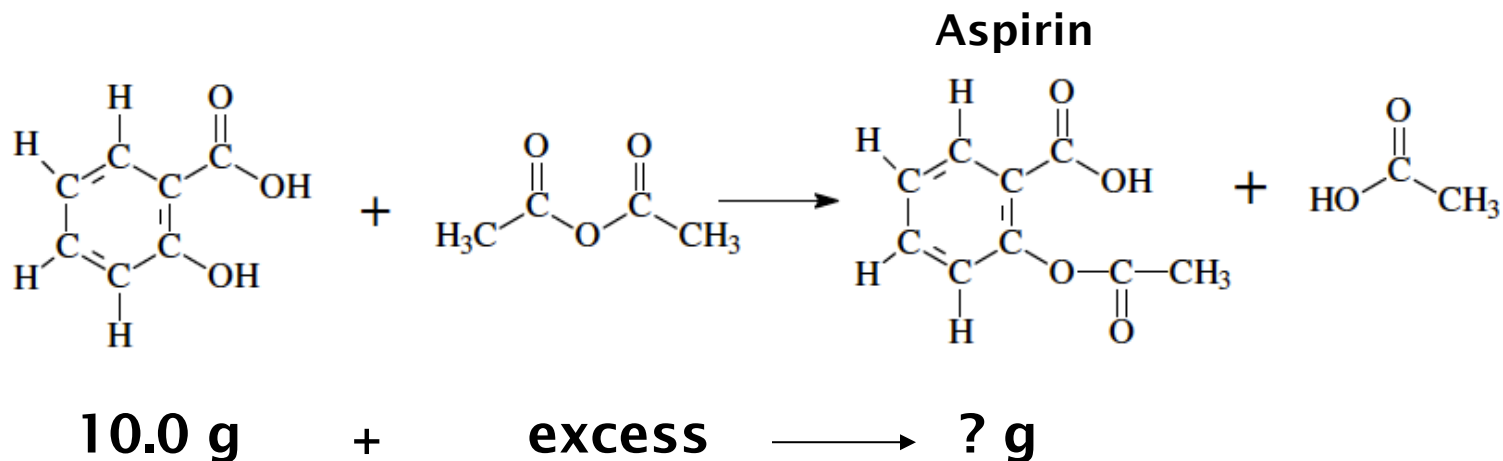
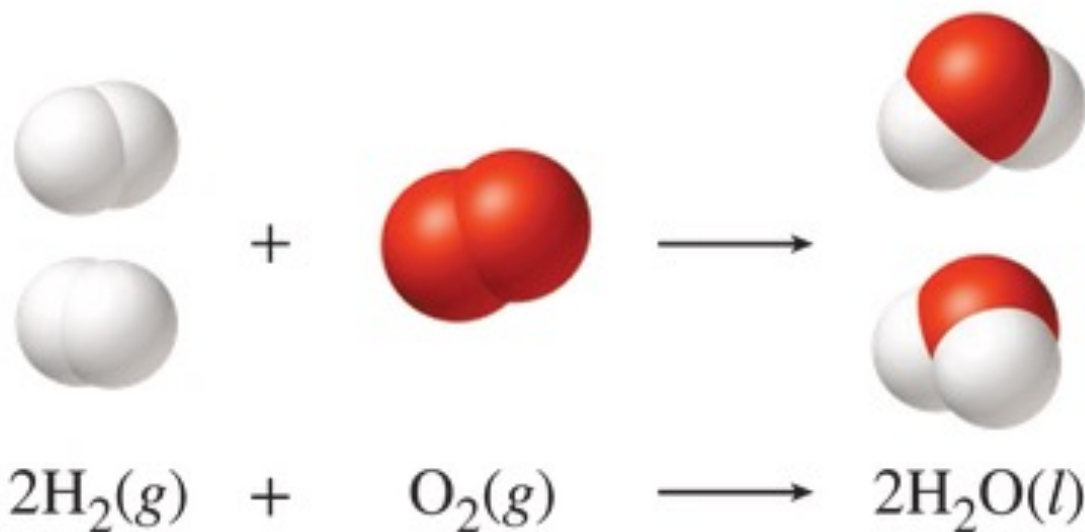


Chapter 8



Chemical Reactions

Chemical Equations



Chemical Equations

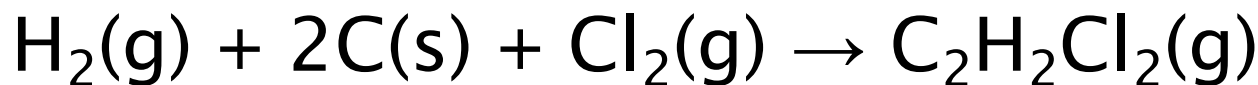
- Shorthand description of a chemical reaction
- Like a recipe!



- Symbols & formulas = elements & compounds
- Letters in parentheses = phases of matter



Chemical Equations



Reactants: Starting substances on left: H_2 , C , Cl_2

Products: Substances formed on right: $\text{C}_2\text{H}_2\text{Cl}_2$

Values in front of symbols: **Stoichiometric coefficients**

Coefficients = # moles of that substance

→ If there is no #, the coefficient is 1

+ sign: Think of it as “and”; not mathematical adding!

Arrow (produces, yields) – change from reactants to products

→ Shows the direction of reaction (\rightarrow , \leftarrow , \leftrightarrow , \rightleftharpoons)

(g), (s), (l), (aq): chemical phase: gas, solid, liquid, aqueous

Aqueous = dissolved in water

Remember naming.....

One mole of solid barium hydroxide reacts with two moles of aqueous nitric acid (HNO_3) to form one mole of aqueous barium nitrate and two moles of liquid water.

Law of Conservation of Mass

Total mass is constant during a chemical reaction

Mass of reactants must exactly match mass of products



2lbs potatoes + 3 ounces milk + 1 ounce butter = 2 lbs 4 oz mashed potatoes

Called mass balance



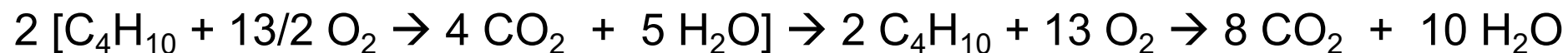
Matter cannot be created or destroyed in chemical reactions!

Chemical Equations must be balanced!

Rules & Hints For Balancing Chemical Equations

Cannot make something out of nothing!

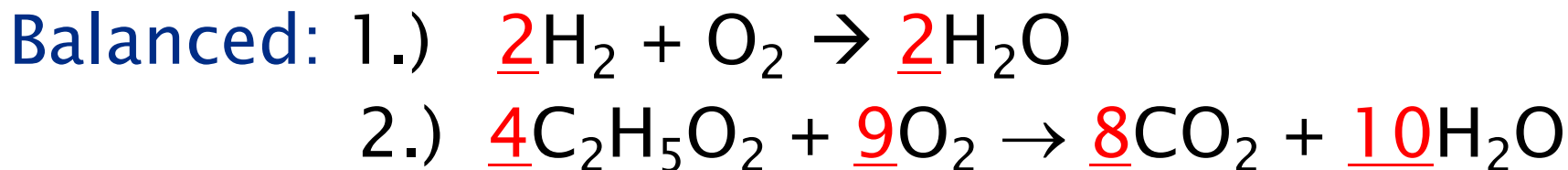
- **ONLY COEFFICIENTS CAN BE CHANGED!!!** $\text{H}_2\text{O} \neq \text{H}_2\text{O}_2$
- If an element(s) is present in just 1 compound on each side of the equation, balance that element(s) first.
- Balance free elements last. (O_2 , C, H_2 , etc.)
- Fractions can be cleared at any time by multiplying all coefficients by a common multiplier (often denominator)



- Groupings of atoms (such as in polyatomic ions) may remain unchanged. In such cases, you can balance these groupings as a unit.

Balancing Chemical Equations

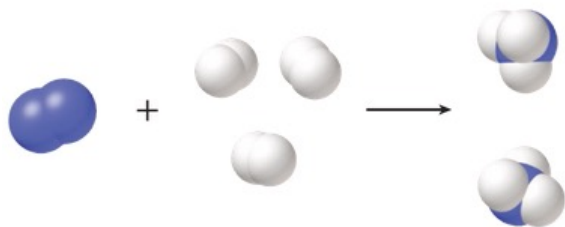
Starting – Unbalanced (no coefficients):



Some Basic Types of Chemical Reactions

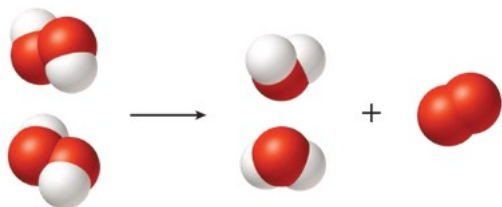
Combination (aka Synthesis): Putting things together

- Two or more reactants combine to form a single product



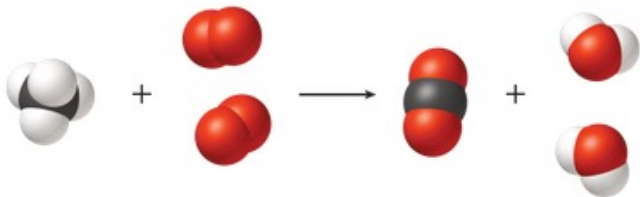
Decomposition: Breaking things apart

- Two or more products form from a single reactant

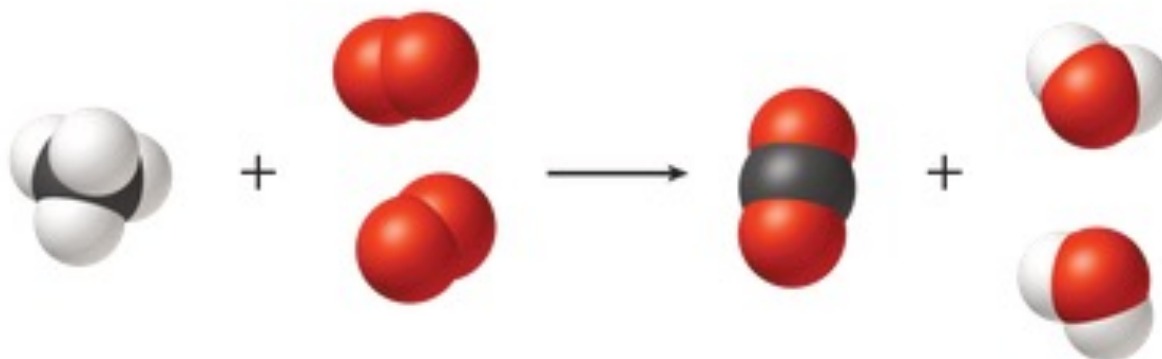


Combustion: Reacting with oxygen

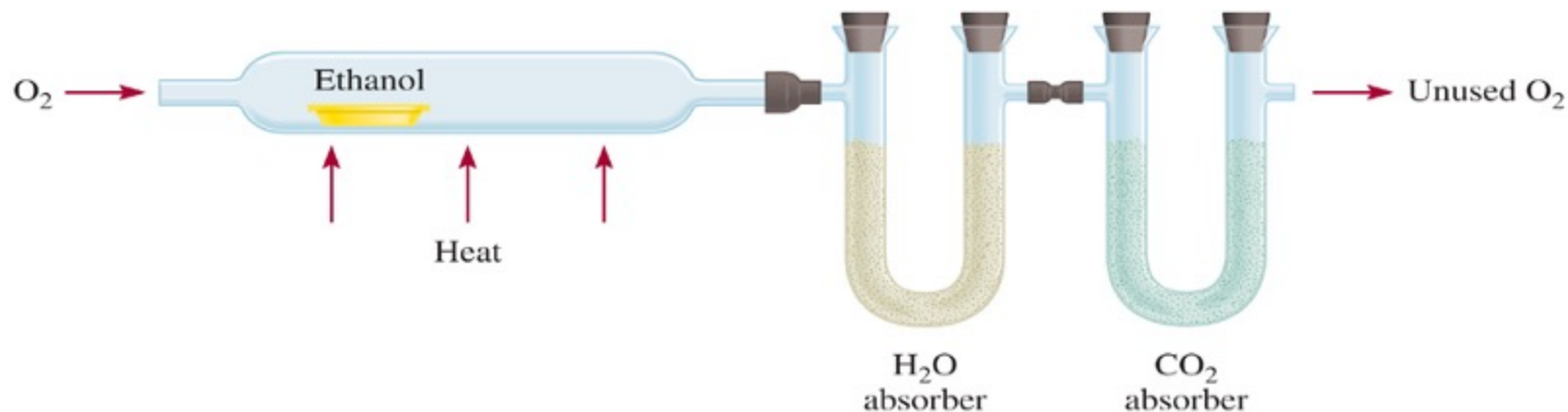
- A substance burns in the presence of oxygen



Combustion Analysis



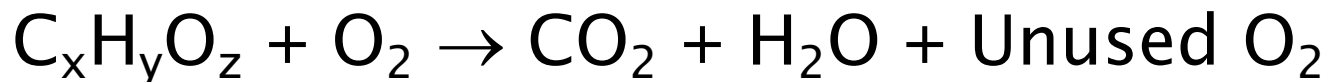
Determination of Empirical Formulas by Elemental Analysis (Combustion)



- Burn measured amount of compound with excess O_2 .
 - $C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O + \text{Unused } O_2$
- Measure mass of products (must know what they are)
- Use mass of products to determine moles & mass of each element present
 - CO_2 and H_2O contain all C and H atoms
 - Determine amount of oxygen by difference
- If know molar mass can determine molecular formula

Determining Empirical Formula from Experiment

A 0.595g sample of a CHO compound burns in O₂ to produce 1.188g CO₂ and 0.486g H₂O. What is the empirical formula?



MM CO₂ = 44.01 g/mol

MM H₂O = 18.016 g/mol

Determine Moles & Mass of C from CO₂

Determine Moles & Mass of H from H₂O

Determine Mass & Moles of O from what is left

Divide by smallest # moles to get formula: **C₂H₄O**

What If You Don't get Whole Numbers?



Multiply Results from Empirical Formula by the smallest possible value to get whole numbers:

$$C = 1.5 \times 2 = 3$$

$$O = 1 \times 2 = 2$$

$$H = 3 \times 2 = 6$$



Amounts of Reactants and Products: Stoichiometry



The Scream by Edvard Munch

Calculations based on chemical reactions

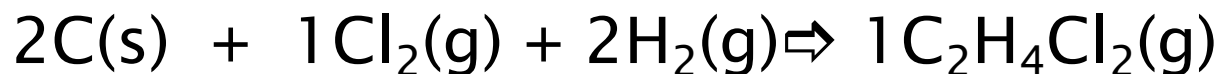
How much do you need to make what you want?

Stoichiometry:

Mole Ratios in Chemical Reactions



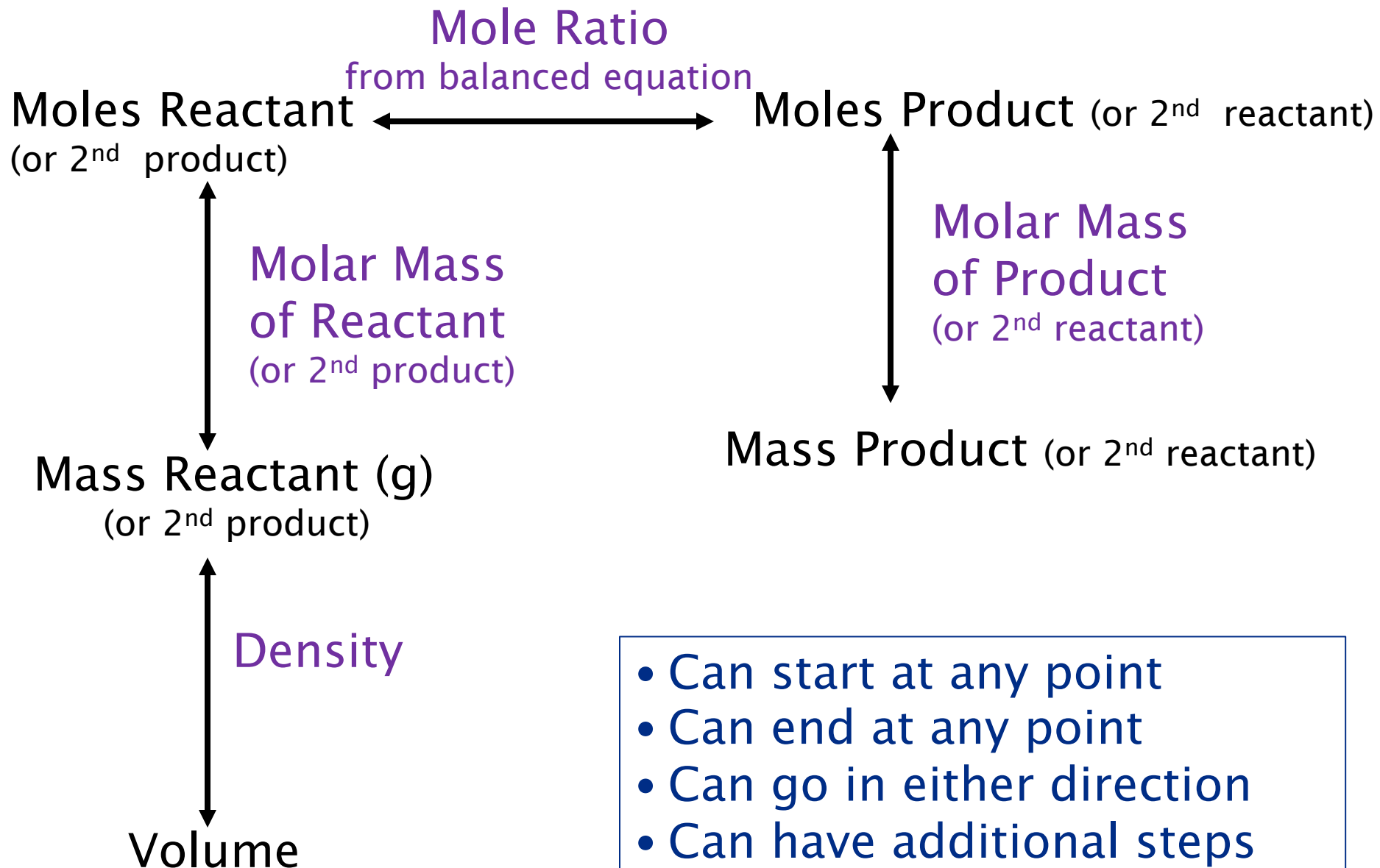
3 eggs and 2 cups of flour react to make one cake
ratio: 3:2:1



2 moles of graphite (carbon), 1 mole of chlorine gas, and 2 moles of hydrogen gas react to form 1 mole of dichloroethane

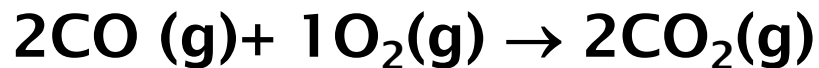
Mole ratio: 2:1:2:1

Stoichiometry Flow Chart



What is the mass of CO₂ produced when 10.7g of O₂ reacts with CO to form CO₂?

Write and balance the equation:



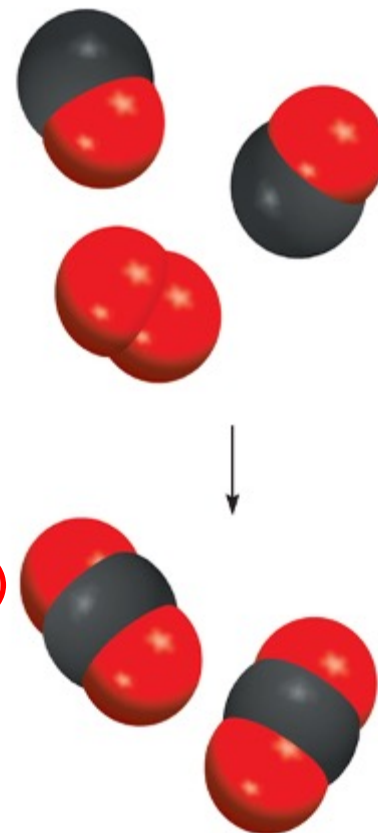
Calculate moles of O₂ (31.9988 g/mol) in 10.7g of O₂. (0.33439mol O₂)

Calculate moles of CO₂ from mole ratio.

(0.668775mol CO₂)

Calculate grams CO₂ (44.0098g/mol) from moles CO₂.

(29.4g CO₂)



Limiting Reagents & Reaction Yield:

- **Limiting Reagent:** Reactant that runs out first!
 - Determines how much product you can make
 - Find by calculating the moles of 1 product from each given amount of reactant
 - Limiting reagent is the reactant producing the smallest amount of product
- **Theoretical Yield:**
 - Max amount of product that you can make
 - Based on limiting reagent!
 - Generally reported in grams





12

unlimited

unlimited

12

12

12

12

6



If you start with 3.0 moles Sb_4O_{10} and 8.0 moles of water, what is your limiting reagent?



If you make silver cyanide, which is used in electroplating, from 20.0 g of silver nitrate and 15.0 g of hydrogen cyanide gas, what is your limiting reagent? What is your theoretical yield of AgCN?

Step 1: Make sure equation is balanced.

Step 2: Moles of reactants – for limiting reagent, need both!

Step 3: Cross the mole bridge. Limiting reagent produces smallest amount of product! (LR = AgNO₃)

Step 4: Use the limiting reagent to determine the mass of AgCN.

(15.8 g)

Why might you want to make either silver nitrate or hydrogen cyanide your limiting reagent?

Yields of Chemical Reactions

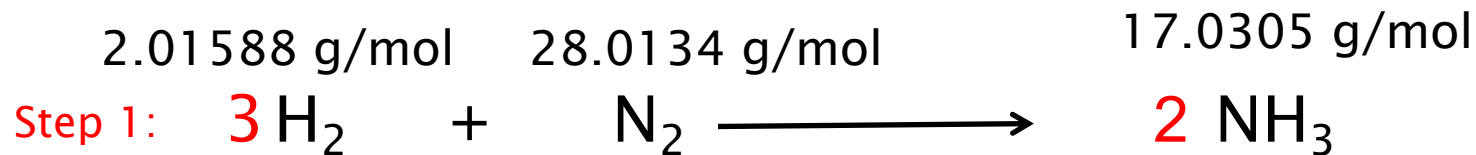
Reactions rarely produce maximum product

- a. Impure reactants
- b. Incomplete reaction
- c. All product not fully recovered
- d. Side reactions may occur

Actual yield: Yield recovered during experiment

Theoretical yield: Yield calculated from limiting reagent

$$\text{Percent yield} = \left(\frac{\text{Actual yield}}{\text{Theoretical yield}} \right) \times 100$$



If you start with 4.00 g of hydrogen gas and 22.00g of nitrogen gas, and make 18.5 g of ammonia, what is your percent yield?

Step 2:

Step 3:

Step 4:

Step 5:

82.1 % yield