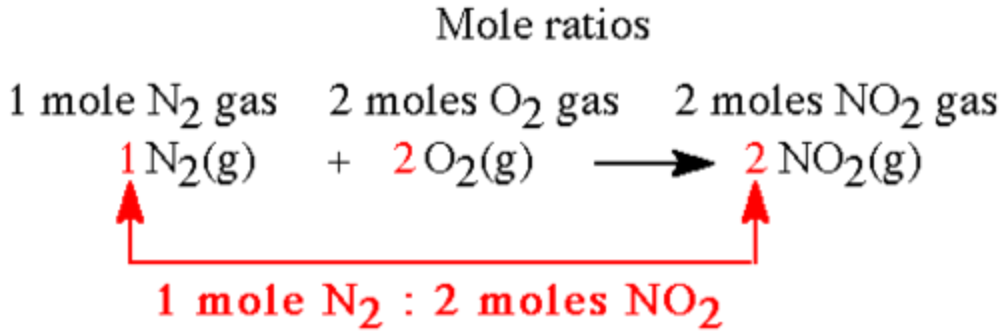
Stoichiometry:

Mole Ratios

*The **coefficients** in a chemical equation represent the relative number of _____ of each compound or element.



Example: Aluminum oxide is decomposed into aluminum metal and oxygen gas.

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

What would be the **mole ratio** of aluminum oxide (Al_2O_3) to aluminum (Al) in this reaction?

Example: If we have **13.0 mol of Al_2O_3** at the beginning of the reaction, how many **moles** of aluminum (Al) can be formed?

Practice: How many moles of oxygen gas would be produced if 2.5 moles of mercury oxide is heated?

$$2\ HgO(s) \rightarrow 2\ Hg(l) + O_2(g)$$

Practice: How many moles of ammonia (NH_3) gas would be required to completely react with 6.0 moles of nitrogen monoxide?

$$4\ NH_3(g) + 6\ NO(g) \rightarrow 5\ N_2(g) + 6\ H_2O(l)$$

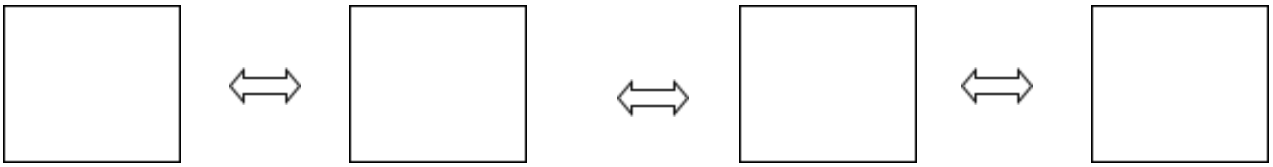
Practice: If we begin with 50.0 moles of aluminum (Al), how many moles of hydrogen gas (H_2) can we potentially make?

$$2\ Al(s) + 3\ H_2SO_4(l) \rightarrow Al_2(SO_4)_3(aq) + 3\ H_2(g)$$

Practice: If 0.60 moles of oxygen gas (O_2) are consumed in the following combustion reaction, how many moles of propane (C_3H_8) must have burned.

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$$

Stoichiometry Road Map



Example: In the following reaction, how many moles of lithium hydroxide are required to react with 20 g of CO_2?

$$CO_2(g) + 2\ LiOH(s) \rightarrow Li_2CO_3(s) + H_2O(l)$$

Example: What mass, in grams, of glucose is produced when 3,000 g of water reacts with carbon dioxide?

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$$

Example: This reaction is run using 824 g of NH_3 and excess oxygen. How many moles of NO are formed?

$$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$$

Practice:

How many moles of ammonia are produced when 6.0 g of hydrogen gas reacts with excess of nitrogen gas?

$$3\ H_2(g) + N_2(g) \rightarrow 2\ NH_3(g)$$

How many grams of potassium chlorate are needed to produce 15 grams of oxygen gas?

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

What mass, in grams, of magnesium oxide is produced from 140 g of magnesium?

$$2\ Mg + O_2 \rightarrow 2\ MgO$$

How many grams of mercury (II) oxide, HgO, are needed to produce 125 moles of oxygen, O_2?

$$2\ HgO \rightarrow 2\ Hg + O_2$$

How many moles of SnF_2 are produced from the reaction of 30.00 g HF with Sn?

$$Sn + 2\ HF \rightarrow SnF_2 + H_2$$

Extended Practice:

1) How many grams of NH_4NO_3 are required to produce 33.0 g N_2O? (Note: This is a skeleton equation!)

_____ NH_4NO_3 → _____ N_2O + _____ H_2O

2) What mass of silver metal is produced from 100. g of Cu? (Note: This is a skeleton equation!)

_____ Cu + _____ $AgNO_3$ → _____ Ag + _____ $Cu(NO_3)_2$

3) How many moles of aluminum are produced by the decomposition of 5.0 kg of Al_2O_3? (Note: This is a skeleton equation!)

$$\_\_\_\_ Al_2O_3 \rightarrow \_\_\_\_ Al + \_\_\_\_ O_2$$

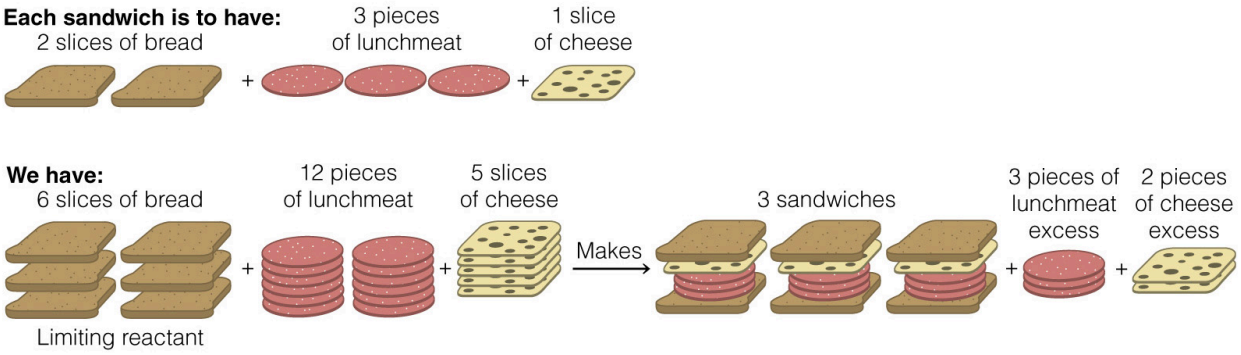
4) Copper(II) oxide (CuO) decomposes into copper (Cu) and oxygen (O_2) gas. What mass of copper will be produced by the decomposition of 1.25 kg CuO?

5) 20.0 g of iron(III) sulfide (Fe_2S_3) was prepared by heating iron (Fe) and excess sulfur (S). How many moles of iron (Fe) were used in the process?

6) Ammonia (NH_3) is produced by the reaction of nitrogen (N_2) and hydrogen (H_2) gases. How many milligrams (mg) of ammonia will be produced if 20.0 moles H_2 reacts with excess N_2?

Limiting reactant:

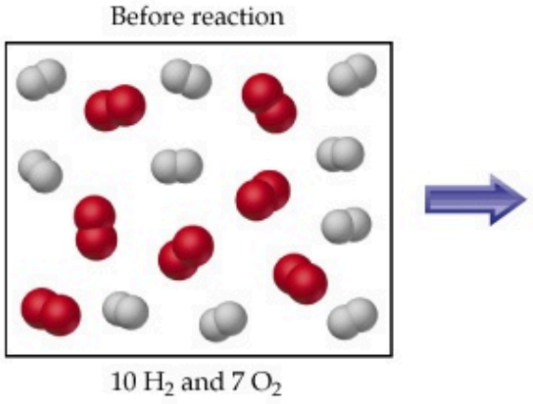
Excess reactant:



Limiting Reactant

Concept Check: In the following chemical reaction, if 10 molecules of H_2 react with 7 molecules of O_2, then how many molecules of H_2O can we form? What is the limiting reactant? How many molecules of the excess reactant would be left over?

$2\ H_2 + O_2 \rightarrow 2\ H_2O$



Example: If 4.0 moles of SiO_2 is add to 12.0 moles of HF, which is the limiting reactant?

$$SiO_2 + 4\ HF \rightarrow SiF_4 + 2\ H_2O$$

Example: What is the limiting reactant in this reaction when 0.750 g N_2H_4 reacts with 1.00 g of H_2O?

$$4\ N_2H_4 + 7\ H_2O_2 \rightarrow 2\ HNO_3 + 8\ H_2O$$

…How much nitric acid (in grams) is formed?

Example: When 0.670 moles of Fe is mixed with 0.360 moles of H_2O, how many moles of Fe_3O_4 is produced? How many moles of the excess reactant are left over?

$$3\ Fe + 4\ H_2O \rightarrow Fe_3O_4 + 4\ H_2$$

Example: If 2.00 g of Zn are heated with 2.00 g of S_8, how many grams of the product are formed? How many grams of the excess reactant are left over?

$$8\ Zn + S_8 \rightarrow 8\ ZnS$$

Practice: If 2.40 moles of carbon (CO_2) are exposed to 3.10 moles of steam (H_2O), identify the limiting reactant. Then, predict the number of moles of O_2 that is formed.

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

Practice: If 30.0 grams of both reactants are combined in the following chemical reaction, which will be limiting? How many grams of water should be produced? How many grams of the excess reactant remain after the reaction goes to completion?

$$B_2H_6 + 3\ O_2 \rightarrow 2\ HBO_2 + 2\ H_2O$$

Practice: In the following chemical equation, 100. g of KO_2 and 75 g of H_2O are combined. How many grams of oxygen gas will form? How many grams of the excess reactant are left over?

$$4\ KO_2 + 2\ H_2O \rightarrow 3\ O_2 + 4\ KOH$$

Percent Yield

Percent Yield:

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

Example: When 36.8 g C_6H_6 reacts with an excess of Cl_2, the actual yield of C_6H_5Cl is 38.8 g. What is the percentage yield of C_6H_5Cl?

$$C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl$$

Example: If 7.3 grams of sodium phosphate (Na_3PO_4) are used and the percent yield is 87.5%, what is the actual yield of tin (VI) phosphate?

$$3\ Sn(CO_3)_2 + 4\ Na_3PO_4 \rightarrow 6\ Na_2CO_3 + Sn_3(PO_4)_4$$

Practice: If 75.0 g of CO reacts to produce 68.4 g CH_3OH, what is the percentage yield of CH_3OH?

$$CO + 2\ H_2 \rightarrow CH_3OH$$

Practice: A student collected H_2O when 5.0 g of H_2 was reacted with excess O_2 gas. Determine the mass of H_2O collected if the percent yield is 74.34%.

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

Practice: Determine the mass of silver nitrate that reacted if 0.455 g of Ag_2CrO_4 is produced at an 84.96% yield.

$$2\ AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2\ KNO_3$$