

$$\frac{F}{A} = E - PV \quad \frac{F}{V} = P$$

See Reif 8.6

SMJOC #2

a) $\rho(V-Nb) = NkT \exp(-Na/kTV)$

b is a correction to the effective volume of a particle due to short-range forces

a is a measure of particle interaction

b) critical point: where $\left(\frac{d^2P}{dV^2}\right)_T = 0$ and $\left(\frac{dP}{dV}\right)_T = 0$

$$\rho = \frac{NkT}{(V-Nb)} \exp(-Na/kTV)$$

$$\frac{dP}{dV} = \frac{-NkT}{(V-Nb)^2} \exp(-Na/kTV) + \frac{NkT}{(V-Nb)} \left(\frac{-Na}{kT} \right) \left(-\frac{1}{V^2} \right) \exp(-Na/kTV) = 0$$

$$\frac{-NkT}{(V-Nb)^2} + \frac{NkT(Na)}{(V-Nb)kTV^2} = 0$$

$$\frac{NkT}{(V-Nb)^2} = \frac{NkT(Na)}{(V-Nb)kTV^2} \quad \frac{1}{V-Nb} = \frac{Na}{kTV^2} \quad \frac{V-Nb}{NV} = \frac{kTV^2}{Na}$$

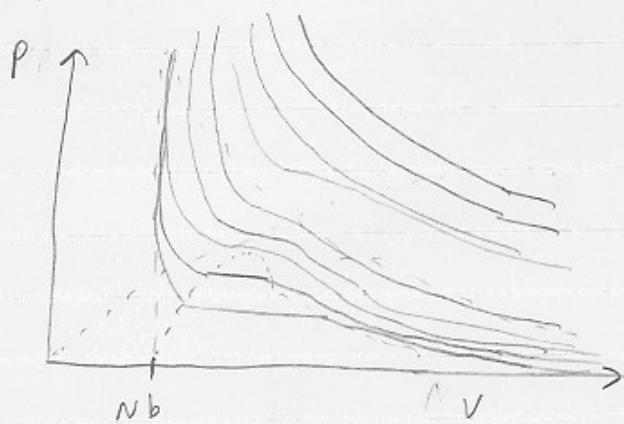
$$V-Nb = \frac{kTV^2}{Na} \quad \frac{kT}{Na} V^2 - V + Nb = 0$$

$$\rho = \frac{NkT}{V}$$

$$\rho(V - Nb) = NkT \exp(-Na/kTV)$$

$$\rho(V - \text{const}) = \text{const} e^{-\text{const}/V}$$

$$\rho(V - \text{const}) e^{\text{const}/V} = \text{const}$$



for V large acts like
ideal gas

for V not large:

$$\rho \propto \frac{1 + e^{-(1/\gamma V)}}{V - \text{const}}$$

$$c) \frac{d^2\rho}{dV^2} = \frac{2NkT}{(V-Nb)^3} \exp(-N\gamma/kTV) - \frac{N^2 \alpha}{(V-Nb)^2 kTV^2} \exp(-N\gamma/kTV)$$

$$\frac{\partial P}{\partial V} = \frac{-NkT}{(V-Nb)^2} \exp(-Nn/kTV) + \frac{N^2 \alpha}{(V-Nb)V^2} \exp(-Nn/kTV)$$

$$\frac{\partial^2 P}{\partial V^2} = \frac{2NkT}{(V-Nb)^3} \exp(-Nn/kTV) - \frac{NkT}{(V-Nb)^2} \left(\frac{-N\alpha}{kT} \right) \left(\frac{1}{V^2} \right) \exp(-Nn/kTV) - \frac{2N^2 \alpha}{(V-Nb)V^3} \exp(-Nn/kTV) - \frac{N^2 \alpha}{V(V-Nb)^2} e^{-\frac{Nn}{kTV}} + \frac{N^2 \alpha}{(V-Nb)V} e^{-\frac{Nn}{kTV}} / C$$

$$\frac{\partial NkT}{\partial V} = \frac{N^2 \alpha}{V^2(V-Nb)^2} - \frac{\partial N^2 \alpha}{(V-Nb)V^3} - \frac{N^2 \alpha}{V^3(V-Nb)^2} + \frac{N^2 \alpha^2}{(V-Nb)V^4 kT} = 0$$

$$\frac{\partial NkT}{\partial (V-Nb)} = \frac{\partial N^2 \alpha}{V^2(V-Nb)^2} - \frac{\partial N^2 \alpha}{(V-Nb)V^3} + \frac{N^2 \alpha^2}{(V-Nb)V^4 kT} = 0$$

$$\frac{\partial kT}{\partial (V-Nb)} = \frac{\partial N^2 \alpha}{V^4(V-Nb)} - \frac{\partial N^2 \alpha}{V^3} + \frac{N^2 \alpha^2}{V^4 kT} = 0$$

$$kT \left(\frac{N^2 \alpha}{kTV} \right)^2 - \frac{\partial N^2 \alpha}{kTV^4} \frac{N^2 \alpha}{kTV} - \frac{\partial N^2 \alpha}{V^3} + \frac{N^2 \alpha^2}{V^4 kT} = 0$$

$$\frac{\partial N^2 \alpha}{kTV^4} = \frac{\partial N^2 \alpha}{kTV^4} - \frac{\partial N^2 \alpha}{V^3} + \frac{N^2 \alpha^2}{V^4 kT} = 0$$

$$\frac{N^2 \alpha}{V^4 kT} = \frac{\partial N^2 \alpha}{V^4 kT} - N^2 \alpha$$

$$\frac{N^2 \alpha}{V kT} = 2$$

$$\frac{kTV}{N^2 \alpha} = \frac{1}{2} = \frac{V-Nb}{NV}$$

$$\frac{V}{b} = V-Nb \quad Nb = \frac{V}{2} \quad \frac{V-Nb}{Nb} = \frac{V}{2} = 0$$

$$\frac{\partial kT}{\partial V} = \frac{N^2 \alpha}{V^2(V-Nb)^2} - \frac{N^2 \alpha^2}{V^3(V-Nb)^2} + \frac{N^2 \alpha^2}{V^4 kT}$$

$$\frac{\partial kT}{\partial (V-Nb)} = \frac{N^2 \alpha}{V^2(V-Nb)^2} - \frac{N^2 \alpha^2}{V^3(V-Nb)^2} + \frac{N^2 \alpha^2}{V^4 kT}$$

$$\boxed{T_c = \frac{\alpha}{4kb}}$$

$$\frac{1}{Nb} = \frac{N\alpha}{kT(V-Nb)^2}$$

$$\boxed{T_c = \frac{\alpha}{4kTNb^2}}$$

$$P_c = \frac{\alpha}{4b^2} e^{-\lambda}$$

$$\frac{1}{Nb} = \frac{N\alpha}{kTV} \quad \frac{1}{Nb} = \frac{V-Nb}{NV} \quad \frac{1}{Nb} = \frac{V}{NV} = \frac{1}{2} = 0$$

$$\boxed{V_c = 2Nb}$$