Chapter Goals 4.1-4.3

- ✓ Write balanced chemical equations.
- ✓ Calculate the molar mass of a molecule from its chemical formula and a table of atomic masses and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.
- ✓ Interconvert grams, moles, and numbers of formula units.
- ✓ Determine the number of moles and grams of one reactant needed to react with a given number of moles and grams of another reactant, and the number of moles and grams of product(s) that result from the reaction **"Stoichiometry"**
- ✓ Calculate the mass of products produced from a given mass of reactants and % yield.
- ✓ Identify the limiting and excess reactants in a reaction mixture.

– Law of conservation of mass
– Balancing equations by balancing atoms

- **The coefficients in a chemical reaction specify the relative amounts in moles of each of the substances involved in the reaction.**

Stoichiometry: The math of chemical reactions
Use the **ratios** in the ***balanced rxn eqn*** to calculate amounts of substances.

$2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$
stoichiometric ratio: 2 moles C_8H_{18} : 16 moles CO_2

The ratio of the coefficients acts as a **conversion factor** between the amount in moles of the reactants and products.

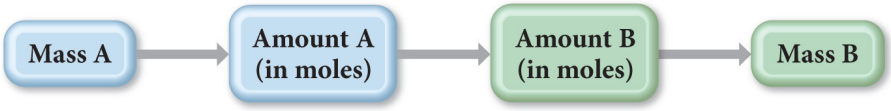
How many moles of Fe_2O_3 can form from 6.0 mole O_2?

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

4.0 mol

Mass-to-Mass Conversions:

1. Balance the chemical equation.
2. Convert mass or volume to moles.
3. Set up mole ratios as conversion factors.
4. Use mole ratios to calculate moles of desired substituent.
5. Convert moles to mass



6.50 grams of aluminum reacts with an excess of oxygen. How many grams of aluminum oxide are formed?

1. Balance the chemical equation **(number (mole) ratio**

2. When starting with masses, molar masses are needed **to convert from mass to moles!**

✓ Calculate molecular mass for each

Al:

O

Al_2O_3:

101.96

Use conversions to Solve

Theoretical Yield = 12.3 g

When 18.6 g ethane gas C_2H_6 burns in oxygen, how many grams of CO_2 are produced?

54.4 g

How many grams of O_2 are needed to produce 0.400 mole Fe_2O_3? (AM of O=16.00g/mol)

$4\ Fe(s) + 3\ O_2(g) \longrightarrow 2\ Fe_2O_3(s)$

19.2 g

Balance the chemical equation given below, and determine the number of grams of MgO needed to produce 15.0 g of Fe_2O_3.

$\_\_MgO(s) + \_\_ Fe(s) \rightarrow \_\_Fe_2O_3(s) + \_\_Mg(s)$

11.4

a) How many grams of Fe used for the same reaction?

10.5

b) How many grams of Mg were produced from the same reaction?

6.85

Theoretical yield : Amount of product that we calculate based on a perfect reaction.

- Reactions usually don't go to 100% product. Some product is lost for several reasons.
- The product you weigh at the end of the experiment is called the ***Actual yield***

$$\% \text{ yield= percent yield} = \frac{\text{Actual yield (g)}}{\text{Theoretical yield (g)}} \times 100$$

If 454 g of NH_4NO_3 decomposes, how much N_2O and H_2O are formed? What is the theoretical yield of products? If you isolated only 131 g of N_2O, what is the percent yield?

$$NH_4NO_3(s) \longrightarrow N_2O(g) + 2\ H_2O(g)$$

249.57

204

52.4%

Practice Without proper ventilation and limited oxygen, the reaction of carbon and oxygen produces carbon monoxide.

$2C(g) + O_2(g) \longrightarrow 2CO(g)$

What is the percent yield if 40.0 g CO are produced when 30.0 g O_2 are used?

52.5

76.2%

Usually we need to maximize the product yield $$$$$$
Think about the reverse case:

For the reaction: $3H_2\ (g) + N_2\ (g) \longrightarrow 2NH_3\ (g)$

We need 26.0 g NH_3, and we only get 30.0% yield for the above reaction. How much H_2 is needed in the presence of excess N_2?

**Remember 26.0 actual yield!!!!!*

86.6 g

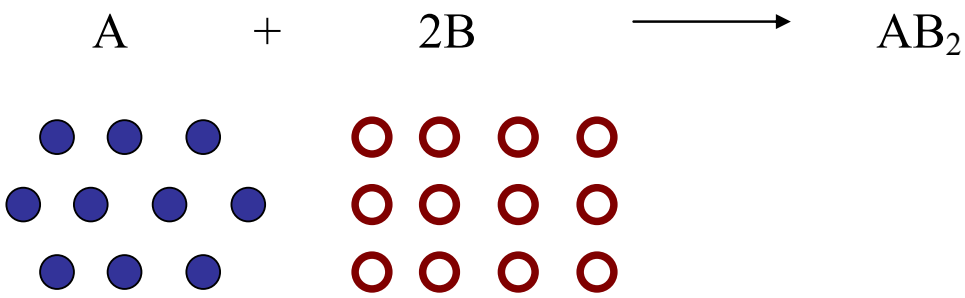
15.4 g

Limiting Reactants

- The limiting reactant is the reactant present in the reactant you'll run out of first.

Cheese + Bread ⟶ Sandwiches

- Which one is the limiting reactant??



- Calculate How much **product** you will get based on the limiting reactant

*A reactant that remains after a reaction is over is called the **excess reactant**

Limiting Reactant Problems:

- When you are given **amounts of two or more reactants**
- You'll need to write your balanced chemical equation (to know your recipe).
- Must solve for **moles of a Product** that would be produced by **each reactant** So it is two Mini Stoichiometry problems. *Work on each reactant separately

✓ The Reactant that will produce LESS Moles of the Product is the Limiting Reactant (LR)

- The Reactant that will Produce More Moles of the product is the Excess Reactant (ER)

❖ *Determination of the amount of excess reagent left over*

- *Calculate the amount of excess reagent (ER) used in chemical reaction (Use mole to mole factor between LR and ER)*
- *Subtract the ER used from original amount of ER.*

When 4.00 moles H_2 is mixed with 2.00 moles Cl_2, how many moles of HCl can form?

Practice If 192.0 gCa are mixed with 28.0 g N_2. Which is the limiting reactant?

$$3Ca(s) + N_2(g) \longrightarrow Ca_3N_2(s)$$

Practice When 7.00×10^{22} molecules of ammonia react with 6.00×10^{22} molecules of oxygen according to the chemical equation shown below, how many grams of nitrogen gas are produced?

$$4\ NH_3(g) + 3\ O_2(g) \rightarrow 2\ N_2(g) + 6\ H_2O(g)$$

 Magnesium oxide can be made by heating magnesium metal in the presence of the oxygen. The balanced equation for the reaction is

$$2Mg(s)+O_2(g)\rightarrow 2MgO(s)$$

When 15.3g Mg is allowed to react with 16.6g O_2, 12.1g MgO is collected.

a) Which is the limiting reactant? **(Show your detailed calculations)**

0.629 mol MgO
from Mg

1.04 mol MgO
from O_2

Limiting reactant

b) Determine the theoretical yield for the reaction. **(Show your calculations**
Express your answer in grams.

Theoretical yield
25.4 g MgO

c) Determine the percent yield for the reaction
Express your answer as a percent.

% yield

47.7%

 For the following reaction:

$2NH_3 + CO_2 \longrightarrow NH_2CO_2NH_4$

2.50 g 2.50 g

a) Which is the limiting reactant?

0.0734 mol

0.0572 mol

b) How many grams of the excess reactant remains after completion of reaction?

1.93 g NH_3 used

0.57g NH_3 remained

c) How much $NH_2CO_2NH_4$ is produced If 80% yield?

4 g