Stoichiometry WS # 5 c.
Stoichiometry of excess quantities and % Yield

Answer Key

A substance that is not present in sufficient quantities to react with all of another substance present is called a limiting reactant; the other substance is said to be in excess.

1. If 2.20 g of cadmium reacts with 0.570 g of sulphur to produce cadmium sulphide as shown by **Cd + S -> CdS.**

a) Which is the limiting reactant?

$$2.20g\ Cd \times \frac{1 mol\ Cd}{112.4g\ Cd} = 0.01957$$

$$0.570g\ S \times \frac{1 mol\ S}{32.1g\ S} = 0.017757 \leftarrow \text{limiting}$$

(1:1 ratio)

b) How much (mass) cadmium sulphide is produced?

$$0.570g\ S \times \frac{1 mol\ S}{32.1g\ S} \times \frac{1 mol\ CdS}{1 mol\ S} \times \frac{144.5g\ CdS}{1 mol\ CdS} = 2.57g$$

b) Which reactant is the reactant with the excess quantity? Calculate the mass of the reactant in excess that is left over from the reaction above.

$$0.017757\ mol\ S\ used \times \frac{1 mol\ Cd}{1 mol\ S} = 0.017757\ mol\ Cd\ used$$

$$0.01957 - 0.017757 = 0.001813\ mol\ Cd\ left \times \frac{112.4g\ Cd}{1 mol\ Cd} = 0.20g$$

2. In an experiment, 8.51 g of H_2 and 9.25 g O_2 are placed in a reaction vessel. The introduction of a spark causes a violent explosion that generates water.

$2H_2 + O_2 \rightarrow 2H_2O$

a) Calculate the mass of water generated from this reaction. (you need to find the limiting reactant first)

$$8.51g\ H_2 \times \frac{1 mol\ H_2}{2.0g\ H_2} = \frac{4.255\ mol\ H_2}{2} \rightarrow 2.128 \text{ excess}$$

★ limiting

$$9.25g\ O_2 \times \frac{1 mol\ O_2}{32.0g\ O_2} = 0.289\ mol \times \frac{2 mol\ H_2O}{1 mol\ O_2} \times \frac{18.0g\ H_2O}{1 mol\ H_2O} = 10.4g\ H_2O$$

b) Calculate the mass of the reactant that was in excess amount.

$$0.289\ mol\ O_2 \times \frac{2 mol\ H_2}{1 mol\ O_2} \times \frac{2.0g\ H_2}{1 mol\ H_2} = 1.16g\ H_2\ used$$

$$8.51 - 1.16 = 7.35g\ H_2\ left$$

3. In a precipitation reaction, 50.0 mL of a 0.40 M $CaCl_2$ reacts with 60.0 mL of 0.30 M Na_2CO_3 solution. Calculate the mass of $CaCO_3$ produced? This is a double replacement reaction.

$CaCl_2 + Na_2CO_3 \rightarrow 2NaCl + CaCO_3$

$$0.0500L \times 0.40M = 0.0200\ mol\ CaCl_2$$

$$0.0600L \times 0.30M = 0.0180\ mol\ Na_2CO_3 \text{ ★ limiting}$$

$$0.0180\ mol\ Na_2CO_3 \times \frac{1 mol\ CaCO_3}{1 mol\ Na_2CO_3} \times \frac{100.1g\ CaCO_3}{1 mol\ CaCO_3} = 1.80g\ CaCO_3$$

Percent Yield. The actual yield divided by the ideal, or theoretical yield, and multiplied by 100 equals the percent yield. Calculate the percent yield of the following:

1. The maximum amount of $CaCO_3$ that could be made during the experiment was 1.2 g. This is referred to as the theoretical yield. The actual amount that was obtained was 0.80 g. What is the percent yield ?

$$\frac{0.80g}{1.20g} \times 100\% = 66.7\%$$

2. $Ca + Cl_2 \rightarrow CaCl_2$

If 40.0 g of Ca and 80.0 of Cl_2 were present as reactants. Only 106 g of $CaCl_2$ is produced. What is the percent yield? You need to find the limiting reactant, and then calculate the theoretical yield first.

$$40.0g\ Ca \times \frac{1\,mol\ Ca}{40.1g\ Ca} = 0.9975\ mol \quad \text{limiting}$$

$$80.0g\ Cl_2 \times \frac{1\,mol\ Cl_2}{71.0g\ Cl_2} = 1.127\ mol$$

$$0.9975\ mol\ Ca \times \frac{1\,mol\ CaCl_2}{1\,mol\ Ca} \times \frac{111.1g\ CaCl_2}{1\,mol\ CaCl_2} = 111g$$

$$\frac{106g}{111g} \times 100\% = 95.5\%$$

3. $N_2 + 3\,H_2 \rightarrow 2\,NH_3$

If 2.8 g of N_2 and 5.0 g of H_2 were present as reactants. Only 1.45 g of NH_3 are produced. What is the percent yield?

$$2.8g\ N_2 \times \frac{1\,mol\ N_2}{28.0g\ N_2} = 0.10\ mol$$

limiting

$$5.0g\ H_2 \times \frac{1\,mol}{2.0g} = \frac{2.5}{3} = 0.83$$

$\div 3$

$$0.10\ mol\ N_2 \times \frac{2\,mol\ NH_3}{1\,mol\ N_2} \times \frac{17.0g\ NH_3}{1\,mol\ NH_3} = 3.4g\ NH_3$$

$$\frac{1.45g}{3.4g} \times 100 = 42.6\%$$

4. What mass of K_2CO_3 is produced when 0.50 g of KO_2 is reacted with an excess of CO_2 according to the reaction:

$$4\,KO_{2\,(g)} + 2\,CO_{2(g)} \text{-----------} > 2\,K_2CO_{3\,(s)} + 3\,O_{2(g)}$$

if the reaction produces a 55.0% yield?

$$0.50g\ KO_2 \times \frac{1\,mol\ KO_2}{71.1g\ KO_2} \times \frac{2\,mol\ K_2CO_3}{4\,mol\ KO_2} \times \frac{138.2g\ K_2CO_3}{1\,mol\ K_2CO_3} = 0.4859g$$

$$0.4859g \times 0.55 = 0.27g\ K_2CO_3$$