

General Chemistry 1

Quarter 1, Lesson 14

LIMITING AND EXCESS REAGENTS

Objectives:

- Define the concept of limiting and excess reactants.
- Determine the limiting and excess reactants using mole ratios from balanced chemical equations.

When a chemical reaction is carried out in a flask, the amount of reactants are not always present in the exact proportion stoichiometrically determined from the balanced equation. To make sure that the more expensive reagent is completely used up and converted to the desired product, chemists usually add the cheaper reagent in excess quantity. The reagent that has completely reacted and used up in a reaction is called the **limiting reagent**. The **excess reagent** is the reactant that is present in quantity higher than what is required to react with the limiting reagent.

Sample Problem 1. Let's use the chemical equation below:



Ammonia, NH_3 , is synthesized from the reaction of H_2 and N_2 gases. Suppose 6 moles of H_2 was initially mixed with 4 moles of N_2 gas at high pressure. To determine which of the 2 reactants is the limiting reagent, the amount of NH_3 produced must be computed given the number of moles of H_2 and N_2 and the mole-mole factor from the balanced equation.

$$\text{moles } NH_3 = \cancel{\# \text{ moles of } H_2} \times \frac{2 \text{ moles } NH_3}{\cancel{3 \text{ moles } H_2}}$$

$$\begin{aligned} \text{moles } NH_3 &= 6 \cancel{\text{ moles of } H_2} \times \frac{2 \text{ moles } NH_3}{\cancel{3 \text{ moles } H_2}} \\ \text{moles } NH_3 &= 4 \text{ moles} \end{aligned}$$

$$\text{moles } NH_3 = \cancel{\text{moles of } N_2} \times \frac{2 \text{ moles } NH_3}{\cancel{1 \text{ mole } N_2}}$$

$$\begin{aligned} \text{moles } NH_3 &= 4 \cancel{\text{ moles of } N_2} \times \frac{2 \text{ moles } NH_3}{\cancel{1 \text{ mole } N_2}} \\ \text{moles } NH_3 &= 8 \text{ moles} \end{aligned}$$

From the computed values we determined that if 6 moles of H_2 completely reacts with N_2 , it can produce 4 moles of NH_3 while 4 moles of N_2 can produce 8 moles of NH_3 when fully used up. Since there is less amount of NH_3 produced with 6 moles of H_2 than 4 moles of N_2 , H_2 gas is the limiting reagent while the N_2 gas is the reagent in excess. To determine how much of the 4 moles of N_2 is in excess, we will use the mole-mole factor of N_2 and H_2 .

$$\begin{aligned} \text{moles } N_2 &= 6 \cancel{\text{ moles of } H_2} \times \frac{1 \text{ mole } N_2}{\cancel{3 \text{ moles } H_2}} \\ \text{moles } N_2 &= 2 \text{ moles} \end{aligned}$$

The number of moles of N_2 required to fully react to 6 moles of H_2 is only 2 moles. Thus, the initial 4 moles of N_2 has an excess of 2 moles.

$$\text{excess } N_2 = 2 \text{ moles} - 2 \text{ moles} = 2 \text{ moles}$$

Sample Problem 2. The combustion of ethane produces carbon dioxide and water shown in the reaction below:



- How many moles of CO_2 are produced with 56.2 moles C_2H_6 and 73.4 moles of O_2 ?
Solution:

$$\begin{aligned} \text{moles } CO_2 &= 56.2 \cancel{\text{ moles of } C_2H_6} \times \frac{4 \text{ moles } CO_2}{\cancel{2 \text{ moles } C_2H_6}} \\ \text{moles } CO_2 &= 112.4 \text{ moles} \end{aligned}$$

$$\begin{aligned} \text{moles } CO_2 &= 73.4 \cancel{\text{ moles of } O_2} \times \frac{4 \text{ moles } CO_2}{\cancel{7 \text{ moles } O_2}} \\ \text{moles } CO_2 &= 41.9 \text{ moles} \end{aligned}$$

- Which reagent is the limiting reagent? Which is the excess reagent?
The Limiting reagent is O_2 while the excess reagent is C_2H_6 .
- How many moles of C_2H_6 are in excess?

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