

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 $-85^\circ C$.
- Using the ideal gas law. (1 pt)
 - Using the van der Waals equation ($a = 1.39$; $b = 0.0391$) (1 pts)
 - 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 $-5.0^\circ C$, what would be the pressure exerted by the nitrogen gas? (1 pt)

$$a. \quad 56.0 \div 28.0 = 2.00 \text{ moles}$$

$$P = \frac{(2.00)(0.08206)(188)}{20.00}$$

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

$$P = 1.54 \text{ atm}$$

$$x = 2.20 \text{ atm}$$

$$b. \quad \left[\frac{P}{P + a(n/V)^2} \right] \times [V - nb] = nRT$$

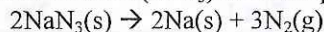
$$\left[\frac{P}{P + 1.39 \left(\frac{2}{20.0} \right)^2} \right] \times [20 - 2(0.0391)] = (2.0)(0.08206)(188)$$

$$P + 0.0139 \times [19.9] = 30.85$$

$$P + 0.0139 = 1.55$$

$$P = 1.54$$

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:



- 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 $-35.00^\circ C$? (1 pt)
- What is the density of nitrogen gas at this temperature? (1 pt)
- How many molecules of nitrogen are present in the volume of gases calculated in part A? (1 pt)
- What is the mass of nitrogen actually produced at the above conditions? (1 pt)

$$a. \quad \frac{PV}{RT} = n = \frac{(733/760)(70)}{(0.08206)(308)} = 2.67 \text{ mol } N_2 \quad \frac{2 \text{ mol } NaN_3}{3 \text{ mol } N_2} \times 65.0 \text{ g} = 11.6 \text{ g } NaN_3$$

$$\text{If } -35 \quad \frac{3.46 \text{ mol } N_2}{(238)} \times \frac{2}{3} \times 65 = 150 \text{ g } NaN_3$$

$$b. \quad \frac{MP}{RT} = \frac{(28.02)(733/760)}{(0.08206)(308)} = 1.07 \text{ g/L}$$

$$\downarrow 238 \quad 1.38 \text{ g/L}$$

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

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

$$d. \quad 2.67 \times 28.02 = 74.8 \text{ g}$$

$$3.46 \times 28.02 = 96.9 \text{ g}$$

3. A mixture of oxygen, O_2 , and nitrogen, N_2 has a total pressure of 745 mm Hg at $15^\circ C$ and contains 8.20 grams of each substance.
- Calculate the partial pressure of each gas in the mixture. (2 pts)
 - Calculate the root mean square velocity of each gas at $15^\circ C$. (2 pts)
 - Determine the density of each gas at the above conditions. (2 pts)
 - Determine the volume of each gas at the above conditions. (2 pts)
 - 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. $8.20 \div 32.0 = 0.256 \text{ mol } O_2$
 $8.20 \div 28.02 = 0.293 \text{ mol } N_2$

b. $\sqrt{\frac{3 \times 8.3145 \times 288}{0.02862}} = 506 \text{ m/s}$
 $\sqrt{\frac{3 \times 8.3145 \times 288}{0.032}} = 473 \text{ m/s}$

c. $d = \frac{(8.20 \times 398/760)}{(0.08206 \times 288)} = 0.620 \text{ g/L}$
 $d = \frac{(8.20 \times 347/760)}{(0.08206 \times 288)} = 0.618 \text{ g/L}$

d. $V = \frac{(0.256 \times 0.08206 \times 288)}{0.457} = 13.2 \text{ L}$
 $V = \frac{(0.293 \times 0.08206 \times 288)}{0.523} = 13.2 \text{ L}$

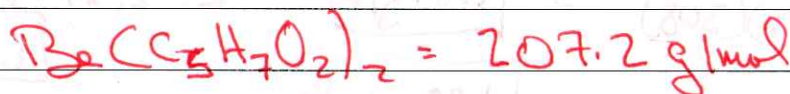
e. $\frac{\sqrt{32}}{\sqrt{28}} = 1.07 \times$
 $41 \div 1.07 = 38 \text{ sec}$

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)

$$M = \frac{(0.2022 \times 0.08206 \times 286)}{\frac{765.2}{760}} = 208.5 \text{ g/mol}$$



Divalent