1. (24) a. Circle the formula that contains the atom with the highest oxidation number out of all atoms in these four compounds.

\[ \text{KMnO}_4 \quad \text{Fe}_2\text{O}_3 \quad \text{Na}_2\text{Cr}_2\text{O}_7 \quad \text{CO}_2 \]

b. Put a check beside any polar molecule.

- \[ \text{SCl}_2 \]
- \[ \text{HCF}_3 \]
- \[ \text{CCl}_4 \]
- \[ \text{PH}_3 \]

c. Which of the following statements is not true? Circle its #.

i. All 1M solutions of strong electrolytes conduct electricity equally well.

ii. All non-electrolyte solutions, regardless of concentration, do not conduct electricity.

iii. Concentration will not affect the electrical conductance of weak electrolyte solutions.

iv. Non-electrolytes may or may not dissolve in water.

d. Circle any compound with \( > 6.02 \times 10^{23} \) atoms of N in a 1 mole sample.

\[ \text{NO}_2 \quad \text{C}_5\text{H}_5\text{N} \quad \text{NH}_3 \quad \text{N}_2\text{H}_4 \]

e. Give the \( \# \) \( \pi \) bonds \( \square \) and \( \# \) \( \sigma \) bonds \( \Box \) in the following molecule.

\[ \text{Structure Image} \]

f. Use the following section of the activity series (shown on the right) to determine which of the following reactions (i-iv) will not occur.

i. \( \text{Ca}(s) \) with \( \text{Cu}^{2+}(aq) \)

\[ \text{Ca}(s) \rightarrow \text{Ca}^{2+}(aq) + 2e^- \]

ii. \( \text{Ca}(s) \) with \( \text{Zn}^{2+}(aq) \)

\[ \text{Mg}(s) \rightarrow \text{Mg}^{2+}(aq) + 2e^- \]

iii. \( \text{Zn}(s) \) with \( \text{Cu}^{2+}(aq) \)

\[ \text{Zn}(s) \rightarrow \text{Zn}^{2+}(aq) + 2e^- \]

iv. \( \text{Zn}(s) \) with \( \text{Mg}^{2+}(aq) \)

\[ \text{Cu}(s) \rightarrow \text{Cu}^{2+}(aq) + 2e^- \]

g. Circle the region where you would most likely find the best oxidizing agents.

h. Circle the species that functions as the reducing agent in the following reduction-oxidation reaction:

\[ \text{ZnO}(s) + \text{(C\( \square \))} \rightarrow \text{Zn}(s) + \text{CO}(g)? \]

!. (5) a. Write a balanced equation for the combustion of dodecane (\( \text{C}_{12}\text{H}_{26} \)).

\[ 2\text{C}_{12}\text{H}_{26} + 37\text{O}_2 \rightarrow 24\text{CO}_2 + 26\text{H}_2\text{O} \]
3. (9) a. Sketch the orbital overlap in H₂CCC₂F₂ that results in bond formation (the central carbon has no C-H bonds).
   b. Label each type of orbital in your sketch.
   c. Give the C-C-C and H-C-H bond angles.

<table>
<thead>
<tr>
<th>Bond angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-C-C</td>
</tr>
<tr>
<td>H-C-H</td>
</tr>
</tbody>
</table>

4. (9) Balance the following redox equation in basic solution.

\[
\begin{align*}
2\times(5e^- + 8H^+ + MnO_4^- & \rightarrow Mn^{2+} + 4H_2O) \\
5\times(4H^+ + C_2O_4^{2-} & \rightarrow 2CO_2 + 2H_2O + 2e^-) \\
10e^- + 16H^+ + 2MnO_4^- + 5C_2O_4^{2-} & \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2 + 10e^- + 16OH^- \\
\end{align*}
\]

\[
\therefore \quad 8H_2O + 2MnO_4^- + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 10CO_2 + 16OH^-
\]

5. (11) Nicotine (162 g/mol), contains only carbon, hydrogen and nitrogen. If combustion of 5.25 mg nicotine generates 14.24 mg CO₂ and 4.083 mg water, determine the molecular formula of nicotine.

\[
\begin{align*}
0.01424 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44 \text{ g CO}_2} \times \frac{1 \text{ mol C}}{1 \text{ mol CO}_2} = 0.0003236 \text{ mol C} = 0.0003836 \text{ g C} \\
0.004083 \text{ g H}_2O \times \frac{1 \text{ mol H}_2O}{18 \text{ g}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2O} = 0.0004567 \text{ mol H} = 0.0004582 \text{ g H} \\
\text{g N} = 0.00535 \text{ g N} \\
\end{align*}
\]

\[
\begin{align*}
\text{C}_{0.003236} \quad \text{H}_{0.0004567} \quad \text{N}_{0.0006487} \\
\sqrt[3]{0.0003236} = 0.04 \text{ mol formula unit} \\
\text{molec. form } = C_5H_7N_2 \\
\text{162 g/mol}
\end{align*}
\]
6. (10) A mixture of CuO (79.5 g/mol) and Cu₂O (143 g/mol) has a total mass of 10.5 g, and yields 8.66 pure Cu when reduced. Find the mass of each compound in the original mixture.

\[
10.5 \text{ g} = \frac{\text{mass CuO}}{x} + \frac{\text{mass Cu}_2\text{O}}{(10.5-x)g}
\]

\[
8.66 \text{ g Cu} \times \frac{1 \text{ mol Cu}}{63.5 \text{ g}} = 0.136 \text{ mol Cu total} = \frac{1 \text{ mol Cu}}{x \text{ g CuO}} + \frac{2 \text{ mol Cu}}{(10.5-x) \text{ g Cu}_2\text{O}}
\]

\[
0.136 = 0.0126x + 0.1469 - 0.01399x
\]

\[
x = \frac{7.86 \text{ g}}{1.649 \text{ g}}
\]

mass CuO = 7.86 g
mass Cu₂O = 2.64 g

7. (11) a. Determine the grams of solid that will form (if any) when 75 mL of 1.1 M copper(II) nitrate and 55 mL of 1.0 M sodium carbonate are mixed.

b. Find the molarity of any sodium ions remaining in solution after any reaction occurs.

\[
\text{Cu(NO}_2\text{)}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CuCO}_3 + 2\text{NaNO}_3 (aq)
\]

\[
0.075 \text{ L} \times \frac{1 \text{ mol Cu(NO}_2\text{)}_2}{1 \text{ L}} \times \frac{1 \text{ mol CuCO}_3}{1 \text{ mol Cu(NO}_2\text{)}_2} = 0.0835 \text{ mol}
\]

\[
\text{limiting}\ \frac{0.55 \text{ L} \times 1 \text{ mol Na}_2\text{CO}_3}{1 \text{ mol CuCO}_3} \times \frac{1 \text{ mol Na}_2\text{CO}_3}{1 \text{ mol CuCO}_3} = 0.055 \text{ mol} \times \frac{123.5 \text{ g}}{1 \text{ mol}} = 6.79 \text{ g solid}
\]

\[
[\text{Na}^+] = \frac{0.055 \text{ L} \times 1 \text{ mol Na}_2\text{CO}_3 \times 2 \text{ mol Na}^+}{1 \text{ mol Na}_2\text{CO}_3} = \frac{0.055 + 0.075}{0.075} \text{ L}
\]

\[
\text{molarity} = \frac{0.846 \text{ M}}{3}
\]

8. (10) DO EITHER PART A OR PART B

a. Using the following unbalanced chemical equation, determine what mass of carbon disulfide would have to be burned to produce a mixture of carbon dioxide and sulfur dioxide with a total mass of 54.2 g?

\[
\text{CS}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{SO}_2
\]

b. If burning 33.8 g CS₂ produces 15 g of carbon dioxide, determine the percent yield for this reaction.

a. Use equation \(1 \text{ mol CS}_2 \rightarrow 1 \text{ mol CO}_2 + 2 \text{ mol SO}_2\)

\[
76 \text{ g} \rightarrow 172 \text{ g}
\]

\[
\frac{76}{172} = \frac{7.4}{54.2}
\]

Ans. 23.4 g CS₂

b. \(33.8 \text{ g CS}_2 \times \frac{1 \text{ mol CO}_2}{76 \text{ g}} \times \frac{44 \text{ g CO}_2}{1 \text{ mol}} = 19.6 \text{ g theor.}\)

\[
\text{96 yield} = \frac{15 \text{ g CO}_2}{19.6 \text{ g}} \times 100 = 76.5\%
\]