Stoichiometry

Quantitative Relationships

A Definition

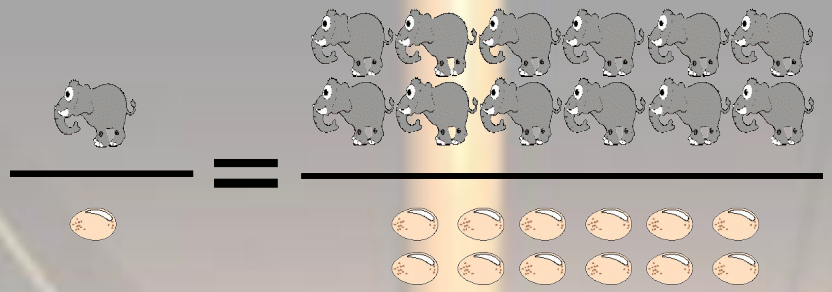
- **Stoichiometry** - calculations based on quantitative relationships in a balanced chemical equation
- Assumptions of stoichiometry:
  - The reaction has no side reactions.
  - The reaction goes to completion.
  - The reactants are completely consumed.

Moles and Dozens

- A mole is a number just like a dozen.
  - 1 dozen = 12
  - 1 mole = 6.02×10^{23}
- This is very useful for working with balanced equations.
  - The balanced equation for the formation of ammonia,
    $$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g),$$
    tells us that **1** molecule of nitrogen combines with **3** molecules of hydrogen to form **2** molecules of ammonia.
  - This means 1 dozen molecules of nitrogen combines with 3 dozen molecules of hydrogen to form 2 dozen molecules of ammonia .
  - This also means 1 mole of nitrogen combines with 3 moles of hydrogen to form 2 moles of ammonia. The mole amounts can be measured in the laboratory.

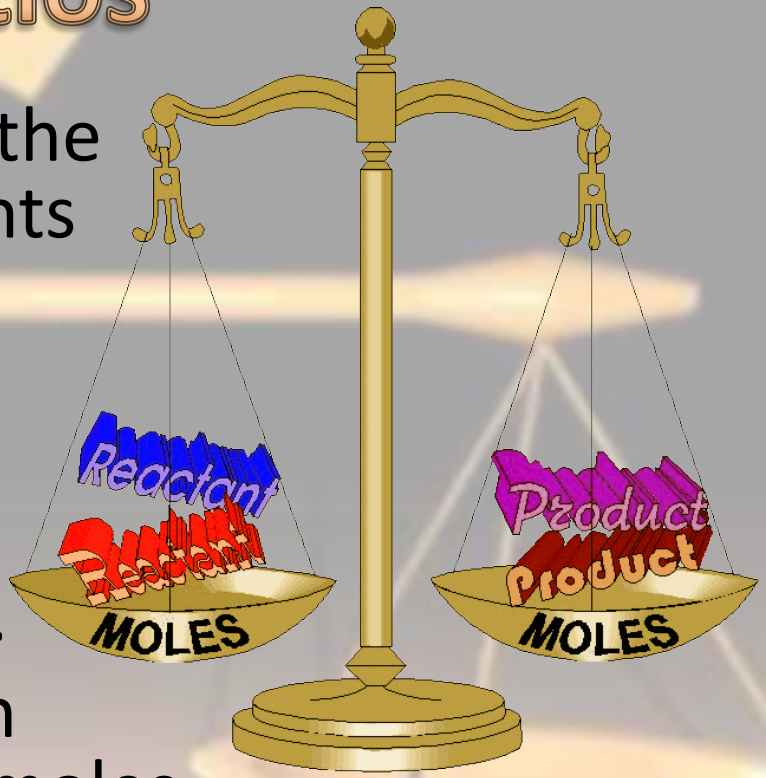
Dozens, Moles, and Proportions

- One elephant compares to one egg in exactly the same way that 1 dozen elephants compares to 1 dozen eggs.



- This is because the ratio of objects is still 1 to 1.
- In the equation $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, 3 molecules of hydrogen compare to 2 molecules of ammonia in exactly the same way that 3 moles of hydrogen compare to 2 moles of ammonia.
- This is because the ratio of objects is still 3 to 2.

Mole Ratios

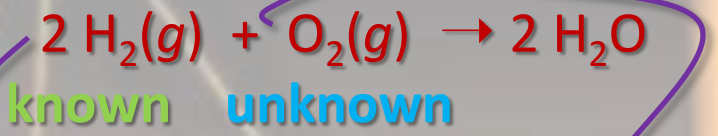


- A balanced equation shows the mole ratios of all the reactants and products involved in a reaction.
- These ratios are fixed no matter what the starting amount of any substance is.
- If the mole ratio of hydrogen to ammonia is 3 moles to 2 moles [$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$], then 6 moles of hydrogen can form 4 moles of ammonia because the mole ratio is still 3 to 2.
- Mole ratio problems can be solved by the factor label method, or by setting up proportions.

Sample Problem

How many moles of oxygen are consumed when 0.6 moles of hydrogen burns to produce water?

- **Step 1:** Write a balanced equation and determine the mole ratios from the equation.



- **Step 2:** Identify the known and the unknown
- **Step 3:** Solve by factor label

Definition: $2 \text{ mol } H_2 = 1 \text{ mol } O_2$

$$(0.6 \text{ mol } H_2)\left(\frac{1 \text{ mol } O_2}{2 \text{ mol } H_2}\right) = 0.3 \text{ mol } O_2$$

- *or* **Step 3:** Set up a proportion and solve for the unknown

$$\frac{2 \text{ mol } H_2}{0.6 \text{ mol } H_2} = \frac{1 \text{ mol } O_2}{x} \qquad x = 0.3 \text{ mol } O_2$$