Chemistry 171  
Exam 1  
January 13, 2011  

Name ________________________________  

\[ N_A = 6.022 \times 10^{23} \quad \text{1 kg = 2.2046 lb} \quad \text{1 in = 2.54 cm} \]  
\[ 1 \text{ L} = 1.057 \text{ qt} \quad \text{1 gal = 4 qt} \]  
\[ (^\circ \text{F} - 32^\circ \text{F}) \times (\frac{5^\circ \text{C}}{9^\circ \text{F}}) = ^\circ \text{C} \]  

**Periodic Table of the Elements**

<table>
<thead>
<tr>
<th>I A</th>
<th>II A</th>
<th>III B</th>
<th>IV B</th>
<th>V B</th>
<th>VI B</th>
<th>VII B</th>
<th>VIII</th>
<th>I B</th>
<th>II B</th>
<th>III A</th>
<th>IV A</th>
<th>V A</th>
<th>VI A</th>
<th>VII A</th>
<th>inert</th>
<th>gases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>1.008</td>
<td>2</td>
<td>He</td>
<td>4.003</td>
<td>5</td>
<td>B</td>
<td>10.81</td>
<td>6</td>
<td>C</td>
<td>12.01</td>
<td>7</td>
<td>N</td>
<td>14.01</td>
<td>8</td>
<td>O</td>
</tr>
<tr>
<td>2</td>
<td>He</td>
<td></td>
<td>3</td>
<td>Li</td>
<td>6.941</td>
<td>4</td>
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<td>5</td>
<td>B</td>
<td>10.08</td>
<td>6</td>
<td>C</td>
<td>12.01</td>
<td>7</td>
<td>N</td>
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<tr>
<td>11</td>
<td>Na</td>
<td>22.98</td>
<td>20</td>
<td>Ca</td>
<td>40.08</td>
<td>21</td>
<td>Sc</td>
<td>44.96</td>
<td>22</td>
<td>Ti</td>
<td>47.90</td>
<td>23</td>
<td>V</td>
<td>50.94</td>
<td>24</td>
<td>Cr</td>
</tr>
</tbody>
</table>
Name ________________________________

Part 1: Short answer (43 points)

1) Give the missing IUPAC name, chemical formula, or element name, for each of the following:
   - NiSO₃  nickel (II) sulfite
   - Al(PO₄)  aluminum phosphate
   - CoP  cobalt (III) phosphide
   - (NH₄)(CH₃COO)  ammonium acetate
   - K₂(C₂O₄)  potassium oxalate
   - NiSO₃  potassium sulfite
   - Al(PO₄)  xenon tetrafluoride
   - CoP  hydrobromic acid
   - (NH₄)(CH₃COO)  ruthenium (III) carbonate

2) Balance the following chemical equation that describes the formation of nitrogen from ammonia.
   \[ 4 \text{NH}_3 + 3 \text{O}_2 \rightarrow 2 \text{N}_2 + 6 \text{H}_2\text{O} \]

3) Write the corresponding value (to 3 sig figs) for each of the following unit conversions.
   a) \( 1.20 \text{mmol} = 1.20 \times 10^9 \text{pmol} \)
   b) \( 14.5 \text{m/s}^2 = 52.2 \text{km/min}^2 \)

4) Perform the following calculations and report the answer with the correct number of significant figures.
   a) \( (3.141 - 1.941)/0.4313 = 2.782 \)
   b) \( (12.3 \times 4.31) - 1.1 = 51.9 \)

5) Provide the symbol of an element for each category below.
   a) transition metal  many choices, non, main group metals.
   b) alkaline earth metal  Be, Mg, Ca, Sr, Ba, Ra
   c) forms an anion with -2 charge  O, S, Se
   d) exists as a diatomic molecule in elemental state  N, O, F, Cl, Br, I, H
   e) 5th period element  Rb, Sr through I, Xe
   f) forms an ionic compound with formula XCl₂ (where X is the element)  Mg, Ca, Sr, Ba

6) a) An ion of \( ^{55}\text{Mn}^{4+} \) is composed of 25 protons, 30 neutrons, and 21 electrons.
   b) The mass of one atom of manganese is 54.94 amu
   c) The mass of one mole of manganese atoms is 54.94 g

7) Give, as appropriate, the base SI unit name and symbol associated with each quantity below.
   a) Temperature  Kelvin
   b) amount of substance  mole
   c) Energy  Joule
8) Thyroxine, a thyroid hormone, has the chemical formula, I\textsubscript{4}C\textsubscript{15}H\textsubscript{10}O\textsubscript{4}N. What is the molar mass of this hormone? Let T be the abbreviation for thyroxine.

\[
\begin{align*}
1 \text{ mol } T &\times 4 \text{ mol I/1 mol T } \times 126.9 \text{ g/mol } = 507.6 \text{ g} \\
1 \text{ mol } T &\times 15 \text{ mol C/1 mol T } \times 12.00 \text{ g/mol } = 180.0 \text{ g} \\
1 \text{ mol } T &\times 10 \text{ mol H/1 mol T } \times 1.008 \text{ g/mol } = 10.08 \text{ g} \\
1 \text{ mol } T &\times 4 \text{ mol O/1 mol T } \times 16.00 \text{ g/mol } = 64.00 \text{ g} \\
1 \text{ mol } T &\times 1 \text{ mol N/1 mol T } \times 14.00 \text{ g/mol } = 14.00 \text{ g}
\end{align*}
\]
\[775.68 \text{ g/mol T}\]

9) For each of the following, circle the best answer.

Rubidium is a(n) ___ (element compound homogenous mixture)

Glyceraldehyde (C\textsubscript{3}H\textsubscript{6}O\textsubscript{3}) is a(n) ___ (element compound homogenous mixture)

Tap water is a ___ (substance homogenous mixture heterogenous mixture)

10) Consider the following equation showing the formation of a precipitate from combining solutions of potassium chromate and barium nitrate. In the space below, provide the ionic equation and the net ionic equation.

\[
\text{K}_2\text{CrO}_4 (aq) + \text{Ba(NO}_3)_2 (aq) \rightarrow 2 \text{KNO}_3 (aq) + \text{BaCrO}_4 (s)
\]

ionic equation:

\[
2 \text{K}^+ (aq) + \text{CrO}_4^{2-} (aq) + \text{Ba}^{2+} (aq) + 2 \text{NO}_3^- (aq) \rightarrow 2 \text{K}^+ (aq) + 2 \text{NO}_3^- (aq) + \text{BaCrO}_4 (s)
\]

net ionic equation:

\[
\text{CrO}_4^{2-} (aq) + \text{Ba}^{2+} (aq) \rightarrow \text{BaCrO}_4 (s)
\]

11) In the space following each compound, indicate if it would be soluble (S) or insoluble (I) in water.

a) K\textsubscript{2}S ___ S__________ b) MgS ___ S__________ c) CuSO\textsubscript{4} ___ S__________

d) Fe(OH)\textsubscript{3} ___ I__________ e) Co(ClO\textsubscript{3})\textsubscript{2} ___ S__________ f) AgCH\textsubscript{3}COO ___ S__________

Part 2: Multiple Choice (18 points)

1) Which one of the following represents the compounds which are ionic?

\[
i. \text{Cl}_2\text{S}_3 \quad ii. \text{NaCl} \quad iii. \text{PCl}_3 \quad iv. \text{Ba(BrO}_3)_2 \quad v. \text{TiO}_4 \quad vi. \text{XeO}_2 \quad vii. \text{NH}_4\text{NO}_3
\]

a. iv, vii, c. i, iii, v, vi e. i, ii, iii, iv, vii

b. ii, iv, vii d. ii, iv, vii f. all are ionic

2) Which of the elements, Na, Al, In, Fe, Pb, Ag, form more than one type of cation?

a) Fe, Ag b) Fe, Pb c) Al, In, Pb d) Fe, In, Pb e) Fe, Pb, In, Ag f) Na, Fe, Pb

3) Which element would have chemical properties most similar to Ca?

a) Na b) Ba c) Mn d) Al e) Mo f) H
4) The formula of the compound formed between Mg\(^{2+}\) and N\(^{3-}\) is
   a) Mg\(_2\)N\(_3\)    b) Mg\(_{3}\)N\(_{1.5}\)    c) Mg(N\(_2\))\(_3\)    d) Mg\(_3\)N\(_2\)    e) Mg\(_{1.5}\)N

5) The mass of 1.5 mole Ca is
   a) 60.1 g    b) 26.7 g    c) 30.0 g    d) 13.3 g    e) 40.1 g

6) Which of the following, in water, would be strong electrolytes?
   i) HNO\(_3\)    ii) NaOH    iii) HCH\(_3\)COO    iv) H\(_2\)SO\(_4\)    v) H\(_3\)PO\(_4\)    vi) NH\(_3\)
   a. i, iv    c. ii, vi    e. vi
   b. i, iii, iv, v    d. i, ii, iv    f. ii, iv

Part 3: Problems (39 points)

1) Consider the following compounds. The molar mass of each compound is parenthesis following the formula. 6 pts
   1) NH\(_3\) (17.03 g/mol)  2) N\(_2\)O (44.02 g/mol)  3) CH(NH\(_2\))\(_3\) (61.1 g/mol)
   a) Consider 1.0 mole of each compound, which would have the largest mass of N? CH(NH\(_2\))\(_3\)
      1 mol NH\(_3\) x 1 mol N/1 mol NH\(_3\) x 14.00 g/mol N = 14.00g
      1 mol N\(_2\)O x 2 mol N/1 mol N\(_2\)O x 14.00 g/mol N = 28.00g
      1 mol CH(NH\(_2\))\(_3\) x 3 mol N/1 mol CH(NH\(_2\))\(_3\) x 14.00 g/mol N = 42.00 g

   b) Consider 1.0 mole of each compound, which would have the largest number of moles of N? CH(NH\(_2\))\(_3\)
      See above, CH(NH\(_2\))\(_3\) has 3 mol N/mol compound.

   c) Which compound has the largest mass percent N? NH\(_3\)
      Using mass values of N in one mole from a and the given molar masses.
      % in NH\(_3\) = (14 g N/17.03 g) x 100 = 82.2 %
      % in N\(_2\)O = (28 g N/44.02 g) x 100 = 63.6 %
      % in CH(NH\(_2\))\(_3\) = (42 g N/61.1 g) x 100 = 68.7 %

2) a) What is the mass, in grams, of 1.00 gallon of pentane (C\(_5\)H\(_{12}\))? The density of pentane is 0.626 g/mL 6 pts
   Convert volume units to mL and use density to obtain mass
   1.00 gal x 4 qt/gal x 1 L/1.057 qt x ml/10\(^{-3}\)L x 0.626 g/ml = 2,370 g

   b) The reaction of pentane with O\(_2\) produces CO\(_2\) and H\(_2\)O. How many moles of O\(_2\) are required to react stoichiometrically with 50.0 g pentane? (pentane molar mass = 72.15 g/mol)
      2C\(_5\)H\(_{12}\) + 16O\(_2\) → 10 CO\(_2\) + 12 H\(_2\)O
      path is mass pentane to moles pentane to moles O\(_2\)
      50.0 g pentane x mol pentane/72.15 mol x 16 mol O\(_2\)/2 mol pentane = 5.54 mol O\(_2\)

   c) If 50.0 g pentane reacts in the presence of excess O\(_2\), how many molecules of CO\(_2\) will be formed.
      path is mass pentane to moles pentane to moles CO\(_2\) to molecules CO\(_2\)
      50.0 g pentane x mol pentane/72.15 mol x 10 mol CO\(_2\)/2 mol pentane x 6.022 x 10\(^{23}\) molecules/mol CO\(_2\) = 2.086 x 10\(^{24}\) molecules CO\(_2\)
3) Consider strontium phosphate (Sr$_3$(PO$_4$)$_2$), molar mass = 452.8 g/mol.

a) How many moles of O are there in 3 moles of strontium phosphate?

$$3 \text{ mol strontium phosphate} \times 8 \text{ mol O/mol strontium phosphate} = 24 \text{ mol O}$$

b) What is the mass percent O in strontium phosphate?

$$1 \text{ mol strontium phosphate} \times 8 \text{ mol O/mol strontium phosphate} \times 16.00 \text{ g/mol O} = 126 \text{ g O/mol Sr$_3$(PO$_4$)$_2$}$$

Mass of O in 15.0 g strontium phosphate:

$$15.0 \text{ g} \times \frac{1 \text{ mol Sr$_3$(PO$_4$)$_2$}}{452.8 \text{ g}} \times 2 \text{ mol P/1 mol Sr$_3$(PO$_4$)$_2$} \times 30.97 \text{ g/mol P} = 2.05 \text{ g}$$

4) Magnesium has three isotopes with 12, 13, and 14 neutrons respectively.

a) Which of the following best describes the number of protons in magnesium?
   i) all isotopes have the same number, 12, of protons
   ii) the number of protons in each isotope equals the number of neutrons
   iii) the number of protons cannot be determined from the information given.

b) Complete the columns for mass number and atomic number in the table below.

c) Using the information in the 4th and 5th columns below and the fact that the average atomic mass of magnesium is 24.31 amu, calculate the mass of the magnesium atom that has 14 neutrons.

<table>
<thead>
<tr>
<th>Magnesium Isotope (neutrons)</th>
<th>Mass number</th>
<th>Atomic number</th>
<th>Isotopic abundance (%)</th>
<th>Atomic mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>24</td>
<td>12</td>
<td>78.99</td>
<td>24.05</td>
</tr>
<tr>
<td>13</td>
<td>25</td>
<td>12</td>
<td>10.00</td>
<td>24.91</td>
</tr>
<tr>
<td>14</td>
<td>26</td>
<td>12</td>
<td>11.01</td>
<td>25.60</td>
</tr>
</tbody>
</table>

$$0.7899(24.05) + (0.1000)(24.91) + (0.1101)(x) = 24.31$$

$$18.99 + 2.491 + (0.1101)(x) = 24.31$$

$$x = 25.60$$

5) Sodium chloride is a very soluble salt.

a) What volume of a 0.575 M solution would contain 0.045 moles?

$$0.045 \text{ mol} \times 0.575 \text{ mol/L} = 0.0782 \text{ L} = 78.2 \text{ mL}$$

b) What mass of NaCl is required to prepare 150 mL of a 0.575 M solution?

Convert mL to L

$$0.150 \text{ L} \times 0.575 \text{ mo/L} \times 58.44 \text{ g/mol} = 5.04 \text{ g}$$

c) What would be the final concentration if 50 mL of a 0.575 M solution of NaCl was added to 250 mL H$_2$O?

This is a dilution problem and $C_1V_1 = C_2V_2$. Convert volumes to L or note that units will cancel.

$$(0.575 \text{ M})(0.050 \text{ L}) = (0.300 \text{ L})(x \text{ M})$$

$$x = 0.0938 \text{ M}$$
Hopamoxin is a naturally occurring compound containing C, H, and S. A sample weighing 0.35 g was burned in oxygen giving 0.0502 mol $\text{CO}_2$. A second sample also weighing 0.35 g was subjected to a series of reactions that transformed all of the sulfur in the compound to sulfate and was found as $\text{BaSO}_4$. The amount of $\text{BaSO}_4$ formed from 0.35 g hopamoxin was 1.332 g. The molecular mass of hopamoxin is 122.6 g/mol.

6 pts

a) What is the empirical formula of hopamoxin $\text{C}_2\text{H}_5\text{S}$ with a mass of 61.1 g

Determine C from $\text{CO}_2$; Determine S from $\text{BaSO}_4$; Determine H from mass sum

b) What is the molecular formula of hopamoxin? Determine n and multiply subscripts

Nylon ($\text{H}_2\text{C}_6\text{H}_8\text{O}_4$, molar mass 146.14 g/mol) is produced by a controlled reaction (see below) between cyclohexane ($\text{C}_6\text{H}_{12}$, molar mass 84.16 g/mol) and oxygen.

$$2 \text{C}_6\text{H}_{12} (l) + 5 \text{O}_2 (g) \rightarrow 2 \text{H}_2\text{C}_6\text{H}_8\text{O}_4 (l) + 2 \text{H}_2\text{O} (l)$$

a) If 25.0 g of cyclohexane and 35.0 g of oxygen are reacted, what mass (in g) of nylon can be formed? Determine how much product can be formed from each reagent if the other is present in excess.

25.0 g $\text{C}_6\text{H}_{12}$ x mol $\text{C}_6\text{H}_{12}$/84.12 g x 2 mol nylon/2 mol $\text{C}_6\text{H}_{12}$ = 0.29 mol nylon

35.0 g $\text{O}_2$ x mol $\text{O}_2$/32.00 g x 2 mol nylon/5 mol $\text{O}_2$ = 0.437 mol nylon

0.29 mol nylon is lesser and $\text{C}_6\text{H}_{12}$ is the limiting reagent.

0.29 mol x 146.14 g/mol nylon = 43.4 g nylon can form

b) What mass of the excess reagent is left after the reaction is complete? Prepare a reaction table

The table must be in moles. Convert 25.0 g $\text{C}_6\text{H}_{12}$ to moles and 35.0 g $\text{O}_2$ to moles, using 84.12 g and 32.00 g as molar masses respectively.

<table>
<thead>
<tr>
<th></th>
<th>$\text{C}<em>6\text{H}</em>{12}$</th>
<th>$\text{O}_2$</th>
<th>$\rightarrow$ nylon</th>
<th>$\text{H}_2\text{O}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial</td>
<td>0.29</td>
<td>1.09</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>change</td>
<td>- 0.29</td>
<td>- 0.725</td>
<td>+ 0.29</td>
<td></td>
</tr>
<tr>
<td>final</td>
<td>0</td>
<td>0.365</td>
<td>0.29</td>
<td></td>
</tr>
</tbody>
</table>

Information above indicates $\text{C}_6\text{H}_{12}$ is the limiting reagent and will be used up. Use reaction stoichiometry to complete table.

0.29 mol $\text{C}_6\text{H}_{12}$ x 5 mol $\text{O}_2$/2 mol $\text{C}_6\text{H}_{12}$ = 0.725 mol $\text{O}_2$ used

0.29 mol $\text{C}_6\text{H}_{12}$ x 2 mol nylon/2 mol $\text{C}_6\text{H}_{12}$ = 0.29 mol nylon made

c) What is the percent yield if 31.7 g nylon are formed? (actual yield/theoretical yield) x 100

$$\left(\frac{31.7 \text{ g}}{43.4 \text{ g}}\right) \times 100 = 73.0 \%$$