A1)

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

- 1HS. stationär: $0 = \dot{m}[h_e - h_a] + \sum \dot{Q}$

$$Q = \dot{m}[h_a - h_e]$$

$$\dot{Q}_{aus} = \dot{m}[c(T_2 - T_1) + \underbrace{v(p_2 - p_1)}_{=0 \rightarrow \text{const}}]$$

Tab. A2: $Q = \dot{m}(h_{aus} - h_{ein})$

$Q_{ab} = -23.04\,kJ$

$h_{ein} = 2333.8$

$h_{aus} = 257.0$

b) $\bar{T}_{KF} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{q_{rev}}{s_a - s_e} = \frac{c(T_2 - T_1) + \overbrace{v(p_2 - p_1)}^{=0 \rightarrow \text{const}}}{c\,\ln(T_2/T_1)}$

$$\bar{T}_{KF} = \frac{T_{aus} - T_{ein}}{\ln(T_{aus}/T_{ein})} = 294{,}57\,K$$

- c) $\dot{S}_{erz}$ zw. Reactor & Kühlmittel.

Entropie, stationär: $0 = \dot{m}[s_e - s_a] + \sum \frac{\dot{Q}}{T} + \dot{S}_{erz}$

$$0 = \dot{m}_{KS,1} s_e - \dot{m}_{KT} s_a + \sum \frac{\dot{Q}_{ab}}{T_{KT}} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = \dot{m}(s_a - s_e) - \frac{\dot{Q}_{ab}}{T_{KT}}$$

$$\dot{S}_{erz} = \dot{m} c \ln(T_{aus}/T_{ein}) - \frac{\dot{Q}_{ab}}{T_{KT}}$$

$$\dot{S}_{erz} = -\frac{\dot{Q}_{ab}}{T_{KT}} = -0{,}165\,kW$$

• d) Δm_{12}

Halboffenes System

$dE/dt = \dot{m}[h_e - h_a] + \sum \dot{Q} + \sum \Delta m_i [h_i]$

$m_{2u2} - m_{1u1} = Q_{R1,2} + \Delta m_{12} h_{12}$

u_2

$$\frac{\dot{m}_R(u_{2R} - u_{1R}) - Q_{R1,2}}{h_{12}} = \Delta m_{1,2}$$

Tab A2:

z_1: $T_R = 100\,°C$ $\quad u_{1R} = 418{,}94$

z_2: $T_R = 70\,°C$ $\quad u_{2R} = 252{,}95$

$T_{ein\,12} = 20\,°C$ $\quad h_{12} = 83{,}96$

$\Delta m_{1,2} = -9052{,}79\ g$ nicht möglich

e) ΔS_{12}

$\Delta S = m_{2s2} - m_{1s1} = \sum \Delta m_i s_i + \sum \frac{\dot{Q}}{T} + \dot{S}_{erz}$

$\Delta S = \dot{m}_R (s_2 - s_1)$

$\Delta S =$

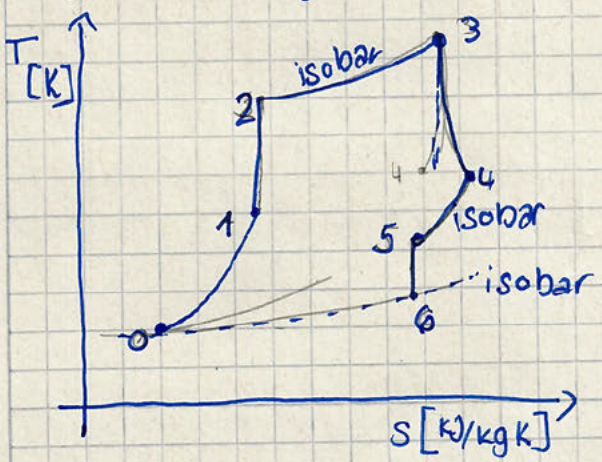
Tab A2:

$s_2 = 0{,}9541$

$s_1 = 1{,}3069$

A2] Luft, ideales Gas, stationär, Epot (0)

a) T-S Diagramm, isobaren Einheiten



6-1 ververdichter adiabat
Lieferung wirkungsgrad

1-2: adiabat revers. Hochdruck
2-3: isobare Wärmezufuhr
3-4: adiabat, irreversibel
4-5) isobare Mischkammer
5-6: reversibel adiabat

b) w_6, T_6 5-6 reversibel adiabat

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

$$T_6 = T_5 \left(\frac{p_0}{p_5}\right)^{\frac{n-1}{n}}$$

$$= 328{,}07\ K$$

$$dE/dt = \sum \dot{m}\,[h_i + ke_i] + \sum \dot{Q} - \sum \dot{W}$$

$$\dot{m}_{ges}(u_6 - u_0) = \Delta \dot{m}_{50}\left(\frac{w_0^2}{2} - \frac{w_6^2}{2}\right)$$

$$2c_V(T_6 - T_0) = \frac{w_0^2}{2} - \frac{w_6^2}{2}$$

$$w_6^2 = w_0^2 + 2c_V(T_0 - T_6)$$

$$c_V = \frac{c_p}{\kappa} = 0{,}7186$$

$$w_6 = 199.85\ m/s$$

c) $\dot{m}_{2S}$ $\Delta ex,str = ex,str\,6 - ex,str\,0$

$$\frac{\dot{E}x_{str}}{\dot{m}_{2W}} = \left[h_6 - h_0 - T_0(s_6 - s_0) + \frac{w_6^2}{2} - \frac{w_0^2}{2}\right]$$

$$= c_p(T_6 - T_0) - T_0\left[\ln(T_6/T_0) - R\ln(p_6/p_0)\right] + \frac{w_6^2}{2} - \frac{w_0^2}{2}$$

($R\ln(p_6/p_0) = 0$)

$$= 110\ \frac{kJ}{kg}$$

d) mges bergen ex,verl

$\dot{E}x,verl = T_0 \dot{S}er$

$Ex,verl = T_0 \left[\dot{m}[s_A - s_E] - \frac{\dot{Q}_j}{T} \right]$

$= T_0 \left[\dot{m}_{ges}[s_B - s_A] - \frac{q_B}{T_B} \right]$

$= T_0 \left[m_{ges} c_p \ln(T_B/T_A) - \frac{Q_B}{T_B} \right]$

$ex,verl = T_0 \left[c_p \ln(T_G/T_0) - \frac{Q_B}{T_B} \right]$

$= -152.15 \ W$

b) $\Delta E = m_2 u_2 - m_1 u_1 + \Delta KE + \Delta PE$

$m_{ges}(u_2 - u_1) = \frac{w_G^2}{2} - \frac{w_0^2}{2}$

$w_G^2 = 2 m_{ges}(u_2$

$0 = \dot{m}\left(h_0 - h_G + \frac{w_0^2}{2} - \frac{w_G^2}{2}\right) + \sum \dot{Q} + \sum \dot{W}$

$\dot{Q}_B = \dot{m}\left(h_0 - h_G + \frac{w_0^2}{2} - \frac{w_G^2}{2}\right)$

$\frac{\dot{Q}_B}{m_{ges}} (h_G - h_0)$

$\frac{w_G^2}{2} = \frac{\dot{Q}}{\dot{m}} + h_0 - h_G + \frac{w_0^2}{2}$

$w_G^2 = 2\frac{\dot{Q}}{\dot{m}} + 2(h_0 - h_G) + w_0^2$

$= 2\frac{\dot{Q}}{\dot{m}} + 2 c_p (T_0 - T_G) + w_G^2$

A3) perfektes Gas, F-F-GW (EW)

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

$$p_g = p_0 + \frac{F}{A} + \cancel{\text{[illegible]}}$$

$$p_{g,0} = 1{,}4 \text{ bar}$$

$$R = \frac{\bar{R}}{M} = 0{,}16628$$

$$pV = mRT$$

$$m_g = \frac{p_g V_g}{R T_g} = 3{,}42 \text{ g}$$

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

~~$p_{g2} = p_{g1}$ da sich die Masse auf der Kolben nicht verändert hat.~~

Volumen EW ändert sich nicht. Gas komprimiert somit höherer Druck jedoch tiefere Temperatur

$$T_{g2} = \frac{p_{g2} V_{g2}}{m_g R}$$

$$pV^n = pV^n$$

isochor: $v = v$

$$v_1 = \frac{RT_1}{p_1} = 9 \times 18 \times 10^{-4}$$

$$V_2 = m_g \cdot v_1 = 3.141 \times 10^{-3}$$

c) Q_{12}

$$\Delta E = m_2 u_2 - m_1 u_2 + \Delta KE + \Delta PE = \sum \Delta m_i \left(h_i + \frac{w_i^2}{2} + g z_i \right] + \sum Q - \sum W$$

$$Q = m_g (u_2 - u_1)$$

$$Q_{12} = m_g c_v (T_2 - T_1)$$

$$Q_{12} = -1082{,}42 \text{ J}$$

d) x_E is 2

$$Q = m_{EW} (u_2 - u_1)$$

$$u_2 = + \frac{Q}{m_{EW}} + u_2$$

~~$u_2 = -444.2342 \text{ kJ/kg}$~~

$$u_2 = -122.59 \text{ kJ/kg}$$

$$u_2 = u_{fest} + x_1 (u_{fest,i} - u_{fest})$$

$$u_2 = -133.41 \text{ kJ/kg}$$

~~$v_2 = \frac{1}{\rho_{fest}}$~~

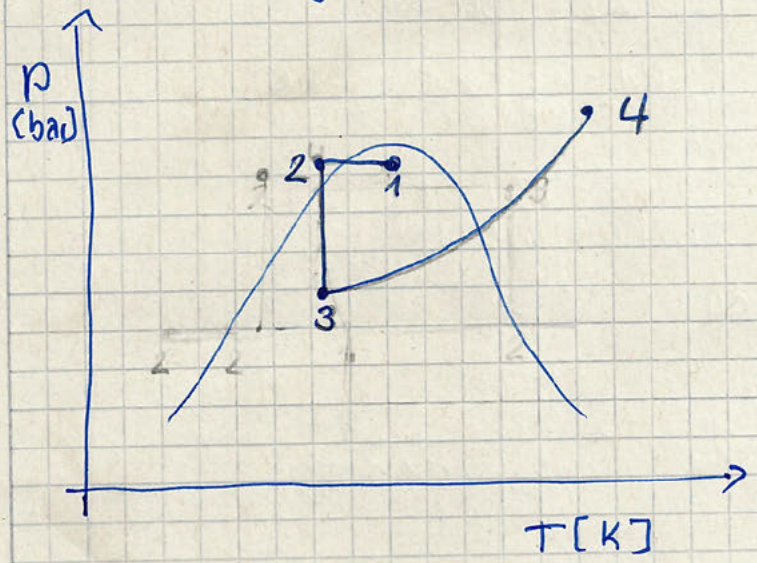
$V_1 = V_2$ somit

$$Q_{12} = m_{EW} c_{if} (T_{EW2} - T_{EW1})$$

$$\frac{Q}{m_{EW} c_{if}} + T_{EW1} = T_{EW2}$$

A4)

a) p-T-Diagramm Schritt i d ii



T2 =

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

$0 = \dot{m}_{R123}\,[h_2 - h_3] + \dot{W}_K$

$\frac{\dot{W}_K}{h_3 - h_2} = \dot{m}_{R123} = 0{,}721\ \frac{kg}{h}$

$\dot{m}_{R12}$

~~s(2) s(1) (8bar) =~~

T2 ?

p3 = 8bar

2 : gls. Dampf

s2 = s3

s2 = sg von T2 Tab A10

h2 = hg Tab A10 = 234.08

Annahme T2 = (-22°C)

s2 = 0,9351 = s3

$h_3 = h(T_{sat}) - \frac{h(40) - h(T_{sat})}{0{,}9066 - 0{,}9374} \cdot (0{,}9359 - 0{,}9066)$

h3 = 272.94

c) $x_1 = \frac{s_4 - s_f}{s_g - s_f}$

Tab A11

$s_4 = \frac{s_f(2.8\,bar) + s_f(3{,}2\,bar)}{2}$

$s_4 = 0{,}2$

p1 = p2

p2 = psat T(22°C) = 1.2192 bar

$s_f(1{,}2192) = s_f(1{,}2) - \frac{s_f(1{,}4) - s_f(1{,}2)}{1{,}4 - 1{,}2} \cdot (1{,}2192 - 1{,}2)$

$s_g(1{,}2192) = s_g(1{,}2) - \frac{s_g(1{,}4) - s_g(1{,}2)}{1{,}4 - 1{,}2} \cdot (1{,}2192 - 1{,}2)$

$s_{f1} = 0{,}08959$

$s_{g1} = 0{,}9350$

$x_1 = 0{,}131$

d) $\varepsilon_K = \frac{Q_W}{W_t} = \frac{\dot{Q}_K}{\dot{W}_K} = \frac{Q_W}{Q_{ab} - Q_W} = \frac{Q_K}{Q_{ab} - Q_K}$

$\dot{Q}_K = \dot{m}_{R134} (h_2 - h_1)$

$\dot{Q}_K = 205,79\ kJ$

$Q_{ab} = \dot{m}_{R134} (h_4 - h_3)$

$Q_{ab} = -156,29$

$\varepsilon_K = \frac{Q_K}{W_t} = 7349,64$

Tab A.10)

$h_2 = 234.08$

$h_1 = h_f + x_1 (h_g - h_f)$

$= 48.87$

$h_2 = 234,08$

$h_4 =$ Tab A.M.

$h_4 = h_f = 93.42$

e) Sie würde nicht über der Sublimationspunkt kommen und somit die Lebensmittel nicht einfrieren.