Chem. 101 Laboratory
Fall 2005 - 2006

Lecture 2

Empirical Formulas and Percent Composition

purpose

- To determine the empirical formula of magnesium oxide by a combination reaction.
- To determine the percent composition of magnesium oxide experimentally and theoretically.
- To determine the percent composition of sodium carbonate experimentally and theoretically by reacting it with hydrochloric acid.

Percent Composition

Percent Composition of a compound: is the mass(g) percent of each element in the compound.

$$\%Composition = \frac{Mass\ of\ Element(g)}{Total\ Mass(g)\ of\ Compound} \times 100$$

Empirical Formula versus Molecular Formula

A ***molecular formula*** shows the exact number of atoms of each element present in one molecule of a compound

An ***empirical formula*** shows the simplest whole-number ratio of atoms present in a compound.

molecular	**empirical**
H_2O	H_2O
O_3	O
H_2O_2	HO
N_2H_4	NH_2
C_3H_6	CH_2
$C_6H_{12}O_6$	CH_2O

Example:

1.45 g of iron is reacted with oxygen to yield 1.92 g of iron oxide.

a- What is the empirical formula of iron oxide?

b- What is the experimental percent composition of iron oxide?

c- What is the theoretical percent composition of iron oxide?

a- Empirical formula

Iron + oxygen ⟶ iron oxide

1.45g 1.92g

Mass of oxygen = 1.92 - 1.45 = 0.47g

Moles of iron = $\frac{1.45g}{55.84g/mole}$ = 0.0260 mol Fe

Moles of oxygen = $\frac{0.47g}{16.00g/mole}$ = 0.029 mol O

Formula is: $\mathbf{Fe_{0.0260}\,O_{0.029}}$

Divide by the smaller subscript to change to whole numbers

Fe: $\frac{0.0260}{0.0260} = 1.00$

O: $\frac{0.029}{0.0260} = 1.1$

Therefore the empirical formula is FeO

b- Experimental Percent Composition

Mass of iron = 1.45g

Mass of oxygen = 0.47g

Mass of iron oxide = 1.92g

$$\%Fe = \frac{1.45\ g\ Fe}{1.92\ g} \times 100 = 75.5\%$$

$$\%O = \frac{0.47g\ O}{1.92g} \times 100 = 24\%$$

c- Theoretical % Composition

Molecular formula: FeO

Molar mass of FeO = 55.84g Fe + 16.00g O

= 71.84 g/mol

$$\%Fe = \frac{55.84 \text{ g Fe}}{71.84 \text{ g}} \times 100 = 77.73\ \%$$

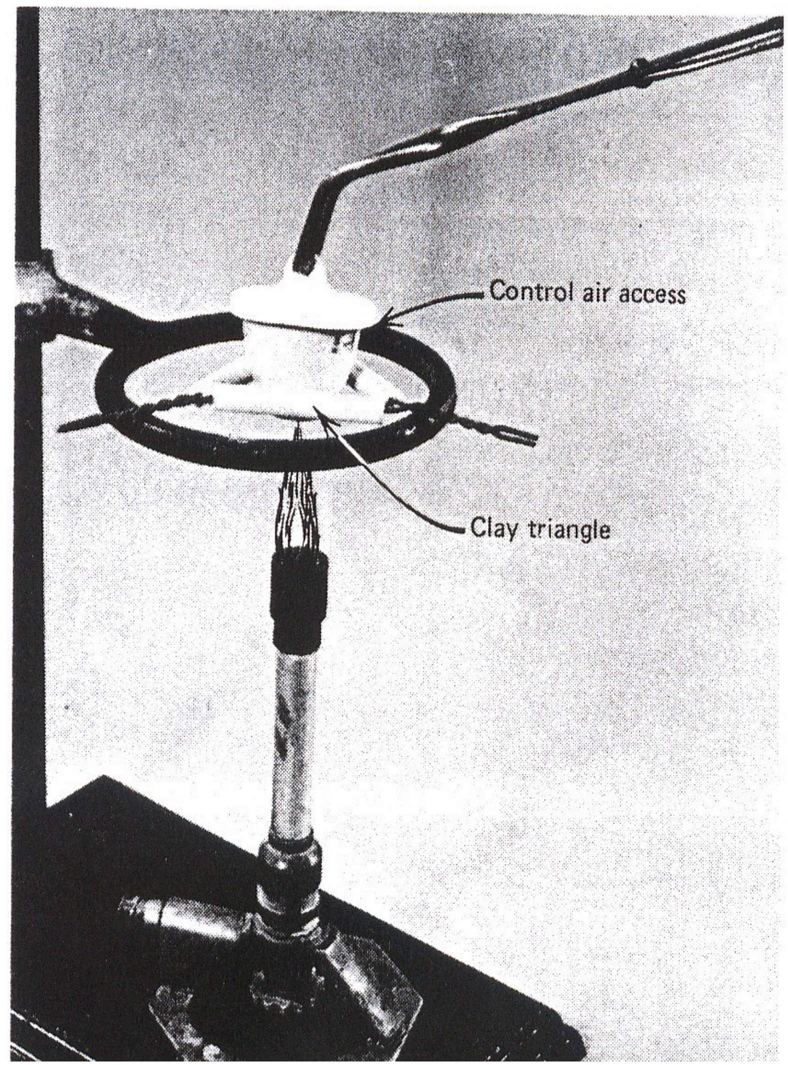
$$\%O = \frac{16.00 \text{ g O}}{71.84 \text{ g}} \times 100 = 22.27\ \%$$

Experiment

A- Empirical formula and percent composition of magnesium oxide:

$2Mg + O_2 \longrightarrow 2MgO$

- Weigh crucible + lid using an Analytical balance
- Place around 0.1g of Mg on the crucible and weigh
- Heat while the lid is on, occasionally lift the lid to allow oxygen in. Keep heating till the bottom of the crucible is *red hot*
- Heat for additional 15 minutes
- *Note: Don't watch the burn,* it may cause temporary blindness
- Cool and weigh



B- Percent Composition of Sodium Carbonate:

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

- Weigh clean dry small beaker using the analytical balance
- Add around 1g of sodium carbonate and weigh
- Add dilute HCl slowly while shaking, continue adding till no more bubbles form and the solution becomes clear.

  (Avoid excess HCl)
- Evaporate the water
- Dry in an oven for half an hour
- Cool and weigh.

B- Report

Data:

a- mass of empty beaker =

b- mass of beaker and Na_2CO_3 =

c- mass of beaker and NaCl =

Calculations:

d - mass of Na_2CO_3 = (b – a) g

e - mass of NaCl = (c - a) g

f- mass of Na in NaCl = e (g NaCl) x 23.00 (g Na) / 58.453 (g NaCl)

g- mass of Na in Na_2CO_3 = (f) g

h- Experimental Percent of Na in Na_2CO_3 = f (g Na) /d (g Na_2CO_3) x 100

i- Experimental Percent of CO_3 in Na_2CO_3 = 100 – h

j- Theoretical Percent of Na in Na_2CO_3 = $\frac{(23.00 \times 2)\ g\ Na}{106.01 g\ Na_2CO_3} \times 100$

k- % Error =