Limiting and Excess Reactants

Read from **Lesson 3: Limiting and Excess Reactants** in the **Chemistry Tutorial Section, Chapter 9** of **The Physics Classroom**:

Part a: Non-Stoichiometric Conditions
Part b: Solving Limiting Reactant Problems
Part c: Determining the Excess Amount

Limiting and Excess Reactants

Limiting reactant and excess reactant problems are different than the usual stoichiometry or percent yield problems. They start off by giving you the amount of both reactants. The **limiting** reactant is the one that runs out first and stops the reaction. This will prevent or "limit" any more product from being made - even if other reactants are still available. The other reactant, the **excess** reactant, is the one that will be left over after all of the limiting reactant is used up. By identifying the limiting reactant, you can calculate the maximum possible yield of the product.

Limiting Reactant	Excess Reactant
• The reactant that is used up first. There is none left when the reaction is over. • The reactant that produces the least amount of product.	• The reactant that is left over. • Availability is greater than the stoichiometrically required amount. • a.k.a., the leftover reactant.

ICE Tables

An ICE (Initial, Change, Ending) table is a simple table format used to simplify calculations in chemistry problems. In stoichiometry problems, it is used to keep track of the amount of reactants and products that are initially present, the amount of change that occurs as the result of the reaction, and the ending amount of reactants and product.

For example, 100. g of hydrogen gas reacts with 200. g of oxygen gas to produce water vapor. $\mathbf{2H_2 + O_2 \rightarrow 2H_2O}$

a. What is the limiting reactant in this reaction?
b. What is the excess reactant and how much of the excess reactant remains after the limiting reactant is used up?
c. What is the maximum amount of water vapor that can be formed?

After converting the grams of reactants to moles of reactants and using mole ratios in the ICE table for calculations, these questions can be answered.

$$100 \text{ g } H_2 \cdot \frac{1 \text{ mol } H_2}{2.02 \text{ g } H_2} = 49.5 \text{ mol } H_2 \qquad 200 \text{ g } O_2 \cdot \frac{1 \text{ mol } O_2}{32.00 \text{ g } O_2} = 6.25 \text{ mol } O_2$$

	$2H_2$	+	O_2	→	$2H_2O$
Initial	49.5 mol		6.25 mol		
Change	(- 2* 6.25 mol) -12.5 mol		- 6.25 mol		(+ 2* 6.25 mol) + 12.5 mol
Ending	37.0 mol		0 mol		12.5 mol

a. Since there are <u>0</u> moles of O_2 left after reacting with the H_2, we can say that the **O_2 is the limiting reactant.**

b. **H_2 is the excess reactant** and the number of moles of H_2 that remain after all of the O_2 is used up is 37.0 mol or (37.0 mol * 2.02 g/mol) or **74.7 g H_2 remain after all of the O_2 is used up**.

c. The maximum amount of H_2O that can be produced is 12.5 mol or (12.5 mol * 18.02 g/mol) or **225 g H_2O produced**.

Stoichiometry **Name**___________________________________

Limiting and Excess Reactants Problems

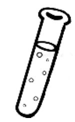
Solve the following problems using ICE tables to set up the problem. Show your work on a separate piece of paper. Answer these questions for each problem:

a. What is the balanced equation for the reaction?
b. What is the limiting reactant in the reaction?
c. What is the excess reactant and how much of the excess reactant remains after the limiting reactant is used up?
d. What is the maximum amount of specified product that can be formed?
e. If all of the excess reactant were to be used up, how much more of the limiting reactant would be needed?

1. The average human body contains around 0.250 g sodium chloride. How much sodium chloride could be produced from the reaction of 1.00 mol of sodium and 1.00 mol of chloride gas?

2. Sodium hydroxide and carbon dioxide react to produce sodium carbonate and water. If 1.00 mol of each reactant is allowed to react, use the production of sodium carbonate in your calculations.

3. Ellie Ment is producing hydrogen gas for a demonstration in chemistry class. She reacts 0.500 mol zinc metal with a 15.0 g hydrochloric acid solution. Zinc chloride is also produced but use hydrogen gas in your calculations.



4. Silver nitrate and sodium phosphate react in a double replacement reaction to form silver phosphate and sodium nitrate. Focus on how much sodium nitrate can be produced if 75.0 g of each reactant are used.

5. When Alka Seltzer® tablets dissolve in water, carbon dioxide bubbles form. The reaction of 1.90 g sodium hydrogen carbonate and 1.00 g citric acid ($H_3C_6H_5O_7$) in each tablet produces the carbon dioxide bubbles, water, and sodium citrate ($Na_3C_6H_5O_7$). Use water as your target product in your calculations. Oh, what a relief it is to do limiting reactant problems!

6. Chef Toast Malone uses a standard lighter to light his gourmet grill. The lighter uses 4.36 g of butane (C_4H_{10}) and 10.0 g of oxygen gas to produce carbon dioxide and water in its combustion reaction. Use carbon dioxide as your target product in your calculations.

7. Pollutants from power plants can cause sulfuric acid (acid rain). Some farmers use slaked lime (calcium hydroxide) to neutralize acid rain by putting slaked lime on their fields. Consider the reaction of 100 g of sulfuric acid and 100 g of calcium hydroxide and how much water could be produced from this neutralization reaction.

8. In a precipitation reaction in chem lab, Molly Cule combines 7.00 g of sodium phosphate to react with 8.9 of barium nitrate. Consider calculations for the production of the precipitate from this reaction.