vdW: $\left(P + \frac{aN^2}{V^2}\right)(V - Nb) = Nk_BT$

$dG = -S\,dT + V\,dP + \mu\,dN$

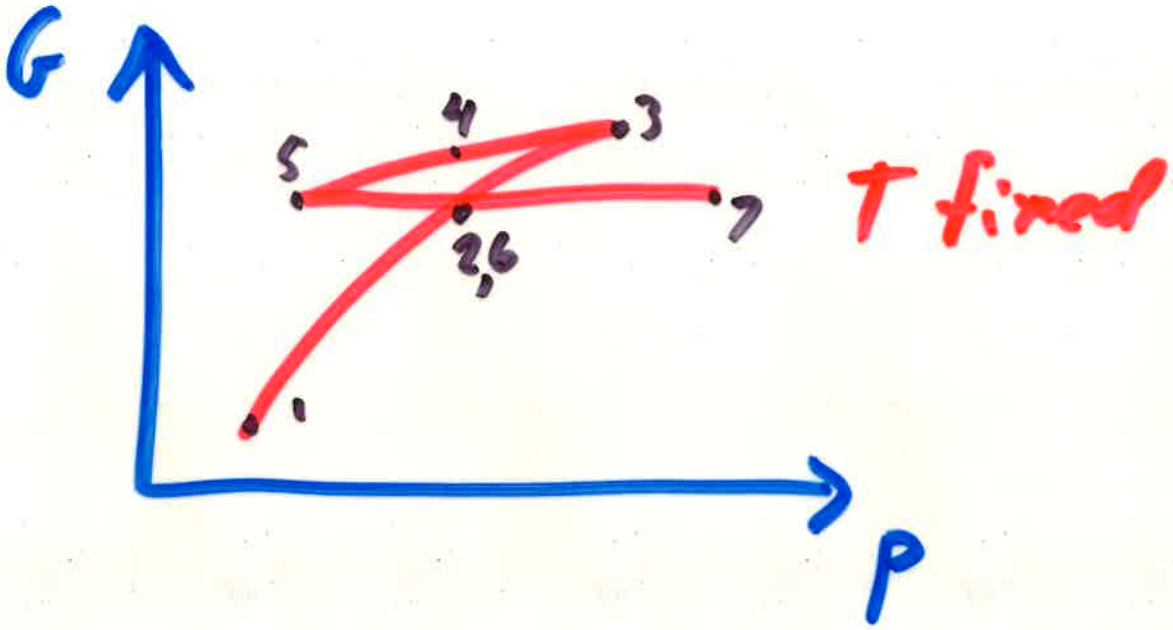
N fixed, $dN = 0$; isotherm, $dT = 0$

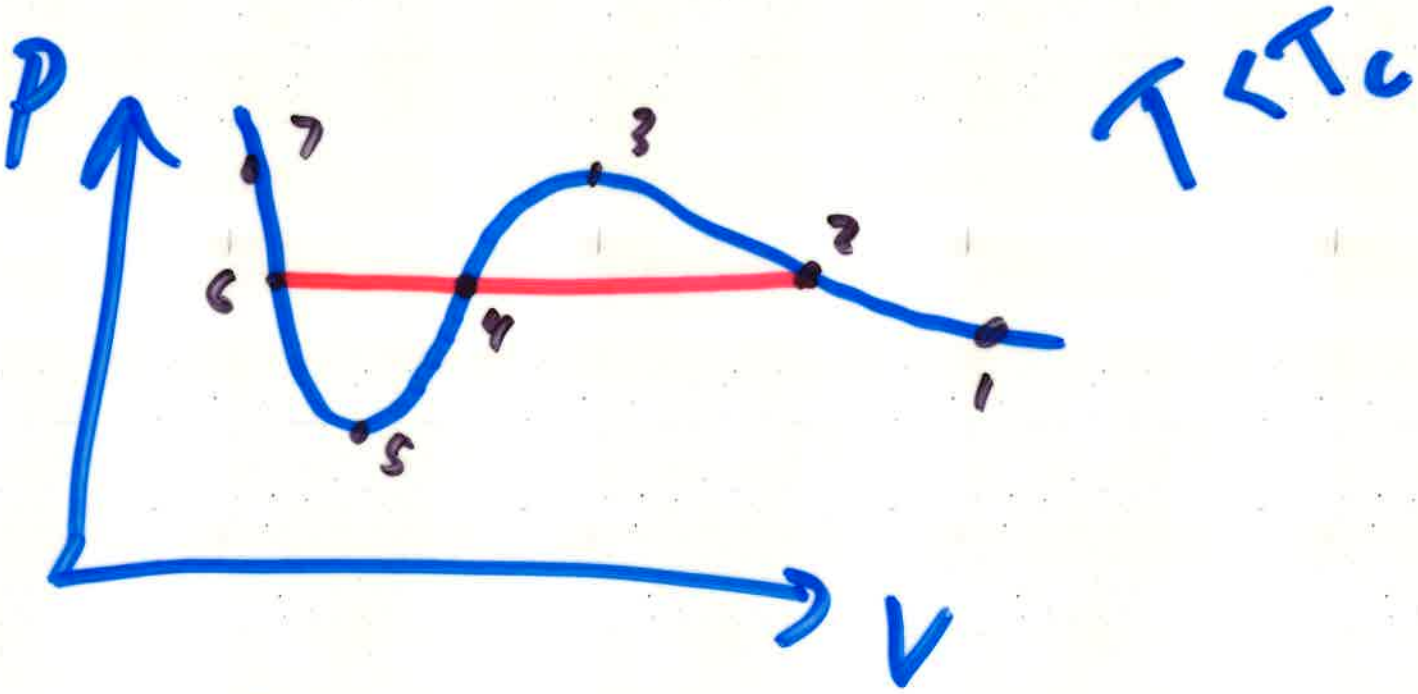
$$\left(\frac{\partial G}{\partial V}\right)_{NT} = V\left(\frac{\partial P}{\partial V}\right)_{NT}$$

$$= -\frac{NK_BTV}{(V-Nb)^2} + \frac{2aN^2}{V^2}$$

$$G = -NK_BT\ln(V-Nb) + \frac{NK_BT(Nb)}{V-Nb} - \frac{2aN^2}{V} + f(T)$$

Use vdW to write $P(V)$
then plot $G(V)$ vs. $P(V)$





$$0 = \oint_{loop} dG = \int \left(\frac{\partial G}{\partial P}\right)_{TN} dP = \int V\,dP$$

Equal areas