

CHM2131: Thermodynamics of Gases and Solutions
 Assignment 2 2016
 Ideal and Real Gases
 Due: Friday Sept. 23

1. At sufficiently high temperatures, the van der Waals equation has the form: $p = \frac{RT}{V_m - b}$

Justify this behaviour using a potential energy diagram (like the figure on slide 41 of the lecture notes).

2. a) What is the significance of the Boyle Temperature ?

b) Determine the Boyle Temperature for N₂ gas assuming it is well described by i) the van der Waals equation of state and ii) the virial equation of state.

c) Under what temperature and pressure conditions will attractive forces dominate the behaviour of a sample of nitrogen gas?

3. The experimental critical constants of NH₃ are:

$$T_c = 405.4 \text{ K}, P_c = 113.53 \text{ bar}, \text{ and } V_{mc} = 72.5 \times 10^{-3} \text{ l mol}^{-1}.$$

Use the values of P_c and T_c to calculate V_{mc} assuming NH₃ behaves as (a) an ideal gas; (b) a VDW gas and (c) a Redlich-Kwong gas at the critical point (you may need to use a computer or a programmable calculator to get an answer here based on RK equation of state).

Redlich-Kwong equation of state:

$$p = \frac{RT}{V_m - b} - \frac{a}{\sqrt{T}} \left(\frac{1}{V_m(V_m + b)} \right) \quad \text{a miracle occurs and } a = \frac{R^2 T_c^{5/2}}{9 P_c (2^{1/3} - 1)} \quad \text{and } b = \frac{(2^{1/3} - 1) R T_c}{3 P_c}$$

d) Which equation of state gives the best results ?

4. Below is the equation of state expressed in terms of the critical constants p_c and T_c.

$$pV_m = RT \left(1 + \frac{8}{57} \frac{p T_c}{p_c T} \left[1 - 4 \left(\frac{T_c}{T} \right)^2 \right] \right)$$

a) Derive an expression for the compressibility factor, Z.

b) Determine the Boyle temperature in terms of constants R, p_c and T_c.

5. The parameter “a” in the VDW equation is greater for H₂O than for He. What does this say about the form of the potential function (potential energy vs. intermolecular separation) for the two gases? Draw me a picture and explain.