CHEM 1364 (Day)
Test #4
Spring 2010 (Buckley)

1. (4 points) State the number of $\sigma$ and $\pi$ bonds in each of the following structures.
   
   a. Number of $\sigma$ bonds = 6  Number of $\pi$ bonds = 2

   ![Structure a]

   b. Number of $\sigma$ bonds = 8  Number of $\pi$ bonds = 4

   ![Structure b]

2. (10 points) Draw Lewis structures for the following species and indicate the formal charge on each atom.

   a. $\text{NO}_3^-$

   ![Lewis Structure a]

   b. $\text{IF}_5$

   ![Lewis Structure b]
3. (25 points) State the number of electron domains, the electron-domain geometry, the molecular geometry, the polarity (polar or nonpolar), and the hybridization about the central atom for each of the following species.

<table>
<thead>
<tr>
<th>Species</th>
<th># electron-domains</th>
<th>Electron-domain geometry</th>
<th>Molecular geometry</th>
<th>Polar or Nonpolar? (P/NP)</th>
<th>Hybridization</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{F} - \text{N} - \text{H}$</td>
<td>4</td>
<td>Tetrahedral</td>
<td>$\text{P}$</td>
<td>$\text{P}$</td>
<td>$\text{sp}^3$</td>
</tr>
<tr>
<td>$\text{N} = \text{N} - \text{O}$</td>
<td>2</td>
<td>Linear</td>
<td>$\text{P}$</td>
<td>$\text{P}$</td>
<td>$\text{sp}$</td>
</tr>
<tr>
<td>$\left[ \text{O} - \text{B} - \text{O} \right]$</td>
<td>4</td>
<td>Tetrahedral</td>
<td>Tetrahedral</td>
<td>$\text{NP}$</td>
<td>$\text{sp}^3$</td>
</tr>
<tr>
<td>$\text{O} = \text{O} - \text{O}$</td>
<td>3</td>
<td>Trigonal Planar</td>
<td>Bent</td>
<td>$\text{P}$</td>
<td>$\text{sp}^2$</td>
</tr>
<tr>
<td>$\text{F} = \text{S} - \text{F}$</td>
<td>4</td>
<td>Tetrahedral</td>
<td>Bent</td>
<td>$\text{P}$</td>
<td>$\text{sp}^3$</td>
</tr>
</tbody>
</table>
4. (5 points) 75.0-g of Ne gas is confined to a container of volume 45.5-L at a temperature of 100 °C. What is the pressure of the Ne? **SHOW YOUR WORK.**

\[ P = \frac{nRT}{V} = \frac{(3.75 \text{ mol})(0.08206 \text{ L atm/mol K})(373 \text{ K})}{45.5 \text{ L}} \]

\[ P = 2.55 \text{ atm} \]

5. (5 points) The temperature of the container in Problem 4 is changed to 275 °C. What is the new pressure of the Ne? **SHOW YOUR WORK.**

\[ P_1 = 2.55 \text{ atm} \]
\[ T_1 = 100 °C = 373 \text{ K} \]
\[ T_2 = 275 °C = 548 \text{ K} \]

Here \( V_1 = V_2 \) so

\[ \frac{P_1}{T_1} = \frac{P_2}{T_2} \]

\[ \frac{2.55 \text{ atm}}{373 \text{ K}} = \frac{P_2}{548 \text{ K}} \]

\[ P_2 = \frac{2.55 \text{ atm} \times 548 \text{ K}}{373 \text{ K}} = 3.75 \text{ atm} \]

6. (5 points) A 55.0-L vessel contains 4.52 mol of CO₂, 2.35 mol of O₂, and 5.12 mol of N₂ at a temperature of 45.0 °C. Find the total gas pressure in the vessel and the partial pressures of each of the components in the vessel.

\[ \text{Total mol} = N_{\text{CO}_2} + N_{\text{O}_2} + N_{\text{N}_2} = 4.52 \text{ mol} + 2.35 \text{ mol} + 5.12 \text{ mol} = 11.99 \text{ mol} \]

\[ T = 45.0 °C = 318 \text{ K} \]
\[ V = 55.0 \text{ L} \]
\[ n = 11.99 \text{ mol} \]

**PARTIAL PRESSURES**

\[ \text{Mole fractions: } \]
\[ X_{\text{CO}_2} = \frac{4.52 \text{ mol}}{11.99 \text{ mol}} = 0.377 \]
\[ X_{\text{O}_2} = \frac{2.35 \text{ mol}}{11.99 \text{ mol}} = 0.196 \]
\[ X_{\text{N}_2} = \frac{5.12 \text{ mol}}{11.99 \text{ mol}} = 0.427 \]

\[ P_{\text{CO}_2} = 0.377 \times (5.69 \text{ atm}) = 2.14 \text{ atm} \]
\[ P_{\text{O}_2} = 0.196 \times (5.69 \text{ atm}) = 1.12 \text{ atm} \]
\[ P_{\text{N}_2} = 0.427 \times (5.69 \text{ atm}) = 2.43 \text{ atm} \]
7. (9 points) Air bags in cars generate N\textsubscript{2} quickly to inflate using the chemical reaction:

\[ 2 \text{NaN}_3 (s) \rightarrow 2 \text{Na} (s) + 3 \text{N}_2 (g) \]

Let's work a problem step-by-step to see how many grams of NaN\textsubscript{3} would be required to generate 40.0-L of N\textsubscript{2} at a pressure of 1.25-atm and a temperature of 28.0 °C. **SHOW YOUR WORK**

a. How many mol of N\textsubscript{2} are to be generated in this problem?

\[ \theta V = nRT \]
\[ n = \frac{\theta V}{RT} = \frac{(1.25 \text{ atm})(40.0 \text{ L})}{0.08206 \text{ atm} \cdot \text{mol} \cdot \text{K}} = 2.02 \text{ mol N}_2 \]

b. For the number of mol of N\textsubscript{2} you found in part a, how many mol of NaN\textsubscript{3} would be required to form that much N\textsubscript{2}?

\[ 2 \text{ mol NaN}_3 \times \frac{2 \text{ mol NaN}_3}{3 \text{ mol N}_2} = 1.35 \text{ mol NaN}_3 \]

c. Based on your answer to part b, how many grams of NaN\textsubscript{3} are required to generate the number of mol of N\textsubscript{2} indicated in part a?

\[ ? \text{ g NaN}_3 = \frac{1.35 \text{ mol NaN}_3}{65 \text{ g NaN}_3} \times 1 \text{ mol NaN}_3 = 87.5 \text{ g NaN}_3 \]

Potentially Useful Information for this test:

PV = nRT

\[ \frac{PV_1}{T_1} = \frac{PV_2}{T_2} \]

\[ R = 0.08206 \text{ L} \cdot \text{atm/mol} \cdot \text{K} \]

0.08206