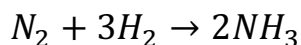


Unit 3: Quantities in Chemical Reactions

7.1 & 7.2: What is Stoichiometry

Stoichiometry: the study of the quantitative (mass and mole) relationship between reactants and products in a chemical reaction.

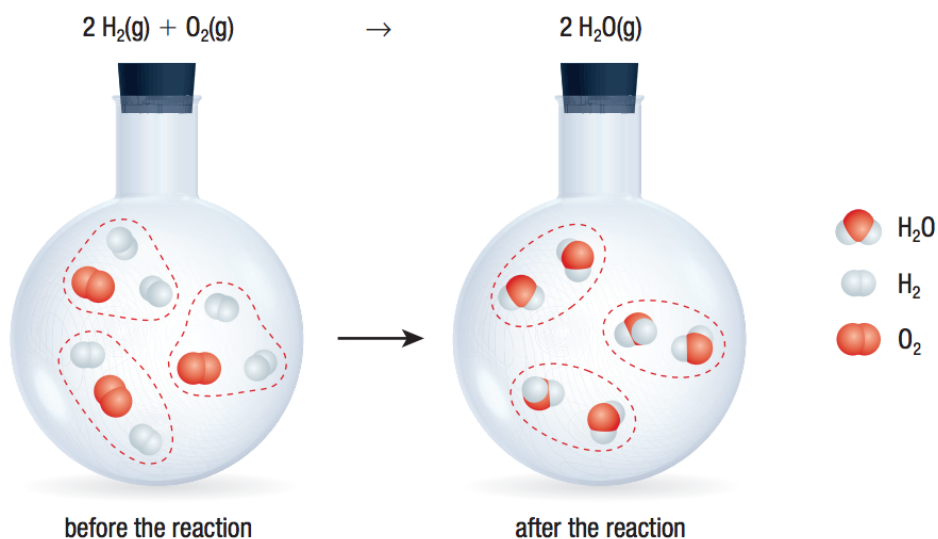
Example 1: consider the following reaction



- a) If you wanted to produce 20 molecules of NH_3 , how many N_2 mole would you need? _____
- b) How many molecules of H_2 are required to react with 9 molecules of nitrogen? _____

Mole ratios in chemical equations:

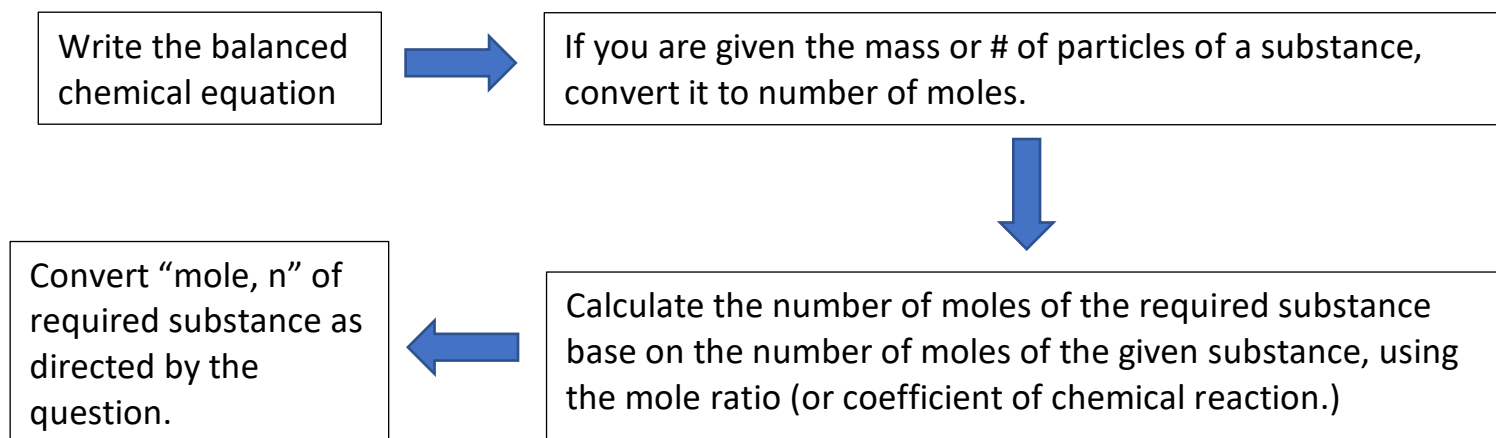
- A chemical equation is like a recipe
- The chemical formula indicates the “ingredients” of the reaction.
- The coefficients tell you the amount needed.
- For example: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$ shows that 2 hydrogen molecules combined with 1 oxygen molecule and produce 2 molecules of water.



- **Mole ratio:** The ratio of the amount in moles of chemicals in a chemical equation
- the coefficient in the balanced equation tells us the mole ratio.
- Hence, the mole ratio of $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$ is:
2 mole of hydrogen : 1 mole of oxygen : 2 mole of water
- We use mole ratios to predict the amounts of moles of other substances in a reaction.

Steps for solving stoichiometric problems:

Start with a properly skeleton chemical equation!



Example 2: Solid aluminum reacts with oxygen to produce aluminum oxide. Given 25.0 g of Al, how much its oxide is produced?

Example 3: How much magnesium is required to produce 4.03 g of magnesium oxide?

Practice:

1. What mass of oxygen gas is required to produce a complete combustion 34.95 g of propane?
2. If 13.2 g barium chloride is reacted with excess potassium sulfate, what number of barium sulfate molecules is produced?
3. What mass of water is produced if 7.39×10^{25} molecules of methane, CH_4 , are completely combusted?
4. What mass of precipitate should form if 2.00 g of silver nitrate in solution is reacted with excess sodium sulfide solution?
5. Silver metal can be recovered from waste silver nitrate solutions by reaction with copper metal. What mass of silver can be obtained using 50.00 g of copper?

Unit 3: Quantities in Chemical Reactions

7.3 – 7.5: Limiting Reactants and reaction Yields

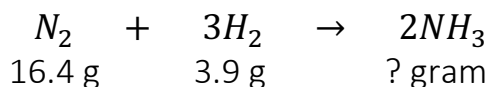
Limiting & Excess Reactants:

- A chemical reaction will stop once any one of the reactants runs out
- This reactant is known as the limited – the react which is completely used (or consumed) in the chemical reaction.
 - Each reaction can only have 1 limiting reactant.
- Any other reactant is an excess reactant – the reactant(s) that are leftover after a reaction is over.
 - There may be more than 1 excess reactant.

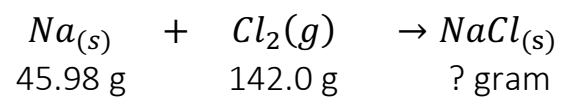
Steps to Stoichiometry with a limiting reactant:

1. Balance the chemical equation
2. Assume one of the reactant as limiting (make an assumption)
3. Calculate mass of excess reactant is consumed if all of the limiting reactant is used.
4. Compare mass calculated to mass given of excess reactants
 - If mass calculated smaller than mass given – assumption is correct (excess has leftover)
 - If mass calculated bigger than mass given – assumption is incorrect
5. Complete stoichiometric calculation using the limiting reactant.

Example 1:



Example 2:



Example 3: 15.00 g of aluminum sulfide added to 10.00 g of water.

How much aluminum hydroxide is produced ?

How much excess reactant is left?

Reaction Yields:

- Theoretical yield – the amount of product that is predicted by stoichiometric calculation
- Actual yield – the actual amount of product that is produced when the chemical reaction is carried out in an experiment
 - Most always less than the theoretical yield

Percentage yield

- Ratio of actual to theoretical, expressed as a percentage

$$\text{Percentage yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\%$$

Example 4: In a laboratory experiment, 8.75 g of copper is produced when 11.2 g of zinc is added to 23.9 g of copper (II) sulfate solution. What is the percentage yield of copper?

Example 5: Sodium oxide reacts with water to form the base sodium hydroxide. If this reaction has a 91% yield, what mass of sodium hydroxide is obtained when 0.483 mol of sodium oxide reacts with excess water?