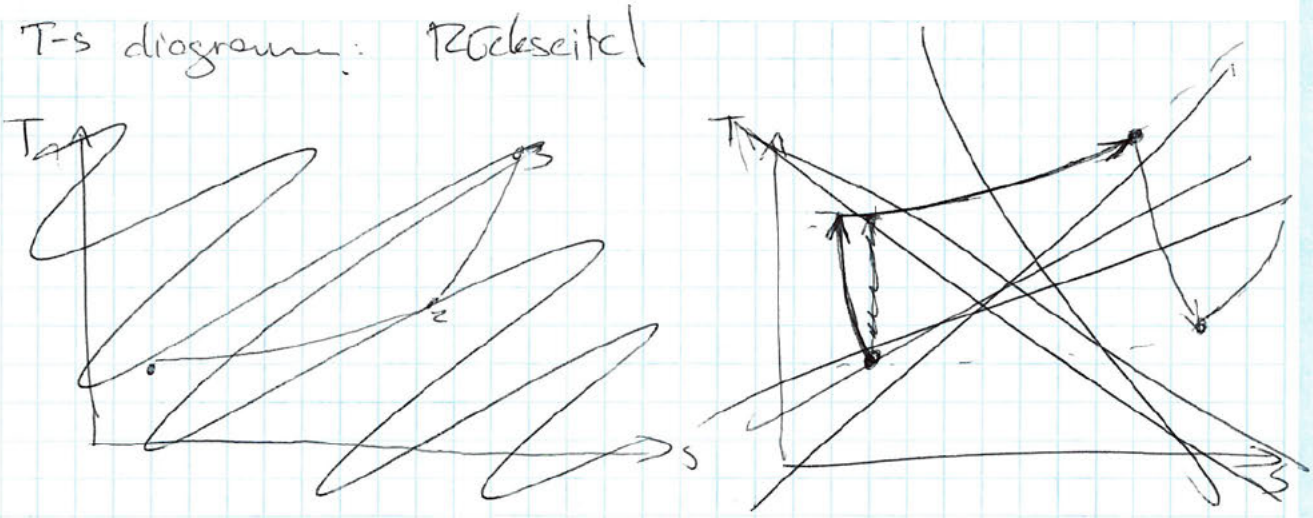
$u_{70} = 252.95 + (2465.6 - 252.95) \cdot 0.005 = 303.6$

$m_{12}[h_{12}] + Q_R = 5755(425.3 - 303.8) = 722454$

$\frac{722454.5 - 35 \times 10^3}{83.95 \cdot 10} = 8.1 \, kg \times 10^3 kg = 8100 \, kg$

Aufgabe (2) [redacted]

a) T-s diagramm: Rückseite



b) ges p_6, w_6

$w_5 = 220\ m/s$ $\quad p_6 = p_0 = 0.191\ bar$

$p_5 = 0.5\ bar$

$T_5 = 431.9\ K$

adiabat: $\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} \Rightarrow \frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$

$\Rightarrow T_6 = 431.9 \left(\frac{0.191 \cdot 10^5}{0.5 \cdot 10^5}\right)^{\frac{1.4-1}{1.4}} = 328.07\ K = 328.1\ K$

$w_6 = k_e = \frac{w^2}{2}$

stationärer Fliessprozess:

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

$h_e - h_a = \int_{T_1}^{T_6} c_p^{is}(T)\,dT = c_p^{is}(328.1 - 431.9) = -104.4778\ kJ/kg$

$0 = \frac{w_e^2 + w_a^2}{2} - 104.477{,}8$

$\Rightarrow 2(104.477{,}8 - \frac{w_e^2}{2}) = w_a^2 = 160.444$

$\Rightarrow w_a = \sqrt{160.444} = 400.55\ m/s$

c) Exergiebilanz:

$\dot{E}_{x,str} = \dot{m}\left[h - h_0 - T_0(s - s_0) + k_e\right]$

$\dot{E}_{x,str} = \dot{m}_{ges}\left[h_6 - h_0 - T_0(s_6 - s_0) + k_e\right]$

$e_{x,str} = \int_{T_1}^{T_6} c_p^{is}(T)\,dT - T_6\left(\int_{T_1}^{T_6} \frac{c_p^{is}(T)}{T}\,dT - R\ln\left(\frac{p_1}{p_1}\right)\right) + \frac{w_6^2}{2}$

$$e_{x\,str} = 1.006(328.1 - 243.15) - \frac{243.15}{328.1}\left(1.006\ln\left(\frac{328.1}{243.15}\right) - R\ln(1)\right) + \frac{(400.55)^2}{2}$$

$$\Delta e_{x\,str} = 80234.17\ J/kg = 80.2\ kJ/kg$$

d)

$$\frac{dE_x}{dt} = \sum \dot{E}_{x\,str} - \dot{E}_{i\,vol} + \sum \dot{E}_{x,Q,j} - \sum\left[\dot{W}_n(t) - p_0\frac{dV(t)}{dt}\right]$$

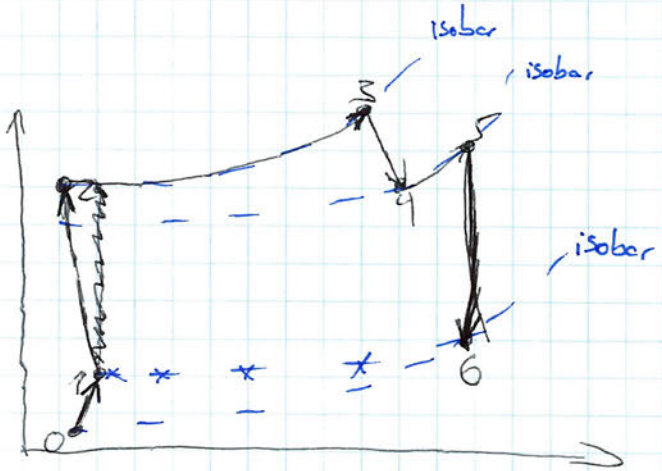
$$\dot{e}_{x,Q} = \int_a^{}\left(1 - \frac{T_0}{T_a}\right)\delta Q \quad (\text{da } q_B \text{ gewonnen})$$

$$\frac{de_x}{dt} = \sum \dot{e}_{str} + \sum \dot{e}_{x,Q,j} - \dot{e}_{x,vol} = 80.2\ kJ/kg + \quad - e_{x,vol}$$

$$E_{x,u} + KE = 80.2 + e_{x,Q} - e_{x,vol}$$

$$\Rightarrow e_{x,vol} = 80.2 + e_{x,Q} - e_{x,u} - ke \qquad \left\{ ke = \frac{w^2}{2} \right.$$

a)



Aufgabe 3

[redacted]

a) ges: $p_{g,1}$, m_g

geg: $w_S = 50 \frac{g}{kmol}$ $T_{S,1} = 500°C$ $V_{S,1} = 3.14L$

$pV = mRT$ $R = \frac{\bar{R}}{m} = \frac{8.31}{50} = 0.166 \frac{J}{gK}$

$\frac{p}{V} = \frac{RT}{V} = \frac{0.166 \cdot 773.15}{3.14} = 37.84$.

b) ges: $T_{S,2}$, $p_{S,2}$

c) $E_2 - E_1 = \sum Q_j - \sum W_{v,k}$

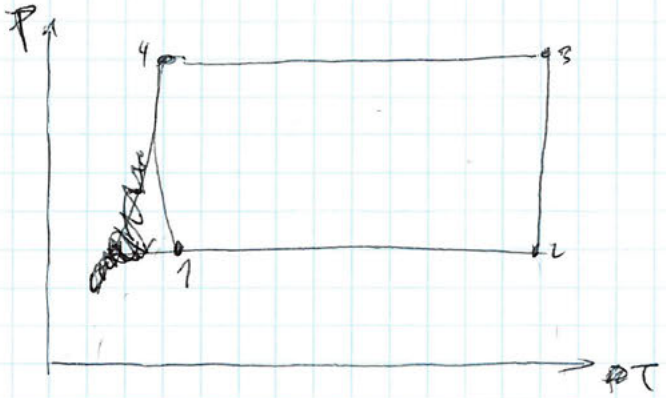
$E_2 - E_1 = Q_{12}$

d) $x = 0.003 \rightarrow u_{fest} = -333.442$ $u_{flüssig} = -0.033$

$\Rightarrow u_{tot} = u_f + x_{Eis} (u_{flüssig} - u_{fest})$

Aufgabe (4) [redacted]

a) p-T Diagramm



b) gas in R134a

stat. Fliessprozess:

$0 = \dot{m}[h_2 - h_1] + \dot{Q}_{zu} - \sum \dot{W}_{t,12}$

$0 = \dot{m}[h_2 - h_3] + \sum \dot{W}$

$\frac{\dot{Q}_{zu}}{h_2 - h_3} = \dot{m}$

$p_2 = 1\,bar$

c) $p_4 = p_3 = 8\,bar$
$p_1 = 1\,bar$

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

e) Temperatur sinkt da höher massenstrom durch 2 und deshalb 1 fliessen wird wegen der grössere Druckdifferenz an der Verdichter (2→3)