① Paramagnet

a) $C_H(H) = ?$

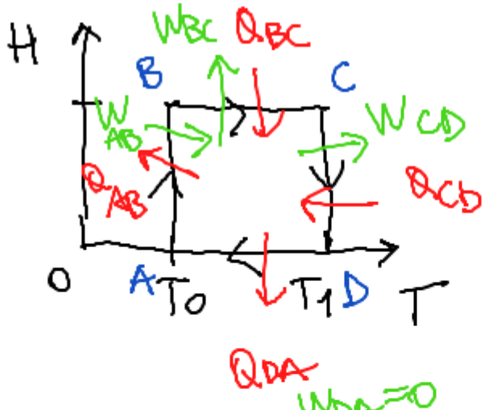
$$\left(\frac{\partial C_H}{\partial H}\right)_T = \left(\frac{\partial}{\partial H}\frac{T}{m}\left(\frac{\partial S}{\partial T}\right)_H\right)_T = \frac{T}{m}\left(\frac{\partial}{\partial T}\left(\frac{\partial S}{\partial H}\right)_T\right)_H \overset{\text{Maxwell}}{=} \frac{T}{m}\left(\frac{\partial}{\partial T}\mu_0 V\left(\frac{\partial M}{\partial T}\right)_H\right)_H \overset{*}{=} \frac{2\mu_0 a H}{\rho T^2}$$

$M(T,H) = \frac{aH}{T}$

$$\Delta C_H = \int_0^H \left(\frac{\partial C_H}{\partial H}\right)_T dH = \frac{\mu_0 a H^2}{\rho T^2} = 251\ \frac{J}{kg\,K}$$ *

½ tache

b) cykel; $\eta = ?$



$$\frac{Q_{AB}}{m} = \frac{T_0}{m}\int_0^H \left(\frac{\partial S}{\partial H}\right)_T dH = \frac{T_0}{m}\mu_0 V\int_0^H \left(\frac{\partial M}{\partial T}\right)_H dH \overset{*}{=} -\frac{\mu_0 a H^2}{2\rho T_0} = -1{,}256\ \frac{kJ}{kg}$$ odv.

$$\frac{Q_{BC}}{m} = \int_{T_0}^{T_1} c_H(H,T)\,dT = \int_{T_0}^{T_1}\left(c_H^0 + \frac{\mu_0 a H^2}{\rho T^2}\right)dT = c_H^0(T_1 - T_0) - \frac{\mu_0 a H^2}{\rho}\left(\frac{1}{T_1} - \frac{1}{T_0}\right)$$ *

$$= +16{,}257\ \frac{kJ}{kg}$$ dov.

$$\frac{Q_{CD}}{m} = \frac{T_1}{m}\int_H^0 \left(\frac{\partial S}{\partial H}\right)_T = \ldots = \frac{\mu_0 a H^2}{2\rho T_1} = +0{,}628\ \frac{kJ}{kg}$$ dov.

$$\frac{Q_{DA}}{m} = \int_{T_1}^{T_0} c_H^0\,dT = c_H^0(T_0 - T_1) = -15\ \frac{kJ}{kg}$$ odv.

$$\eta = \frac{|W|_{krivka}}{Q_{DOV}} = 1 + \frac{Q_{ODV}}{Q_{DOV}} = 1 + \frac{Q_{AB} + Q_{DA}}{Q_{BC} + Q_{CD}} = 3{,}7\%$$

½ tache

(2) vdW tekočina ; $X = -\frac{3}{2}y^3 + 4z - 6zy$

a) $\beta(T_c+1K, V_m^c) = ?$ $\quad p = konst.$

$\hookrightarrow dx = -\frac{9}{2}y^2 dy + 4dz - 6y\,dz - 6z\,dy = 0$

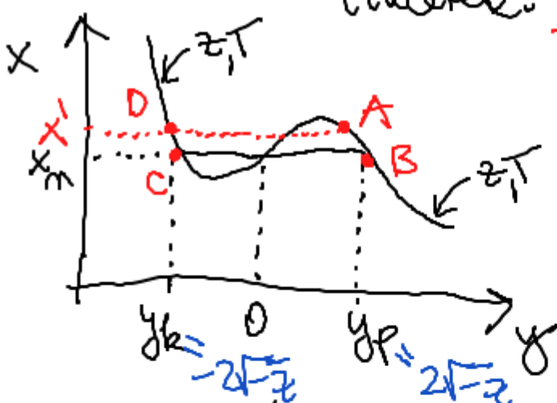
$\Rightarrow \left(\frac{\partial y}{\partial z}\right)_x = \frac{4-6y}{\frac{9}{2}y^2 + 6z}$

$\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p = \frac{1}{T_c}\frac{1}{1+y}\left(\frac{\partial y}{\partial z}\right)_x = \frac{1}{T_c}\frac{1}{1+y}\frac{4-6y}{\frac{9}{2}y^2+6z} = \frac{1}{T_c}\cdot\frac{2}{3z} = \frac{2}{3(T-T_c)}$

$y=0,\ V_m = V_m^c,\ p = p_c$

$= 0{,}67\,K^{-1}$ $\qquad$ 1/2 točke

b1) ekstrapolacija podhlajene pare (začetek: A ; konec: D) ; določiti T:



$y_A = 0{,}03$

$y_D = -0{,}046$

$x^1 = -\frac{3}{2}y_A^3 + 4z - 6zy_A = -\frac{3}{2}y_D^3 + 4z - 6zy_D$

$z = \frac{y_A^3 - y_D^3}{4(y_D - y_A)} = -4{,}1\cdot 10^{-4} \Rightarrow T - T_c = -0{,}265\,K, °C$

1/4 točke

b2) izmenjana toplota @ p=konst.: $Q = \Delta H = \Delta H_{AB} + \Delta H_{BC} + \Delta H_{CD}$

$dH = TdS + Vdp$

$\left(\frac{\partial H}{\partial V}\right)_T = T\left(\frac{\partial S}{\partial V}\right)_T + V\left(\frac{\partial p}{\partial V}\right)_T = \frac{T}{T_c}p_c\left(\frac{\partial x}{\partial z}\right)_y + \frac{V_m}{V_m^c}p_c\left(\frac{\partial x}{\partial y}\right)_z$

$\left(\frac{\partial p}{\partial T}\right)_V$ $\qquad$ 4-6y $\qquad$ $-\frac{9}{2}y^2 - 6z$

$= \int_A^B \left(\frac{\partial H}{\partial V}\right)_T dV - Q_i + \int_C^D \left(\frac{\partial p}{\partial V}\right)_T dV$ $\qquad$ 1/4 točke

Q_i vnesje!

$\frac{Q}{m} = \frac{p_c V_m^c}{M}(0{,}0395 - 0{,}3234 - 0{,}0236) = -21{,}1\ \frac{kJ}{kg}$