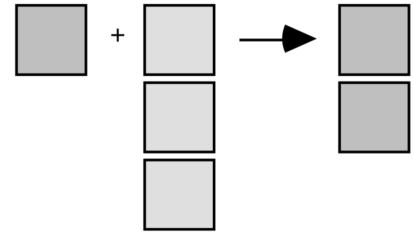
10 • Mathematics of Chemical Equations
Coefficients and Relative Volumes of Gases
(1 of 8)

Since every **gas** takes up the same amount of room (22.4 L for a mole of a gas at STP), the **coefficients** in an equation tell you about the **volumes** of gas involved.

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



10 • Mathematics of Chemical Equations
Heart of the Problem
(2 of 8)

The "heart of the problem" conversion factor relates the Given and the Desired compounds using the coefficients from the balanced equation.

Example: $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

♥ could be $\frac{3 \text{ moles } H_2}{2 \text{ moles } NH_3}$

…which means that every time 2 moles of NH_3 is formed, 3 moles of H_2 must react.

The format is always, $\frac{\text{moles of } \textbf{Desired}}{\text{moles of } \textbf{Given}}$

10 • Mathematics of Chemical Equations
Mass-Mass Problems
Mass-Volume Problems
(3 of 8)

Mass-Mass problems are probably the most common type of problem. The Given and Desired are both masses (grams or kg).

The pattern is:

Given x molar mass of Given x ♥ x molar mass of Desired

In **Mass-Volume problems**, one of the molar masses is replaced with $\frac{22.4 \text{ L}}{1 \text{ mole}}$ depending on whether the Given or the Desired is Liters.

10 • Mathematics of Chemical Equations
Mass-Volume-Particle Problems
(4 of 8)

If the Given or Desired is **molecules**, then the **Avogadro's Number** conversion factor, $\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mole}}$ is used and the problem is a Mass-Particle or Volume-Particle problem.

The **units** of the Given and Desired will guide you as to which conversion factor to use:

Mass	grams or kg
Volume	Liters or mL
Particles	molecules or atoms

10 • Mathematics of Chemical Equations Limiting Reactant Problems (5 of 8)

In a problem with **two Given values,** one of the Given's will limit how much product you can make. This is called the **limiting reactant.** The other reactant is said to be **in excess.**

Solve the problem **twice** using each Given… the reactant that results in the **smaller** amount of product is the **limiting reactant** and the **smaller** answer is the **true** answer.

Example: $N_2 + 3 H_2 \rightarrow 2 NH_3$
When **28.0 grams of N_2** reacts with **8.00 grams of H_2,** what mass of NH_3 is produced?
(in this case, the N_2 is the limiting reactant)

10 • Mathematics of Chemical Equations How Much Excess Reactant is Left Over (6 of 8)

Example: $N_2 + 3 H_2 \rightarrow 2 NH_3$
When **28.0 grams of N_2** reacts with **8.00 grams of H_2,** what mass of NH_3 is produced?
(in this case, the N_2 is the limiting reactant)

To find out how much H_2 is left over, do another line equation:
Given: 28.0 g N_2
Desired: ? g H_2

subtract the answer of this problem from 8.00 g H_2

10 • Mathematics of Chemical Equations Limiting Reactants (7 of 8)

It is difficult to simply **guess** which reactant is the limiting reactant because it depends on **two** things:
(1) the molar mass of the reactant and
(2) the coefficients in the balanced equation

The smaller mass is **not** always the limiting reactant.

Example: $N_2 + 3 H_2 \rightarrow 2 NH_3$
1 mole (28 g N_2) will **just react** with 3 moles (6.06 g H_2) so, if we react 28.0 g N_2 with 8.0 g H_2, only 6.06 g H_2 will be used up and 1.94 g of H_2 will be left over.
In this case, N_2 is the L.R. and H_2 is in XS.

10 • Mathematics of Chemical Equations Lab 16 (Baking Soda Lab) Ideas (8 of 8)

The reaction: $NaHCO_3 + HCl \rightarrow H_2O + CO_2(g) + NaCl$

The Point:
We can **calculate** the mass of **NaCl** expected from any starting mass of $NaHCO_3$
We can also **experimentally measure** the mass of **NaCl** left over after reacting $NaHCO_3$ and HCl
These two values **should** match. **Percent error** is a good way to report how good your experimental value is.

Techniques:
We used excess HCl. The CO_2 escapes as a gas. The H_2O is driven off by evaporation. Drying thoroughly is impt.