Exercises

1. Given the balanced chemical equation:

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

   calculate the mass of nitrogen dioxide that can be made from 30.0 grams of NO and 30.0 grams of O_2.

2. Zinc, Zn, and iodine, I_2, react to form zinc iodide, ZnI_2 (the reactants and the product are all solids at room temperature).

   a) Write a balanced chemical equation for this reaction.
   b) Suppose that 50.0 g of zinc and 50.0 g of iodine are used to form zinc(II) iodide.
      1) Assuming that the reaction goes to completion, which element will be totally consumed in the formation of the zinc(II) iodide?
      2) What is the limiting reagent?
      3) How many grams of zinc(II) iodide can be produced?
      4) How many grams of the excess element remain unreacted?

3. Acetylene gas, HCCH, is commonly used in high temperature torches.

   a) Write a balanced chemical equation for the reaction of acetylene with hydrogen gas (H_2) to form ethane (C_2H_6).
   b) How many grams of ethane can be produced from a mixture of 30.3 grams of HCCH and 4.14 grams of H_2?

4. Titanium (Ti) is a strong, lightweight metal that is used in the construction of rockets, jet engines, and bicycles. It can be prepared by reacting $TiCl_4$ with Mg metal at very high temperatures. The products are Ti(s) and $MgCl_2$.

   a) Provide a balanced chemical reaction for the reaction described above.
   b) How many grams of Ti metal can be produced from a reaction involving 3.54×10^4 g of $TiCl_4$ and 6.53×10^3 g of Mg?

5. The first step in the manufacturing process of phosphorous is the reaction below:

   $2\ Ca_3(PO_4)_2(s) + 6\ SiO_2(s) \rightarrow 6\ CaSiO_3(s) + P_4O_{10}(g)$

   The MW of $Ca_3(PO_4)_2(s)$ is 310.2 g/mole and the MW of $SiO_2(s)$ is 60.1 g/mole. If 20.0 g of $Ca_3(PO_4)_2(s)$ and 20.0 g of $SiO_2(s)$ are reacted, how many grams of $P_4O_{10}(g)$ can be produced?

6. How many grams of N_2 (28.01 g/mole) can be obtained by reacting 24.5 g of NH_3 (17.03 g/mole) with 30.8 g of O_2 (MW = 32.00 g/mole)?

   $4\ NH_3(g) + 3\ O_2(g) \rightarrow 2\ N_2(g) + 6\ H_2O(l)$

Answer key to Limiting reagent Exercises

#1. $2\,NO + O_2 \rightarrow 2\,NO_2$

30.0 g 30.0 g

$$\frac{30.0\text{ g NO}}{30.01\text{ g NO}} \times \frac{1\text{ mol NO}}{2\text{ mol NO}} \times \frac{2\text{ mol } NO_2}{} = 0.9996 \rightarrow 1.00\text{ mol } NO_2$$

$$\frac{30.0\text{ g } O_2}{32.00\text{ g } O_2} \times \frac{1\text{ mol } O_2}{1\text{ mol } O_2} \times \frac{2\text{ mol } NO_2}{} = 1.875 \rightarrow 1.88\text{ mol } NO_2$$

If all NO is used, 1.00 mol NO_2 formed. ← less, so NO is limiting reagent.

If all O_2 is used, 1.88 mol NO_2 is formed.

✳ The limiting reagent determines amount of product:

$$\frac{1.00\text{ mol } NO_2}{1\text{ mol } NO_2} \times \frac{46.01\text{ g } NO_2}{} = 46.01\text{ g } NO_2 \text{ is formed}$$

#2. a) $Zn + I_2 \rightarrow ZnI_2$

b) 50.0 g Zn → 0.765 mol Zn → 0.765 mol ZnI_2

→ 50.0 g I_2 → 0.197 mol I_2 → 0.197 mol ZnI_2

1) I_2 will be completely consumed (it's limiting)

2) I_2

3) 0.197 mol ZnI_2 → 62.9 g ZnI_2

4) 0.765 mol Zn − 0.197 mol Zn used = 0.568 mol Zn left

similar to lab exp 9 on limiting reactant.

37.1 g Zn

#3. a) $HCCH + 2H_2 \rightarrow C_2H_6$

b) $30.3\ g\ HCCH \mid \frac{1\ mol\ HCCH}{26.04\ g\ HCCH} \mid \frac{1\ mol\ C_2H_6}{1\ mol\ HCCH}$

$= 1.16\ mol\ C_2H_6$ if all HCCH is used

$4.14\ g\ H_2 \mid \frac{1\ mol\ H_2}{2.02\ g\ H_2} \mid \frac{1\ mol\ C_2H_6}{2\ mol\ H_2}$

H_2 is limiting

$= 1.02\ mol\ C_2H_6$ if all H_2 is used.

↓

$30.68\ g\ C_2H_6$

#4. a) $TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$

b) $3.54 \times 10^4\ g\ TiCl_4 \rightarrow 187$ moles Ti

$6.53 \times 10^3\ g\ Mg \rightarrow 134$ moles Ti → Mg is limiting

↓

$6430\ g\ Ti$

#5. MW = molecular weight (molar mass)

$20.0\ g\ Ca_3(PO_4)_2 \rightarrow 0.0322$ moles $P_4O_{10} \rightarrow 9.14\ g\ P_4O_{10}$

$20.0\ g\ SiO_2 \rightarrow 0.0554$ moles P_4O_{10}

$Ca_3(PO_4)_2$ is limiting!

#6. $24.5\ g\ NH_3 \rightarrow 0.719\ mol\ N_2$

$30.8\ g\ O_2 \rightarrow 0.642\ mol\ N_2 \rightarrow 17.973 \rightarrow 18.0\ g\ N_2$