

Unit 6: Stoichiometry

Resources:

- ✓ Periodic Table
- ✓ Polyatomic Ions List

Chemical Equations:

- Reactants --> Products
 - Reactants are the substances that exist before a chemical reaction occurs
 - Products are the substances that exist after a chemical reaction has occurred
 - Reactants are always on the left, products always on the right

Balancing Equations

- The Law of Conservation of Mass - the number of atoms of each element must be the same before and after any chemical reaction
- Add COEFFICIENTS in front of any compound's formula to change the ratio
- No coefficient is written if the number is 'one'
- These coefficients represent the ratio of moles of each substance that participate in the reaction

The Mole

- The mole is the fundamental unit of amount, representing Avogadro's Number of particles
- Avogadro's Number = 6.02×10^{23} atoms/molecules/formula units/particles/etc.
- The MOLAR MASS of an element is the mass of 6.02×10^{23} atoms of that element
 - The molar mass is the atomic mass in grams
- The molar mass of a compound is the sum of the molar masses of the elements that make it up
- Use DIMENSIONAL ANALYSIS to interconvert between moles and grams

EXAMPLE #1: What is the mass of 3.2mol of lithium nitrate?

The molar mass of LiNO_3 is 68.95g/mol ($6.94 = 14.01 + 3(16.00) = 68.95$)

$$3.2 \text{ mol LiNO}_3 \times \frac{68.95 \text{ g LiNO}_3}{1 \text{ mol LiNO}_3} = 220.64 \text{ g LiNO}_3$$

EXAMPLE #2: How many formula units are in 25.0g of ammonium carbonate?

The molar mass of $(\text{NH}_4)_2\text{CO}_3$ is 96.11g/mol [$2(14.01) + 8(1.01) + 12.01 + 3(16.00) = 96.11$]

$$25.0 \text{ g } (\text{NH}_4)_2\text{CO}_3 \times \frac{1 \text{ mol } (\text{NH}_4)_2\text{CO}_3}{96.11 \text{ g } (\text{NH}_4)_2\text{CO}_3} \times \frac{6.02 \times 10^{23} \text{ formula units}}{1 \text{ mol } (\text{NH}_4)_2\text{CO}_3} = 1.57 \times 10^{23} \text{ formula units}$$

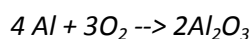
Stoichiometry

- Used when the amount of one substance is used to determine the amount of a different substance involved in the same chemical reaction.
- Substances are related by the mole ratio (coefficients of the balanced equation)
 - Convert to moles
 - Compare moles
 - Convert from moles

Limiting Reactants

- A reaction will stop when one reactant is completely used up
- The limiting reactant determines the amount of products that can be produced
- Other reactants will be in excess (more than enough)
- The easiest way to determine the limiting reactant is:
 - Calculate the theoretical yield of a product for EACH reactant
 - The reactant that can produce the least amount of product is the L.R.
- Also, the Limiting Reactant should be used to determine the amount of the other reactants that are used
 - Subtract this from the initial amount to find the amount in excess

EXAMPLE #3: 50.0g of Al react with 50.0g of O₂. (a) What mass of Al₂O₃ will be formed? (b) How much of which reactant is left over?



$$50.0\text{g Al} \times \frac{1\text{mol Al}}{26.987\text{g Al}} \times \frac{2\text{mol Al}_2\text{O}_3}{4\text{mol Al}} \times \frac{101.96\text{g Al}_2\text{O}_3}{1\text{mol Al}_2\text{O}_3} = 94.5\text{g Al}_2\text{O}_3$$

$$50.0\text{g O}_2 \times \frac{1\text{mol O}_2}{32.00\text{g O}_2} \times \frac{2\text{mol Al}_2\text{O}_3}{3\text{mol O}_2} \times \frac{101.96\text{g Al}_2\text{O}_3}{1\text{mol Al}_2\text{O}_3} = 106\text{g Al}_2\text{O}_3$$

* ALUMINUM is the LIMITING REACTANT, so only 94.5g of product will be made.

$$50.0\text{g Al} \times \frac{1\text{mol Al}}{26.987\text{g Al}} \times \frac{3\text{mol O}_2}{4\text{mol Al}} \times \frac{32.00\text{g O}_2}{1\text{mol O}_2} = 44.5\text{g O}_2 \text{ are USED}$$

* Since we STARTED with 50.0g of O₂ and 44.5g of O₂ are used in the reaction, there will be 5.5g EXCESS

Yield

- The calculated maximum amount of product determined by stoichiometry is the THEORETICAL YIELD
- Due to error, the EXPERIMENTAL or ACTUAL YIELD will be less than the theoretical yield
- Percent Yield is a measure of the efficiency of a reaction
 - $\% \text{ Yield} = \frac{\text{Experimental Yield}}{\text{Theoretical Yield}} \times 100$

Molarity

- Describes the concentration of a solution
- Molarity = moles of solute per liter of solution
- M = mol/L