1. What is the mass of a single molecule of water?
   a) 2.992 x 10^{-23} grams  
   b) 1.00 gram  
   c) 6.022 x 10^{-22} grams  
   d) 18.02 grams  
   e) 2.992 x 10^{-23} grams

\[
\text{1 molecule} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ molecules}} \times 18.02 \text{ g} = 2.992 \times 10^{-23} \text{ g H}_2\text{O}
\]

2. What are the units for molarity?
   a) g/L  
   b) mol/mL  
   c) mol/L  
   d) L/mol

3. Another term for molarity is:
   a) concentration  
   b) molar mass  
   c) molecular formula  
   d) moles/gram

4. The percentage of calcium (by mass) in the molecule Ca_3Fe_2(SiO_4)_3 is
   a) 7.887 %  
   b) 21.98 %  
   c) 23.67 %  
   d) 37.78 %

\[
\text{Show your work below:}
(3 \times 40.08) + (2 \times 55.85) + (3 \times 28.09) + (12 \times 16.00) = 508.21 \text{ g/mol}
\]

\[
(3 \times 40.08) = 120.24 \text{ g/mol}
\]
\[
\frac{120.24 \text{ g/mol} \times 100 \%}{508.21 \text{ g/mol}} = 23.66 \%
\]

5. A molecular formula tells us:
   a) The actual number of atoms of each element in a compound  
   b) The lowest ratio of atoms of each element in a compound  
   c) All possible multiples of an empirical formula  
   d) The concentration of that compound in a solution

6. The empirical formula tells us:
   a) the actual number of atoms in a compound  
   b) the concentration of a compound  
   c) the molar mass of a compound  
   d) the lowest ratio of each element in a compound

7. At the same temperature and pressure, which sample of gas contains the same number of particles as one liter of oxygen, O_2?
   a) one liter of He  
   b) three liters of CO_2  
   c) two liters of Ne  
   d) two liters of H_2

\[\text{At STP all gases} \quad 22.4 \text{ L/mol}\]
1. How many atoms are in \( \text{Ni}(\text{H}_2\text{O})_2(\text{NH}_3)_3\text{Cl}_2 \)?

21 atoms

2. Aspartame is an artificial sweetener that is 160 times sweeter than sucrose (table sugar) when dissolved in water. It is marketed as NutraSweet. The molecular formula for aspartame is \( \text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_5 \).
   a. Calculate the molar mass of aspartame.
   \[
   (14 \times 12.01) + (18 \times 1.01) + (2 \times 14.01) + (5 \times 16.00) = 294.34 \text{ g/mol}
   \]

   b. How many moles of molecules are present in 10.0 g of aspartame?
   \[
   10.0 \text{ g} \times \frac{1 \text{ mol}}{294.34 \text{ g}} = 0.0340 \text{ mol aspartame}
   \]

   c. Calculate the mass in grams of 1.56 mol of aspartame.
   \[
   1.56 \text{ mol} \times \frac{294.34 \text{ g}}{1 \text{ mol}} = 459 \text{ g aspartame}
   \]

   d. How many molecules are in 5.0 mg of aspartame?
   \[
   5.0 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{294.34 \text{ g}} \times \frac{6.022 \times 10^{23} \text{ molec.}}{1 \text{ mol}} = 1.0 \times 10^{19} \text{ molecules of aspartame}
   \]

3. What is the mass of a 250.0 mL sample of hydrogen sulfide (H\(_2\)S) at STP?
   \[
   250.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{34.09 \text{ g}}{1 \text{ mol}} = 0.380 \text{ g H}_2\text{S}
   \]

4. At STP, 1 mole of argon gas has a molar volume of \( \boxed{22.4 \text{ L}} \).

5. How many molecules of potassium iodide are in 10.0 g of potassium iodide?
   \[
   10.0 \text{ g} \times \frac{1 \text{ mol}}{166.00 \text{ g}} \times 6.022 \times 10^{23} \text{ molec.} = 3.63 \times 10^{22} \text{ molecules KI}
   \]
6. What molar concentration of KCl is produced by measuring out 1.0 g KCl and adding water up to 0.350 L of solution?

\[
\frac{1.0 \text{ g}}{0.350 \text{ L}} \times \frac{1 \text{ mol}}{74.55 \text{ g}} = 0.038 \text{ M}
\]

7. A 0.600 mol sample of an unknown gas has a mass of 52.8 g and contains only carbon and fluorine.
   A. What is the molar mass of this unknown gas?

\[
\frac{52.8 \text{ g}}{0.600 \text{ mol}} = 88.0 \text{ g/mol}
\]

B. What is the molecular formula of this unknown gas given that each molecule contains only 1 carbon atom?

\[
\begin{align*}
\text{C} &= 12.01 \text{ g/mol} \\
\text{F} &= 19.00 \text{ g/mol}
\end{align*}
\]

\[
(1 \times 12.01) + (x \times 19.00) = 88.0 \text{ g/mol}
\]

\[
19.00x = 75.99
\]

\[
x = \frac{75.99}{19.00} \approx 4
\]

\[
\text{CF}_4
\]

8. Find the volume occupied by 21.6 g of N\textsubscript{2}H\textsubscript{4} gas at STP.

\[
21.6 \text{ g} \times \frac{1 \text{ mol}}{32.06 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 15.1 \text{ L N}_2\text{H}_4
\]

9. The molar volume of H\textsubscript{2} at 21.0\textdegree C, 100.4 kPa is 24.3 L/mol. Calculate the mass of 0.213 L of H\textsubscript{2} at this temperature and pressure.

\[
0.213 \text{ L} \times \frac{1 \text{ mol}}{24.3 \text{ L}} \times \frac{2.02 \text{ g}}{1 \text{ mol}} = 0.0177 \text{ g H}_2
\]
10. An experiment is conducted to calculate the molar volume. The following data is collected:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moles of N\textsubscript{2} gas</td>
<td>0.00166 mol</td>
</tr>
<tr>
<td>Volume of N\textsubscript{2} collected</td>
<td>47.2 mL</td>
</tr>
<tr>
<td>Room temperature</td>
<td>21.0°C</td>
</tr>
<tr>
<td>Pressure</td>
<td>100.4 kPa</td>
</tr>
</tbody>
</table>

Calculate the molar volume of N\textsubscript{2} at 21.0°C and 100.4 kPa using the data.

\[
\frac{47.2 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}}{0.0472 \text{ L}} = \frac{0.00166 \text{ mol}}{28.4 \text{ L/mol}}
\]

11. Nitrosyl chloride (NOCl) is a gas used in the synthesis of some pharmaceutical compounds. Find the mass of a 5.62 mL sample of nitrosyl chloride at STP.

\[
5.62 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times 65.46 \text{ g/mol} = 0.0164 \text{ g NOCl}
\]

12. Find the empirical formula for the following compounds:

a) 15.9% B, 84.1% F

\[
\frac{15.9 \text{ g B}}{10.81 \text{ g}} \times \frac{1 \text{ mol}}{1 \text{ mol}} = 1.47 \text{ mol B}
\]

\[
\frac{4.43 \text{ mol F}}{1.47 \text{ mol B}} = 3.01 \approx 3
\]

\[\text{BF}_3\]

b) 70.0% Fe, 30.0% O

\[
\frac{70.0 \text{ g Fe}}{55.85 \text{ g}} \times \frac{1 \text{ mol}}{1 \text{ mol}} = 1.25 \text{ mol Fe}
\]

\[
\frac{30.0 \text{ g O}}{16.00 \text{ g}} \times \frac{1 \text{ mol}}{1 \text{ mol}} = 1.88 \text{ mol O}
\]

\[
\frac{1.88 \text{ mol O}}{1.25 \text{ mol Fe}} = 1.50 \times 2 = 3.00
\]

\[\text{Fe}_2\text{O}_3\]