

Stoichiometry

Chapter 11

Objectives

- **Describe** the types of relationships indicated by a balanced chemical equation
- **State** the mole ratios from a balanced chemical equation
- **MAIN IDEA:** The amount of each reactant present at the start of a chemical reaction determines how much product can be formed

Stoichiometry

- **Stoichiometry** – study of the amount of substances consumed and produced in chemical reactions
 - Can calculate the quantities of substances in a chemical equation from other substances as long as the chemical equation is **balanced**
 - Stoichiometry will combine all of the things we have already learned
 - Chemical reactions stop when one of the reactants is used up

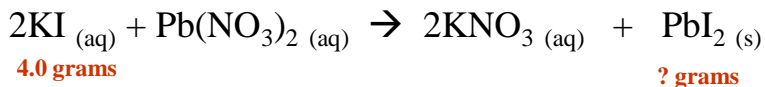
- **To solve stoich problems:**
 - Will need a **balanced** chemical equation
 - Determine known(s) and unknown(s)
 - Determine mole ratio of known and unknown(s)

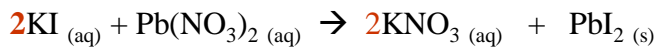
Remember the 2 clear liquids that formed a yellow precipitate?

- 4.0 grams of Potassium iodide is combined with an excess amount lead II nitrate will produce how many grams of precipitate?

1st write Balanced equation

2nd include knowns and unknowns





4.0 grams

? grams

- The **coefficients** in the balanced eqn give the relative number of moles of reactants and products
- A **molar ratio** is a ratio between the numbers of moles of any two substances in a balanced equation. **Gets you from what you know to what you don't know!**
- In Stoichiometric Calculations – **Must go through MOLES!!!** Will use MOLAR RATIO
- How do we start problem?? **START WITH WHAT YOU KNOW!!!!!!**

Molar Ratio

$$\left(\frac{4.0 \text{ g KI}}{1}\right) \left(\frac{1 \text{ mole KI}}{166.0 \text{ g KI}}\right) \left(\frac{1 \text{ mole PbI}_2}{2 \text{ mole KI}}\right) \left(\frac{461.0 \text{ g PbI}_2}{1 \text{ mole PbI}_2}\right) = \boxed{5.6 \text{ g PbI}_2}$$

Objectives – Limiting Reactants

- **Calculate** the mass of product when the amounts of more than one reactant are given
- **Identify** the limiting reactant in a chemical equation
- **Identify** the excess reactant, and calculate the amount remaining after the reaction is complete

Why do reactions stop?

- Reactions proceed until one of the reactants is **used up** and one is left in **excess**
- The **Limiting Reactant** limits the extent of the reaction and determines the amount of product formed
- The **Excess Reactant** are all the leftover unused reactants
- Determining the limiting reactant is important **because the amounts of the products formed depends on this reactant**

Cookie Recipe

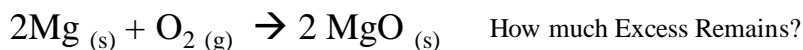
<u>Supply in House (given)</u>	<u>Recipe (formula)</u>	<u>Product</u>
12 eggs	2 eggs	1 dozen cookies
20 cups of flour	2 cups flour	
3 cups of chips	1 cup chips	
5 cups sugar	1 cup sugar	

- Which will you run out of 1st?
 - Chips: This is the **Limiting Reactant**
 - The rest are **Excess Reactants**
- How much product can we make?
 - Chips is limiting so you can make 3 dozen cookies

Limiting/Excess Reactions

- It is a **limiting/excess** problem when the amounts of more than one reactant are given

Which one is Excess?



How much Excess Remains?

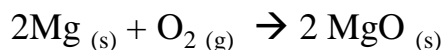
Have 5.6 g 15.6 g ? g How many grams of MgO are produced?

Step 1: Ignore amount Given for one of the Reactants

Determine how much you **NEED** of Ignored Reactant

$$\left(\frac{5.6 \text{ g Mg}}{1}\right) \left(\frac{1 \text{ mole Mg}}{24.3 \text{ g Mg}}\right) \left(\frac{1 \text{ mole O}_2}{2 \text{ mole Mg}}\right) \left(\frac{32.0 \text{ g O}_2}{1 \text{ mole O}_2}\right) = \boxed{3.7 \text{ g O}_2}$$

Need



Have 5.6 g 15.6 g ? g

Need

3.7 grams O₂

Step 2: Compare what you **HAVE** and what you **NEED**

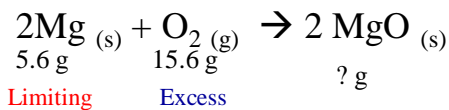
Determine Excess and Limiting

15.6 g O₂ Have

3.7 g O₂ Need

11.9 g O₂ Excess

And then Mg has to be the limiting reactant



Step 3: Determine Products – START with LIMITING!!!!

$$\left(\frac{5.6\text{ g Mg}}{1} \right) \left(\frac{1\text{ mole Mg}}{24.3\text{ g Mg}} \right) \left(\frac{2\text{ mole MgO}}{2\text{ mole Mg}} \right) \left(\frac{40.3\text{ g MgO}}{1\text{ mole MgO}} \right) = \boxed{9.3\text{ g MgO}}$$

How much Product?

- Laboratory reactions do not always produce the calculated amounts of products
 - Reactants stick to containers
 - Spills
 - Competing reactions form other by products

- The **Theoretical yield** is the maximum amount of product that can be produced from a given amount of reactant
 - This is what we figure out with **math!**

- The **actual yield** is the amount of product actually produced when the chemical reaction is carried out in an experiment
 - Accounts for lost chemicals: The **amount measured** in the lab!



How much product?

- The **percent yield** of a product is the ratio of the actual yield expressed as a percent
 - Percent yield is important in the cost effectiveness of many industrial manufacturing processes

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



Key Concepts

- Balanced chemical equations can be interpreted in terms of moles, mass, and representative particles (atoms, molecules, formula units).
- The **law of conservation of mass** applies to all chemical reactions.
- **Mole ratios** are derived from the coefficients of a balanced chemical equation. Each mole ratio relates the number of moles of one reactant or product to the number of moles of another reactant or product in the chemical reaction
- Chemists use stoichiometric calculations to predict the amounts of reactants used and products formed in specific reactions.
- The first step in solving stoichiometric problems is writing the balanced chemical equation.
- Mole ratios derived from the balanced chemical equation are used in stoichiometric calculations.



Key Concepts

- Stoichiometric problems make use of mole ratios to convert between mass and moles
- The limiting reactant is the reactant that is completely consumed during a chemical reaction. Reactants that remain after the reaction stops are called excess reactants.
- To determine the limiting reactant, the actual mole ratio of the available reactants must be compared with the ratio of the reactants obtained from the coefficients in the balanced chemical equation.
- Stoichiometric calculations must be based on the limiting reactant.



Key Concepts

- The **theoretical yield** of a chemical reaction is the maximum amount of product that can be produced from a given amount of reactant. Theoretical yield is calculated from the balanced chemical equation.
- The **actual yield** is the amount of product produced. Actual yield must be obtained through experimentation.
- **Percent yield** is the ratio of actual yield to theoretical yield expressed as a percent. High percent yield is important in reducing the cost of every product produced through chemical processes.