Limiting Reagents

The idea in a limiting reagent problem is that one of the reactants may be limiting. In other words, when you combine 2 reagents one will run out first and the reaction will stop at that point. You need to find out which one runs out first. The easiest way to solve these problems is to treat them as multiple stoichiometry problems. Compare the answers and the one that makes the least amount of material is the limiting reagent.

You combine 10.0 grams of hydrogen gas and 15.0 grams of oxygen gas. How many grams of water vapor are made? Which, if any, is your limiting reagent?

$$2H_2 + O_2 \rightarrow 2H_2O$$

$$10.0\text{ g }H_2 \times \frac{1\text{ mole }H_2}{2.02\text{ g }H_2} \times \frac{2\text{ moles }H_2O}{2\text{ mole }H_2} \times \frac{18.02\text{ g }H_2O}{1\text{ mole }H_2O} = 89.2\text{ g }H_2O$$

$$15.0\text{ g }O_2 \times \frac{1\text{ mole }O_2}{32.0\text{ g }O_2} \times \frac{2\text{ moles }H_2O}{1\text{ mole }O_2} \times \frac{18.02\text{ g }H_2O}{1\text{ mole }H_2O} = 16.9\text{ g }H_2O$$ ⇦ ***Limiting Reagent and grams of H_2O made.***

Problems:

1. Magnesium metal will burn in the presence of oxygen gas forming magnesium oxide.
   a.) What is the balanced equation for this reaction?
   b.) How many grams of oxygen gas reacts with 20.0g of magnesium metal?
   c.) How many grams of magnesium oxide are made when 35.0g of magnesium metal is burned in excess oxygen gas?

   Answer

2. If 2.35 moles of H_2 gas react with 5.33 mol of N_2 gas to make ammonia gas (NH_3):
   a.) How many grams of NH_3 can you make?
   b.) Will there be any reactants left over? If so, which one and how many grams of it will remain?

   Answer

Solution:

1. Magnesium metal will burn in the presence of oxygen gas forming magnesium oxide.
   a) What is the balanced equation for this reaction?
   b) How many grams of oxygen gas reacts with 20.0g of magnesium metal?
   c) How many grams of magnesium oxide are made when 35.0g of magnesium metal is burned in excess oxygen gas?

a) $\mathbf{2Mg_{(s)} + O_2 \longrightarrow 2MgO_{(s)}}$

b) $20.0\ \text{g Mg} \times \dfrac{1\ \text{mole Mg}}{24.31\ \text{g Mg}} \times \dfrac{1\text{mole } O_2}{2\ \text{moles Mg}} \times \dfrac{32.00\ \text{g } O_2}{1\ \text{mole } O_2} = \mathbf{13.2\ g\ O_2}$

c) $35.0\ \text{g Mg} \times \dfrac{1\ \text{mole Mg}}{24.31\ \text{g Mg}} \times \dfrac{2\ \text{moles MgO}}{2\ \text{mole Mg}} \times \dfrac{40.31\ \text{g MgO}}{1\ \text{mole MgO}} = \mathbf{58.0\ g\ MgO}$

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Solution:

2. If 2.35 moles of H_2 gas react with 5.33 mol of N_2 gas to make ammonia gas (NH_3):
   a) How many grams of NH_3 can you make?
   b) Will there be any reactants left over? If so, which one and how many grams of it will remain?

a) $3H_{2(g)} + N_{2(g)} \longrightarrow 2NH_{3(g)}$

b) $2.35 \text{ moles } \mathbf{H_2} \times \frac{2 \text{ moles } NH_3}{3 \text{ moles } H_2} \times \frac{17.04 \text{ g } NH_3}{1 \text{ mole } NH_3} = 26.7 \text{ g } NH_3$

$5.33 \text{ moles } \mathbf{N_2} \times \frac{2 \text{ moles } NH_3}{1 \text{ mole } N_2} \times \frac{17.04 \text{ g } NH_3}{1 \text{ mole } NH_3} = 182.6 \text{ g } NH_3 = 183 \text{ g } NH_3$

H_2 is the limiting reagent. 26.7 g NH_3 can be made. N_2 will be left over.
To determine how much N_2 is left over, take the amount of NH_3 that would be made if all of the N_2 is used, and subtract the amount of NH_3 actually made. (26.7 g) Now, convert the NH_3 back to N_2 to get the remaining N_2. 183 g NH_3 – 26.7 g NH_3 = 156.3 g = 156 g NH_3

$156 \text{ g } NH_3 \times \frac{1 \text{ mole } NH_3}{17.03 \text{ g } NH_3} \times \frac{1 \text{ mole } N_2}{2 \text{ mole } NH_3} \times \frac{28.02 \text{ g } N_2}{1 \text{ mole } N_2}$

128.3 g = **128 g of N_2 is left over.**

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