1. Fill in either the name or formula, as required.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu₂S</td>
<td>copper(I) sulfide</td>
</tr>
<tr>
<td>Ba₃N₂</td>
<td>barium nitride</td>
</tr>
<tr>
<td>Al(ClO₃)₃</td>
<td>aluminum chlorate</td>
</tr>
<tr>
<td>N₂O₆</td>
<td>dinitrogen hexoxide</td>
</tr>
</tbody>
</table>

2. Boron forms a large number of compounds with hydrogen, called boranes, which are named by their own nomenclature system. Consider a 25.00-g sample of pentaborane-9, B₅H₉. [m.w. B₅H₉ = 63.12 u; at. wt. B = 10.81 u; at. wt. H = 1.008 u]

a. How many moles of B₅H₉ are in the sample?

\[
\text{molB}_5\text{H}_9 = \left(\frac{25.00 \text{ gB}_5\text{H}_9}{63.12 \text{ gB}_5\text{H}_9}\right) = 0.3961 \text{ molB}_5\text{H}_9
\]

b. How many moles of hydrogen are in the sample?

\[
\text{molH} = \left(0.3961 \text{ molB}_5\text{H}_9\right) \left(\frac{9 \text{ molH}}{\text{molB}_5\text{H}_9}\right) = 3.565 \text{ molH}
\]

c. How many boron atoms are in the sample?

\[
\text{B atoms} = \left(0.3961 \text{ molB}_5\text{H}_9\right) \left(\frac{5 \text{ molB}}{\text{molB}_5\text{H}_9}\right) \left(\frac{6.022 \times 10^{23} \text{ B atoms}}{\text{molB}}\right) = 1.193 \times 10^{24} \text{ B atoms}
\]

d. What is the weight percentage of boron in the sample?

\[
\% \text{ B} = \left(\frac{5 \times 10.81}{63.12}\right) \times 100\% = 85.63\%
\]

3. Complete and balance the following reactions:

a. C₃H₇OH + O₂ → (combustion) \[2 \text{C}_3\text{H}_7\text{OH} + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 8 \text{H}_2\text{O}\]

b. NH₃ + O₂ → N₂ + H₂O \[4 \text{NH}_3 + 3 \text{O}_2 \rightarrow 2 \text{N}_2 + 6 \text{H}_2\text{O}\]

c. B₂O₃ + C + Cl₂ → BCl₃ + CO₂ \[2 \text{B}_2\text{O}_3 + 3 \text{C} + 6 \text{Cl}_2 \rightarrow 4 \text{BCl}_3 + 3 \text{CO}_2\]
4. A compound is analyzed and found to consist of 43.58\% phosphorus and 56.42\% sulfur. What is its empirical formula? Assuming that the empirical and molecular formulas are the same, what is the name of the compound? \([\text{at. wt. } P = 30.97 \text{ u}; \text{at. wt. } S = 32.07 \text{ u}]\)

Assume 100 g compound:

\[
\text{molP} = \frac{(43.58 \text{ g P})}{30.99 \text{ g P}} = 1.407 \text{ molP}
\]

\[
\text{molS} = \frac{(56.42 \text{ g S})}{32.07 \text{ g S}} = 1.759 \text{ molS}
\]

\[
\text{mol P : mol S} = 1.00 : 1.25 = 4 : 5
\]

empirical formula = \(\text{P}_4\text{S}_5\)  
name = tetraphosphorus pentasulfide

5. A 0.7323-g sample of a certain hydrocarbon (compound of carbon and hydrogen only) is analyzed by combustion, yielding 2.218 g CO\(_2\)(g) and 1.135 g H\(_2\)O(l). If the molecular weight is found to be 58.12 u, what is the molecular formula? \([\text{m.w. } \text{CO}_2 = 44.01 \text{ u}; \text{m.w. } \text{H}_2\text{O} = 18.02 \text{ u}; \text{at. wt. } \text{C} = 12.01 \text{ u}; \text{at. wt. } \text{H} = 1.008 \text{ u}]\).

\[
\text{molC} = \frac{(2.218 \text{ g CO}_2)}{44.01 \text{ g CO}_2} = 0.05040 \text{ molC}
\]

\[
\text{molH} = \frac{(1.135 \text{ g H}_2\text{O})}{18.02 \text{ g H}_2\text{O}} = 0.1260 \text{ molH}
\]

\[
\text{mol C : mol H} = 1.0 : 2.5 = 2 : 5
\]

empirical formula = \(\text{C}_2\text{H}_5\)  
f.w. = 29.06 u  
m.w./f.w. = 58.12/29.06 = 2

molecular formula = \(\text{C}_4\text{H}_{10}\)
6. Diborane, $B_2H_6$ (m.w. = 27.67 u), is a useful reagent in organic syntheses. It can be prepared by the reaction

$$4 BF_3 + 3 NaBH_4 \rightarrow 2 B_2H_6 + 3 NaBF_4$$

How many grams of diborane should be produced in the reaction of 6.00 g of $BF_3$ (m.w. = 67.80 u) and 2.75 g of $NaBH_4$ (f.w. = 37.83 u)?

\[
\text{mol} BF_3 = (6.00 \text{ g} BF_3) \left( \frac{\text{mol} BF_3}{67.80 \text{ g} BF_3} \right) = 0.088496 \text{ mol} BF_3
\]

\[
\text{mol} NaBH_4 = (2.75 \text{ g} NaBH_4) \left( \frac{\text{mol} NaBH_4}{37.83 \text{ g} NaBH_4} \right) = 0.072694 \text{ mol} NaBH_4
\]

Using the “set” method to identify the limiting reagent, divide each number of moles by its stoichiometric coefficient. The smaller number identifies the limiting reagent.

$BF_3$ “sets” = $0.088496 / 4 = 0.0221$ \( \neq \) Limiting Reagent

$NaBH_4$ “sets” = $0.072694 / 3 = 0.0242$

Now, base the calculation on the number of moles of $BF_3$, the limiting reagent:

\[
g B_2H_6 = (0.088496 \text{ mol} BF_3) \left( \frac{2 \text{mol} B_2H_6}{4 \text{mol} BF_3} \right) \left( \frac{27.67 \text{ g} B_2H_6}{\text{mol} B_2H_6} \right) = 1.22 \text{ g} B_2H_6
\]