

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.

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

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

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:



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

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

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

2. 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 .
3. How many moles of C_2H_6 are in excess?

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David Baud



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Table of Contents Sample Problem Of Limiting Reactants Answer Key

1. Understanding the eBook Sample Problem Of Limiting Reactants Answer Key
 - The Rise of Digital Reading Sample Problem Of Limiting Reactants Answer Key
 - Advantages of eBooks Over Traditional Books
2. Identifying Sample Problem Of Limiting Reactants Answer Key
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Sample Problem Of Limiting Reactants Answer Key
 - User-Friendly Interface
4. Exploring eBook Recommendations from Sample Problem Of Limiting Reactants Answer Key
 - Personalized Recommendations
 - Sample Problem Of Limiting Reactants Answer Key User Reviews and Ratings
 - Sample Problem Of Limiting Reactants Answer Key and Bestseller Lists
5. Accessing Sample Problem Of Limiting Reactants Answer Key Free and Paid eBooks
 - Sample Problem Of Limiting Reactants Answer Key Public Domain eBooks
 - Sample Problem Of Limiting Reactants Answer Key eBook Subscription Services
 - Sample Problem Of Limiting Reactants Answer Key Budget-Friendly Options
6. Navigating Sample Problem Of Limiting Reactants Answer Key eBook Formats
 - ePub, PDF, MOBI, and More
 - Sample Problem Of Limiting Reactants Answer Key Compatibility with Devices
 - Sample Problem Of Limiting Reactants Answer Key Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Sample Problem Of Limiting Reactants Answer Key
 - Highlighting and Note-Taking Sample Problem Of Limiting Reactants Answer Key
 - Interactive Elements Sample Problem Of Limiting Reactants Answer Key

8. Staying Engaged with Sample Problem Of Limiting Reactants Answer Key
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Sample Problem Of Limiting Reactants Answer Key
9. Balancing eBooks and Physical Books Sample Problem Of Limiting Reactants Answer Key
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Sample Problem Of Limiting Reactants Answer Key
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Sample Problem Of Limiting Reactants Answer Key
 - Setting Reading Goals Sample Problem Of Limiting Reactants Answer Key
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Sample Problem Of Limiting Reactants Answer Key
 - Fact-Checking eBook Content of Sample Problem Of Limiting Reactants Answer Key
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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