Name ____________________ **AP Chem** ___/___/___

Chapter 5 Homework

Answer each of the following questions clearly. Show all work when necessary. 18 points.

1. Calculate the pressure exerted by 56.0 grams of N_2 in a 20.00 L container at -85°C.
   a. Using the ideal gas law. (1 pt)
   b. Using the van der Waals equation (a = 1.39; b = 0.0391) (1 pts)
   c. Many gases deviate from "ideal" behavior at low temperatures and high pressures. As a result you should use your pressure result from part b. If the volume is held constant, and the temperature rises to -5.0°C, what would be the pressure exerted by the nitrogen gas? (1 pt)

a. 56.0 ÷ 28.0 = 2.00 moles

$P = \frac{(2.00)(.08206)(188)}{20.00}$

P = 1.54 atm

c. $\frac{1.54}{188} = \frac{x}{268}$

x = 2.20 atm

b. $[P + a(n/V)^2] \times [V - nb] = nRT$

$[P + 1.39(\frac{2}{20.0})^2] \times [20 - 2(0.0391)] = (2.0)(0.08206)(188)$

P + 0.0139 × [19.9] = 30.85

P + 0.0139 = 1.55

P = 1.54

2. Air bags are activated when a severe impact causes a steel ball to compress a spring and electrically ignite a detonator cap. This causes sodium azide (NaN_3) to decompose explosively according to the following reaction:

   $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$

   a. What mass of $NaN_3(s)$ must be reacted to inflate an air bag to 70.0 L at a pressure of 733 mm Hg and a temperature of -35.00 °C? (1 pt)
   b. What is the density of nitrogen gas at this temperature? (1 pt)
   c. How many molecules of nitrogen are present in the volume of gases calculated in part A? (1 pt)
   d. What is the mass of nitrogen actually produced at the above conditions? (1 pt)

a. $\frac{PV}{RT} = n = \frac{(733/760)(70)}{(.08206)(308)}$ = 2.67 mol N_2 | 2 mol NaN_3 / 3 mol N_2 | 65.0 g / 1 mol = 116 g NaN_3

if -35 → (238)

3.46 mol N_2 | 2 / 3 | 65 = 150 g NaN_3

b. $d = \frac{MP}{RT} = \frac{(28.02)(733/760)}{(.08206)(308)}$ = 1.07 g/L

238 → 1.38 g/L

c. $2.67 \times 6.022 \times 10^{23}$ = 1.61×10^{24}

$3.46 \times 6.022 \times 10^{23}$ = 2.08×10^{24}

d. 2.67 × 28.02 = 74.8 g

3.46 × 28.02 = 96.9 g

3. A mixture of oxygen, O_2, and nitrogen, N_2 has a total pressure of 745 mm Hg at 15°C and contains 8.20 grams of each substance.

a. Calculate the partial pressure of each gas in the mixture. (2 pts)
b. Calculate the root mean square velocity of each gas at 15°C. (2 pts)
c. Determine the density of each gas at the above conditions. (2 pts)
d. Determine the volume of each gas at the above conditions. (2 pts)
e. If it is determined that it takes oxygen,(O_2) 41 seconds to completely effuse. How long does it take nitrogen, (N_2) at the above conditions? (1 pt)

a. 8.20 ÷ 32.0 = 0.256 mol O_2

8.20 ÷ 28.02 = 0.293 mol N_2

a. $N_2 = \frac{0.293}{0.549} \times 745 = $ 398 mmHg

$O_2 = \frac{0.256}{0.549} \times 745 = $ 347 mmHg

b. $\sqrt{\frac{(3)(8.3145)(288)}{0.02802}} = $ 506 m/s

$\sqrt{\frac{(3)(8.3145)(288)}{0.032}} = $ 473 m/s

e. $\frac{\sqrt{32}}{\sqrt{28}} = 1.07\times$

41 ÷ 1.07 = 38 sec

c. $d = \frac{(28.02)(398/760)}{(.08206)(288)} = $ 0.620 g/L

$d = \frac{(32.0)(347/760)}{(.082016)(288)} = $ 0.618 g/L

d. $V = \frac{(0.256)(0.08206)(288)}{0.457} = $ 13.2 L

$V = \frac{(0.293)(0.08206)(288)}{0.523} = $ 13.2 L

4. One of the chemical controversies of the 19th century concerned the element beryllium (Be). Berzelius originally claimed that beryllium was a trivalent element (Be^{3+}) and it gave an oxide with the formula Be_2O_3. This resulted in a calculated atomic mass of 13.5 for beryllium. In formulating his periodic table, Mendeleev proposed that beryllium was divalent (Be^{2+}) and it gave an oxide with the formula BeO. This assumption gives an atomic mass of 9.0. In 1894 A. Combes (*Comptes Rendus* 1894, p. 1221) reacted beryllium with the anion $C_5H_7O_2^-$ and measured the density of the gaseous product. Combes's data for two different experiments are as follows:

	Test 1	Test 2
Mass	0.2022 g	0.2224 g
Volume	22.6 cm^3	26.0 cm^3
Temperature	13°C	17°C
Pressure	765.2 mm Hg	764.6 mm Hg

If beryllium is a divalent metal, the molecular formula of the product will be $Be(C_5H_7O_2)_2$; if it is trivalent, the formula will be $Be(C_5H_7O_2)_3$. Show how Combes's data help to confirm that beryllium is a divalent metal. You must show calculations and give a brief statement explaining your answer. (2 pts)

$M = \frac{\left(\frac{0.2022}{0.0226}\right)(0.08206)(286)}{\frac{765.2}{760}} = 208.5$ g/mol

$Be(C_5H_7O_2)_2 = 207.2$ g/mol

divalent