Percent Composition, Empirical and Molecular Formulas

Applying percentages to Chemistry

A percent is a ratio of the part in the whole compared to 100.

The percent composition of a compound can be found from

* Mass data
* Chemical formula

Percent Composition from Mass Data

$$\%\ \text{mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100\%$$

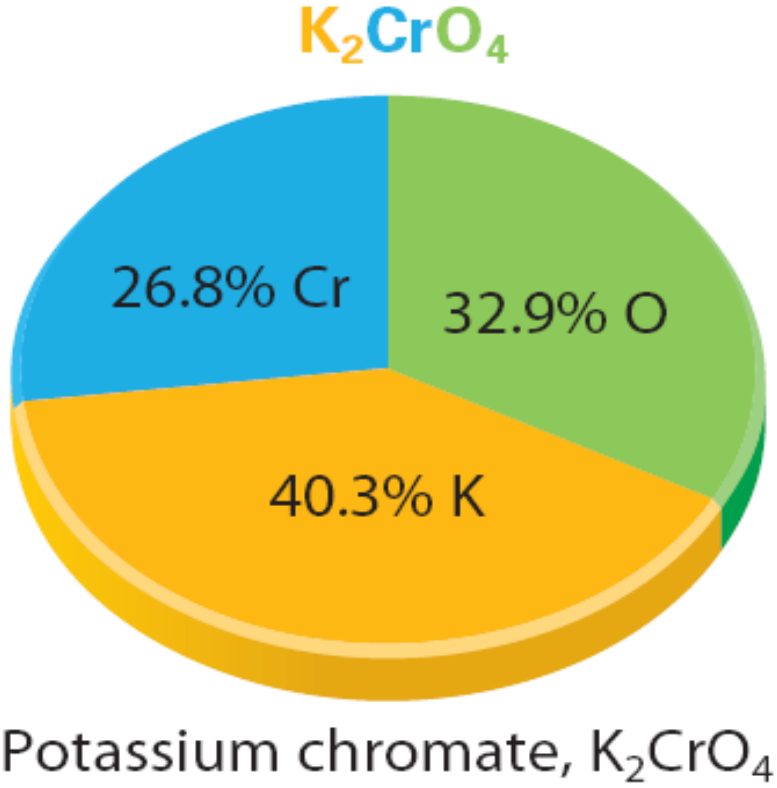
Practice:

A 13.60 g sample of compound made of oxygen and magnesium contains 5.40 g of oxygen.

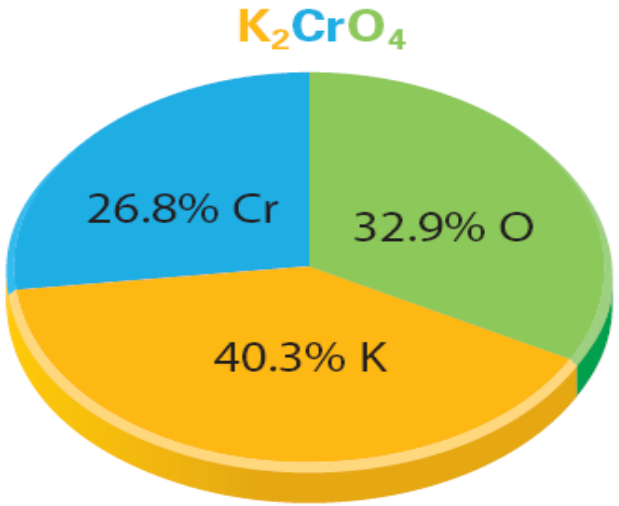
Calculate the percent composition of the compound.

Percent composition from Chemical formula

How could the percentages in the graph be calculated?



Percentages of elements in a compound are calculated using the molar mass of the atoms in the compounds.



Potassium chromate, K_2CrO_4

K_2CrO_4

- The percent composition is the mass percent in any sample.

- For example if the % comp of carbon is 50%, then any sample of the substance would be 50% carbon by mass.

Formulas

Empirical formula: the lowest whole number ratio of atoms in a compound.

Molecular formula: the true number of atoms of each element in the formula of a compound.

- molecular formula = $(\text{empirical formula})_n$
- molecular formula = $C_6H_6 = (CH)_6$
- empirical formula = CH

Formulas (continued)

Formulas for ionic compounds are <u>ALWAYS</u> empirical (lowest whole number ratio).

Examples:

$NaCl$ $Al_2(SO_4)_3$

$MgCl_2$ K_2CO_3

Formulas (continued)

Formulas for molecular compounds <u>MIGHT</u> be empirical (lowest whole number ratio).

Molecular:	H_2O	$C_6H_{12}O_6$	$C_{12}H_{22}O_{11}$
	↓	↓	↓
Empirical:	H_2O	CH_2O	$C_{12}H_{22}O_{11}$

Empirical Formula Determination

1. Base calculation on 100 grams of compound. Determine moles of each element in 100 grams of compound.
2. Divide each value of moles by the smallest of the values.
3. Multiply each number by an integer to obtain all whole numbers.

Empirical Formula Determination

Adipic acid contains 49.32% C, 43.84% O, and 6.85% H by mass. What is the empirical formula of adipic acid?

1. Treat % as mass, and convert grams to moles

$$\frac{49.32\ g\ carbon}{}\left|\frac{1\ mol\ carbon}{12.01\ g\ carbon}\right. = 4.107\ mol\ carbon$$

$$\frac{6.85\ g\ hydrogen}{}\left|\frac{1\ mol\ hydrogen}{1.01\ g\ hydrogen}\right. = 6.78\ mol\ hydrogen$$

$$\frac{43.84\ g\ oxygen}{}\left|\frac{1\ mol\ oxygen}{16.00\ g\ oxygen}\right. = 2.74\ mol\ oxygen$$

Empirical Formula Determination

2. Divide each value of moles by the smallest of the values.

Carbon: $$\frac{4.107\,mol\,carbon}{2.74\,mol} = 1.50$$

Hydrogen: $$\frac{6.78\,mol\,hydrogen}{2.74\,mol} = 2.47$$

Oxygen: $$\frac{2.74\,mol\,oxygen}{2.74\,mol} = 1.50$$

Empirical Formula Determination

3. Multiply each number by an integer to obtain all whole numbers.

Carbon: 1.50	Hydrogen: 2.50	Oxygen: 1.00
x 2	x 2	x 2
3	5	2

Empirical formula: $C_3H_5O_2$

Finding the Molecular Formula

The empirical formula for adipic acid is $C_3H_5O_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

1. Find the formula mass of $C_3H_5O_2$

3(12.01 g) + 5(1.01) + 2(16.00) = 73.08 g

Finding the Molecular Formula

The empirical formula for adipic acid is $C_3H_5O_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

3(12.01 g) + 5(1.01) + 2(16.00) = 73.08 g

2. Divide the molecular mass by the mass given by the emipirical formula.

$$\frac{146}{73} = 2$$

Finding the Molecular Formula

The empirical formula for adipic acid is $C_3H_5O_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

$$\frac{146}{73} = 2$$

$(C_3H_5O_2) \times 2 = C_6H_{10}O_4$

3. Multiply the empirical formula by this number to get the molecular formula.