Chemistry 217
Fall 2011
Problem Set 1

1.1 12.0 moles of molecular nitrogen are contained in a 2.0 L cylinder at 30°C. Calculate the pressure in bar according to the

(a) Ideal Gas law

(b) Van der Waals equation. The Van der Waals constants for N_2 are a = 1.408 $L^2.bar.mol^{-2}$ and b = 0.03913 $L.mol^{-1}$. Assuming that the Van der Waals equation gives the right answer, what is the percent error in using the ideal gas law?

1.2 Nitrogen Tetroxide is partially dissociated in the gas phase according to the reaction

$$N_2O_4(g) = 2NO_2(g)$$

A mass of 1.588 g of N_2O_4 is placed in a 500 cm^3 glass vessel at 298 K and dissociates to an equilibrium mixture at 1.0133 bar.

(a) What are the mole fractions of N_2O_4 and NO_2?

(b) What percentage of the N_2O_4 has dissociated? Assume that the gases are ideal.

1.3 (a) At 1.0 atm pressure the volume of 1.0 mole of nitrogen gas is 22,401 cm^3 at 0.00°C and 30,627 cm^3 at 100°C. Using only these data, estimate the temperature of the absolute zero on the centigrade scale.

(b) At 0.1 atm pressure the molar volume of nitrogen is 224,130 cm^3 at 0.00°C and 306,200 cm^3 at 100°C. From these data, again estimate the temperature of the absolute zero.

(c) If we extrapolate the results of parts (a) and (b) to zero pressure, what is the calculated temperature of the absolute zero?

1.4 The coefficients of isobaric thermal expansion α and isothermal compressibility κ are defined by

$$\alpha = (1/V)(V/T)_P \text{ and } \kappa = -(1/V)(V/T)_T$$

(a) Obtain expressions for α_{ideal} and κ_{ideal} for a gas that obeys the ideal gas law. Simplify these expressions as much as possible and give the answers in terms of p and T only.

(b) Derive expressions for the ratios α/α_{ideal} and κ/κ_{ideal} for a slightly nonideal gas that obeys the equation of state $p\overline{V} = RT + bp$ where $\overline{V} = V/n$. Again simplify your answers as much as possible (you may need more than just p and T for this answer).

1.5 It is of interest to calculate the total and partial pressures at the top of Mt. Everest [Most Nepali people refer to the mountain as *Sagarmatha,* meaning "Forehead in the Sky." Speakers of Tibetan languages, including the Sherpa people of northern Nepal, refer to the mountain as *Chomolungma,* Tibetan for "Goddess Mother of the World." The height of Mount Everest has been determined to be 29,035 feet.]

Calculate the total pressure and oxygen partial pressure at the mountain top. For the barometric formula, use an "average molecular weight of air" equal to $(0.781\times28+0.209\times32+0.010\times40)$.
It is a reasonable approximation to use an average air temperature between sea level and 10,000 m equal to 0°C (273 K). The significance of the O_2 partial pressure you calculate will be evident to anyone who has actually attempted to climb Mt. Everest or, indeed, any mountain peak over 12,000 feet.