Ch 100: Fundamentals for Chemistry

Ch 9: Calculations from Chemical Reactions
Lecture Notes (Sections 9.1 to 9.5)

Chemical Equations: What do they tell us?

A properly written chemical equation will provide the following information:

1. All reactants & products involved in the reaction
2. The physical state of all reactants & products
3. The presence of any catalysts involved in the chemical reaction
4. The relative quantity of all reactants & products
   a. Molecule to molecule ratios
   b. Mole to mole ratios
   c. Even mass to mass ratios can be determined (with use of molar mass values)

Information Given by the Chemical Equation

A balanced chemical equation provides the relationship between the relative numbers of reacting molecules and product molecules

Example: *The formation of carbon dioxide from carbon monoxide and oxygen gas*

$$2\ CO + O_2 \rightarrow 2\ CO_2$$

In this chemical equation, it is indicated that 2 CO molecules react with every 1 O_2 molecule to produce 2 CO_2 molecules

Alternative interpretation: *there is a 2:1 (numerical) ratio of CO to O_2 for this completed reaction,* 2 CO:1 O_2 :2 CO_2

Interpretation of the Chemical Equation

- Since the information given in a balanced chemical reaction is relative:

  $$2\ CO + O_2 \rightarrow 2\ CO_2$$

  the following are alternative interpretations of the chemical equation:
  a. 200 CO molecules react with 100 O_2 molecules to produce 200 CO_2 molecules
  b. 2 billion CO molecules react with 1 billion O_2 molecules to produce 20 billion CO_2 molecules
  c. 2 moles CO molecules react with 1 mole O_2 molecules to produce 2 moles CO_2 molecules
  d. 12 moles CO molecules react with 6 moles O_2 molecules to produce 12 moles CO_2 molecules
- **Note:** *The coefficients in the balanced chemical equation also shows the molecules and mole ratio of the reactants and products*
- Since moles can be converted to masses, we can determine the mass ratio of the reactants and products as well

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Mole and Mass Ratios in Chemical Equations

For the following chemical equation:

$$2\ CO + O_2 \rightarrow 2\ CO_2$$

The following mole relations are implied:

$$2 \text{ moles CO} : 1 \text{ mole } O_2 : 2 \text{ moles } CO_2$$

Note the molar masses of the compounds in this reaction:

a. 1 mole of CO = 28.01 g
b. 1 mole O_2 = 32.00 g
c. 1 mole CO_2 = 44.01 g

The mass ratio of the compounds in this reaction can be determined using the molar mass values:

$$2(28.01)\ g\ CO : 1(32.00)\ g\ O_2 : 2(44.01)\ g\ CO_2$$

The mass ratio of the compounds in this reaction are:

56.02 g CO : 32.00 g O_2 : 88.02 g CO_2

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Example

Determine the Number of Moles of Carbon Monoxide required to react with 3.2 moles Oxygen, and the moles of Carbon Dioxide produced

1. Write the balanced equation

$$2\ CO + O_2 \rightarrow 2\ CO_2$$

2. Use the coefficients to find the mole relationship

$$2 \text{ moles CO} : 1 \text{ mol } O_2 : 2 \text{ moles } CO_2$$

3. Use dimensional analysis to obtain the # of moles
   a. The # mol of CO:

$$3.2 \text{ moles } O_2 \times \left(\frac{2 \text{ moles CO}}{1 \text{ mole } O_2} \right) = 6.4 \text{ moles CO}$$

   b. The # mol of CO_2:

$$3.2 \text{ moles } O_2 \times \left(\frac{2 \text{ moles } CO_2}{1 \text{ mole } O_2} \right) = 6.4 \text{ moles } CO_2$$