CHEM 331
Physical Chemistry
Fall 2009 Name: ____

Midterm Examination 1

1. Calculate the density of Methane gas at 298.15K and 1 atm assuming Ideal behavior.

2. The Compressibility Factor Z for N_2 gas is 0.85 at a concentration of 10.0 mole/L at 200K.

   a) What Pressure would be exerted by the gas at this concentration if it were Ideal?

   b) What Pressure is exerted by N_2 at this concentration?

   c) What is the percentage error introduced into the Pressure by assuming the gas is Ideal?

3. A mixture of 1 mole H_2 and 2 mole O_2 is at 25°C in a 20 L flask. Calculate P_{H2} and x_{H2}. Provide a reasonable definition of the partial volume V_i and use it to calculate V_{H2}.

4. Given the van der Waals Equation of State:

$$P = \frac{RT}{(\bar{V} - b)} - \frac{a}{\bar{V}^2}$$

a) Determine $\left(\frac{\partial P}{\partial \bar{V}}\right)_T$.

b) Use this result to determine:

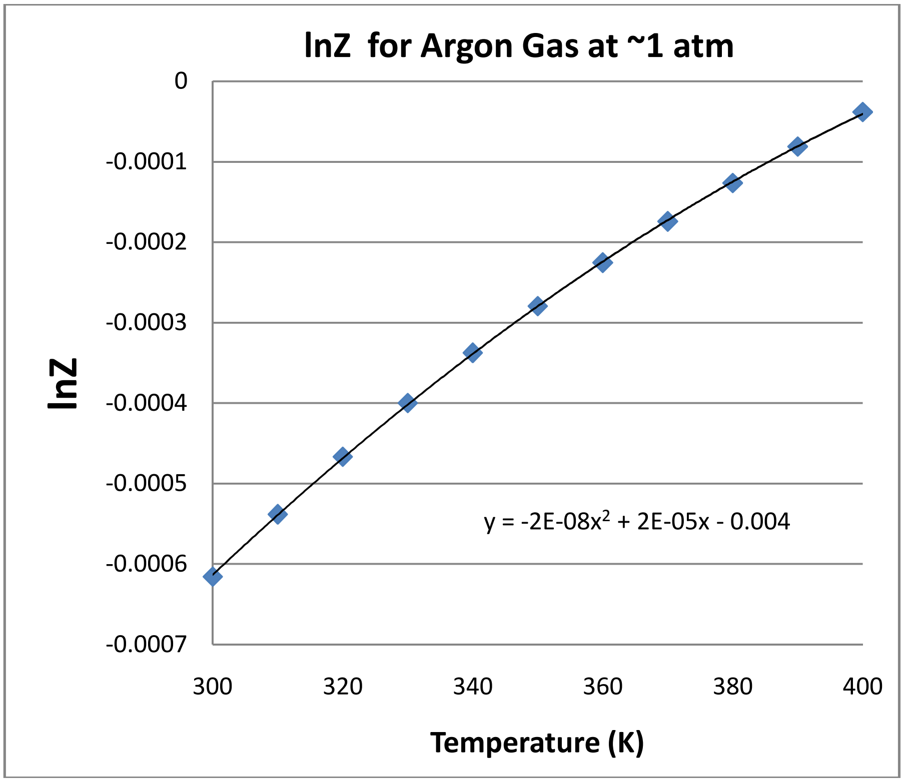
$$\kappa = \frac{1}{\bar{V}}\left(\frac{\partial \bar{V}}{\partial P}\right)_T$$

for CO_2 at $\bar{V}$ = 22.4 L/mole and 273.15K. (a = 3.592 L^2atm/mol^2, b = 0.04267 L/mol)

5. We have found that the Thermal Compressibility α depends on the Compressibility Factor Z as:

$$T\,\alpha = 1 + T\left(\frac{\partial lnZ}{\partial T}\right)_P$$

A plot of lnZ *vs* T for Argon gas at approximately 1 atmosphere pressure gives:



Calculate α for Argon at 1 atm and 273.15 K.

6. For 1 kg of Water between 0^{o}C and 40^{o}C, the volume can be represented as:

$$V = 999.87 - 0.06426\, t + (8.5045 \times 10^{-3})\, t^2 - (6.79 \times 10^{-5})\, t^3$$

a) Calculate the Isothermal Compressibility α for Water at 0^{o}C. Recall:

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$$

b) Compare this result with that for Argon gas at the same temperature and pressure. (See Problem 5)

7. We have shown:

$$\alpha = -\left(\frac{1}{\rho}\right)\left(\frac{\partial \rho}{\partial T}\right)_P$$

For Water at 80°C, the density is 0.971792 g/cm^3 and α = 6.4127 x 10^{-4} K^{-1}. Estimate the density of Water at 81°C. Compare this result with the measured value of 0.971166 g/cm^3.

8. On present scale of Absolute Temperature T, 0°C is defined as 273.15K. Suppose we were to define a new Absolute scale T' such that 0°C is 300K. If the boiling point of Water on the Celsius scale is 100°C, what is the boiling point of Water on the T' scale?

Recall: The thermometric equation is:

$$t = \frac{y - y_1}{y_2 - y_1}(t_2 - t_1) + t_1$$