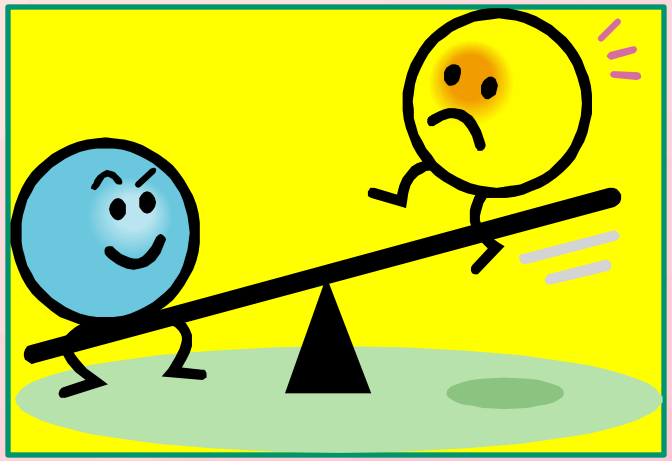
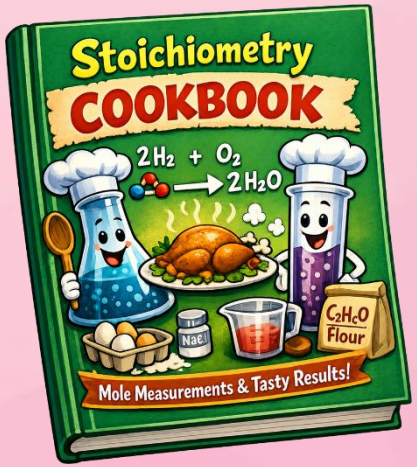
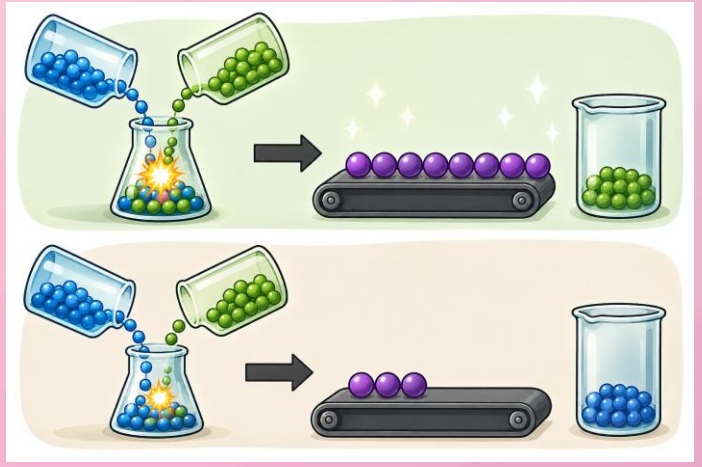






Counting Particles In Chemical Reactions

Chemistry

Karl Steffin

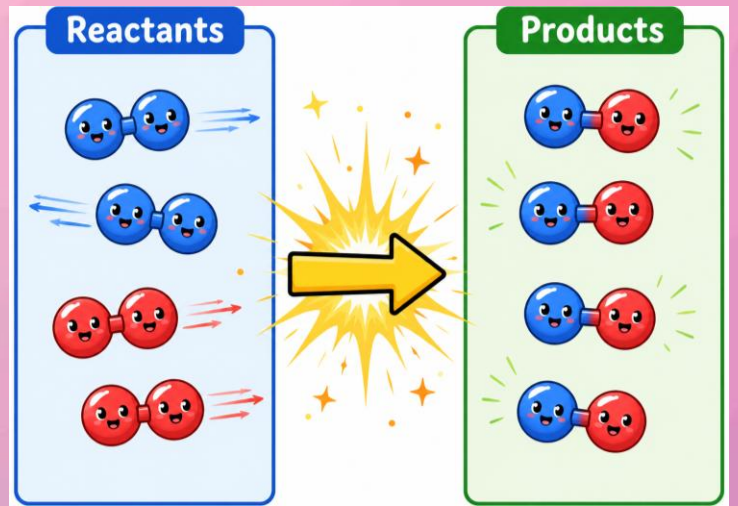
7/29/2026

By end of this unit I can…

- A.1 Create and/or evaluate models of chemical transformations.
- B.1 Explain the relationship between the quantity of reactants consumed and the quantity of products formed in a chemical transformation.
- B.2 Perform stoichiometric calculations involving the quantity of reactants and products in a chemical system.
- C.1 Create and/or evaluate models of a reaction mixture before and/or after a reaction has occurred, including situations with a limiting reactant.
- D.1 Calculate the theoretical yield and/or percent yield of a chemical reaction.

What equations show

- **Chemical Reaction: Process in which one or more substances are converted into new substance(s) with different physical and chemical properties.**
  - **Reactant(s): the chemical(s) being introduced in the reaction.**
  - **Product(s): the chemical(s) being produced by the reaction.**



What equations show

- As in the last unit Chemical Compounds can not be altered.
  - Ex: H_2SO_4: ~~H_4SO_4~~, ~~$H_22(SO_4)$~~, $2H_2SO_4$ ✓
- Chemical reactions must be balanced.
  - Conservation of matter
  - All individual elements on the reactant side must be present on the product side in the same quantities.
  - Ex: $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

Review: Balancing

$$2KCl \rightarrow 2K + Cl_2$$

2 1 K 1 2

2 1 Cl 2

$$2Ba(NO_3)_2 + K_4PO_4 \rightarrow 4KNO_3 + Ba_2PO_4$$

2 1 Ba 2

4 2 NO_3 1 4

4 K 1 4

1 PO_4 1

Signs and terms

Yields: $\longrightarrow$

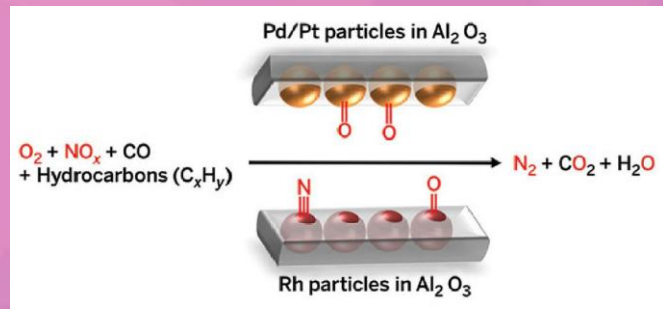
Heat is added: $\xrightarrow{\Delta}$

Reaction is reversible: $\longleftrightarrow$ or $\rightleftharpoons$

- **Used to show the presence of two chemicals without caring about the bonds.**
  - **Hydrates: While forming a solid some salts incorporate water in them. Boiling the water off (anhydrous) does not change the chemical properties.**

Catalyst: Things that increase the rate of a reaction without being consumed by it.

Ex for Platinum: $\xrightarrow{Pt}$



Stoichiometry

- **Unit changes: Three Molar ratios.**
- **Relationships between product and reactant set up new truths.**
- **Being able to determine the amounts and study the quantitative relationships of equations is called stoichiometry.**
- **The most important idea in this chapter is to look at the coefficients of the formula.**

$$N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$$

Using Coefficients

$$N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$$

- This reaction needs the following:
  - 1 mole of N_2H_4 and 2 moles of H_2O_2
  - To produce…
  - 1 mole of N_2 and 4 moles of H_2O
- How many moles of H_2O are produced if you have 3.55 moles of N_2H_4? (assume you have enough Hydrogen Peroxide)

Same as it ever was

3.55-mol ?-mol

$$N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$$

- Use the *same* ideas from before:
  - Circle what you have and what you want…
  - Write what you know…
  - What you have on bottom, what you want on top.
    - Include the coefficients

$$3.55 - \cancel{mol\ N_2H_4}\ x\ \frac{4 - mol\ H_2O}{1 - \cancel{mol\ N_2H_4}}$$

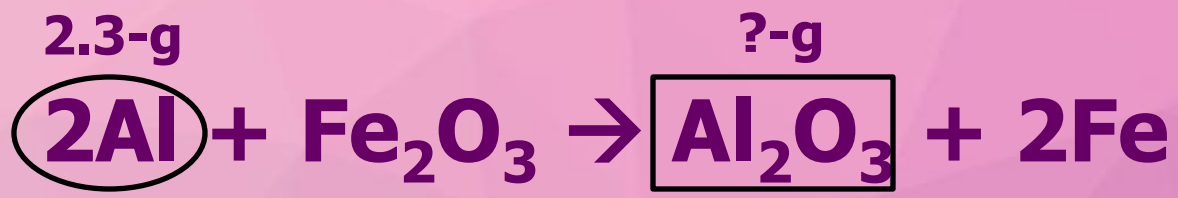
14.2 moles H_2O

Upping the Ante

- The last problem was a mole-to-mole problem.
- If given grams, Liters (of gas) or particles, it is still possible to solve with one new thought:
  - Write what you know.
  - Ask 'Is it in moles?' if not, convert to moles first.
  - Then proceed to change the chemical.
  - Ask 'Does it want moles?' if not convert out of moles.

Thermite Reaction

- **In a thermite reaction Aluminum powder reacts with Iron (III) Oxide to form Aluminum Oxide and Molten Iron… If in a complete reaction 2.3-g of Aluminum are needed, how many grams of Aluminum Oxide are produced?**



Thermite Reaction

2.3-g ?-g

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$$

- **Convert Grams to Moles…**

$$2.3 - \cancel{g}\ Al\ x\ \frac{1 - mol}{27 - \cancel{g}} = .0851 - mol\ Al$$

- **Use Molar Ratio…**

$$.0851 - mol\ \cancel{Al}\ x\ \frac{1\ Al_2O_3}{2\ \cancel{Al}} = .0425 - mol\ Al_2O_3$$

- **Convert Back to Grams…**

$$.0425 - \cancel{mol}\ Al_2O_3 x\ \frac{102 - g}{1 - \cancel{mol}} = \boxed{4.4 - g\ Al_2O_3}$$

Limiting Reactants

- With five car bodies and twelve tires how many cars get produced?
  - Each body needs four tires.
  - After the green car there are no tires left.
  - Tires limited our ability to make more cars.
  - We also have excess car bodies.

Solving For a Limiting Reactant

- **Write what you know**
  - **If not given the balanced formula**
  - **Circle both given amounts**
- **Find out how much product each reactant will produce. (double the work)**
  - **If not told specifically solve for any one product.**
- **The one that produces the least amount is the limiting reactant.**

Limiting Reactant Example

- **What is the limiting reactant when 27-g of Sodium and 26-L of Chlorine gas at STP produce Table Salt?**

27-g 26-L ?-g

$$2Na + Cl_2 \rightarrow 2NaCl$$

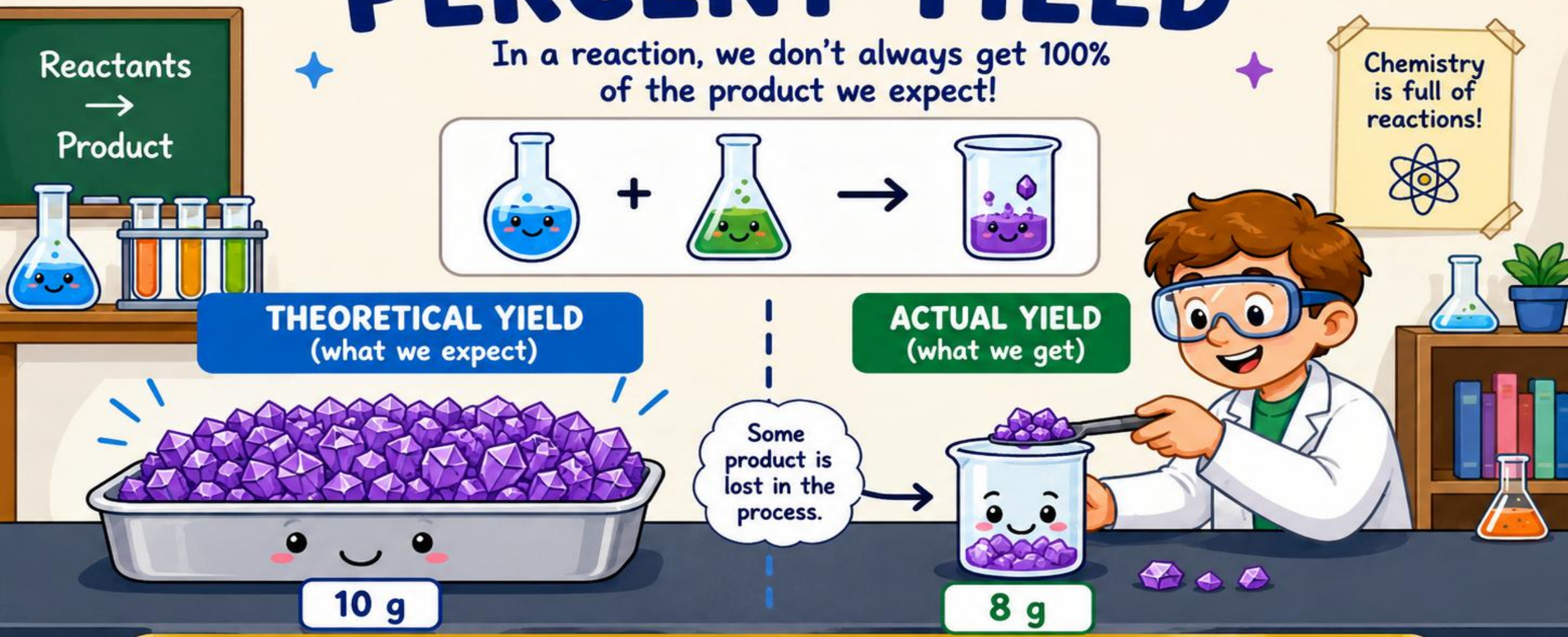
$$27 - \cancel{g}\ \cancel{Na}\ x\ \frac{1 - mol}{23 - \cancel{g}}\ x\ \frac{2 - NaCl}{2 - \cancel{Na}} = 1.17\ - mol\ NaCl$$

$$26 - \cancel{L}\ \cancel{Cl_2}\ x\ \frac{1 - mol}{22.4 - \cancel{L}}\ x\ \frac{2 - NaCl}{1 - \cancel{Cl_2}} = 2.32 - mol\ NaCl$$

Na produced the least

PERCENT YIELD

In a reaction, we don't always get 100% of the product we expect!



$$\text{PERCENT YIELD} = \frac{\text{ACTUAL YIELD}}{\text{THEORETICAL YIELD}} \times 100\%$$

Percent Yield Example

- **A piece of Copper (5.0-g) is placed in a solution of excess Silver Nitrate. When separated 7.2-g of Silver is produced. What is the Percent Yield?**

5.0-g ?-g

$$\mathbf{Cu} + AgNO_3 \rightarrow \mathbf{Ag} + CuNO_3$$

$$5 - \cancel{g}\ \cancel{Cu}\ x\ \frac{1 - \cancel{mol}}{63.5 - \cancel{g}}\ x\ \frac{1 - Ag}{1 - \cancel{Cu}}\ x\ \frac{107.9 - g}{1 - \cancel{mol}} = 8.5 - g\ Ag$$

5.0-g Cu should produce 8.5-g Ag

Percent Yield Example

- So in the reaction the 5.0-g of Copper theoretically yields 8.5-g of Silver, but the problem stated only 7.2-g was actually produced.

$$\frac{7.2 - g}{8.5 - g} = \boxed{85\%}$$

- A Percent Yield can never be more than 100%.