

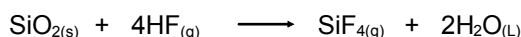
Notes Limiting Reactant and Percent Yield

Limiting Reactants

Once one of the reactants is used up, no more product can be produced and the reaction will stop. The **limiting reactant** is the reactant that is completely used up in the reaction and limits the amount of product that can be produced.

To determine the limiting reactant you will use a mole ratio of two reactants.

Silicon dioxide which is quartz is usually unreactive but will react with hydrogen fluoride.



If 6.0 mol of HF is added to 4.5 mol of SiO₂, which is the limiting reactant?

Steps to solving

1. State the given: 6.0 mol of HF
4.5 mol of SiO₂

State the unknown: limiting reactant

2. The mole ratio of HF to SiF₄ and the mole ratio of SiO₂ to SiF₄ will be needed.

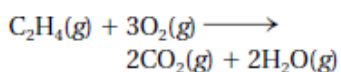
$$\frac{6.0 \text{ mol HF}}{1} \times \frac{1 \text{ mol SiF}_4}{4 \text{ mol HF}} = 1.5 \text{ mol SiF}_4$$

$$\frac{4.5 \text{ mol SiO}_2}{1} \times \frac{1 \text{ mol SiF}_4}{1 \text{ mol SiO}_2} = 4.5 \text{ mol SiF}_4$$

Because 6.0 moles of HF can only make 1.5 moles of SiF₄, HF is the limiting reactant.

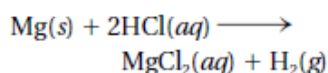
Practice Problems

25. The equation for the complete combustion of ethene (C₂H₄) is



If 2.70 mol C₂H₄ is reacted with 6.30 mol O₂, identify the limiting reagent.

26. Hydrogen gas can be produced by the reaction of magnesium metal with hydrochloric acid.



Identify the limiting reagent when 6.00 g HCl reacts with 5.00 g Mg. **Ans: HCl**

$$2.70 \text{ mol C}_2\text{H}_4 \times \frac{2 \text{ mol CO}_2}{1 \text{ mol C}_2\text{H}_4} = 5.40 \text{ mol CO}_2$$

$$6.30 \text{ mol O}_2 \times \frac{2 \text{ mol CO}_2}{3 \text{ mol O}_2} = 4.20 \text{ mol CO}_2$$

Which is limiting? O₂ but why?

Produces the least amount of CO₂

Try #26.

Notes Limiting Reactant and Percent Yield

Percent Yield

The amounts of products calculated under ideal conditions represent theoretical yields. **Theoretical yield** is the maximum amount of product that can be produced from a given amount of reactant. Most chemical reactions actually produce less than what the theoretical yield states.

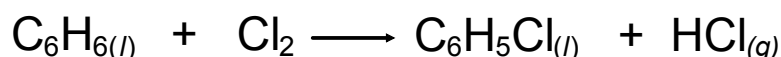
Why is this? There are many reasons, reactants may contain impurities that form byproducts and many reactions do not go to completion.

Ideal stoichiometric calculations can only predict what can be produced. The **Actual yield** is the measured amount of product that is obtained from doing the reaction in the lab. It is important to chemists and industries to know the efficiency of a reaction.

The efficiency is determined by **Percentage yield** which compares the ratio of actual yield to theoretical yield.

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

Chlorobenzene, $\text{C}_6\text{H}_5\text{Cl}$ is used in the production of aspirin. To make chlorobenzene, benzen must be reacted with chlorine.



When 36.8 g C_6H_6 react with an excess of Cl_2 , the actual yield of $\text{C}_6\text{H}_5\text{Cl}$ is 38.8 g. What is the percentage yield of $\text{C}_6\text{H}_5\text{Cl}$?

Steps to solving

1. State the given: 36.8 g of C_6H_6
38.8 g $\text{C}_6\text{H}_5\text{Cl}$ actual yield
State the unknown: percentage yield of $\text{C}_6\text{H}_5\text{Cl}$
2. Molar mass of C_6H_6 and $\text{C}_6\text{H}_5\text{Cl}$ is needed and the mole ratio of C_6H_6 and $\text{C}_6\text{H}_5\text{Cl}$ is needed.

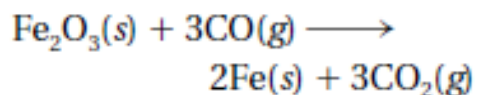
$$\frac{36.8 \text{ g } \text{C}_6\text{H}_6}{1} \times \frac{1 \text{ mol } \text{C}_6\text{H}_6}{78.12 \text{ g } \text{C}_6\text{H}_6} \times \frac{1 \text{ mol } \text{C}_6\text{H}_5\text{Cl}}{1 \text{ mol } \text{C}_6\text{H}_6} \times \frac{112.56 \text{ g } \text{C}_6\text{H}_5\text{Cl}}{1 \text{ mol } \text{C}_6\text{H}_5\text{Cl}} =$$

$$= 53.0 \text{ g } \text{C}_6\text{H}_5\text{Cl} \text{ (theoretical yield)}$$

$$\text{percentage yield} = \frac{38.8 \text{ g}}{53.0 \text{ g}} \times 100 = 73.2\%$$

Practice Problems

29. When 84.8 g of iron(III) oxide reacts with an excess of carbon monoxide, iron is produced.



What is the theoretical yield of iron?

30. When 5.00 g of copper reacts with excess silver nitrate, silver metal and copper(II) nitrate are produced. What is the theoretical yield of silver in this reaction?