[redacted]

1a.) $\dot{Q}_{aus}$

$\dot{m}_{Wasser} = 0.5\,kg/s$

$h_1 = h_f(70°C) = 292.98 \frac{kJ}{kg} = h_{ein}$ (A-2)

h_{ein}

$\dot{Q}_{aus} = \dot{m}_w (h_{aus} - h_{ein})$

$h_2 = h_f + x(h_g - h_f) = 430.29 \frac{kJ}{kg}$ (A-2, 100°C)

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

$\dot{Q}_{aus} = -\dot{Q}_R + \dot{m}_w (h_{aus} - h_{ein}) = -62.188\,kW$ //

b.) $\overline{T}_{KF} = \frac{\int T\,ds}{s_a - s_e} = \frac{q_{rev}}{s_a - s_e} = \frac{\int_{T_1}^{T_2} c_{if}\,dT + v_{if}(p_2 - p_1)}{\int_{T_1}^{T_2} \frac{c_{if}}{T}\,dT}$

$\overline{T}_{KF} = \frac{c_{if}(\overline{T}_2 - \overline{T}_1) + v_{if}(p_2 - p_1)^{\to 0}}{c_{if}\,\ln\left(\frac{\overline{T}_2}{\overline{T}_1}\right)} = \frac{(\overline{T}_2 - \overline{T}_1)}{\ln\left(\frac{\overline{T}_2}{\overline{T}_1}\right)}$

$\overline{T}_{KF} = \frac{298.15K - 288.15K}{\ln\left(\frac{298.15}{288.15}\right)} = \frac{10}{\ln\left(\frac{T_{aus}}{T_{ein}}\right)} = 293.12K$ //

d.) $\dot{Q}_{aus} + \dot{Q}_R = 0$

$U_{Reaktor} = m_g u_r \overset{A-2}{=} 5755kg\left((1-x)u_f + x_D u_g\right) =$

$u_f = 418.94 \frac{kJ}{kg}$ $\quad u_g = 2506.5 \frac{kJ}{kg}$

$U_r = 30 \cdot 10^6\,kJ$

$U_r(70°C) = m_g \cdot u_f(70°C) \Rightarrow 292.95 \frac{kJ}{kg} 5755kg = 1.69 \cdot 10^6\,kJ$

$\Rightarrow -28.31 \cdot 10^6\,kJ$ in form von Wasser hinzufügen

d.) $\Delta U_W \overset{A-2}{=} u_f(70°C) - u_f(20°C) = -83.95 \frac{kJ}{kg} + 292.95 \frac{kJ}{kg}$

$35 \cdot 10^3 kJ$

$\Delta m \, \Delta U_W + 35 MJ = 28.31 \cdot 10^6 kJ$

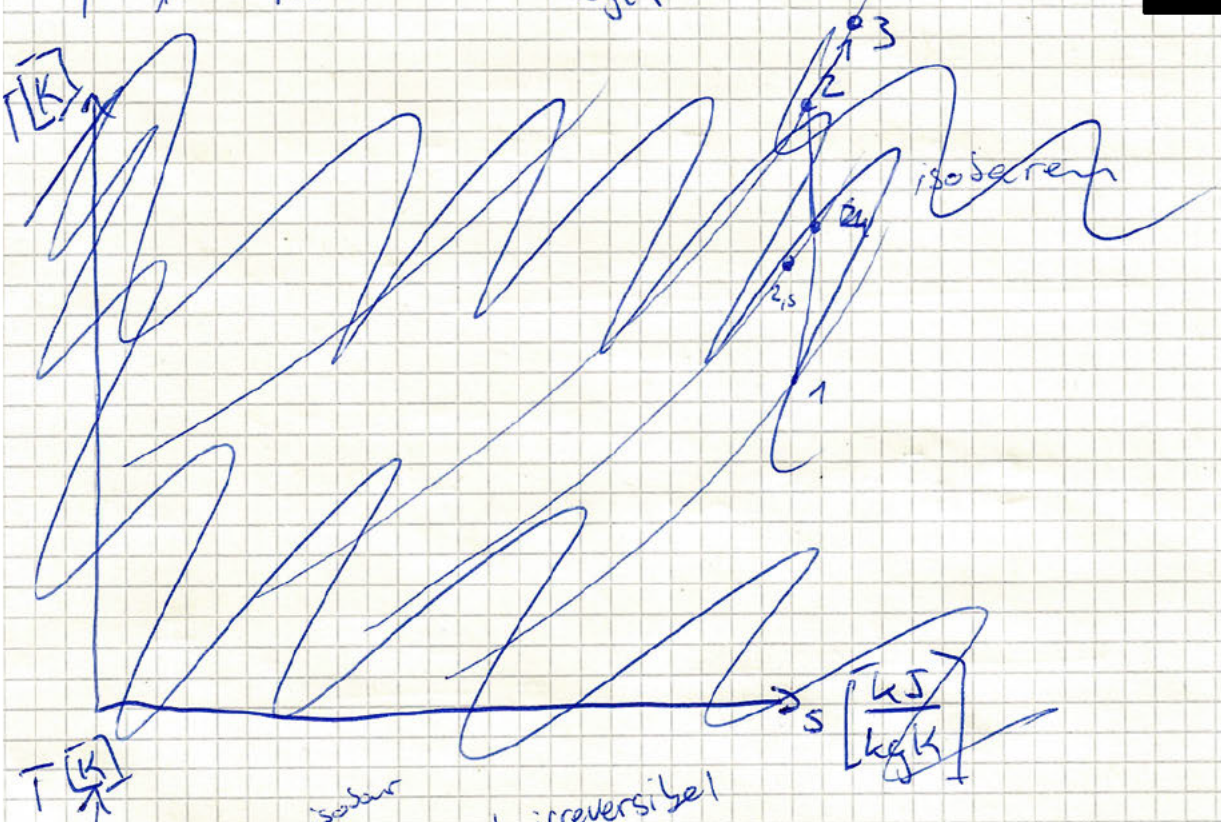
$$\Delta m = \frac{28.31 \cdot 10^6 kJ - 35 \cdot 10^3 kJ}{\Delta U_W}$$

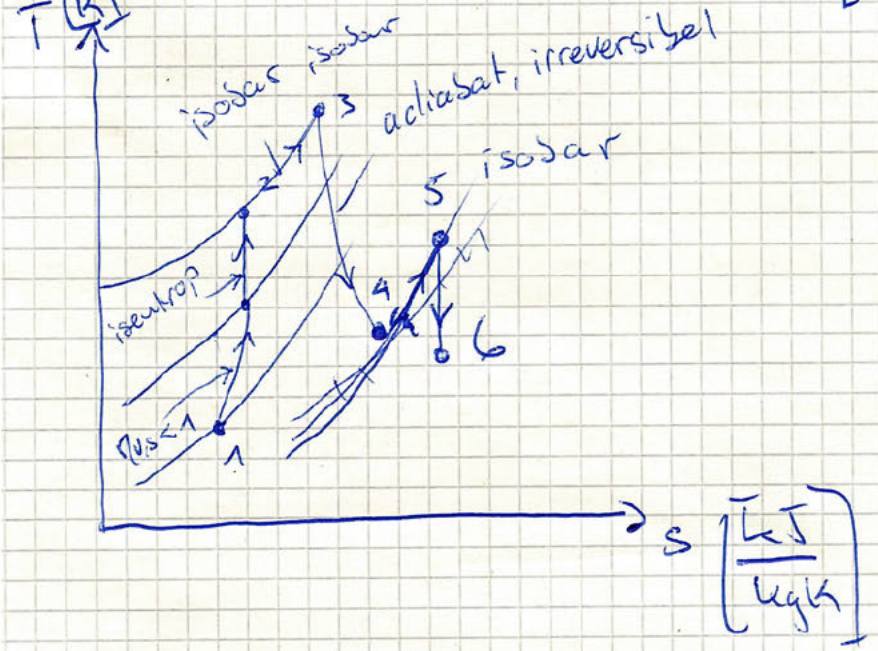
$\Delta U_W = 209 \frac{kJ}{kg}$ $\quad \Delta m = 135.287 \cdot 10^3 kg$

c.) $\dot{S}_{erz} = \dot{m}(s_2 - s_1) + \frac{\dot{Q}_{aus}}{T_{KF}}$

$= \dot{m}$

2.) $c_p^{ig} = 1.006 \frac{kJ}{kgK}$ $\quad \kappa = k = 1.4$





b.) ~~$w_2 v_2 - w_1 v_1 + q_{12} + w_{t12}$~~

$$w_{in}\left(h_{ein} - h_{aus} + \frac{(w_{ein})^2 - (w_{aus})^2}{2}\right) \dot{q} = 0$$

$$h_0 - h_6 + \frac{w_L^2}{2} - \frac{w_6^2}{2} = 0$$

$$\frac{w_6^2}{2} = h_0 - h_6 + \frac{w_L^2}{2}$$

$$w_6 = \sqrt{2(h_0 - h_6) + w_L^2}$$

$$w_6 = \sqrt{2 c_p^{ig}(T_0 - T_6) + w_L^2}$$

$$w_6 = 1.006 \frac{kJ}{kgK}$$

[redacted]

c) ~~$w_6 = 510 \frac{m}{s}$ $T_6 = 340\,K$~~

b) ~~$w_5 = \sqrt{2 c_p^{ig} (T_4 - T_5)}$~~ $T_6 = T_5 \left(\frac{0.191}{0.5} \right)^{\frac{0.4}{1.4}} = 328\,K$

$w_6 = \sqrt{2 c_p^{ig} (T_0 - T_6) + w_L^2}$ = ...

c) $e_{x,str} = \frac{\dot{E}_{x,str}}{\dot{m}} = h_6 - h_0 - T_0 (s_6 - s_0) + \frac{(510 - 200 \frac{m}{s})^2}{2}$

~~$\frac{\dot{e}_{x,str}}{h_6 - h_0}$~~ $= c_p^{ig} (T_6 - T_0) - T_0 \left(c_p^{ig} \ln \left(\frac{T_6}{T_1} \right) - R \ln(1) \right)$ (ln(1) → 0)

$T_0 = -30°C = 273.15 - 30K = 243.15\,K$

$= 15 \frac{kJ}{kg}$

3a.) $p_{g,1} = \frac{m_{ges} \cdot g}{A}$ $\quad A = 25cm^2 \cdot \pi = 78.5cm^2$

$m_{ges} = 32kg + 0.1kg (m_{EW}) = 32.1kg$

$p_{g,1} = 1bar + \frac{32.1kg \cdot 9.81 m/s^2}{78.5cm^2} = 10^5 Pa + 40.1 \cdot 10^3 Pa = 1.4bar$ //

~~b.)~~ d.) $c_v = 0.633 \frac{kJ}{kgK}$ $\quad U_g = c_v m_g T_g$

$R = \frac{8.314 \frac{kJ}{kmolK}}{30 \frac{kg}{kmol}} = 166.28 \frac{J}{kgK}$ $\quad m_g = \frac{p_g V_g}{R T_g} = 3.42g$ //

$U_g = 0.633 \frac{kJ}{kgK} \cdot 773.15K \cdot 3.42g = 1.67kJ$

Zustand 2: $p_g \approx p_{EW} = 1.4bar$ im thermodyn. GGW

$\hookrightarrow T_{GGW} = 0.000°C$

~~In der Tabelle ist ersichtlich, dass nur bei $T = 0.003°C$ auch einen Fest(eis) Anteil im Gemisch~~

$U_{EW} = (1-x) U_{FL} + x U_{fest}$

b.) da sich das Gemisch im Zustand 2 im Gleichgewicht befindet und fest der Gleiche Druck herrscht, ist $p_2 = 1.4bar$, $T_2 = 0.000°C$ aus der Tabelle abgelesen.

c.) $|Q_{12}| = |m c_v^{is} (T_2 - T_1)| = |3.42g \cdot 0.633 \frac{kJ}{kg} \cdot 500K|$

$= |1.08kJ| = -1082.4J$ //

$\hookrightarrow$ da Wärmeabfluss

d.)

3c) $U_{1EW} + |Q_{12}| = U_{2EW}$

$$U_{1EW} = m\left((1-x)\,u_{Flüssig} + x\,u_{fest}\right) \quad (1.4\,bar,\ 0°C)$$

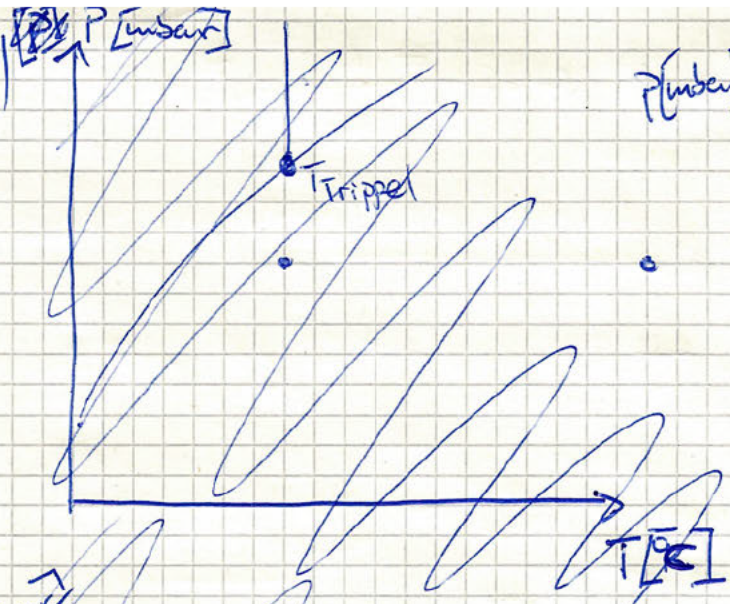
$$= 0.1kg\left(0.4 \cdot \left(-0.045\ \frac{kJ}{kg}\right) + 0.6\left(-333.458\ \frac{kJ}{kg}\right)\right) = -20\,kJ$$

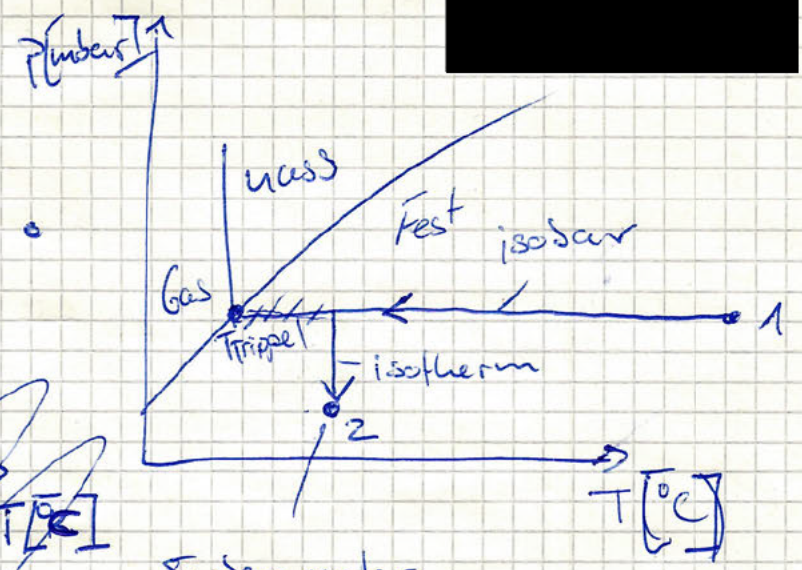
$$-20kJ + 1082.4J = 0.1kg\left((1-x)\left(-0.045\ \frac{kJ}{kg}\right) + x\left(-333.458\ \frac{kJ}{kg}\right)\right)$$

$$u_2 = \frac{-18.9176\ kJ}{0.1kg} = -189.176\ \frac{kJ}{kg}$$

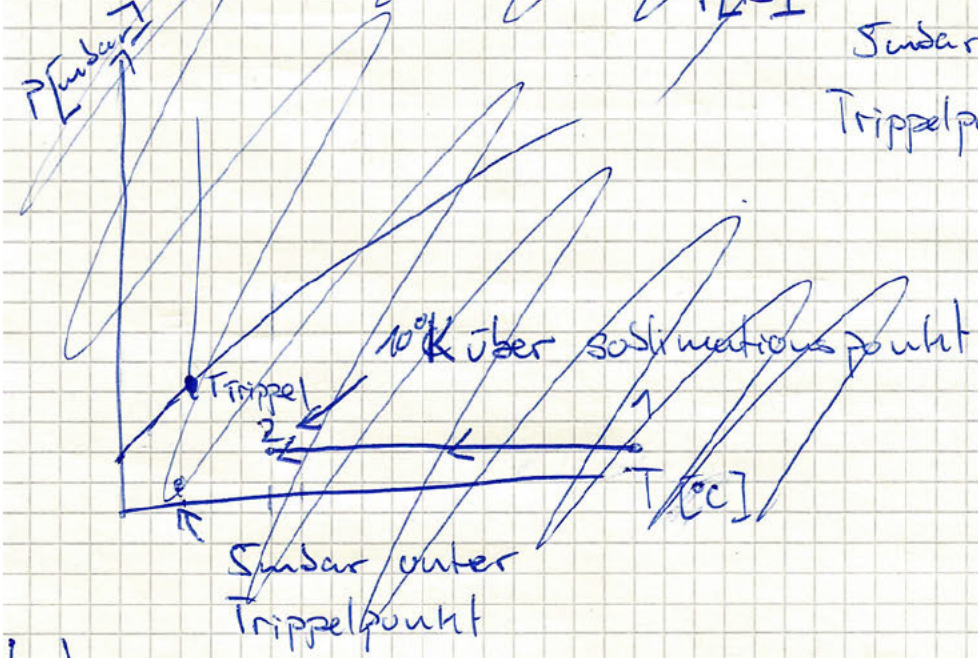
$$x_2 = \frac{u_2 - u_{fl}}{u_{fest} - u_{fl}} = \frac{-189.176\ \frac{kJ}{kg} + 0.045\ \frac{kJ}{kg}}{-333.458 + 0.045\ \frac{kJ}{kg}} = 0.567$$

4a.)





5mbar unter Trippelpunkt, 10K über sublim. Punkt



b.)

$\dot{m}_{R134a}$

$T_1 = -10°C$

$T_2 = -16°C$ //

$\dot{W}_K = \dot{m}_R (h_2 - h_3)$

$s_2 = s_3 = 0.9298 \frac{kJ}{kgK}$

$h_2 = h_g(-16°C) = 237.79 \frac{kJ}{kg}$ (A-10)

$x_3 = \frac{s_2 - s_f(8bar)}{s_g - s_f(8bar)} =$ (A-11)

$x_3 = \frac{0.9298 - 0.3959 \frac{kJ}{kgK}}{0.9066 - 0.3959 \frac{kJ}{kgK}} = 1.04 \ldots \rightarrow$ nicht möglich

$\dot{m}_R = \frac{\dot{W}_K}{(h_2 - h_3)}$ //

c.) $p_3 = p_4 = 8\,bar$

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

~~$p_2 = 1.5748\,bar$~~ (A-10)

$p_1 = 1.5748\,bar\ (A\text{-}10, -16°C)$

~~$h_4 = h_1 = 31.330$~~ $x_1 = \frac{h_1 - h_f}{h_g - h_f}$ $h_1 = h_4$ dann isenthalp drossel

A-10 (-16°C)

$$x_1 = \frac{93.42 \frac{kJ}{kg} - 29.30 \frac{kJ}{kg}}{208.45 \frac{kJ}{kg}} = 0.308$$

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