[redacted]

1. a) 1. HS:

$$0 = \dot{m}\,(h_1 - h_2) + \dot{Q}_R - \dot{Q}_{aus}$$

$$\dot{Q}_{aus} = \dot{Q}_R + \dot{m}\,(h_1 - h_2) = \underline{62.182\ kW}$$

h2f $h_1 = h_f(70°C) = 292.98\ kJ/kg$

$h_2 = h_f(100°C) = 419.04\ kJ/kg$

b) $$\bar{T}_{KF} = \frac{\int_e^a T\,ds}{s_1 - s_2}$$

p = const.

ideale Flüssigk.

$$= \frac{h_1 - h_2}{s_1 - s_2} = \frac{\cancel{c^{if}}\,(T_1 - T_2)}{\cancel{c^{if}}\,\ln\left(\frac{T_1}{T_2}\right)} = \frac{-10k}{\ln\left(\frac{288.15k}{298.15k}\right)} = \underline{293.15k}$$

c) $$0 = \dot{m}\,(s_1 - s_2) + \frac{\dot{Q}_R}{\bar{T}} - \frac{\dot{Q}_{aus}}{\bar{T}} + \dot{S}_{erz}$$

d) $\cancel{\frac{dE}{dt} = -\dot{Q}_{R12}}$ $\qquad \Delta E = m(u_2 - u_1) = -Q_{R12}$

$\cancel{m_2 u_2}$

e) $$\Delta S = S_2 - S_1 = m(s_2 - s_1)$$

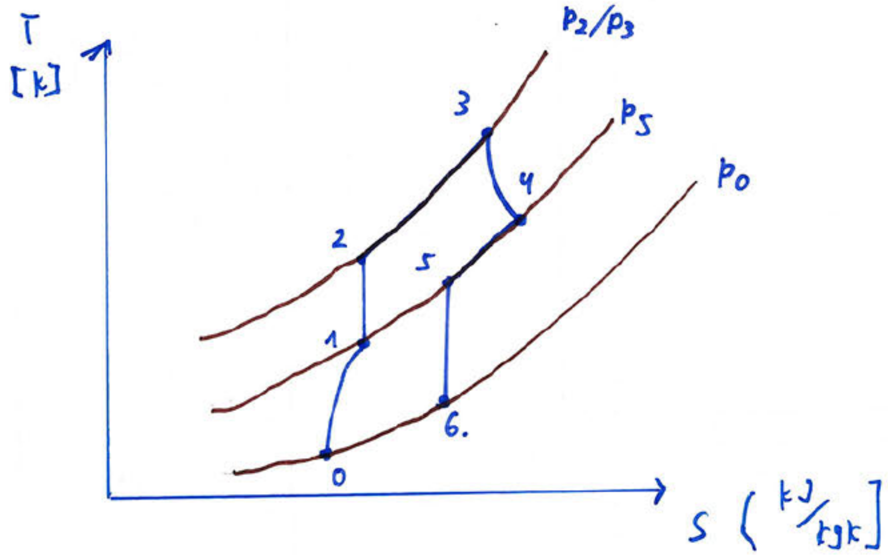
$$\Delta S = 5755kg + 3600kg\ (s_2 - s_1) = \underline{-3292.96\ \frac{kJ}{K}}$$

$s_1 = s_f(100°C) = 1.3069\ \frac{kJ}{kgK}$

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

[redacted]

2a)



b)

$$0 = \dot{m}_{ges}\left(h_5 - h_6 + \frac{w_5^2 - w_6^2}{2}\right) - \dot{W}_{t56}$$

$$\dot{W}_{t56} = \dot{m}\left(-\int_1^2 \cancel{p}\; v\,dp\right)$$

$$= -\dot{m}\,(p_2 - p_1)\,v$$

$$pv = RT \,, \quad v_5 = \frac{RT_5}{p_5} \,, \quad \cancel{R \neq c_p^{ig} - c_v^{ig}}$$

$$\cancel{k = \frac{c_p^{ig}}{c_v^{ig}}}$$

$$\cancel{\Rightarrow R = c_v^{ig}(k-1)}$$

$$\cancel{=}$$

$$R = c_p^{ig} - c_v^{ig}$$

$$k = \frac{c_p^{ig}}{c_v^{ig}} \,, \quad \cancel{p}\; c_v^{ig} = \frac{c_p^{ig}}{k}$$

$$R = c_p^{ig} - \frac{c_p^{ig}}{k} = \left(1 - \frac{1}{k}\right)c_p^{ig} = 0.287\ \mathrm{kJ/kgK}$$

$$v_5 = \frac{0.287\ \mathrm{kJ/kgK} \cdot 431.9\,\mathrm{K}}{50'000\,\mathrm{Pa}} = \cancel{0.00248}\ 2.479\ \cancel{\mathrm{k}}\cdot \mathrm{m^3/kg}$$

$$\dot{W}_{t56} =$$

[redacted]

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

$T_6 = T_5 \cdot \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} = 431.9k \cdot \left(\frac{19100Pa}{50000Pa}\right)^{\frac{0.4}{1.4}}$

$= \underline{328k}$

c) $\Delta e_{xstr} = (h_6 - h_0 - T_0(s_6 - s_0))$ $\quad R = 287 \, J/kgk$

$= c_p^{ig}(T_6 - T_0) - T_0\left(c_p^{ig} \ln\left(\frac{T_6}{T_0}\right) - R \ln\left(\frac{p_6}{p_0}\right)\right)$

$= \cancel{1.00}\ 1006 \, J/kgk (328k - 243.15k)$

$- 243.15k \left(1006 \, J/kgk \ln\left(\frac{328k}{243.15k}\right) - \cancel{287 \, J/kgk \ln\left(\frac{p_6}{p_0}\right)}^{=0}\right)$

$= \underline{12.14 \, kJ/kg}$

d) $\dot{E}_{x\,verl} = -\Delta \dot{E}_{xstr} + \left(1 - \frac{T_0}{T}\right)\dot{Q}_B$

$\dot{Q}_B = 1195 \, kJ/kg \cdot \dot{m}_K$

$\dot{E}_{xver} = -\Delta \dot{E}_{xstr} + \left(1 - \frac{243.15k}{1289k}\right) \cdot \frac{\dot{m}_{ges}}{6.293}$

$\underline{\dot{E}_{xver} = -100 \, kJ/kg + 0.129 \, \dot{m}_{ges}}$

$\dot{m}_k + \dot{m}_m = \dot{m}_{ges}$

$\cancel{\dot{m}_m}$

$\dot{m}_k + 5.293 \, \dot{m}_k = \dot{m}_{ges}$

$6.293 \, \dot{m}_k = \dot{m}_{ges}$

$\dot{m}_{ges} = \frac{1}{6.293} \dot{m}_{ges}$

[redacted]

3. a) $p_{g,1}$, m_g c_v , M_g $\frac{J}{mol\,K} \cdot \frac{mol}{kg}$

πr^2

$pV = n \bar{R} T$

$R = \frac{\bar{R}}{M} = \frac{8.314 \, J/molK}{0.05 \, kg/mol} \approx 166.28 \, J/kgK$

Kräftegleichgewicht:

$\cancel{0.1 kg}$

$F_{Ew} + p_{amb} A + m_k g = p_{1,g} \cdot A$

$\frac{0.1kg \cdot 9.81\,m/s^2 + 100'000Pa \cdot \pi \cdot (0.05m)^2 + 9.81\,m/s^2 \cdot 32kg}{\pi (0.05m)^2} = p_{1g}$

$\underline{p_{1g} = 1.401\,bar}$

Ideales Gasgesetz: $pV = mRT$

$m_g = \frac{p_1 V_1}{R T_1} = \frac{140094 Pa \cdot 0.00314\, m^3}{166.28\, J/kg\,K \cdot 773.15K}$

$\underline{m_g = 3.42g}$

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

$T_{g,2} = T_{Ew,2}$. Da es immernoch Eis im Eis-Wasser gemisch hat, ist die Temperatur noch bei $T_{Ew,1}$.

$\underline{T_{g,2} = 0°C}$

V_{const} , m_{const} , R_{const} => $\frac{p_1}{T_1} = \frac{p_2}{T_2}$, $p_{g,2} = \frac{p_1}{T_1} \cdot T_2 = \frac{140094Pa \cdot 273.15}{773.15K}$

$p_{g,2} = \underline{0.495 bar}$

[redacted]

c) $\frac{dE}{dt} = \dot{Q}_{12}$ 1. HS im Gasbehälter.

$m(u_2 - u_1) = Q_{12}$

$m(c_v^{ig}(T_2 - T_1)) = Q_{12}$

$0.00342\,kg \cdot 0.633\,\frac{kJ}{kgK}(273.15K - 773.15K) = Q_{12}$

$\underline{Q_{12} = -1082\,J}$ (negativ da aus Systemgrenze fliesst)
(von Gas zu EW Gemisch)

d) $u_2 = u_1$, da Temp. konstant

$x_{Eis,1} = \frac{m_{Eis}}{m_{EW}} = 0.6$

$u_2 = u_f + x(u_g - u_f)$

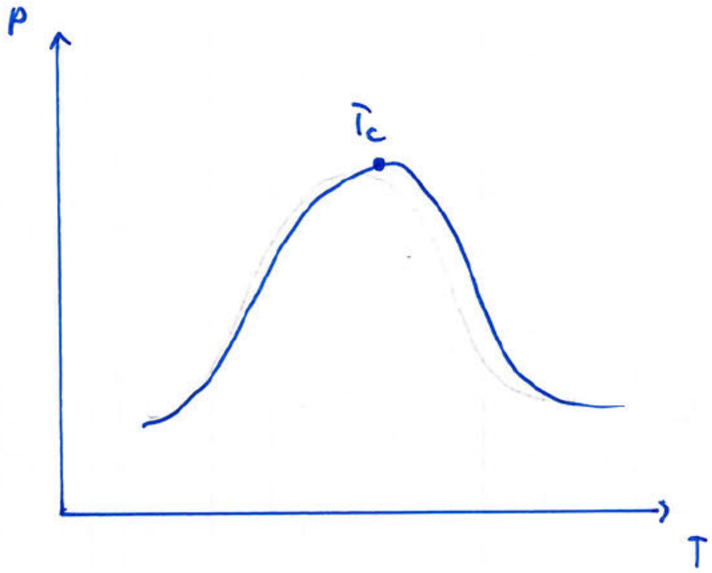
$m_{Eis,1} = 0.6 \cdot 0.1\,kg = 0.06\,kg$

[redacted]

1 mbar = 0.001 bar

1 mm = 0.001

4a)



T_i = −20°C

[redacted]

4.

b) $\dot{m}_{R134a}$ $\quad$ ~~$T_i = 20°C$~~ ~~$-22°C$~~ $\quad T_2 = -22°C$

1. HS über Verdichter: $2 \to 3$

$$0 = \dot{m}_{R134} (h_2 - h_3) + \dot{W}_K$$

$$h_2 = h_g(-22°C) = 234.08 \,\tfrac{kJ}{kg}$$

$$h_3 \Rightarrow \quad s_2 = s_3 \Rightarrow \quad s_2 = s_g(-22°C) = 0.9351 \,\tfrac{kJ}{kgK}$$

$$s_3 = 0.9351 \,\tfrac{kJ}{kgK}$$

$$h_3 \left(8bar, 0.9351 \tfrac{kJ}{kgK}\right) = 264.15 \tfrac{kJ}{kg} + \frac{(0.9351 - 0.9066) \tfrac{kJ}{kgK}}{0.9379 \tfrac{kJ}{kgK} - 0.9066 \tfrac{kJ}{kgK}}$$

264.15 0.9066
x
273.66 0.9379

$$\cdot (0.9379 \tfrac{kJ}{kgK} - 0.9066 \tfrac{kJ}{kgK}$$

$$= 264.18 \,\tfrac{kJ}{kg}$$

$$0 = \dot{m}_{R134} (h_2 - h_3) + \dot{W}_K$$

$$\dot{m}_{R134} = \frac{-\dot{W}_K}{(h_2 - h_3)} = \frac{-0.028 kW}{234.08 \tfrac{kJ}{kg} - 264.18 \tfrac{kJ}{kg}} = \underline{3.349 \,\tfrac{kg}{h}}$$

c) $x_4 = 0$, Drossel isenthalp da adiabat + keine
$p_4 = 8bar$ $\quad$ Arbeit , $h_4 = h_1$

$$h_4 = h_f(8bar) = 93.42 \,\tfrac{kJ}{kg}$$

~~Fa~~

$$h_1 = h_f + x(h_g - h_f) \quad \text{at} \quad \text{1 mbar}$$

~~$p_1 = 1 mbar$~~ 15 mbar

[redacted]

4c) $x_4 = 0$, Drossel isenthalp

$p_4 = 8 bar$ da Arbeit $=0$ und adiabat

$h_4 = h_1$

$h_4 = h_f(8bar) = 93.42 \, kJ/kg$

$h_1 = h_f + x(h_g - h_f)$ at T_1

$\Rightarrow x = \frac{h_1 - h_f}{h_g - h_f} = \frac{93.42 \, kJ/kg - 21.77 \, kJ/kg}{234.08 \, kJ/kg - 21.77 \, kJ/kg}$

$\underline{x_1 = 0.337}$

d) $\varepsilon_K = \frac{|\dot{Q}_{zu}|}{|\dot{W}_t|} = \frac{|\dot{Q}_{K}|}{28W} =$

$h_1 = 93.42 \, kJ/kg$

$0 = \dot{m}(h_1 - h_2) + \dot{Q}_K$

$h_2 = h_f(-22°C)$

e) Temperatur würde konstant bleiben. bei OK