Limiting Reagents Worksheet

1. Nitric oxide (NO) reacts with oxygen gas to form nitrogen dioxide (NO_2), a dark brown gas:

$$2NO(g) + O_2 \rightarrow 2NO_2$$

In one experiment 0.866 mol of NO is mixed with 0.503 mol of O_2.
a)Determine the limiting reagent
b) Calculate the number of moles of NO_2 produced.

2. The depletion of ozone (O_3) in the stratosphere has been a matter of great concern among scientists in recent years. It is believed that ozone can react with nitric oxide (NO) that is discharged from high altitude planes. The reaction is

$$O_3 + NO \rightarrow O_2 + NO_2$$

If 7.40 g of O_3 reacts with 0.670 g of NO,

a) Which compound will be the limiting reagent?
b) How many grams of NO_2 will be produced?
c) Calculate the number of moles of the excess reagent remaining at the end of the reaction.

3. Consider the reaction

$$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + H_2O$$

If 0.86 mol of MnO_2 and 48.2 g of HCl react, which reagent will be used up first? How many grams of Cl_2 will be produced?

4. 15.00 g of aluminum sulfide and 10.00 g of water react until the limiting reagent is used up:

$$Al_2S_3 + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2S$$

a) Which is the limiting reagent?

b) What is the maximum mass of hydrogen sulfide that can form?

c) How much excess reagent remains after the reaction is complete?

1. Nitric oxide (NO) reacts with oxygen gas to form nitrogen dioxide (NO_2), a dark brown gas:

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In one experiment 0.866 mol of NO is mixed with 0.503 mol of O_2.
a)Determine the limiting reagent
b) Calculate the number of moles of NO_2 produced.

This is a limiting reagent problem. Let's calculate the moles of NO_2 produced assuming complete reaction for each reactant.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

$$0.886 \text{ mol NO} \times \frac{2 \text{ mol } NO_2}{2 \text{ mol NO}} = 0.886 \text{ mol } NO_2$$

$$0.503 \text{ mol } O_2 \times \frac{2 \text{ mol } NO_2}{1 \text{ mol } O_2} = 1.01 \text{ mol } NO_2$$

NO is the **limiting reagent**; it limits the amount of product produced. The amount of product produced is
0.886 mole NO_2.

2. The depletion of ozone (O_3) in the stratosphere has been a matter of great concern among scientists in recent years. It is believed that ozone can react with nitric oxide (NO) that is discharged from high altitude planes. The reaction is

   $O_3 + NO \rightarrow O_2 + NO_2$

   If 7.40 g of O_3 reacts with 0.670 g of NO,

   a) Which compound will be the limiting reagent?
   b) How many grams of NO_2 will be produced?
   c) Calculate the number of moles of the excess reagent remaining at the end of the reaction.

Strategy: Note that this reaction gives the amounts of both reactants, so it is likely to be a limiting reagent problem. The reactant that produces fewer moles of product is the limiting reagent because it limits the amount of product that can be produced. How do we convert from the amount of reactant to amount of product? Perform this calculation for each reactant, then compare the moles of product, NO_2, formed by the given amounts of O_3 and NO to determine which reactant is the limiting reagent.

Solution: We carry out two separate calculations. First, starting with 0.740 g O_3, we calculate the number of moles of NO_2 that could be produced if all the O_3 reacted. We complete the following conversions.

grams of O_3 $\rightarrow$ moles of O_3 $\rightarrow$ moles of NO_2

Combining these two conversions into one calculation, we write

$$? \text{ mol } NO_2 = 0.740 \text{ g } O_3 \times \frac{1 \text{ mol } O_3}{48.00 \text{ g } O_3} \times \frac{1 \text{ mol } NO_2}{1 \text{ mol } O_3} = 0.0154 \text{ mol } NO_2$$

Second, starting with 0.670 g of NO, we complete similar conversions.

grams of NO $\rightarrow$ moles of NO $\rightarrow$ moles of NO_2

Combining these two conversions into one calculation, we write

$$? \text{ mol } NO_2 = 0.670 \text{ g NO} \times \frac{1 \text{ mol NO}}{30.01 \text{ g NO}} \times \frac{1 \text{ mol } NO_2}{1 \text{ mol NO}} = 0.0223 \text{ mol } NO_2$$

The initial amount of $\mathbf{O_3}$ limits the amount of product that can be formed; therefore, it is the **limiting reagent**.

The problem asks for grams of NO_2 produced. We already know the moles of NO_2 produced, 0.0154 mole. Use the molar mass of NO_2 as a conversion factor to convert to grams (Molar mass NO_2 = 46.01 g).

$$\textbf{? g NO}_\mathbf{2} = 0.0154 \text{ mol NO}_2 \times \frac{46.01 \text{ g NO}_2}{1 \text{ mol NO}_2} = \textbf{0.709 g NO}_\mathbf{2}$$

Check: Does your answer seem reasonable? 0.0154 mole of product is formed. What is the mass of 1 mole of NO_2?

Strategy: Working backwards, we can determine the amount of NO that reacted to produce 0.0154 mole of NO_2. The amount of NO left over is the difference between the initial amount and the amount reacted.

Solution: Starting with 0.0154 mole of NO_2, we can determine the moles of NO that reacted using the mole ratio from the balanced equation. We can calculate the initial moles of NO starting with 0.670 g and using molar mass of NO as a conversion factor.

$$\text{mol NO reacted} = 0.0154 \text{ mol NO}_2 \times \frac{1 \text{ mol NO}}{1 \text{ mol NO}_2} = 0.0154 \text{ mol NO}$$

$$\text{mol NO initial} = 0.670 \text{ g NO} \times \frac{1 \text{ mol NO}}{30.01 \text{ g NO}} = 0.0223 \text{ mol NO}$$

mol NO remaining = mol NO initial − mol NO reacted.

mol NO remaining = 0.0223 mol NO − 0.0154 mol NO = **0.0069 mol NO**

3. Consider the reaction

$$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + H_2O$$

If 0.86 mol of MnO_2 and 48.2 g of HCl react, which reagent will be used up first? How many grams of Cl_2 will be produced?

This is a limiting reagent problem. Let's calculate the moles of Cl_2 produced assuming complete reaction for each reactant.

$$0.86 \text{ mol } MnO_2 \times \frac{1 \text{ mol } Cl_2}{1 \text{ mol } MnO_2} = 0.86 \text{ mol } Cl_2$$

$$48.2 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.46 \text{ g HCl}} \times \frac{1 \text{ mol } Cl_2}{4 \text{ mol HCl}} = 0.330 \text{ mol } Cl_2$$

HCl is the limiting reagent; it limits the amount of product produced. It will be used up first. The amount of product produced is 0.330 mole Cl_2. Let's convert this to grams.

$$\mathbf{?\ g\ Cl_2} = 0.330 \text{ mol } Cl_2 \times \frac{70.90 \text{ g } Cl_2}{1 \text{ mol } Cl_2} = \mathbf{23.4\ g\ Cl_2}$$