Stoichiometry

Chapter 9

Mass Percent Composition

$$\text{Mass \% Element} = \frac{\text{mass of element in a given mass of the compound}}{\text{given mass of the compound}} \times 100$$

Mass Percent Composition from the Formula

For example, the mass % hydrogen in water is:

11.19%

Empirical Formulas

The smallest whole number ratio of the elements in a compound.

For example benzene and acetylene.

Calculating the empirical formula from mass % composition.

For example: 60.00% C, 4.48% H, 35.53% O

This gives 60.00 g C, 4.48 g H, and 35.53 g O.

This gives 4.995 mol C, 4.44 mol H, and 2.221 mol O.

Calculating the empirical formula from mass % composition (continued).

$$\boxed{\frac{2.249\,\text{mol C}}{1\,\text{mol O}} \times \frac{4}{4} = \frac{8.998\,\text{mol C}}{4\,\text{mol O}}}$$

$$\boxed{\frac{2.001\,\text{mol H}}{1\,\text{mol O}} \times \frac{4}{4} = \frac{8.008\,\text{mol H}}{4\,\text{mol O}}}$$

$$\boxed{\Rightarrow \; C_9H_8O_4}$$

To find the molecular formula from the percent composition, you must be told the molecular mass.

For example, given that a compound has a percent composition 60.00% C, 4.48% H, 35.53% O, and a molar mass of 540.48 g/mol find the molecular formula.

$\mathbf{C_{27}H_{24}O_{12}}$

Evidence of a Chemical Reaction

Color change

Precipitate formation (solid)

Gas evolution

Heat absorption or evolution

Light emission

Writing Balanced Chemical Equations

Balance the elements on both sides of the arrow.

If any element is by itself on one side of the arrow, balance it last.

Writing Balanced Chemical Equations

When the following equation is balanced, what is the sum of the coefficients?

$$\mathrm{Fe(NO_3)_{3(\mathit{aq})}} + \mathrm{K_2S_{(\mathit{aq})}} \rightarrow \mathrm{KNO_{3(\mathit{aq})}} + \mathrm{Fe_2S_{3(\mathit{s})}}$$

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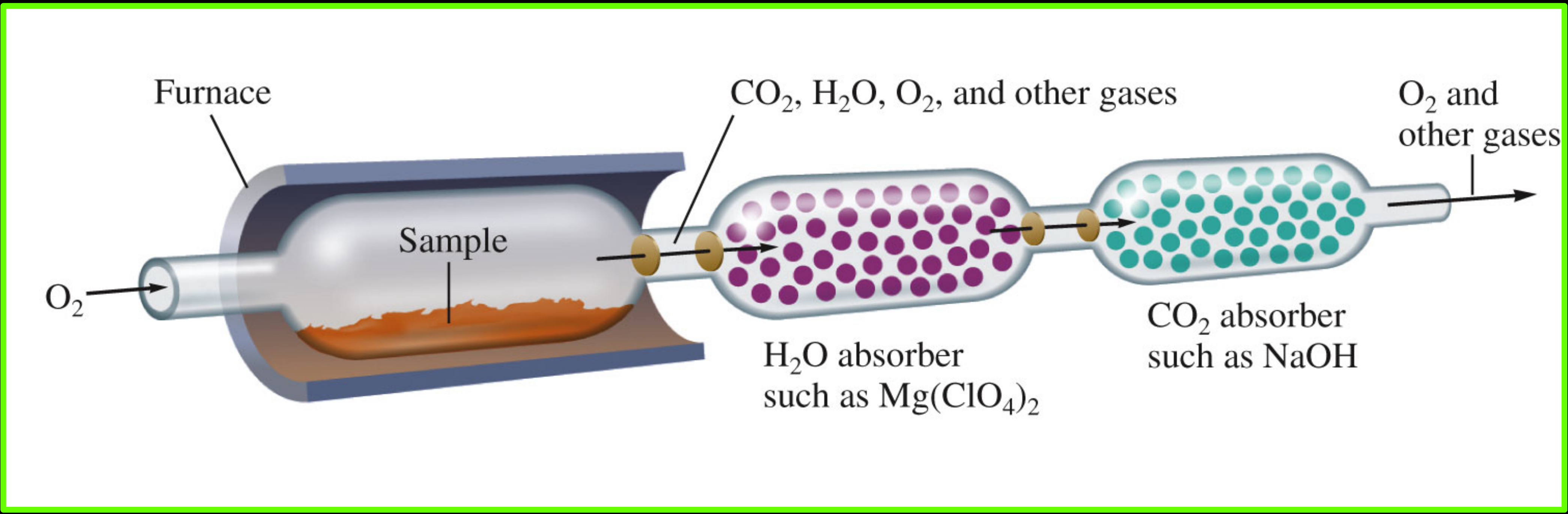
Combustion analysis is used for analyzing compounds containing carbon and hydrogen.



In combustion analysis:

All of the carbon in the sample ends up in the CO_2.

All of the hydrogen ends up in the H_2O.

To analyze the results of a combustion analysis experiment:

The combustion of 17.995 grams of a hydrocarbon produces 49.9088 g CO_2 and 14.1439 g H_2O. What is the empirical formula of this compound?

The coefficients in a BALANCED chemical equation give us more conversion factors!

Given this balanced equation, how many moles of aluminum are required to react with 0.217 mol of zinc sulfate?

$$\boxed{2\ Al_{(s)} + 3\ ZnSO_{4(aq)} \rightarrow 3\ Zn_{(s)} + Al_2(SO_4)_{3(aq)}}$$

0.145 mol Al

Usually we deal in grams rather than moles.

How many grams of water can be produced by the reaction of 5.199 grams of methane with excess oxygen in the following reaction?

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

The reactant that is consumed first determines the amount of everything else present after the reaction stops.

This reactant is called the limiting reactant.

The L.R. is all used up, there is none left after the reaction is complete.

To find the limiting reactant, find number of moles of each reactant.

Divide moles of each reactant by it's coefficient in the balanced chemical equation.

The reactant that gives you the smallest result of this division is the L.R.

What is the L.R. when 0.845 moles of calcium hydroxide react with 0.601 moles of phosphoric acid?

$$3\ Ca(OH)_{2(aq)} + 2\ H_3PO_{4(aq)} \rightarrow Ca_3(PO_4)_{2(s)} + 3\ H_2O_{(l)}$$

$Ca(OH)_2$

What is the L.R. when 0.445 grams of hydrogen react with 0.601 grams of oxygen?

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

O_2

The MOLES of the L.R. is ALWAYS the starting point for all other dimensional analysis involving that reaction.

How many grams of water can theoretically be produced by the reaction of 0.445 grams of hydrogen with 0.601 grams of oxygen?

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

0.677 g H_2O

Percent Yield

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

What is the percent yield when 3.445 grams of oxygen reacts with 0.259 grams of hydrogen to produce 0.798 grams of water?

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

69.0%