Chemistry 135 Semester 01-2012
Homework for Submission #2

Answer the following questions and submit them for marking on or before 5 pm Thursday 23rd February in the chemistry drop box. Proper setting out is crucial, and only answers showing full working can attract full marks. Express your answers to the correct number of significant figures. Answers showing evidence of copying will attract zero marks. Students are requested to print out this page on letter-sized paper, work out their answers in rough, and submit their answers on it. Sheets must be carefully stapled and marked with full name, lecturer's name, and student number.

1) At a temperature of 25°C and a pressure of 750 Torr, 1.00 g of cyanogen gas occupies 0.476 L. Determine the molar mass of cyanogen. Given that the empirical formula is CN, determine the molecular formula.

$PV = nRT$

$\therefore n = \frac{PV}{RT} = \frac{750\ \text{torr} \times 0.476\ \text{L}}{0.0821\ \text{L atm mol}^{-1}\text{K}^{-1} \times (25+273)\ \text{K}} = 0.01920\ \text{mol}$ (760)

$\therefore$ Molar mass $= \frac{1.00\ \text{g}}{0.01920\ \text{mol}} = 52.08406\ \text{g mol}^{-1} = 52.1\ \text{g mol}^{-1}$ to 3 s.f. 3

Since RFM of CN = 12 + 14 = 26 and 52.1/26 ≃ 2, molecular formula of cyanogen = $(CN)_2$ or C_2N_2 2

2) A gas is enclosed in a cylinder with a gas-tight plunger. *Explain* carefully, with reference to molecules, the effect of pushing the plunger in on:

a) the density of the gas.

As the plunger is pushed in the molecules are pushed closer together. Since only the molecules have mass, this concentrates the same mass in a smaller volume, making the density higher. 3

b) the pressure of the gas.

Since the molecules are closer together they hit the wall more frequently, creating a greater force on unit area of wall. Thus the pressure is increased. 3

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3) Calculate the pressure in atmospheres of a 1.000 mol of chlorine gas enclosed in a 1.000 dm^3 vessel at 25°C assuming:

a) it behaves ideally. (Use R = 0.08206 dm^3 atm mol^{-1} K^{-1}).

$PV = nRT$

$\therefore P = \frac{nRT}{V} = \frac{1.000 \text{ mol} \times 0.08206 \text{ dm}^3 \text{ atm mol}^{-1} \text{K}^{-1} \times (25+273) \text{K}}{1.000 \text{ dm}^3}$

$= 24.45388$ atm

$= \underline{24.5 \text{ atm}}$ to 3 s.f. 3

Note: if 273.15 is used, 4 s.f. may be given.

b) it behaves according to the Van der Waals equation.

Van der Waals equation is: $\left(P + a\frac{n^2}{V^2}\right)(V - nb) = nRT$

$\therefore P = \frac{nRT}{V-nb} - a\frac{n^2}{V^2} = \frac{1 \text{ mol} \times 0.08206 \text{ dm}^3 \text{ atm mol}^{-1} \text{K}^{-1} \times (25+273) \text{K}}{1.000 \text{ dm}^3 - 1.000 \text{ mol} \times 0.0562 \text{ dm}^3 \text{ mol}^{-1}}$

$+ \frac{6.49 \text{ dm}^6 \text{ atm mol}^{-2} \times 1.000^2 \text{ mol}^2}{1.000^2 \text{ dm}^6}$

$= 25.9043 - 6.49$ atm 3

$= 19.41453$ atm $= \underline{19.4 \text{ atm}}$ to 3 s.f.

Note: neither equation is really accurate enough to justify 4 s.f.

c) Comment on the difference between the values.

The pressure calculated by the Van der Waals equation is considerably lower than that for an ideal gas. This is mainly due to the factor $a\frac{n^2}{V^2}$ which allows for the attractive forces between the molecules: these tend to lessen the pressure. The volume occupied by the molecules themselves, encapsulated in the factor "b" has a much smaller effect. 5

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