Announcements

We finished Chapter 4

Skip Chapter 5

Starting Chapter 6

- 6.1 Molar Mass ✓
- 6.2 Empirical & Molecular formulas Today
- 6.3 Molarity (Concentration)

New Quiz on Canvas Electronic Config

New homework Chapter 4

Nomenclature worksheet — Turned in

Empirical formula is the smallest ratio of atoms in a molecule

$C_6H_{12}O_6$ Molecular formula

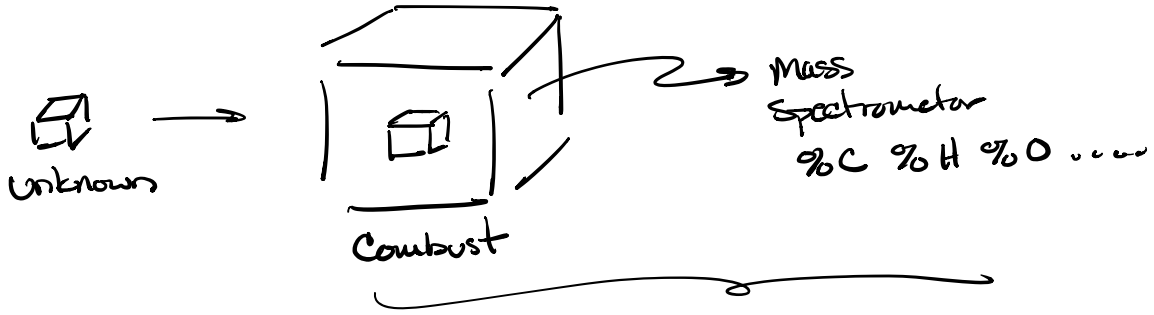
CH_2O Empirical formula

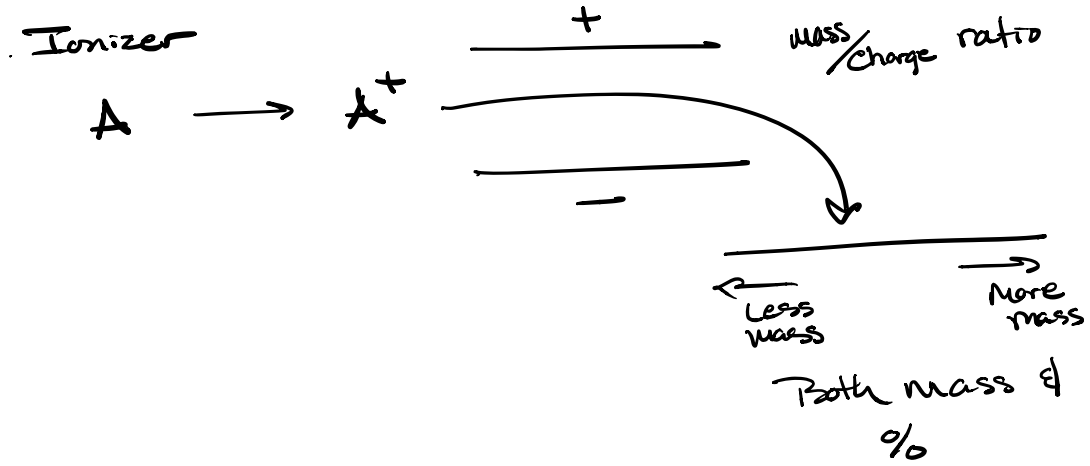
$$\frac{C_6}{6}\frac{H_{12}}{6}\frac{O_6}{6} = CH_2O$$

$$6(CH_2O) = C_6H_{12}O_6$$

6x Empirical = Molecular formula

$6 \times 30.03\ g/mol = 180.16\ g/mol$





A combustion analysis on a meterial gives 40.00% C, 6.71% H, and 53.29% oxygen. The molar mass of the compound is 180.16 g/mole. Find both the empirical & molecular formula for the compound.

Steps

① Convert % to mass in g
② Convert grams to moles of each element
③ Find the smallest whole number ratios of moles
④ If ratios are fractional, multiply to obtain whole #'s

} % to mass, mass to mole, divide by small mult. til whole

⟹ Empirical

⑤ Find molar mass of Empirical
⑥ Divide molar mass of Compound by molar mass of Empirical
⑦ Mult Subscripts of Empirical by the result of division in step 6 ⟹ Molecular formula

	C	H	O
%	40.00%	6.71%	53.29 %
g	40.00 g	6.71 g	53.29 g

assume 100g Sample

mole

$40.00\,g\,C \times \frac{1\ mole\ C}{12.01\,g\,C}$ $\quad 6.71\,g \times \frac{1\ mole\ H}{1.008\,g\,H}$ $\quad 53.29\,g \times \frac{1\ mole\ O}{16.00\,g}$

smallest

$= 3.330557868$ mole C $\quad = 6.652746032$ mole H $\quad = 3.330625$ mole O

Ratio

$\frac{3.330557868}{3.330557868} = 1$ $\quad \frac{6.652746032}{3.330557868} = 2$ $\quad \frac{3.330625}{3.330557868} = 1$

$= 1.99868 \approx 2$

Ratios

$C_1H_2O_1$ Empirical formula

Fractional Ratio Ex

$2(C_1H_{1.5}) = C_2H_3$

$4(C_1H_{2.25}) = C_4H_9$

$1.5 = \frac{3}{2}$ $\qquad$ $1.25 = \frac{5}{4}$

$2 \times \frac{3}{2} = 3$ $\qquad$ $4 \times \frac{5}{4} = 5$

Emperical Formula CH_2O

Molecular Mass 180.16 g/mol

$x\ CH_2O = C_xH_{2x}O_x$

$x\ 30.03\ g/mol = 180.16\ g/mole$

$x = \frac{180.16\ g/mol}{30.03\ g/mol} = 6$

Calc

given in problem

5.9972
6.001723 $\}\approx 6$

C $1 \times 12.01 = 12.01$

H $2 \times 1.008 = 2.016$

O $1 \times 16.00 = +16.00$

30.026 g/mole

Emperical CH_2O

Molecular $= 6(CH_2O) = C_6H_{12}O_6$

A compound with a molar mass of 240. g/mole is found to have a composition of 75.95% C, 17.72% N and 6.33% H. What is the molecular formula?

	C	N	H
%	75.95%	17.72%	6.33%
mass	75.95 g	17.72 g	6.33 g
mole	$75.95\,g \times \frac{1\ mole}{12.01\,g}$	$17.72\,g \times \frac{1\ mole}{14.01\,g}$	$6.33 \times \frac{1\ mole}{1.008\,g}$
	$= 6.323896752706$	$= 1.2648108493\underline{93}$ Smallest	$= 6.27976190476\underline{2}$
Ratio	$\frac{6.323896752706}{1.264810849393}$	$\frac{1.264810849393}{1.264810849393}$	$\frac{6.279761904762}{1.264810849393}$
	5	1	$4.96 \approx 5$

Empirical $C_5NH_5 = 79.10$ g/mole

$$\frac{\text{molar mass}}{\text{Empirical}} \quad \frac{240\ g/mole}{79.10\ g/mole} = 3.033 \approx 3 = X$$

$$3(C_5H_5N) = C_{15}H_{15}N_3$$

CHONS

1 1.25 1.50 1.75

$\frac{5}{4}$ $\frac{3}{2}$ $\frac{7}{4}$

1

$4 \times \frac{5}{4} = 5$

$2 \times \frac{3}{2} = 3$

$4 \times \frac{7}{4} = 7$

Percent Composition

We can calculate % Composition from a formula.

Ex Calculate the % composition of Nitrogen and Hydrogen in ammonia (NH_3)

$$\% = \frac{\text{Part}}{\text{Whole}} \times 100$$

$$\%N = \frac{N}{NH_3} \times 100 = \frac{14.01\ g/mole}{17.034\ g/mole} \times 100$$

$$= 82.24727017\ \%$$

$$= \boxed{82.25\ \%\ N}$$

$$\%\,H = \frac{3H}{NH_3} \times 100$$

$$= \frac{3(1.008)}{14.01 + 3(1.008)} \times 100$$

$$= \frac{3.024\ g/mole}{17.034\ g/mole} \times 100 = 17.7527\,2983\,\%$$

$$= \boxed{17.75\%\ H}$$

what is the % of NO_3^- in $Fe(NO_3)_3$?

$$\% = \frac{Part}{whole} \times 100$$

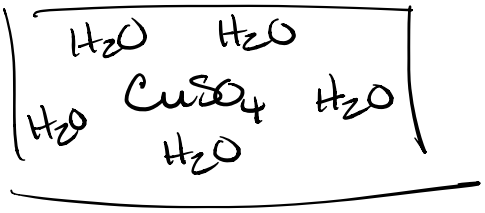
$$\%\ NO_3^- = \frac{3\ NO_3^-}{Fe(NO_3)_3} \times 100$$

$$= \frac{3(14.01 + 3\times 16)}{55.845 + 3(14.01 + 3\times 16)} = \frac{186.03\ g/mole}{241.875\ g/mole} \times 100$$

$$= \boxed{76.91\%\ NO_3^-}$$

What % of $CuSO_4 \cdot 5H_2O$ is water?

$\underbrace{CuSO_4 \cdot 5H_2O}_{\text{Hydrate}}$



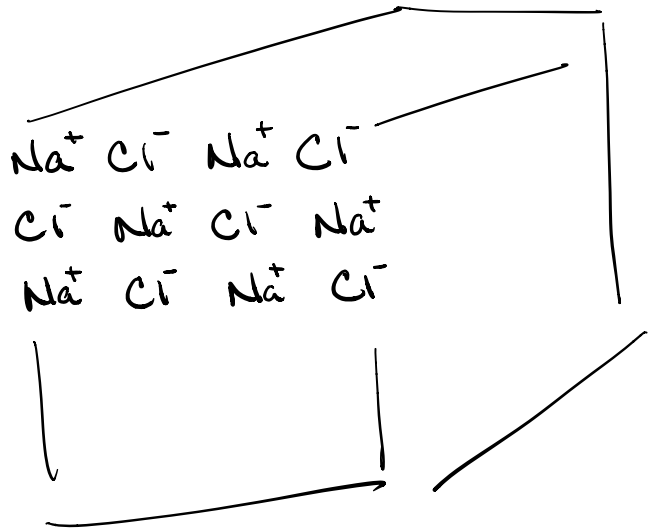
1 mole $CuSO_4$ there are 5 moles H_2O in the crystal

$$\% = \frac{\text{Part}}{\text{whole}} \times 100$$

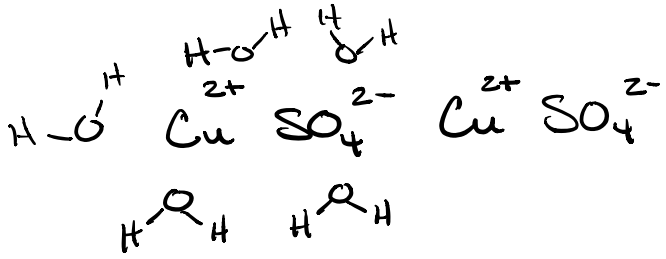
$$\%\, H_2O = \frac{5\, H_2O}{CuSO_4 \cdot 5H_2O} \times 100$$

$$= \frac{5(2 \times 1.008 + 16.00)}{63.55 + 32.07 + 4(16.00) + 5(2 \times 1.008 + 16.00)} \times 100$$

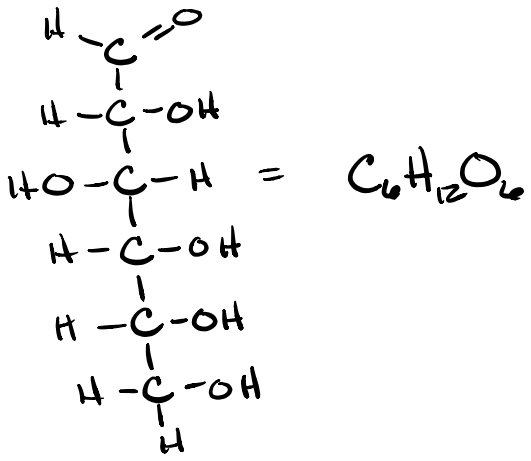
$$= \frac{90.08\ g/mole}{249.70\ g/mole} \times 100 = \boxed{36.08\ \%\ H_2O}$$



NaCl Ionic Formula



$CuSO_4 \cdot 5H_2O$



Concentration

The measurement of the part out of the whole

Many types ⇒ mainly used for Solutions

Solution = Solute ⇐ Thing dissolved
Solvent ⇐ Thing doing the dissolving

Salt water

Solute = NaCl

Solvent = H_2O

Solution = NaCl + H_2O

Molarity = $\frac{\text{moles Solute}}{\text{L Solution}}$

Molality
Normality
osmolarity
} Similar to Molarity & used for special types

% Types

% = part per hundred
Parts per million (ppm)
Parts per billion (ppb)

% as Concentration

Percent can be % by weight % wt/wt

or

Percent by volume % v/v (wine, beer)

Ex Wine list % alcohol 13.0 % v/v ← unitless

$$\frac{\text{part}}{\text{whole}} \times 100 \qquad \frac{13 \text{ mL alcohol}}{100 \text{ mL wine}} \times 100$$

or

$$\frac{13 \text{ gal alcohol}}{100 \text{ gal wine}} \times 100$$

Ex How many mL of alcohol are in a 750. mL bottle of wine with a concentration of 12.5% v/v alcohol?

$$\frac{12.5 \text{ mL alcohol}}{100 \text{ mL wine}} \qquad 12.5 \text{ mL alcohol} = 100 \text{ mL wine}$$

Road Map

mL wine → mL alcohol

$$750.\ \text{mL wine} \times \frac{12.5 \text{ mL alcohol}}{100 \text{ mL wine}} = 93.75 \text{ mL alcohol}$$

(3 sig figs; 100 exact)

$$= 93.8 \text{ mL alcohol}$$

$$ppm = \frac{\text{part}}{\text{whole}} \times 1{,}000{,}000$$

$$\% = \text{part per hundred} = \frac{\text{part}}{\text{whole}} \times 100$$

Ex

5.23 % v/v alcohol in beer

$$\frac{5.23 \text{ mL alcohol}}{100 \text{ mL beer}}$$

if 5.23 ppm alcohol in water

$$\frac{5.23 \text{ mL alcohol}}{1{,}000{,}000 \text{ mL } H_2O} = \frac{5.23 \text{ mL alcohol}}{1 \times 10^6 \text{ mL } H_2O}$$