# Chemical Calculations

Looking at the formation of ammonia

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

we can look at the moles of each to see the mole ratio of the reaction.

The mole ratio is a conversion factor derived from the coefficients of a balanced chemical equation.

In chemical calculations, mole ratios are used to convert between moles of reactants and moles of products, between moles of reactants, or between moles of products.

## Example

How many moles of ammonia are produced when 0.60 mol of nitrogen reacts with hydrogen?

There are 3 possible mole conversions we can look at

$$\frac{1 \text{ mol } N_2}{3 \text{ mol } H_2} \qquad \frac{2 \text{ mol } NH_3}{1 \text{ mol } N_2} \qquad \frac{3 \text{ mol } H_2}{2 \text{ mol } NH_3}$$

We need to get from moles of nitrogen to moles of ammonia

$$0.60 \cancel{\text{ mol } N_2} \times \frac{2 \text{ mol } NH_3}{\cancel{1 \text{ mol } N_2}} = 1.2 \text{ mol } NH_3$$

This is an example of a mole-mole calculation

# Example 2: Mass-Mass Calculations

Calculate the number of grams of $NH_3$ produced by the reaction of 5.40 g of hydrogen with an excess of nitrogen. The balanced equation is

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

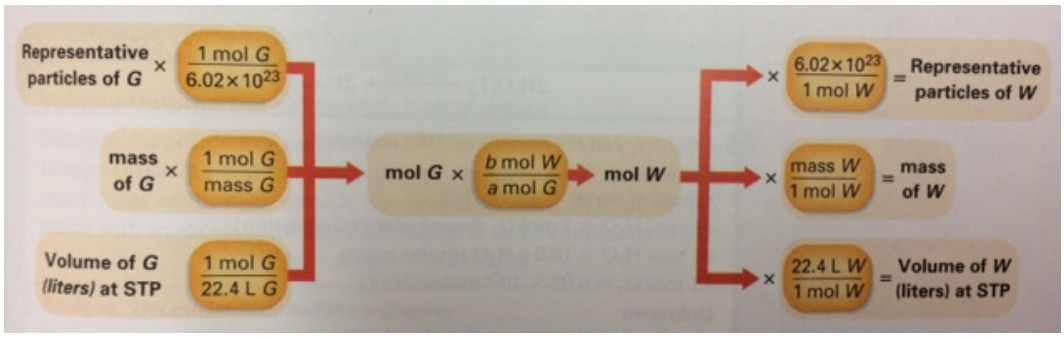
$$5.40\ g\ H_2 \times \frac{1\ mol\ H_2}{2.02\ g\ H_2} \times \frac{2\ mol\ NH_3}{3\ mol\ H_2} \times \frac{17.04\ g\ NH_3}{1\ mol\ NH_3}$$

$$5.40\ \cancel{g\ H_2} \times \frac{1\ \cancel{mol\ H_2}}{2.02\ \cancel{g\ H_2}} \times \frac{2\ \cancel{mol\ NH_3}}{3\ \cancel{mol\ H_2}} \times \frac{17.04\ g\ NH_3}{1\ \cancel{mol\ NH_3}} = 30.36\ g\ NH_3$$

$$= 30.4\ g\ NH_3\ (3\ sig\ dig)$$

In a typical stoichiometric problem,

- The given quantity is first converted to moles.
- Then the mole ratio from the balanced equation is used to calculate the number of moles of the wanted substance.
- Finally, the moles are converted to any other unit of measurement related to the unit mole, as the problem requires.



## Example 3 - Calculating Molecules of a Product

How many molecules of oxygen are produced when 29.2 grams of water is decomposed by electrolysis to this balanced equation?

$$2H_2O(l) \xrightarrow{\text{electricity}} 2H_2(g) + O_2(g)$$

## Example 4 - Volume-Volume Calculations

Nitrogen monoxide and oxygen gas combine to form the brown gas nitrogen dioxide, which contributes to smog. How many liters of nitrogen dioxide are produced when 34 L of oxygen reacts with an excess of nitrogen monoxide? Assume conditions of STP.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

## Example 5 - Finding the Volume of Gas

Assuming STP, how many milliliters of oxygen are needed to produce 20.4 mL $SO_3$ according to this balanced equation?

$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$

Try questions 11-24 on pages 360-366