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Afg. 1

a) E-Bil. Ein-Aus (stat., isotherm, isochor)

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

$h_{ein} = h_f(70°C) \overset{A-2}{=} 292.98 \frac{kJ}{kg}$

$h_{aus} = h_f(100°C) \overset{A-2}{=} 419.04 \frac{kJ}{kg}$

$\Rightarrow \dot{Q}_{aus} \approx -62.782\ kW$

b) $\overline{T}_{KF} = \frac{h^{KF}_{aus} - h^{KF}_{ein}}{s^{KF}_{aus} - s^{KF}_{ein}} \approx \frac{T^{KF}_{aus} - T^{KF}_{ein}}{\ln\left(\frac{T_{aus}}{T_{ein}}\right)} \approx 293.12\ K$

$h^{KF}_{aus} - h^{KF}_{ein} = c(T^{KF}_{aus} - T^{KF}_{ein}) + v(\cancel{p^{KF}_{aus} - p^{KF}_{ein}}) \to 0$

$s^{KF}_{aus} - s^{KF}_{ein} = c \ln\left(\frac{T^{KF}_{aus}}{T^{KF}_{ein}}\right)$

c) S-Bil. Reaktorwand (stationär, kein Massenstrom)

$\dot{S}_{erz} = -\frac{\dot{Q}_{aus}}{\overline{T}_{KF}} \approx 272.74 \frac{W}{K}$

d) E-Bilanz 1-2 (offen, adiabat da $Q_{R12} + Q_{aus12} = 0$, isochor)

$\Delta U = u_2(m_1 + \Delta m_{12}) - u_1 m_1 = \Delta m_{12} h_{ein,12}$

$\Rightarrow \Delta m_{12} = \frac{u_2 m_1 - u_1 m_1}{h_{ein12} - u_2} \approx 3756.84\ kg$

$u_2 = u_f(70°C) \overset{A-2}{\approx} 292.95 \frac{kJ}{kg}$

$u_1 = u_f(100°C) + x_D(u_g(100°C) - u_f(100°C)) \overset{A-2}{\approx} 429.3778 \frac{kJ}{kg}$

$h_{ein12} = h_f(20°C) \overset{A-2}{=} 83.96 \frac{kJ}{kg}$

e) ~~$\Delta S_{12} = m_1(s_f(20°C) + x_D(s_g$~~

$-\Delta S_{12} = m_1 s_1 - m_2 s_2 = m_1 s_1 - s_2(m_1 + \Delta m_{12})$ ~~$\approx -1387.615 \frac{kJ}{K}$~~

$s_1 = s_f + x_D(s_g - s_f) \overset{A-2}{\approx} 1.33714 \frac{kJ}{kgK}$

$s_2 = s_f(70°C) \overset{A-2}{=} 0.9549 \frac{kJ}{kgK}$

$\Rightarrow \Delta S_{12} = m_2 s_2 - m_1 s_1 = 1387.6 \frac{kJ}{K}$

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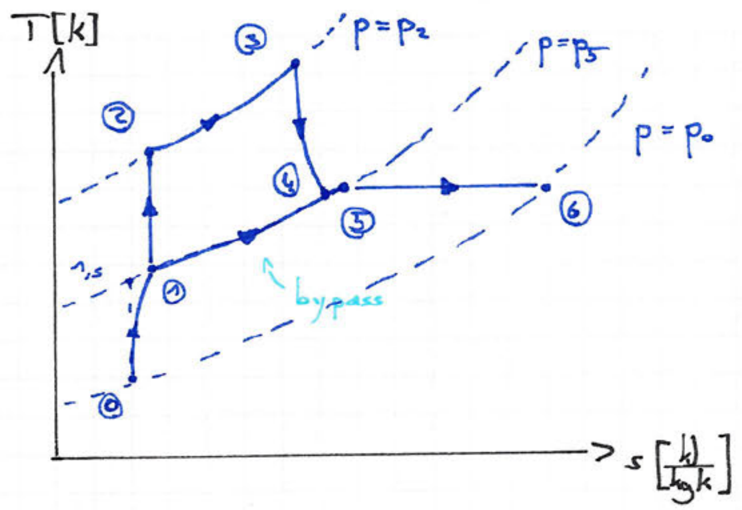
Afg. 2

a)



b) $p_5 v_5 = R T_5 \quad \Rightarrow \quad v_5 = \frac{R T_5}{p_5} \approx 3.476 \frac{m^3}{kg}$

mit $R = n c_v - c_v = c_v(n-1) \approx 402.4 \frac{J}{kg k}$

$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \quad \Rightarrow \quad T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \approx 328.07\,k$ mit $p_6 = p_0$

1. HS: $\Delta U = \frac{0}{const} \quad \Rightarrow \quad u_6 - u_5 + ke_6 - ke_5 = 0$

$\Rightarrow c_v(T_6 - T_5) + \frac{1}{2}(w_6^2 - w_5^2) = 0$

$\Rightarrow w_6 = \sqrt{w_5^2 - 2 c_v (T_6 - T_5)} = 507.244\, m/s$

c) ~~mit $w_6 = 510\, m/s$~~

$\Delta e_{x,str} = h_6 - h_0 - T_0(s_6 - s_0) + \frac{1}{2}(w_6^2 - w_0^2)$

$= n c_v (T_6 - T_0) - T_0 c_p \ln\left(\frac{T_6}{T_0}\right) - \cancel{T_0 R \ln\left(\frac{p_6}{p_0}\right)}^{0} + \frac{1}{2}(w_6^2 - w_0^2)$

$\approx 125.67\, \cancel{kW/kg}\, \frac{kJ}{kg}$

d) Ex-Bil. Triebwerk (stationär)

$e_{x,verl} = -\Delta e_{x,str} + \left(1 - \frac{T_0}{T_B}\right) q_B \approx 843.973 \frac{kJ}{kg}$

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Afg. 3

a) $R = \frac{\bar{R}}{M_g} \approx 166.289 \frac{J}{kg K}$ → A

$A = \frac{\pi}{4} D^2 \approx 0.00785 \, m^2$ → B

$p_{g1} = (m_{EW} + m_k) g/A + p_{amb} \approx \underline{1.4 \text{ bar}}$

$p_{g1} V_{g1} = m_g R T_{g1} \Rightarrow m_g = \frac{p_{g1} V_{g1}}{R T_{g1}} \approx \underline{3.422 \, g}$

b) $\underline{T_{g2} = 273.16 \, K}$, die Temperatur des Eiswassers (Tripelpunkt von Wasser)

$\underline{p_{g2} = p_{g1}} \approx 1.4$ bar, der Ampient Pressure und das Gewicht von Eiswasser + kolben bleiben unverändert.

c) E-Bilanz Gas (geschlossen, isobar)

$\Delta U = m_g (u_2 - u_1) = Q_{12} - W_{12}$

$\Rightarrow Q_{12} = m_g c_v (T_2 - T_1) + m_g \int_1^2 p_{g1} \, dv$

$= m_g c_v (T_2 - T_1) + p_{g1} \left(V_2 - \frac{m_g R T_2}{p_2}\right)$

$V_2 = \frac{m_g R T_2}{p_{g2}} \approx 0.111 \, L$

$\Rightarrow Q_{12} \approx \underline{-1.507 \, kJ}$

d) E-Bil Wasser (geschlossen, isobar, isochor) $T = 0.01 \, °C$

$\Delta U_{12} = Q_{12} \Rightarrow u_2 = \frac{Q_{12}}{m_{EW}} + u_1 \overset{T\text{-}1}{\approx} -184.9706 \frac{kJ}{kg}$

$u_1 = u_{Flüssig} + x_1 (u_{Fest} - u_{Flüssig}) \overset{T\text{-}1}{\approx} -200.0406 \frac{kJ}{kg}$

$x_2 = \frac{u_2 - u_{Flüssig}}{u_{Fest} - u_{Flüssig}} \overset{T\text{-}1}{\approx} \underline{0.5548} \approx \underline{0.555}$

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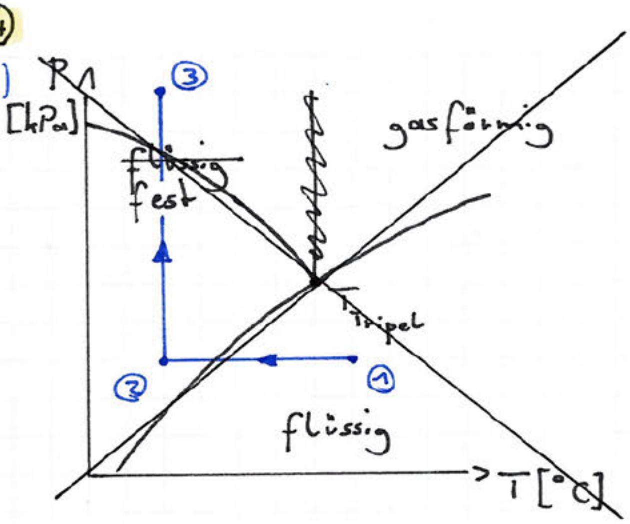
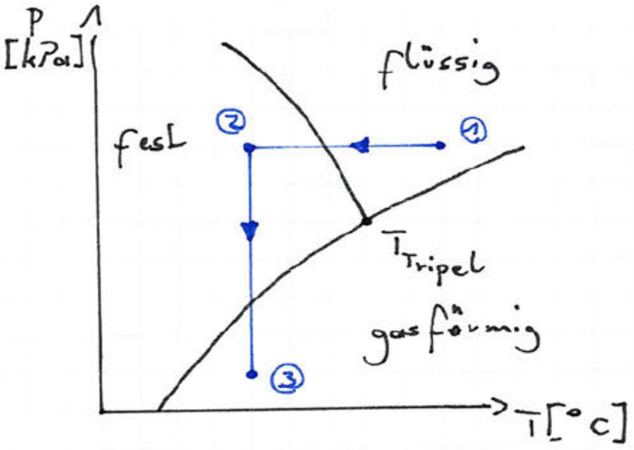
Afg. 4

a)





b) T_v 4 K über T_{sub} $\Rightarrow T_v = -16°C$

E-Bil 2-3 (stationär, adiabat)

$\dot m_{R134a} = \frac{\dot W_k}{h_2 - h_3} \approx 0.834 \, g/s$

$h_2 = h_g(-16°C) \overset{A-10}{\approx} 237.74 \frac{kJ}{kg}$

$h_3 = h(8 \, bar, s = s_3) \overset{A-12}{\approx} \frac{273.66 - 264.15}{0.9374 - 0.9066}(0.9298 - 0.9066) + 264.15 \approx 271.31 \frac{kJ}{kg}$

$s_2 = s_3 = s_g(-16°C) \overset{A-10}{\approx} 0.9298 \frac{kJ}{kgK}$

c) $h_1 = h_4 = h_f(8 \, bar) \overset{A-11}{=} 93.42 \frac{kJ}{kg}$

$x_1 = \frac{h_1 - h_f}{h_g - h_f} \overset{A-10}{\approx} 0.3076$ bei $T_1 = -16°C$

d) $\varepsilon_k = \frac{|\dot Q_{zu}|}{|\dot W_t|} = \frac{\dot Q_k}{|\dot W_k|}$

E-Bil. 1-2 (stat, isobar)

$\rightarrow \dot Q_k = \dot m_{R134a}(h_2 - h_1) \approx 120.36 \, W$

$\hookrightarrow \varepsilon_k = 4.299$

e) Die Temperatur würde weiter sinken bis $T_v = T_i$ und dann konstant bleiben bei der gleichen Temperatur wie im Verdampfer (T_v)

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