5. $Q(N,V,T) = \frac{1}{N!}\left(\frac{2\pi m k_B T}{h^2}\right)^{3N/2}(V-Nb)^N e^{aN^2/Vk_BT}$ b/c $\beta = \frac{1}{k_BT}$

$\langle E\rangle = k_B T^2 \left(\frac{\partial \ln Q}{\partial T}\right)_{N,V}$ $\quad C_V = \frac{d\langle E\rangle}{dT}$

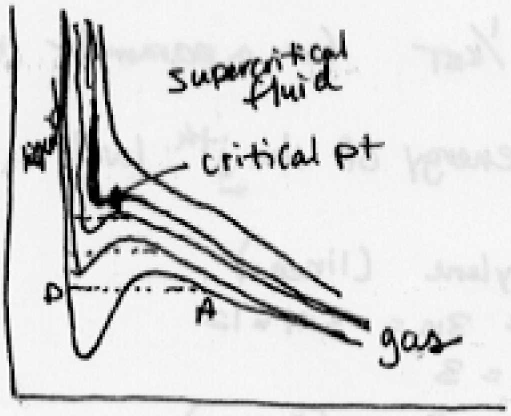
$\ln Q = -\ln N! + \frac{3N}{2}\ln\left(\frac{2\pi m k_B}{h^2}\right) + \frac{3N}{2}\ln T + N\ln(V-Nb) + \frac{aN^2}{Vk_BT}$

$\frac{\partial \ln Q}{\partial T} = \frac{3N}{2T} - \frac{aN^2}{Vk_BT^2}$

$\langle E\rangle = k_BT^2\left(\frac{3N}{2T} - \frac{aN^2}{Vk_BT^2}\right) = \frac{3}{2}Nk_BT - \frac{aN^2}{V}$

$C_V = \frac{d\langle E\rangle}{dT} = \frac{3}{2}Nk_B$

6.



- Between A + D, gases + liquids co-exist.
- van der Waals equation can't accurately describe the coexistance line. Because VDW is a cubic EOS w/ respect to $\bar{V}$, there are 3 real solutions below critical pt (1 @ critical pt; 1 real above c.p.) yielding VDW loops.

7. e Elec > vib > rot > trans

8. b. $f_2(F) > f_2(He)$ b/c it's easier to populate f_2 for F

9. ideal gas assumptions: 1. no interactions between gases 2. no molecular size
VDW introduces empirical parameters a + b to account for interaction + size, respectively

10. $\tilde{\nu} = \nu/c = \frac{5.3\times10^{13}\ 1/s}{2.9979\times10^{10}\ cm/s} = 1767.9\ cm^{-1}$