Limiting Reagents and Percent Yield

In a chemical reaction, an insufficient quantity of any of the reactants will limit the amount of product that forms.

In the ammonia reaction

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

exactly 1 mole of nitrogen gas reacts with 3 moles of hydrogen gas.

What if we were to react 2 moles of N_2 with 3 moles of H_2?

$$2N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

The reaction to make ammonia will still take place, but will have an excess mol of nitrogen gas.

Before the reaction After the reaction

$$2N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

$N_2(g)$ <----- extra reactant

In this reaction, only the hydrogen is completely used up. It is the limiting reagent.

The limiting reagent determines the amount of product that can be formed by a reaction. The reaction occurs only until the limiting reagent is used up.

The reactant that is not completely used up is called the excess agent. In this example, nitrogen will be the excess agent.

Example

Copper reacts with sulfur to form copper(I) sulfide according to the following balanced equation.

$$2Cu(s) + S(s) \longrightarrow Cu_2S(s)$$

What is the limiting reagent when 80.0g of Cu reacts with 25.0g of S?

Example 2

What is the maximum number of grams of Cu_2S that can be formed when 80.0g Cu reacts with 25.0g S?

$$2Cu(s) + S(s) \longrightarrow Cu_2S(s)$$

Percent Yield

When an equation is used to calculate the amount of product that will form during a reaction, the calculated value represents the theoretical yield.

The actual yield is the amount of product that actually forms in the laboratory experiment.

The percent yield is the ratio connect these together.

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

The percent yield is the measure of the efficiency of a reaction carried out in the laboratory.

Example 3

Calcium carbonate, which is found in seashells, is decomposed by heating. The balanced equation for this reaction is:

$$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$$

What is the theoretical yield of CaO if 24.8g $CaCO_3$ is heated?

Example 4

What is the percent yield if 13.1 g CaO is actually produced when 24.8g $CaCO_3$ is heated?

$$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$$

Try questions 25-35 on pages 370-375