CHEM 1364
Test #3
Summer 2014 (Buckley)

Circle the letter corresponding to the best answer for each of the following multiple choice questions. Each question is worth 2 points.

1. Which one of the following is the sulfate ion?
   a. $\text{SO}_3^{2-}$  
   b. $\text{SO}_4^{2-}$  
   c. $\text{S}^2-$  
   d. $\text{SO}_3^{3-}$  
   e. $\text{SO}_4^{2-}$  

2. Which one of the following is the ammonium ion?
   a) $\text{NH}_4^+$  
   b. $\text{NH}_3$  
   c. $\text{NO}_3^-$  
   d. $\text{NH}_4^-$  
   e. $\text{NO}_2^-$  

3. Which one of the following is the nitrate ion?
   a. $\text{NH}_4^+$  
   b. $\text{NH}_3$  
   c. $\text{NO}_3^-$  
   d. $\text{NH}_4^-$  
   e. $\text{NO}_2^-$  

4. Which one of the following is the phosphate ion?
   a. $\text{PO}_3^{3-}$  
   b. $\text{PO}_4^{3-}$  
   c. $\text{FO}_4^{3-}$  
   d. $\text{PO}_3^{2-}$  
   e. $\text{PO}_4^-$  

5. Which one of the following is the phosphite ion?
   a) $\text{PO}_3^{3-}$  
   b. $\text{PO}_4^{3-}$  
   c. $\text{FO}_4^{3-}$  
   d. $\text{PO}_3^{2-}$  
   e. $\text{PO}_4^-$  

6. The correct name for $\text{PCl}_5$ is:
   a. phosphorous chloride  
   b. phosphorous (V) chloride  
   c. phosphorous pentachloride  
   d. phosphorous chlorine  
   e. phosphorous tetrachloride  

7. The correct name for $\text{CoCl}_3$ is:
   a. cobalt chloride  
   b. cobalt (II) chloride  
   c. cobalt trichloride  
   d. chromium trichloride  
   e. chromium (III) chloride
8. An atom with four electron domains will have _____ hybridization.
   a. sp  b. sp\(^2\)  c. sp\(^3\)  d. sp\(^3\)d  e. sp\(^2\)d\(^2\)

9. An atom with five electron domains around it will have a ___________ electron-domain geometry.
   a. linear  b. trigonal planar  c. tetrahedral  d. trigonal bipyramid  e. octahedral

10. The central atom in a molecule is surrounded by four electron domains. Two of the domains are lone pair electrons and two of the domains are bonded atoms. The molecular geometry around this central atom is:
    a. linear  b. square planar  c. trigonal pyramid  d. trigonal planar  e. bent

11. The molecule referred to in Question 10 will be:
    a. polar  b. nonpolar  c. not enough information given to decide

12. Consider the following reaction:

   \[ 2 \text{HCl (aq)} + \text{CaCO}_3 (s) \rightarrow \text{CaCl}_2 (aq) + \text{H}_2\text{O (l)} + \text{CO}_2 (g) \]

   In an experiment, 4.0-mol of HCl are reacted with 3.0-mol of CaCO\(_3\). Which is the limiting reactant?
    a. HCl  b. CaCO\(_3\)  c. not enough information given to decide

13. How many \(\sigma\) and \(\pi\) orbitals are in the structure below?
    a. 10 \(\sigma\), 3 \(\pi\)  b. 8 \(\sigma\), 5 \(\pi\)  c. 3 \(\sigma\), 10 \(\pi\)  d. 5 \(\sigma\), 8 \(\pi\)  e. 6 \(\sigma\), 7 \(\pi\)

14. Which of the following elements routinely has less than octet around it in Lewis structures?
17. (5 points) Balance the following equations.

\[
P_4O_{10}(l) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)
\]

\[
CO_2(g) + 2KOH(aq) \rightarrow K_2CO_3(aq) + H_2O(l)
\]

\[
2Rb(s) + 2H_2O(l) \rightarrow 2RbOH(aq) + H_2(g)
\]

\[
2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)
\]

\[
C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)
\]

18. (5 points) Name each of the following compounds.

<table>
<thead>
<tr>
<th>Name</th>
<th>Chemical Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaBr₂</td>
<td><strong>Calcium Bromide</strong></td>
</tr>
<tr>
<td>PbBr₃</td>
<td><strong>Thallium Bromide</strong></td>
</tr>
<tr>
<td>PbSO₄</td>
<td><strong>Lead(S) Sulfate</strong></td>
</tr>
<tr>
<td>Cu(NO₃)₂</td>
<td><strong>Copper(II) Nitrate</strong></td>
</tr>
<tr>
<td>N₂O₄</td>
<td><strong>Nitrogen Tetroxide</strong></td>
</tr>
</tbody>
</table>

**Be sure to do the next page**
Problems. Point totals are indicated to the right of each problem number in parentheses.

15. (8 points) Answer each of the following. SHOW YOUR WORK.

a. How many moles are in 175.0-g of Ba(NO₃)₂?

\[ \text{mol} = \frac{175.0 \text{ g}}{261 \text{ g/mol}} = 0.6705 \text{ mol} \]

b. How many grams are in 0.0675-mol of CaCl₂·2H₂O?

\[ \text{g} = \frac{0.0675 \text{ mol CaCl₂·2H₂O}}{1} \times \frac{147 \text{ g CaCl₂·2H₂O}}{1 \text{ mol CaCl₂·2H₂O}} = 9.92 \text{ g CaCl₂·2H₂O} \]

16. (12 points) Consider the following reaction.

\[ \text{MnO}_2 + \text{4HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O} \]

15.0-g of MnO₂ are reacted with 20.0-g of HCl. Answer the following questions related to this reaction.

a. Balance the equation. You can just insert the coefficients in the equation above if you would like.

b. How many grams of MnCl₂ could be formed from the quantities indicated above? Show your work.

Assume MnCl₂ limit: \[ \text{g MnCl}_2 = \frac{15.0 \text{ g MnO}_2}{1} \times \frac{126 \text{ g MnCl}_2}{87 \text{ g MnO}_2} = 21.7 \text{ g MnCl}_2 \]

Assume HCl limit: \[ \text{g MnCl}_2 = \frac{20.0 \text{ g HCl}}{1} \times \frac{126 \text{ g MnCl}_2}{146 \text{ g HCl}} = 17.3 \text{ g MnCl}_2 \]

(c. Which is the limiting reactant. Explain your reasoning.

**HCl IS THE LIMITING REACTANT.** It forms the least amount of MnCl₂ so the reaction is done when the HCl runs out.
<table>
<thead>
<tr>
<th>Atom (N or N)</th>
<th>Resonance</th>
<th>Hybridization</th>
<th>Molecular Geometry</th>
<th>Geometry</th>
<th>Domains</th>
<th>Domains</th>
<th>Bonds</th>
<th>Lone Pair</th>
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**Lewis Structure:** Fill in each of the columns as indicated.

19. (20 points) Draw the Lewis structure for each of the following in the left-hand column. Also, place the nonzero formal charges on the atoms of your structure.