Part A: Review of Calculations Based on Chemical Reactions

For this worksheet, we begin by reviewing what we learned about mole ↔ mole conversion factors:

1) Ammonium nitrate is a common fertilizer and was also the explosive used in the Oklahoma City bombing. When heated, solid ammonium nitrate decomposes into nitrogen and oxygen gases and water vapor.
   a) Write the balance equation for this reaction.

   b) Based on your balanced reaction, what is the conversion factor that allows you to relate moles of ammonium nitrate to total moles of gas produced?

   c) How many total gas molecules can be produced from 95 g of ammonium nitrate?

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2) Copper metal reacts with aqueous nitric acid to produce aqueous copper(II) nitrate, nitrogen monoxide gas and water.
   a) Write the balance equation for this reaction. [Hint: If you get really stuck, there should be a "3" in front of the copper and an "8" in front of the nitric acid on the reactant side]

   b) Based on your balanced reaction, what is the conversion factor that allows you to relate moles of copper to moles of nitrogen monoxide?

   c) In 1982, the price of copper became too high and the US mint switched from pennies made of 95% copper to pennies that are made of a zinc core that is coated in copper. These new pennies are about 2.5% copper by mass. If a new penny has a mass of 3.045 g (only 2.5% of which is actually copper), how many grams of nitrogen monoxide gas will be produced when dissolving all of the copper off of a new penny?

Part B: An Introduction to Limiting Reactants

3) Scrap aluminum metal can react with chlorine gas to produce solid aluminum chloride, an inexpensive chemical used in many industrial processes.
   a) Write the balanced equation for the synthesis of aluminum chloride.

Imagine that you have 150. grams each of aluminum and chlorine gas and want to figure out how much aluminum chloride you can make. Let's break it down into steps.

   b) Based on your balanced reaction, what is the conversion factor that allows you to relate moles of aluminum to moles of aluminum chloride?

   c) Assuming that the 150. g of aluminum metal is the limiting reactant, how many grams of aluminum chloride can be made?

   d) Based on your balanced reaction, what is the conversion factor that allows you to relate moles of chlorine gas to moles of aluminum chloride?

   e) Assuming that the 150. g of chlorine gas is the limiting reactant, how many grams of aluminum chloride can be made?

   f) Given your answers to questions 3c) and 3e), what is the actual limiting reactant and how much aluminum chloride can you actually make? Briefly explain your choice.

4) Iron(III) oxide is also called hematite and is a common ore of iron. Iron metal can be made by reacting the hematite with carbon monoxide. In addition to the desired iron metal, the process also produces carbon dioxide gas.
   a) Write the balanced equation for the reaction of hematite and carbon monoxide to produce iron and carbon dioxide.

If you start with 2.00 kg of each reactant, what is the maximum amount of iron you can produce?

   b) Based on your balanced reaction, what is the conversion factor that allows you to relate moles of iron to moles of hematite?

   c) Assuming that the 2.00 kg of hematite is the limiting reactant, how many grams of iron can be made?

   d) Based on your balanced reaction, what is the conversion factor that allows you to relate moles of iron to moles of carbon monoxide?

   e) Assuming that the 2.00 kg of carbon monoxide is the limiting reactant, how many grams of iron can be made?

   f) Given your answers to questions 4c) and 4e), what is the actual limiting reactant and how much iron can you actually make? Briefly explain your choice.

Part C: Extra Problems If You Have Time

These problems have not been broken down into steps for you, so look back at the two previous questions if you get stuck and need a model.

5) The cancer chemotherapy agent, cisplatin, $Pt(NH_3)_2Cl_2$, is produced by the following unbalanced reaction:

$$\_\_\_\_ (NH_4)_2PtCl_4\ (s) + \_\_\_\_ NH_3\ (aq) \rightarrow \_\_\_\_ NH_4Cl\ (aq) + \_\_\_\_ Pt(NH_3)_2Cl_2\ (s)$$

What is the maximum mass, in g, of cisplatin that can be made from 0.85 g of $(NH_4)_2PtCl_4$ and 0.15 g of NH_3?

6) Sulfur dioxide is a toxic gas that contributes to acid rain. It is produced as an unwanted product during the burning of sulfur containing coal. The gaseous sulfur dioxide can be removed from the smokestacks of coal burning power plants by reacting it with limestone (calcium carbonate) and oxygen. The products are solid calcium sulfate and carbon dioxide gas.

What is the maximum mass, in kg, of sulfur dioxide that can be treated if you have 85.0 lbs of limestone and 650. L of oxygen? Assume each mole of oxygen has a volume of 22.4 L.