Cycle 2 Chemistry II Lesson 3

Determining a compound's empirical formula from percentage composition

AGENDA

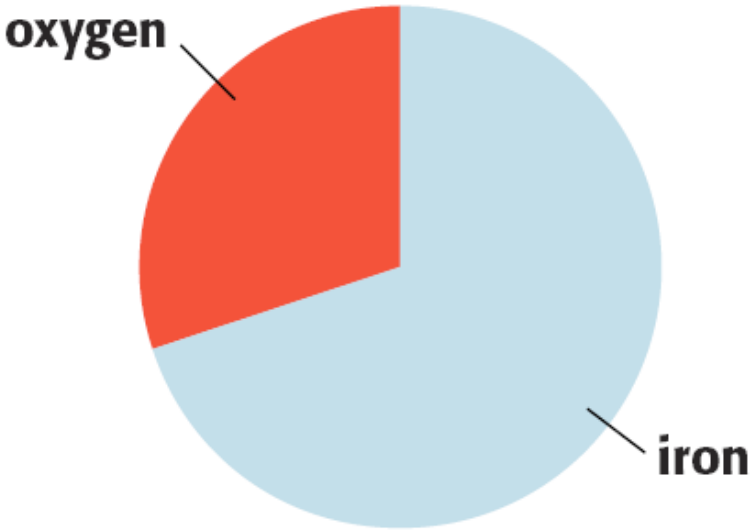
Vocab: Percentage Composition, Empirical Formula

Problems: p. 243 #1-4 (HONORS – Handout PS #2)

Using Analytical Data

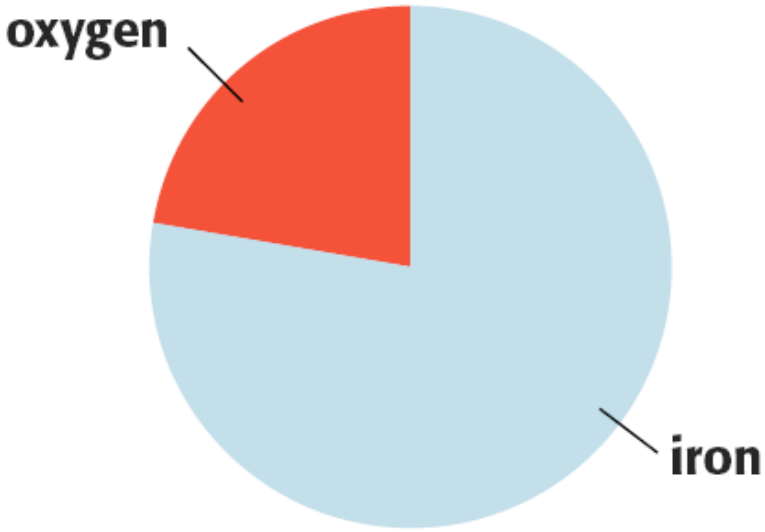
- The **percentage composition** is the percentage by mass of each element in a compound.
- Percentage composition helps verify a substance's identity.
- Percentage composition also can be used to compare the ratio of masses contributed by the elements in two different substances.

Percentage Composition of Iron Oxides



iron(III) oxide, Fe_2O_3

iron	69.9%
oxygen	30.1%



iron(II) oxide, FeO

iron	77.7%
oxygen	22.3%

Using Analytical Data, *continued*

Determining Empirical Formulas

- An **empirical formula** is a chemical formula that shows the simplest ratio for the relative numbers and kinds of atoms in a compound.
- An *actual formula* shows the actual ratio of elements or ions in a single unit of a compound.
- For example, the empirical formula for ammonium nitrite is NH_2O, while the actual formula is NH_4NO_2.

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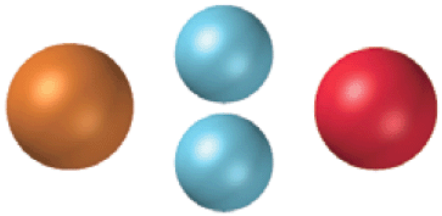
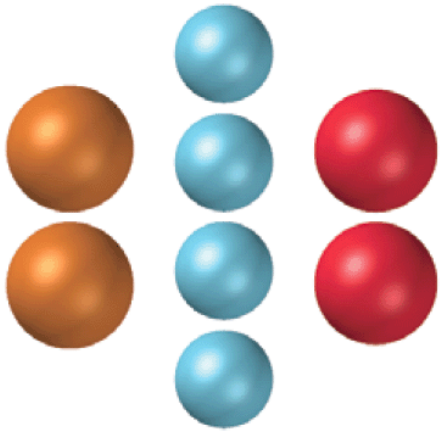
Empirical and Actual Formulas

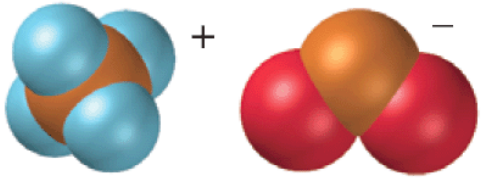
Empirical formula NH_2O



Actual formula NH_4NO_2



Space-filling model



Using Analytical Data, *continued*

Determining Empirical Formulas, *continued*

- You can use the percentage composition for a compound to determine its empirical formula.

1. Convert the percentage of each element to g.
2. Convert from g to mol using the molar mass of each element as a conversion factor.
3. Compare these amounts in mol to find the simplest whole-number ratio among the elements.

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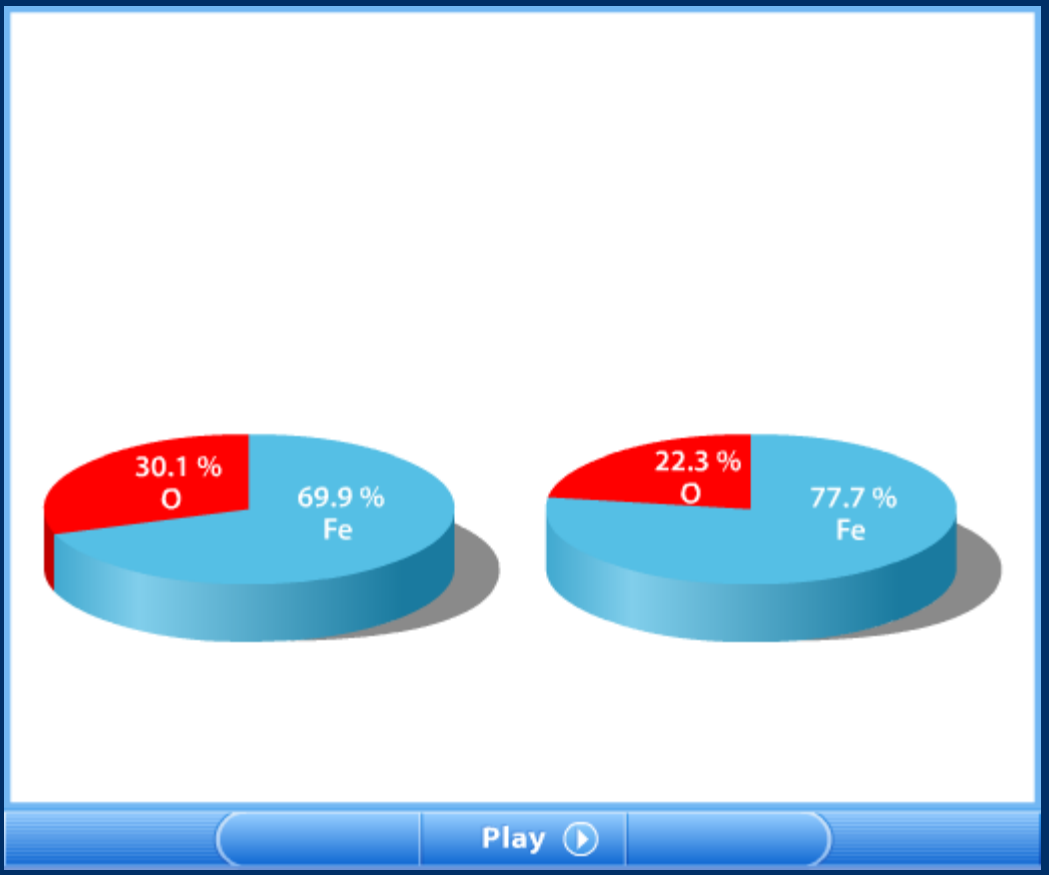
Percentage Composition



Determining an Empirical Formula from Percentage Composition

Sample Problem G

Chemical analysis of a liquid shows that it is 60.0% C, 13.4% H, and 26.6% O by mass. Calculate the empirical formula of this substance.

Determining an Empirical Formula from Percentage Composition

Sample Problem G Solution

Assume that you have a 100.0 g sample, and convert the percentages to grams.

for C: $60.0\% \times 100.0\ g = 60.0\ g\ C$

for H: $13.4\% \times 100.0\ g = 13.4\ g\ H$

for O: $26.6\% \times 100.0\ g = 26.6\ g\ O$

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Determining an Empirical Formula from Percentage Composition

Sample Problem G Solution, *continued*

Convert the mass of each element into the amount in moles, using the reciprocal of the molar mass.

$$60.0\ \text{g C} \times \frac{1\ \text{mol C}}{12.01\ \text{g C}} = 5.00\ \text{mol C}$$

$$13.4\ \text{g H} \times \frac{1\ \text{mol H}}{1.01\ \text{g H}} = 13.3\ \text{mol H}$$

$$26.6\ \text{g O} \times \frac{1\ \text{mol O}}{16.00\ \text{g O}} = 1.66\ \text{mol O}$$

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Determining an Empirical Formula from Percentage Composition

Sample Problem G Solution, *continued*

The formula can be written as $C_5H_{13.3}O_{1.66}$, but you divide by the smallest subscript to get whole numbers.

$$\frac{5.00 \text{ mol C}}{1.66} = 3.01 \text{ mol C}$$

$$\frac{13.3 \text{ mol H}}{1.66} = 8.01 \text{ mol H}$$

$$\frac{1.66 \text{ mol O}}{1.66} = 1.00 \text{ mol O}$$

The empirical formula is C_3H_8O.