Part I. 4 points each – Circle your answers

1. If a sample of matter is uniform throughout and cannot be separated into other substances by physical means, it is _______.
   A) a compound
   B) either a compound or an element
   C) a homogeneous mixture
   D) a heterogeneous mixture
   E) an element

2. Which of the following would be an extensive property for a given substance?
   A) density
   B) mass
   C) temperature
   D) melting point
   E) formula weight

3. Which of the following fragments would not appear in a mass spectrum of boron trifluoride?
   A) \(^{11}\text{BF}_2^+\)
   B) \(^{10}\text{BF}_2^+\)
   C) \(^{11}\text{BF}_2\)
   D) \(^{10}\text{BF}_3^+\)
   E) \(^{10}\text{B}^+\)

4. If 5 mol of both hydrochloric acid and sodium sulfide are reacted according to the unbalanced equation below, how many moles of hydrogen sulfide (H\(_2\)S) are produced?
   \[ 2\text{HCl}_{(aq)} + \text{Na}_2\text{S}_{(s)} \rightarrow \text{H}_2\text{S}_{(g)} + 2\text{NaCl}_{(aq)} \]
   A) 1 mol
   B) 1.25 mol
   C) 2.5 mol
   D) 3 mol
   E) 5 mol

5. Which of the following is not a physical process?
   A) distillation
   B) filtration
   C) chromatography
   D) evaporation
   E) none of the above
Part II. 8-16 points each

6. Complete the following table (all empty cells):

<table>
<thead>
<tr>
<th>NAME</th>
<th>FORMULA</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitric acid</td>
<td>HNO₃</td>
</tr>
<tr>
<td>carbon tetrabromide</td>
<td>CBr₄</td>
</tr>
<tr>
<td>ammonium phosphate</td>
<td>(NH₄)₃PO₄</td>
</tr>
<tr>
<td>iron(III) oxide</td>
<td>Fe₂O₃</td>
</tr>
</tbody>
</table>

7. Complete the following table (all empty cells in both rows):

<table>
<thead>
<tr>
<th>Symbol</th>
<th># of protons</th>
<th># of neutrons</th>
<th># of electrons</th>
<th>atomic number</th>
<th>mass number</th>
</tr>
</thead>
<tbody>
<tr>
<td>⁵¹V⁵⁺</td>
<td>23</td>
<td>28</td>
<td>18</td>
<td>23</td>
<td>51</td>
</tr>
<tr>
<td>³⁴S²⁻</td>
<td>16</td>
<td>18</td>
<td>18</td>
<td>16</td>
<td>34</td>
</tr>
</tbody>
</table>

8. What mass (in grams) of glucose contains $3.14 \times 10^{24}$ molecules of glucose (Molar mass of glucose = 180.16 g/mol)?

\[
(3.14 \times 10^{24} \text{ molecules glucose}) \left( \frac{1 \text{ mol glucose}}{6.022 \times 10^{23} \text{ molecules glucose}} \right) \times \left( \frac{180.16 \text{ g glucose}}{1 \text{ mol glucose}} \right) = 939 \text{ g glucose}
\]
9. Selenium, an element used in the manufacture of solar energy devices, forms an oxide that contains only one atom of selenium and is 37.8% oxygen by mass. What is the molecular formula of the oxide?

Oxide molecular formula = SeO\(_x\)

\[
\text{% O by mass} = \frac{x \cdot 15.9994 \text{ g/mol}}{(1 \cdot 78.971 \text{ g/mol}) + (x \cdot 15.9994 \text{ g/mol})} \cdot 100\% = 37.8\%
\]

\[
15.9994 x = 0.378 (15.9994 x + 78.971)
\]

\[
x = 2.99961
\]

Oxide molecular formula = SeO\(_3\)

10. Using a mass spectrometer, you measure the abundances of 3 naturally occurring silicon (Si) isotopes as follows:

<table>
<thead>
<tr>
<th>isotopic mass (amu)</th>
<th>abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>92.13 %</td>
</tr>
<tr>
<td>29</td>
<td>4.783 %</td>
</tr>
<tr>
<td>30</td>
<td>3.087 %</td>
</tr>
</tbody>
</table>

What is the average molar atomic mass of silicon based on your calculations?

*It is reasonable to treat the isotopic masses as exact numbers. 1 amu = 1 g/mol*

\[
\text{atomic mass} = \left[ (28 \text{ g/mol} \cdot 0.9213) + (29 \text{ g/mol} \cdot 0.04783) + (30 \text{ g/mol} \cdot 0.03087) \right]
\]

\[
\begin{array}{cccccc}
2 & 5 & . & 7 & 9 & 6 & 4 \\
1 & . & 3 & 8 & 7 & 0 & 7 \\
+ & 0 & . & 9 & 2 & 6 & 1 \\
\hline
2 & 8 & . & 1 & 0 & 9 & 5 & 7
\end{array}
\]

atomic mass of Si = 28.11 g/mol
11. Cubane, a component in rocket fuel, contains only carbon and hydrogen. The combustion of 0.322 g of cubane in excess oxygen produces 1.0885 g carbon dioxide and 0.2228 g water. If the molecular mass of cubane is 104.15 g/mol, what is its molecular formula? (Molar masses that may prove useful: CO₂ = 44.0095 g/mol, H₂O = 18.0153 g/mol)

Unbalanced reaction: \( C_xH_y(l) + O_2(g) \rightarrow CO_2(g) + H_2O(g) \)

Need molar quantity of CO₂ and H₂O…

\[
\text{(1.0885 g CO}_2\text{)}\left(\frac{\text{mol CO}_2}{44.0095 \text{ g CO}_2}\right) = 2.47333 \times 10^{-2} \text{ mol CO}_2
\]

\( \therefore 2.47333 \times 10^{-2} \text{ mol carbon atoms} \)

\[
\text{(0.2228 g H}_2\text{O)}\left(\frac{\text{mol H}_2\text{O}}{18.0153 \text{ g H}_2\text{O}}\right) = 1.2367 \times 10^{-2} \text{ mol H}_2\text{O}
\]

\( \therefore 2.4734 \times 10^{-2} \text{ mol hydrogen atoms} \)

**Empirical formula of cubane:** CH \quad **Molecular formula of cubane:** C₈H₈

\[
FW = \left[(x \cdot 12.0107 \text{ g/mol}) + (x \cdot 1.00794 \text{ g/mol})\right] = 104.15 \text{ g/mol}
\]

\[13.01864 x = 104.15 \quad 13.01864 x = 104.15 \quad x = 8.00007\]

**Molecular formula of cubane:** C₈H₈
12. Plants sequester carbon dioxide by converting it into cellulose \((\text{C}_6\text{H}_{10}\text{O}_5)\) through a process that can be (greatly) simplified to the chemical equation shown below.

\[
6 \text{CO}_2(\text{g}) + 5 \text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{10}\text{O}_5(\text{s}) + 6 \text{O}_2(\text{g})
\]

a) Add coefficients to the equation above to properly balance the equation above.

b) What mass of water is required for a tree to produce 1.000 kg of cellulose by this process?

\[
\begin{align*}
\text{FW (cellulose)} &= \\
&= \left[ (6 \cdot 12.0107 \frac{g}{\text{mol}}) + (10 \cdot 1.00794 \frac{g}{\text{mol}}) + (5 \cdot 15.9994 \frac{g}{\text{mol}}) \right] \\
&= 162.1406 \frac{g}{\text{mol}} \\
\end{align*}
\]

\[
\begin{align*}
(1.000 \text{ kg cellulose}) \left( \frac{1000 \text{ g cellulose}}{1 \text{ kg cellulose}} \right) \left( \frac{\text{mol cellulose}}{162.1406 \text{ g cellulose}} \right) \left( \frac{5 \text{ mol water}}{1 \text{ mol cellulose}} \right) \cdots \\
\left( \frac{18.0153 \text{ g water}}{1 \text{ mol water}} \right) &= 555.5 \text{ g water}
\end{align*}
\]