# Chapter 4 Part 3

Dr. Turner

# Mole Ratio

- A mole ratio is the ratio between the amounts in moles of any two compounds involved in a chemical reaction
- They can be found by examining the coefficients in front of compounds in a balanced chemical equation

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

For example, the mole ratio of $CH_4$ to $O_2$ is 1:2

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What is the mole ratio of $H_2O$ to $CO_2$?

# Jumbo Jack's Ham Sandwiches

"The Jumbo" Recipe

1. 2 slices of bread
2. 6 pieces of ham
3. 1 slice of cheese

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How many Jumbos can you make with 8 slices of bread with unlimited pieces of ham and unlimited slices of cheese?

A. 1
B. 2
C. 3
D. 4

# How can we relate this to chemical reactions?

We combine the ingredients to make the dish in accordance with the recipe

# How can we relate this to chemical reactions?

We combine the _____ to make the _____ in accordance with the _____.

Word bank:
mole ratio, reactants, products

# Chemical Reactions

How many moles of water, $H_2O$, could be produced by the reaction of 3 moles of methane, $CH_4$, with excess oxygen gas, $O_2$?

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

A. 1.5
B. 2
C. 3
D. 6

# Stoichiometry

- Stoichiometry is the calculation of quantities of any substances involved in a chemical reaction from the quantities of the other substances.
- Stoichiometry refers to the ratios of substances in a chemical reaction and, thus, requires a balanced chemical equation.
- Stoichiometry essentially relates dimensional analysis to chemical reactions by incorporating mole ratios

# Mole Stoichiometry

Calculate the number of moles of aluminum that will react with 3.18 mol oxygen to form aluminum oxide.

$$4\ Al(s) + 3\ O_2(g) \rightarrow 2\ Al_2O_3(s)$$

# Formula Unit Stoichiometry

A sample of 0.1146 mol solid $KClO_3$ decomposes into KCl and $O_2$ gas. Calculate the number of molecules of oxygen gas produced.

$$2\ KClO_3(s) \rightarrow 3\ O_2(g) + 2\ KCl(s)$$

# Mass Stoichiometry

Calculate the mass of chlorine gas in grams that can be produced by the electrolysis of 50.0 g of sodium chloride in concentrated aqueous solution.

$$2\ NaCl(aq) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + Cl_2(g) + H_2(g)$$

# Mass Stoichiometry

Calculate the number of moles of $SO_2$ gas required to prepare 50.0 metric tons of liquid $H_2SO_4$ (1 metric ton $= 1 \times 10^6$ g).

$$2\ SO_2(g) + O_2(g) + 2\ H_2O(l) \rightarrow 2\ H_2SO_4(l)$$

# Jumbo Jack's Ham Sandwiches

"The Jumbo" Recipe

1. 2 slices of bread
2. 6 pieces of ham
3. 1 slice of cheese

If you are given 6 slices of bread, 6 pieces of ham, and 8 slices of cheese, how many Jumbos can you make?

# Limiting Reagents

How many carbon dioxide moles can be produced from a reaction of 12 moles of methane with 6.0 moles of oxygen gas?

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

# Jumbo Jack's Ham Sandwiches

"The Jumbo" Recipe

1. 2 slices of bread
2. 6 pieces of ham
3. 1 slice of cheese

If you are given 600 grams of ham, 200 grams of bread, and 60 grams of cheese, how many Jumbos can you make?

# Jumbo Jack's Ham Sandwiches

"The Jumbo" Recipe

1. 2 slices of bread (50 grams per slice)
2. 6 pieces of ham (100 grams per slice)
3. 1 slice of cheese (30 grams per slice)

If you are given 600 grams of ham, 200 grams of bread, and 60 grams of cheese, how many Jumbos can you make?

# Limiting Reagents

How many grams of $CO_2$ (44 g/mol) could be formed by the reaction of 8.0 g of $CH_4$ (16 g/mol) with 48 g of $O_2$ (32 g/mol)?

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

# Limiting Reactants

For $H_2O(l) + N_2O_5(g) \rightarrow 2\ HNO_3(aq)$ what happens when you have 1 mol $H_2O$ and 0.5 mol $N_2O_5$?

A. The reaction cannot proceed.
B. The reaction can proceed to form 0.5 mol $HNO_3$.
C. The reaction can proceed to form 1 mol $HNO_3$.
D. The reaction can proceed to form 1.5 mol $HNO_3$.
E. The reaction can proceed to form 2 mol $HNO_3$.'

# Limiting Reagents

If 1.84 g of Al are allowed to react with 75.0 mL of 2.95 M HCl (36.46 g/mol), (A) what is the limiting reactant? (B) How many grams of $H_2$ are produced by the reaction? (C) How many grams of the excess reactant are remaining?

$$2\ Al(s) + 6\ HCl(s) \rightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$$

# Actual Yield vs. Theoretical Yield

## Actual Yield

- The actual yield is the amount of product that is actually obtained in an experiment.
- Comes from an experiment
- Indicated by words like (isolated, separated, produced, etc.)

## Theoretical Yield

- The theoretical yield is the maximum amount of product that can be formed from a reaction, based on the amounts of reactants available.
- Found using a stoichiometry calculation (usually a limiting reagent calculation)

# Percent Yield

- The percent yield is defined as 100% times the ratio of the actual yield to the theoretical yield.

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

# Forming Nitrobenzene

(A) How many grams of nitric acid, $HNO_3$ (63.0 g/mol), are required to fully react with 15.6 grams of benzene, $C_6H_6$ (78.1 g/mol)? (B) How many grams of nitrobenzene, $C_6H_5NO_2$ (123.1 g/mol), are produced by this reaction? (C) If a student is able to successfully isolate 24.2 g of nitrobenzene, $C_6H_5NO_2$ (123.1 g/mol). What is the percent yield of this reaction?

$$C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$$

# Forming Nitrobenzene (Part C)

(A) How many grams of nitric acid, $HNO_3$ (63.0 g/mol), are required to fully react with 15.6 grams of benzene, $C_6H_6$ (78.1 g/mol)? (B) How many grams of nitrobenzene, $C_6H_5NO_2$ (123.1 g/mol), are produced by this reaction? (C) If a student is able to successfully isolate 24.2 g of nitrobenzene, $C_6H_5NO_2$ (123.1 g/mol). What is the percent yield of this reaction?

$$C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$$

(C)

$$\frac{24.2\ \text{g}\ C_6H_5NO_2}{24.6\ \text{g}\ C_6H_5NO_2\ \text{(from part A)}} \times 100 = 98.4\ \%$$

# Percent Yield

How many grams of nitric acid, $HNO_3$ (63.0 g/mol), would be consumed in the production of 45.3 g of nitrobenzene, $C_6H_5NO_2$ (123.1 g/mol), at 89.0% yield?

$$C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$$