Aufgabe 1

a) Energiebilanz am Reaktionsgemisch:

$$\frac{dE}{dt} \overset{\text{St.FP}}{=} \sum_i \dot{m}_i [h_i + ke_i + pe_i] + \sum_j \dot{Q}_j - \sum_n \dot{W}_n$$

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

$$\dot{m}_{ein} = \dot{m}_{aus}$$

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

h_{ein}: $h_f(70°C) = h_{ein} = 292{,}98\ kJ/kg \rightarrow$ TAB-A2 @ 70°C

h_{aus}: $h_f(110°C) = h_{aus} = 419{,}04\ kJ/kg \rightarrow$ TAB-A2 @ 110°C

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

b) $$\bar{T} = \frac{\int_e^a T\,ds}{s_a - s_e}$$

c) Entropiebilanz zwischen Kühlmittel und Reaktor:

$$\frac{dS}{dt} \overset{\text{Stationär}}{=} \sum_j \frac{\dot{Q}_j}{\bar{T}_j} + \dot{S}_{erz} \qquad \bar{T}_{KF} = 295\ K$$

$$\Rightarrow \dot{S}_{erz} = + \frac{\dot{Q}_{aus}}{\bar{T}_{KF}} = 0{,}21\ kJ/kg\,K = 210\ J/kg\,K$$

d) Energiebilanz am Reaktionsgemisch

↳ $\Delta E = \Delta m_{12} (u_2 - u_1) = m_{ges,1} \cdot h_1 + \dot{Q}_{R,1} - \dot{Q}_{aus}$

$\Rightarrow \Delta m_{12} = \frac{m_{ges,1} \cdot h_1 + \dot{Q}_R - \dot{Q}_{aus}}{u_2 - u_1}$ $\quad \dot{Q}_R = \dot{Q}_{aus}$

h_1: $h_1 = h_f(100°C) + x_D \cdot (h_g(100°C) - h_f(100°C)$

$= 419,04 + 0,005 (2676,1 - 419,04) = 430,325$ kJ/kg

u_1: $u_1 = u_f(100°C) + x_D \cdot (u_g(100°C) - u_f(100°C)$

$= 418,911 + 0,005 (2506,5 - 418,94) = 429,377$ kJ/kg

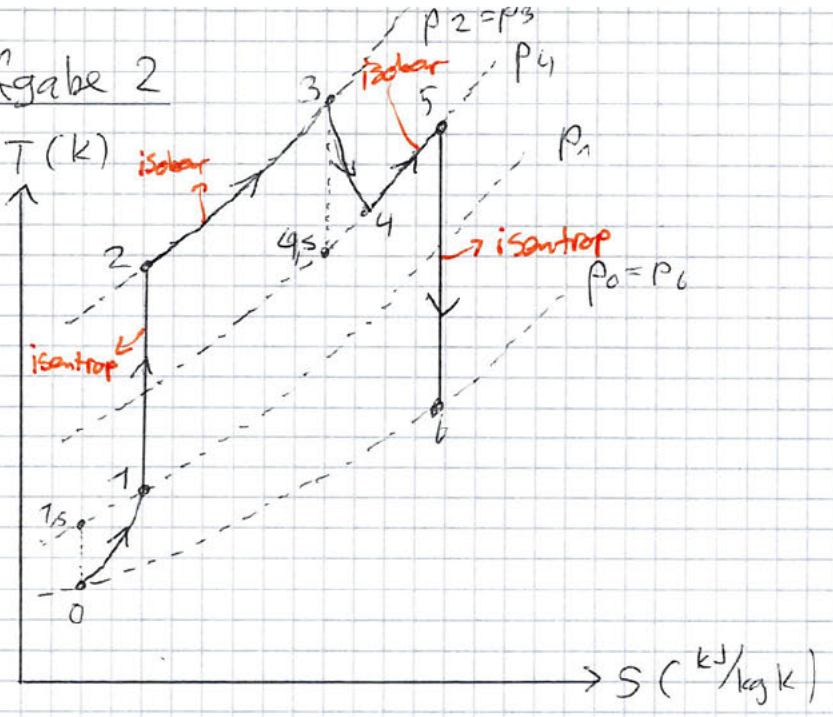
u_2: $T_2 = 70°C$

e) Entropiebilanz ~~da~~ Reaktionsgemisch:

↳ $\Delta S_{12} = \Delta m_{12} \cdot s_{12} + Q_{R,12} - Q_{aus,12} + S_{erz}$

Aufgabe 2

a)



adiabat-reversibel ≡ isentrop

b) Energiebilanz an Schubdüse:

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

$\Rightarrow 2(h_5 - h_6) = w_5^2 - w_6^2$

$\Rightarrow w_6 = \sqrt{-2(h_5 - h_6) + w_5^2}$

h_5: Interpolieren aus TAB-A22 @ 430 k & 440 k

↳

430	431,43	
431,9	h_5	$\Rightarrow h_5 = 431{,}43 + \frac{441{,}61 - 431{,}43}{440 - 430}(431{,}9 - 430)$
440	441,61	

$= 433{,}36412$ kJ/kg

h_6: isentrop Schubdüse $\rightarrow s_5 = s_6 = 2{,}06979$ kJ/kgk

430	2,06533	
431,9	s_5	$\Rightarrow s_5 = 2{,}06533 + \frac{2{,}08878 - 2{,}06533}{440 - 430}(431{,}9 - 430)$
440	2,08878	

$= 2{,}06979$ kJ/kgk

{ Interpoliert aus TAB-A22

↳ Rückseite

T_6: $\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$ $\quad n = 1{,}4$

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

h_6: Interpolieren aus TAB-A22 (mit T_6):

325 K	325,31
328,075 K	h_6
330 K	330,34

$$\Rightarrow h_6 = 325{,}31 + \frac{330{,}34 - 325{,}31}{330 - 325}(328{,}075 - 325)$$

$$= 328{,}4035 \ \mathrm{kJ/kg}$$

$$\Rightarrow w_6 = \sqrt{2(h_6 - h_5) + w_5^2} = 219{,}52 \ \mathrm{m/s}$$

Aufgabe 3

[redacted]

a) $p_{g,1}$:

$p_{amb} = 1\,bar = 100\,000\,Pa$

$p_{Kolben} = \frac{F_G}{A} = \frac{m_K \cdot g}{\pi (\frac{D}{2})^2} = 39969{,}54\,Pa = 0{,}3997\,bar$

$p_{eis} = \frac{F_G}{A} = \frac{m_{EW} \cdot g}{\pi (\frac{D}{2})^2} = 0{,}00078\,Pa$

$p_{g,1} = p_{amb} + p_{Kolben} + p_{EW} = 139969{,}5408\,Pa = 1{,}399695\,bar$

mg: $R_G = \frac{\overline{R}}{M_G} = 76{,}28\,\frac{J}{kg\,K}$ $\quad T_{g,1} = 500°C = 773{,}15\,K$

$V_{g,1} = 3{,}74\,L = 0{,}00374\,m^3$

$\Rightarrow m_g = \frac{p_{g,1} V_{g,1}}{R_G \cdot T_{g,1}} = 0{,}00342\,kg = 3{,}42\,g$

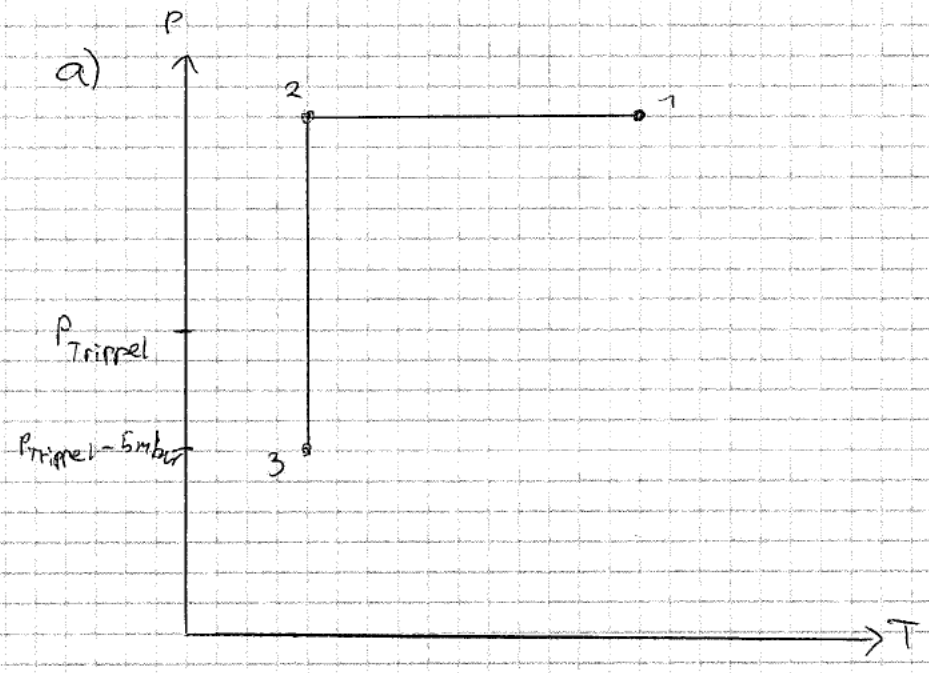
b)

c)

d) $T_{g,2} = 0{,}003°C = 273{,}153\,K$

Aufgabe 4:

a)



b) Energiebilanz am Kompressor

⇒ stationärer Fliessprozess

↳ $0 = \dot{m}_{R134a}(h_2 - h_3) + \dot{W}_{ic}$

$\Rightarrow \dot{m}_{R134a} = \frac{\dot{W}_{ic}}{h_3 - h_2}$

h_2: ~~$T_2 = ?$, isentrop $\Rightarrow s_3 = s_2$~~ $T_1 = -20\,°C$

1 → 2 isobar $\Rightarrow p_2 = p_1$ $\Rightarrow T_{Verdampfer} = -26\,°C = T_2$

↳ $T_2 = -26\,°C$

$\Rightarrow h_2 = h_g(-26\,°C) = 231{,}62\ kJ/kg$ → TAB - A 10 @ -26 °C

h_3: isentrop → $s_3 = s_2 = s_g(-26\,°C) = 0{,}0390$ → TAB - A 10 @ -26 °C

~~h_3~~ = h_3 interpolieren aus TAB A-12 mit s_3

↳ 0,9374 273,66 kJ/kg

$s_3 \rightarrow$ 0,0390 h_3

0,9771 284,39 kJ/kg

$\Rightarrow h_3 = 273{,}66 + \frac{284{,}39 - 273{,}66}{0{,}9771 - 0{,}9374}(0{,}0390 - 0{,}9374)$

$= 274{,}17\ kJ/kg$

$\Rightarrow \dot{m}_{R134a} = 0{,}000648\ \frac{kg}{s} = 0{,}03948\ \frac{kg}{h}$

c) Drossel adiabat $\Rightarrow u_4 = u_1$

isobare Kondensation $\rightarrow p_4 = p_3 = 8\,bar$

$\Rightarrow u_4 = u_3 = u_g(8\,bar) = 0{,}0245\ kJ/kg$

$\Rightarrow$

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

e)