1. Which of the following will form a covalent bond?
   a) Nitrogen and oxygen  
   b) Calcium and sulfur  
   c) Zinc and chlorine  
   d) Potassium and bromine

2. Give the following answer to the correct number of significant figures:
   \[ \frac{31.87}{1.367} \times \frac{127.16}{1.367} = 93.0 \]

3. Rubidium has two naturally occurring isotopes, $^{85}$Rb (relative mass 84.9118 amu) and $^{87}$Rb (relative mass 86.9092 amu). If rubidium has an average atomic mass of 85.47 amu, what is the abundance of each isotope (in percent)?
   \[ 1 = x + 4 \]
   \[ 4 = 1 - x \]

4. Give the formula for the following compounds:
   a) Lithium sulfate
   b) Beryllium phosphate
   c) Dinitrogen monoxide
   d) Phosphorous acid
   e) Calcium acetate

5. Name the following compounds:
   a) FeSO$_4$ iron (II) sulfate
   b) K$_2$S potassium sulfide
   c) HNO$_3$ nitric acid
   d) P$_2$O$_5$ diphosphorus pentoxide
   e) Cl$_2$O$_3$ dichlorine trioxide
   f) Cu(OH)$_2$ copper (II) hydroxide

6. Which of the following lengths is the largest?
   a) 6.7 m
   b) 8.9 x 10$^{-4}$ km $\times 10^3 = 0.89$ m
   c) 7.3 x 10$^{10}$ nm $\times 10^{-9} = 73$ m
   e) 5.4 x 10$^3$ mm $\times 10^{-3} = 5.4$ m
7. A chemist set up a synthesis of phosphorus trichloride by mixing 18.8 g of white phosphorus (P₄) with 59.4 g of chlorine gas and obtained 72.4 g of liquid phosphorus trichloride.

\[ \text{P}_4(\text{s}) + 6\text{Cl}_2(\text{g}) \rightarrow 4\text{PCl}_3 \]

a. Calculate the mass (in g) of phosphorus trichloride that can be made from the reactants.

\[
\begin{align*}
18.8 \text{ g P}_4 & \times \frac{1 \text{ mol P}_4}{124 \text{ g P}_4} \times \frac{6 \text{ mol Cl}_2}{1 \text{ mol P}_4} \times \frac{71 \text{ g Cl}_2}{1 \text{ mol Cl}_2} = 64.6 \text{ g Cl}_2 \Rightarrow \text{LR} \\
59.4 \text{ g Cl}_2 & \times \frac{1 \text{ mol Cl}_2}{71 \text{ g Cl}_2} \times \frac{4 \text{ mol PCl}_3}{1 \text{ mol Cl}_2} \times \frac{137.5 \text{ g PCl}_3}{1 \text{ mol PCl}_3} = 76.7 \text{ g PCl}_3
\end{align*}
\]

b. Calculate the percentage yield of the product.

\[
\text{Percentage yield} = \left( \frac{72.4 \text{ g}}{76.7 \text{ g}} \right) \times 100\% = 94.4\%
\]

8. In the following list, which is not an example of a chemical reaction?

a. Dissolution of a penny in nitric acid
b. A burning candle
c. The condensation of water vapor
d. The formation of polyethylene from ethylene

9. Consider the following reaction:

\[ 3 \text{NH}_4\text{NO}_3 + \text{Na}_3\text{PO}_4 \rightarrow (\text{NH}_4)\text{PO}_4 + 3\text{NaNO}_3 \]

a. Which reactant is limiting, assuming we started with 30.0 grams of ammonium nitrate and 50.0 grams of sodium phosphate?

\[
\begin{align*}
30.0 \text{ g NH}_4\text{NO}_3 & \times \frac{1 \text{ mol NH}_4\text{NO}_3}{80.05 \text{ g}} \times \frac{1 \text{ mol Na}_3\text{PO}_4}{3 \text{ mol NH}_4\text{NO}_3} \times \frac{163.9 \text{ g}}{1 \text{ mol}} = 20.5 \text{ g Na}_3\text{PO}_4 \\
30.0 \text{ g NH}_4\text{NO}_3 & \times \frac{1 \text{ mol NH}_4\text{NO}_3}{80.05 \text{ g}} \times \frac{1 \text{ mol} (\text{NH}_4)\text{PO}_4}{1 \text{ mol}} \times \frac{149.12 \text{ g} (\text{NH}_4)\text{PO}_4}{1 \text{ mol}} = 18.6 \text{ g (NH}_4)\text{PO}_4 \\
30.0 \text{ g NH}_4\text{NO}_3 & \times \frac{1 \text{ mol NH}_4\text{NO}_3}{80.05 \text{ g}} \times \frac{3 \text{ mol NaNO}_3}{3 \text{ mol NH}_4\text{NO}_3} \times \frac{85 \text{ g NaNO}_3}{1 \text{ mol}} = 31.9 \text{ g NaNO}_3
\end{align*}
\]

b. What is the mass of each product that can be formed?

\[
\text{NH}_4\text{NO}_3 \text{ is limiting reactant.}
\]

c. What mass of the excess reactant(s) is left over?

\[ 50.0 \text{ g} - 20.5 \text{ g Na}_3\text{PO}_4 = 29.5 \text{ g Na}_3\text{PO}_4 \text{ left over} \]
10. You are running a series of experiments to determine the amount of carbon in a 10 g of a liquid. The accepted value of carbon is 5 g. Label each of the following as having a GOOD or BAD level of precision and accuracy:
   a. 4.0 g, 1.9 g, 9.9 g, 8.3 g: bad precision, bad accuracy
   b. 3.3 g, 3.2 g, 3.0 g, 3.2 g: good precision, bad accuracy
   c. 5.1 g, 5.0 g, 4.9 g, 5.2 g: good precision, good accuracy

11. Draw propane, butane, 3-pentene, and 2-propanol. Write the empirical formula of each compound.

   Propane: $\text{C}_3\text{H}_8$
   Butane: $\text{C}_4\text{H}_{10}$
   3-Pentene: $\text{C}_5\text{H}_{10}$
   2-Propanol: $\text{C}_3\text{H}_7\text{OH}$

12. Automobile batteries contain sulfuric acid, which is commonly referred to as battery acid. Calculate the number of grams of sulfuric acid in 1.00 gallon of battery acid if the solution has a density of 1.28 g/ml and is 38.1% sulfuric acid by mass.
   (1 Gallon = 3.78541 L)

   $1.00 \text{ gal} \times \frac{3.78541 \text{ L}}{1 \text{ gal}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{128 \text{ g}}{1 \text{ mL}} = 4,845.33 \text{ g} \times 0.381 = 1,850 \text{ g H}_2\text{SO}_4$

13. An inorganic compound that is a colorless, flammable liquid with a strong odor and used as a fuel in certain pharmaceuticals contains 87.42% by mass nitrogen and 12.58% by mass hydrogen.
   a. What is the empirical formula of this inorganic compound?

   $87.42 \text{ g N} \times \frac{1 \text{ mol N}}{14 \text{ g}} = 6.24 \text{ mol N}$
   $12.58 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g}} = 12.45 \text{ mol H}$

   b. At 20 °C, the density of this liquid is 1.021 g/cm$^3$. By evaporating 10.00 mL of the compound into a closed container, it was determined to contain 0.3191 mol of the compound. What is the molecular formula of this compound?

   $D = \frac{m}{V} = \frac{1.021 \text{ g/mL}}{10.00 \text{ mL}} \Rightarrow m = 10.21 \text{ g} \Rightarrow \frac{m}{0.3191 \text{ mol}} = \frac{x \text{ g}}{1 \text{ mol}}$

   $M_W = 31.996 \text{ g/mol}$

14. How many molecules are in 3 moles of Cl$_2$?

   $3 \text{ mol Cl}_2 \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol Cl}_2} = 1.81 \times 10^{24} \text{ Cl}_2 \text{ molecules}$
15. Which of the following is not a homogeneous mixture?
   a. Salt water
   b. Ice water
   c. Air
   d. Steel

16. A pure solid is heated and it decomposes into two substances, one a liquid and the other a gas. One can conclude with certainty that:
   a. The two products are elements
   b. One of the two products is an element
   c. The original solid is not an element
   d. The liquid is a compound and the gas is an element
   e. Both products are compounds

17. Which of the following is not one of the postulates in Dalton’s Atomic Theory?
   a. All matter is made of atoms. Atoms are indivisible and indestructible.
   b. All atoms of a given element are identical in mass and properties.
   c. An atom contains a positively charged nucleus.
   d. Compounds are formed by a combination of two or more different kinds of atoms.
   e. A chemical reaction is a rearrangement of atoms.

18. Which experiment is responsible for the discovery of the mass/charge ratio?
   a. Millikan’s oil drop experiment
   b. Rutherford’s gold foil experiment
   c. Thompson’s cathode ray tube experiment