[redacted]

A1) a) ges $\dot{Q}_{aus}$

$\Delta E = m_2 u_2 - m_1 u_1$ $\qquad \Delta E = \Delta U$

$\dot{Q}_{aus} = \dot{m}(u_2 - u_1)$

reines Wasser

$T_1 = 343.15K$

$T_2 = 373.15K$

$p_1 = 1 bar$

$p_2 = 1 bar$

$\dot{Q}_{aus} = 37797\ kJ$

$u_1(343.15K, 1bar) = 292.95\ \frac{kJ}{kg}$

u_1: 298.15

$u_2(373.15K, 1bar) = 418.94\ \frac{kJ}{kg}$

15°C

$u_1(288.15K) = 62.99\ \frac{kJ}{kg}$

$u_2(298.15K) = 83.95\ \frac{kJ}{kg}$

20°C

$\dot{Q}_{aus} = 6.288\ \frac{kJ}{s}$

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

298.15 K

$s_e(343.15K) = 0.9549\ \frac{kJ}{kg \cdot K}$

$s_a(373.15K) = 1.3069\ \frac{kJ}{kg \cdot K}$

15°C

$s_e(288.15K) =$

$s_a(298.15K) =$

20°C

c) $\dot{S}_{erz} \triangleq \frac{dS}{dt} = \sum \dot{m} s + \frac{\dot{Q}}{T} + \dot{S}$

d) ~~ΔT~~ ~~gesucht~~ Δm_{12}

$T = 70°C = 343.15\ K$

$\Delta E = \Delta U$

$\Delta E = Q - W^{\nearrow 0}$

$\Delta U = m_2 u_2 - m_1 u_1$

$35\ MJ = m (u_2 - u_1)$

$u_1 (20°C) = 83.55 \frac{kJ}{kg}$

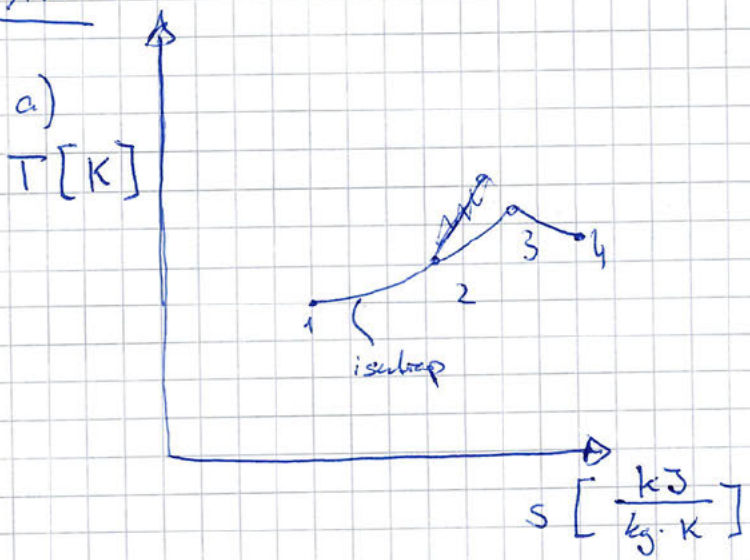
$35'000'000\ J = m \left(418.54 \frac{kJ}{kg} - 83.55 \frac{kJ}{kg}\right)$ $u_2 (100°C) = 418.94 \frac{kJ}{kg}$

$\frac{35'000'000\ J}{418.54 \frac{kJ}{kg} - 83.55 \frac{kJ}{kg}} = m \quad \Rightarrow m = 10'448.73\ kg$

e) $\Delta S = m_1 s_1 + m_2 s_2 + \frac{\dot{Q}}{T} + \dot{S}_{erz}$

A2

a)



b) ges ω_6 und T_6

$p_5 = 0{,}5\,bar$

$\omega_5 = 220\ \frac{m}{s}$

Zustand 5 → Zustand 6

isentrop

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}}$$

$$T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{\kappa-1}{\kappa}} \Rightarrow T_6 = 431.5\,K \cdot \left(\frac{1.5\,kPa}{50\,kPa}\right)^{\frac{\kappa-1}{\kappa}}$$

$$T_6 = 328.07\,K$$

reversibel und adiabat $\Rightarrow \dot{m}\left[h_5 - h_6\right] + \frac{\omega_5^2 - \omega_6^2}{2} = 0$

$\omega_5 = \omega_6$

ω_6

c) $\dot{m} e_{x,str} = \dot{m}\left[h - h_0 - T_0 (s - s_0) + ke \right]$

$e_{x,str,6} =$

$e_{x,str,0} =$

$y = y_1 + \frac{(y_2 - y_1)}{(x_2 - x_1)} (x - x_1)$

$m_k = \frac{\dot{m}_A}{\dot{m}_K} = 5.293$

d) $e_{x,vd} = T_0 \, s_{vg} \cdot \dot{m}_{gas}$

A3

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

$T_{g,1} = 500\,°C = 773.15\,K$

$p_{amb} = 1\,bar = 100\,kPa$

$V_{s,1} = 3.14\,L = 0,00314\,m^3$

$m_{EW} = 0,1\,kg$

$A = r^2\pi \Rightarrow 5^2\pi = 25\pi\,cm^2 = 78.54\,cm^2 = 0,7854\,m^2 = 0,007854\,m^2$

$p_{EW} = p_{amb} + \frac{m_G}{A}$

$p_{EW} = 100\,kPa + \frac{32\,kg \cdot 9.81\,\frac{m}{s^2}}{0,007854\,m^2}$

$p_{EW} = 100\,kPa + 39'956.544\,\frac{kg \cdot m}{s^2 \cdot m^2}$

$39'956.544\,N/m^2 = 39'956.544\,Pa$

$p_{EW} = 100\,kPa + 39'956.544\,Pa$

$p_{EW} = 139,9565\,kPa$

$p_{g,1} = 139,9565\,kPa + \frac{0,1\,kg \cdot 9,81\,\frac{m}{s^2}}{0,007854\,m^2}$

$p_{g,1} = 140,\,kPa$

$m_g = \frac{pV}{RT}$

$R = \frac{8.314\,\frac{kJ}{kmol \cdot K}}{18.02\,\frac{kg}{kmol}}$

$R = 0,4614\,\frac{kJ}{kg \cdot K}$

$m_g = \frac{140\,kPa \cdot 0,00314\,m^3}{0,4614\,\frac{kJ}{kg \cdot K} \cdot 773.15\,K}$

$m_g = 0,001232\,kg$

b) $x > 0$ x muss grösser, immer weniger Eis

~~Es hat ... Eis~~

$T_{g,2}$, $p_{g,2}$

$p_{g,2}$ $p_{g,2}$ = 140 kPa (const) Der Druck bleibt gleich, da die Bedingungen um an das Gas gleich bleiben.

$T_{g_2} = 0,003°C$

c) $\Delta E = Q - W$ → 0 $\Delta E = \Delta U$

$\Delta U = m_2 u_2 - m_1 u_1$

$\Delta U = m (u_2 - u_1)$

m_1

$T_1 = 273.15 K$

$T_2 = 273.153 K$

↳ aus Tab. 1

$u_2 = -333.401 \frac{kJ}{kg}$

d) x_2 ? $T_{g_2} = 0,003°C$ $p_{g_1} = 1.5$ bar

$m_g = 3.6 g$

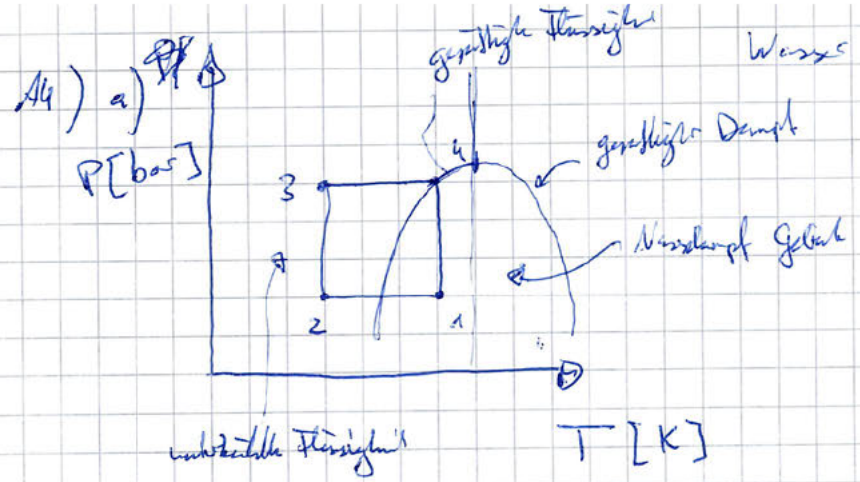
~~$x_2 = \frac{u - u_f}{u_g - u_f}$ ⇒ $\frac{-333.401 \frac{kJ}{kg} - 0}{-333.401} = 1$~~

~~$x_2 = 1$~~

$x_2 = \frac{u - u_f}{u_g - u_f}$

$x_2 = \frac{-333.401 + 0,033}{-333.442 + 0,033} = 0,999877$

A4) a)



Wasser als Kältemittel

6K über Temp verdampft

b) $\dot{m}_{R134a}$?

~~$\dot{Q}_K = \dot{m}\,[h_e - h_a]$~~ $\quad \dot{Q} = \dot{m}\,[h_4 - h_2] + \dot{Q}_K$

$\Rightarrow \dot{Q}_K = \dot{m}\,[h_2 - h_1]$

$h_1 = h_1($

$h_2) =$

~~3 → 4~~

2 → 3 $\quad s = \text{const}$

$s_2 = s_3 \qquad s_3 (8\,\text{bar},$

$\Rightarrow$ 2 → 3 $\quad \dot{W}_K = 28\,W$

$\dot{m}\,[h_2 - h_3] = 28\,W$

ii) 5 mbar als Triplepunkt

$\Rightarrow$ an Abb. 5

$\hookrightarrow$ 1 mbar

$\Rightarrow$ 273.15 K

10 K über sublimationspunkt

$\hookrightarrow$ -30 °C

$\Rightarrow$ 243.15 K $= T_3$

Tverdampfer $T_{evap} = 237.15\,K$

c) $x_1 = \frac{h_1 - h_f}{h_g - h_f}$

$T_1 = 237.15\,k$

$P_1 =$

$T_2 = -22\,^{\circ}C$

$s_2 = s_3 \neq$ ~~$s_1 \neq s_2$~~

$P_2 =$

d) $\epsilon_R = \frac{|\dot{Q}_R|}{|\dot{W}_t|}$