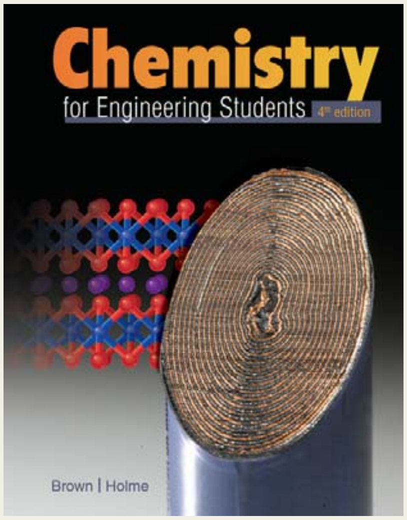

Chapter 4

Stoichiometry

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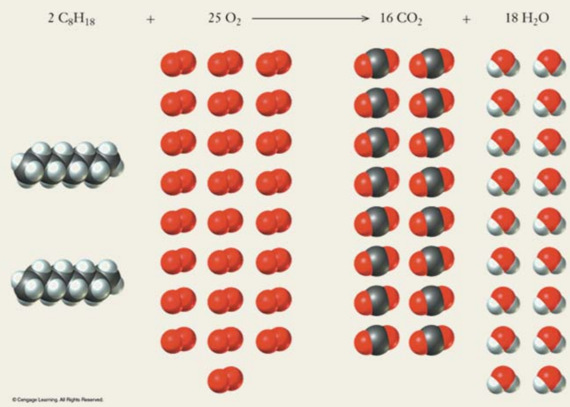
Gasoline and Other Fuels

- Gasoline is a complex mixture of compounds, predominantly containing hydrocarbons
- Most of the hydrocarbon molecules in gasoline are alkanes
- E.g. methane (CH_4), ethane (C_2H_6), propane (C_3H_8)..etc.

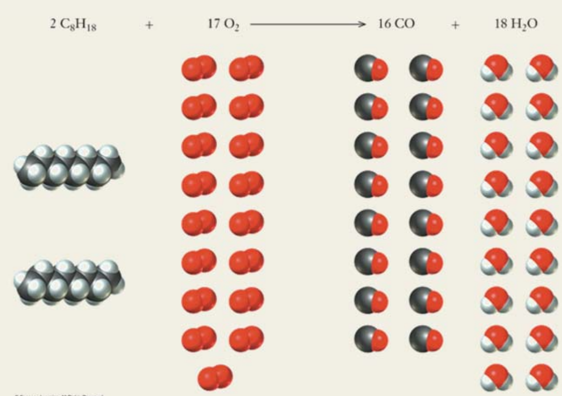
2

Octane: Complete Combustion



- Complete combustion of octane with excess oxygen produces carbon dioxide and water

Octane: Incomplete Combustion



- Incomplete combustion with limited oxygen produces carbon monoxide and water

Fundamentals of Stoichiometry

- Stoichiometry: A term used to describe quantitative relationships in chemistry
  - A balanced chemical equation is needed

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Obtaining Ratios from a Balanced Chemical Equation

$$CH_4(g) + 2\ O_2(g) \longrightarrow CO_2(g) + 2\ H_2O(\ell)$$

- Mole ratios are obtained from the coefficients in the balanced chemical reaction

$$1\ \text{mol}\ CH_4 : 2\ \text{mol}\ O_2$$
$$1\ \text{mol}\ CH_4 : 1\ \text{mol}\ CO_2$$
$$1\ \text{mol}\ CH_4 : 2\ \text{mol}\ H_2O$$
$$2\ \text{mol}\ O_2 : 2\ \text{mol}\ H_2O$$

- These ratios can be used in solving problems as fractions

$$\frac{1\ \text{mol}\ CH_4}{2\ \text{mol}\ O_2} \quad \frac{1\ \text{mol}\ CH_4}{1\ \text{mol}\ CO_2} \quad \frac{1\ \text{mol}\ CH_4}{2\ \text{mol}\ H_2O} \quad \frac{2\ \text{mol}\ O_2}{2\ \text{mol}\ H_2O} \quad \left(\text{or}\ \frac{1\ \text{mol}\ O_2}{1\ \text{mol}\ H_2O}\right)$$

Example Problem

1) In the combustion of methane, how many moles of O_2 are required if 6.75 mol of CH_4 is to be completely consumed?

Answer:

The balanced chemical equation:

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(\ell)$$

The coefficients from this equation give us the ratio between CH_4 and O_2, which can be expressed in either of the following forms:

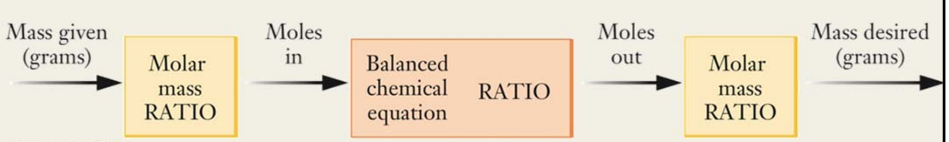
$$\frac{1\,\text{mol}\,CH_4}{2\,\text{mol}\,O_2} \text{ or } \frac{2\,\text{mol}\,O_2}{1\,\text{mol}\,CH_4}$$

To calculate the desired amount of O_2 from the known amount of CH_4, we should use the second form. This gives us the result needed:

$$6.75\,\text{mol}\,CH_4 \times \frac{2\,\text{mol}\,O_2}{1\,\text{mol}\,CH_4} = 13.5\,\text{mol}\,O_2$$

- This flow diagram illustrates the various steps involved in solving a typical reaction stoichiometry problem
  - Similar to unit conversion
  - Usually more than one conversion is necessary
  - Write all quantities with their complete units

They have given the mass of the one species and asked to find out the mass of the other species produced or consumed



Example Problem

2) How many grams of water can be produced if sufficient hydrogen reacts with 26.0 g of oxygen? (molar mass of oxygen is 32.0 g/mol and molar mass of water is 18.0 g/mol)

$$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(g)$$

$$\underbrace{26.0\text{ g }O_2}_{\text{Mass given}} \times \underbrace{\frac{1\text{ mol }O_2}{32.0\text{ g }O_2}}_{\text{Molar mass ratio for oxygen}} \times \underbrace{\frac{2\text{ mol }H_2O}{1\text{ mol }O_2}}_{\text{Mole ratio from equation}} \times \underbrace{\frac{18.0\text{ g }H_2O}{1\text{ mol }H_2O}}_{\text{Molar mass ratio for water}} = 29.3\text{ g }H_2O$$