

Chapter 3

Stoichiometry: Calculations with Chemical Formulas and Equations

Introduction

- Stoichiometry
- Stoicheion "element"
- Metron "measure"

In this chapter -----measurements and reactions
keeping track of atoms

Guiding Principle: Law of Conservation of Mass

In ordinary chemical reactions atoms are neither created nor destroyed.

Chemical Equations

- Antoine Lavoisier(1734-1794) Father of Modern Chemistry
- Beheaded during the French Revolution
- Helped greatly by his wife
- Careful observation of reactions
- Mass before = Mass after

Chemical Reactions

- Chemical equations:
 - Reactants (chemicals before)
 - Products (chemicals after)

Reactants ? Products

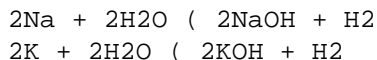
hydrogen and oxygen yield water (word equation)
 $2H_2 + O_2 \rightarrow 2H_2O$ (balanced)

(recall hydrogen and oxygen are diatomic elements so they have subscripts of 2 in their formulas)

- 2 hydrogen molecules react with 1 oxygen molecule to yield 2 water molecules

See picture in center of margin edge page 76.

Other examples of balance reactions, underlined numbers are the stoichiometric coefficients.



Balanced Chemical Equations

Remember- the reason for balancing is to show Law of Conservation of Mass
Have the same number of atoms of each kind of element before and after a reaction.

Steps to write balanced reactions:

- Write correct chemical formulas for reactants & products (correct subscripts) (If you don't get this right, the next step is useless)
- Place numbers to the left of formulas to give the same number of atoms of each element type both left and right of the arrow (sometimes this involves mostly trial and error)

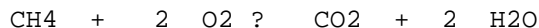
Stoichiometric coefficients: give ratio of reactants & products

See fig.3.3----- H_2O = 1 water molecule that has 2 H atoms and 1 O atom

This one has a coefficient: $2 H_2O$ = 2 whole water molecules (separate ones) for a total
of 4 H atoms and 2 O atoms

H_2O_2 = 1 molecule of hydrogen peroxide, 2 H atoms and
2 O atoms

See fig. 3.4 for another picture of a balanced reaction, the combustion of methane (natural gas):



Methane plus oxygen yields carbon dioxide and water

1 methane molecule plus 2 oxygen molecules yield 1 carbon dioxide molecule plus 2 water molecules

Count the atoms:

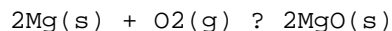
1 C atom	each side of arrow
4 H atoms	each side of arrow
4 O atoms	each side of arrow

Law of conservation of mass: matter cannot be lost in any chemical reactions.

Some Simple Patterns of Chemical Reactivity

Combination and Decomposition Reactions

• Combination reactions have fewer products than reactants:



• The Mg has combined with O₂ to form MgO.

• Decomposition reactions have fewer reactants than products:



(the reaction that occurs in an air bag)

• The NaN₃ has decomposed into Na and N₂ gas.

See table 3.1 for some more examples.

Another type of reaction: Combustion

(Later you'll learn this is a type of oxidation/reduction reaction.)

Combustion is the burning of a substance (fuel) in oxygen:



1 Propane molecule plus 5 oxygen molecules yield 3 carbon dioxide molecules and 4 water molecules

Note: propane = C₃H₈ is sold in tanks under pressure, it is the gas used for gas grills