**Level 1**

Balance the following chemical equations:

1. CH4 + O2 🡪 CO2 + H2O
2. Al + HBr 🡪 AlBr3 + H2
3. CO2 + H2O 🡪 C6H12O6 + O2
4. Solutions of lead (II) nitrate and sodium iodide react to produce solid lead (II) iodide and aqueous sodium nitrate.
5. Solid zinc sulfide reacts with oxygen gas to produce solid zinc oxide and solid sulfur (S8).
6. Boron mononitride reacts with fluorine gas to produce boron trifluoride and nitrogen gas.

**Level 2**:

Use the **balanced** chemical equations in each problem to answer the questions that follow:

1. Fe2O3 + 3H2 🡪 2Fe + 3H2O
   1. Determine the moles of water produced from 6.50 moles of iron (III) oxide.
   2. How many moles of hydrogen gas are required to completely react with 10 moles of Fe2O3?
   3. If 15.0 moles of solid iron are produced, how many moles of hydrogen gas does this require?
2. 4Al + 3O2 🡪 2Al2O3
   1. If 7.59 moles of aluminum are used, how many moles of aluminum oxide can be produced?
   2. Determine the number of oxygen moles that are required to completely react with 4.55 moles of aluminum.
   3. 2.75 moles of aluminum oxide are produced; how many moles of oxygen gas does this require?

**Level 3**:

Use the **balanced** chemical equations in each problem to answer the questions that follow:

1. 2Al + 3H2SO4 🡪 3H2 + Al2(SO4)3
   1. Determine the mass of aluminum sulfate produced from 5.25 moles of sulfuric acid.
   2. How many grams of aluminum are required to react with 8.95 moles of sulfuric acid?
   3. If 6.90 moles of hydrogen gas are produced, how many grams of aluminum does this require?
2. 3Ca + N2 🡪 Ca3N2
   1. How many grams of calcium nitride are produced from 1.29 moles of calcium?
   2. Determine the mass of nitrogen gas required to completely react with 6.44 moles of calcium.
   3. If 9.77 moles of calcium nitride are produced, how many grams of nitrogen gas are required?

Use the following **unbalanced** chemical equation to answer the questions that follow:

1. Al + Cl2 🡪 AlCl3
   1. If 6.55 grams of aluminum chloride are produced, how many moles of chlorine gas are required?
   2. Determine the mass of aluminum needed to completely react with 9.55 moles of chlorine gas.

**Level 4**:

1. V2O5 + 5Ca 🡪 5CaO + 2V
   1. Determine the mass of calcium oxide produced from 5.00 grams of vanadium (V) oxide.
   2. How many grams of calcium are needed to produce 1.96 grams of vanadium?
   3. If 7.98 grams of calcium are used, determine the mass of V2O5 required for a complete reaction.
2. 3Fe + 4H2O 🡪 4H2 + Fe3O4
   1. Determine the mass of Fe3O4 produced from 19.5 grams of Fe.
   2. How many grams of water are needed to produce 1.55 grams of Fe3O4?
   3. If you started with 20.1 grams of water, how many grams of iron are needed for a complete reaction?

Use the following **unbalanced** chemical equation to answer the questions that follow:

1. Calcium hydroxide reacts with ammonium chloride to produce ammonium hydroxide and calcium chloride.
   1. Determine the mass of calcium chloride produced from 17.8 grams of ammonium chloride.
   2. How man grams of ammonium hydroxide can be produced from 9.74 grams of calcium hydroxide?
   3. Your lab group started with 5.65 grams of calcium hydroxide. How many grams of ammonium chloride are required for a complete reaction?

**Level 5**:

Use the following **balanced** chemical equation to answer the questions that follow.

1. C3H8 + 5O2 🡪 3CO2 + 4H2O
   1. Determine the limiting reactant if you started with 5.70 grams of each reactant.
   2. What is the maximum number of **moles** of carbon dioxide that can be produced from 10.1 grams of oxygen and 5.76 grams of propane (C3H8)?
2. K2SO4 + BaCl2 🡪 2KCl + BaSO4
   1. If you started with 4.55 grams of potassium sulfate and 5.90 grams of barium chloride, how many grams of barium sulfate will be produced?
   2. Identify the limiting reactant from the information in question 2a. Then, determine how many grams remain of the reactant in excess.

Use the information in each problem to answer the questions that follow.

1. Na3PO4 + CaCl2 🡪 NaCl + Ca3(PO4)2
   1. Balance the above chemical reaction
   2. Determine the limiting reactant if you used 5.65 grams of each reactant.
   3. What is the maximum amount of calcium phosphate that can be produced based on your answer to question 2b?
2. Na3PO4 + KOH 🡪 NaOH + K3PO4
   1. Balance the above chemical equation
   2. How many grams of each reactant are required to produce 2.15 grams of sodium hydroxide?
   3. Determine the limiting reactant if you started with 1.25 grams of sodium phosphate and 2.55 grams of potassium hydroxide.
   4. Determine the amount remaining for the reactant in excess based on your answer for part 2c.

**Level 6**:

1. Lead (II) hydroxide reacts with hydrochloric acid to produce water and lead (II) chloride.
   1. Determine the limiting reactant if 5.65 grams of lead (II) hydroxide is reacted with 6.95 grams of hydrochloric acid.
   2. Based on your calculations from 1a, calculate the amount of grams remaining for the reactant in excess.
   3. Would you have enough hydrochloric acid to produce 12.5 grams of lead (II) chloride from the information in part 1a?
2. Consider the reaction between gaseous diodine pentoxide and carbon monoxide to produce carbon dioxide and iodine gases.
   1. 80.0 grams of diiodine pentoxide react with 28.0 grams of carbon monoxide. Determine the mass of iodine that can be produced.
   2. What is the percent yield for iodine, in the above situation, if only 0.160 moles of iodine where produced?
3. Silver nitrate reacts with iron (III) chloride to give silver chloride and iron (III) nitrate.
   1. In an experiment, 45.0 grams of iron (III) chloride are mixed with 25.0 grams of silver chloride. Which reactant is the limiting reactant?
   2. What is the maximum number of moles of silver chloride that could be obtained from the mixture in the situation above?
   3. Determine the percent yield for the situation above if you obtained 9.82 grams of iron (III) nitrate.

**Level 7**:

1. The fizz produced when an Alka-Seltzer® tablet is dissolved in water is due to the reaction between sodium bicarbonate and citric acid: NaHCO3 + H3C6H5O7 🡪 CO2 + H2O + Na3C6H5O7.
   1. In a certain experiment, 1.00 grams of sodium bicarbonate and 1.00 grams of citric acid are allowed to react. Which is the limiting reactant?
   2. How many grams of carbon dioxide from?
   3. How many grams of the excess reactant remain?
2. Hydrogen sulfide is an impurity in natural gas that must be removed. Once common removal method is the Claus process, which relies on the reaction 8H2S + 4O2 🡪 S8 + 8H2O. Under optimal conditions the Claus process gives 98% yield of S8 from H2S. If you started with 30.0 grams of hydrogen sulfide and 50.0 grams oxygen, how many grams of S8 would be produced, assuming 98% yield?
3. A particular coal contains 2.5% sulfur by mass. When this coal is burned at a power plant, the sulfur is converted into sulfur dioxide gas, which is a pollutant. To reduce sulfur dioxide emissions, calcium oxide (lime) is used. The sulfur dioxide reacts with calcium oxide to form solid calcium sulfite.
   1. Write the balanced chemical equation for the reaction.
   2. If the coal is burned in a power plant that uses 2000 tons of coal per day, what mass of calcium oxide is required daily to eliminate the sulfur dioxide?
   3. How many grams of calcium sulfite are produced by this power plant?
4. Hydrogen cyanide, HCN, is a poisonous gas. The lethal dose is approximately 300 mg HCN per kilogram of air when inhaled.
   1. Calculate the amount of HCN that gives the lethal dose in a small laboratory room measuring 12 x 15 x 8.0 ft. The density of air at 26°C is 0.00118 g/cm3.
   2. If the HCN is formed by the reaction of NaCN with an acid such as H2SO4, what mass of NaCN gives the lethal dose in the room? 2NaCN + H2SO4 🡪 Na2SO4 + 2HCN
   3. HCN forms when synthetic fibers containing Orlon® or Acrilan® burn. Arcilan® has an empirical formula of CH2CHCN, so HCN is 50.9% of the formula mass. A rug measures 12 x 15 ft and contains 30 oz of Acrilan® fibers per square yard of carpet. If the rug burns, will a lethal dose of HCN be generated in the room? Assume that the yield of HCN from the fibers is 20% and that the carpet is 50% consumed.