# WHAT ABOUT COMPOUNDS? FORMULA WEIGHT

Example: 25.0 g of WATER contain how many MOLES of water molecules?

$H_2O$: H: 2 x 1.008 = 2.016
O: 1 x 16.00 = 16.00

18.016 ← FORMULA WEIGHT of water

$18.016\,g\,H_2O = mol\,H_2O$

FORMULA WEIGHT is the mass of one mole of either an element OR a compound.

$$25.0\,g\,H_2O \times \frac{mol\,H_2O}{18.016\,g\,H_2O} = \boxed{1.38\,mol\,H_2O}$$

Formula weight goes by several names:

- For atoms, it's the same thing as ATOMIC WEIGHT
- For molecules, it's called MOLECULAR WEIGHT
- Also called "MOLAR MASS"

Example: How many grams of barium chloride do we need to weigh out to get 3.65 moles of barium chloride?

1. Barium chloride is IONIC (Ba is a metal):

$Ba^{2+}$ $Cl^-$
$Cl^-$

$BaCl_2$

2. Calculate formula weight:

$Ba: 1 \times 137.3 = 137.3$

$Cl: 2 \times 35.45 = 70.90$

$208.2\ g\ BaCl_2 = mol\ BaCl_2$

3. Find grams barium chloride

$$3.65\ mol\ BaCl_2 \times \frac{208.2\ g\ BaCl_2}{mol\ BaCl_2} = 759.93\ g\ BaCl_2$$

$$= \boxed{76\bar{0}\ g\ BaCl_2}$$

# PERCENTAGE COMPOSITION

- sometimes called "percent composition" or "percent composition by mass"

- the percentage of each element in a compound, expressed in terms of mass

Example: Find the percentage composition of barium chloride.

$BaCl_2$ : Ba : $1 \times 137.3 = \boxed{137.3}$

Cl : $2 \times 35.45 = \boxed{70.90}$

208.2 g $BaCl_2$ = mol $BaCl_2$

These numbers are the masses of each element in a mole of the compound!

Ba : $\dfrac{137.3\text{ g Ba}}{208.2\text{ g BaCl}_2} \times 100 = 65.95\%$ Ba

Cl : $\dfrac{70.90\text{ g Cl}}{208.2\text{ g BaCl}_2} \times 100 = 34.05\%$ Cl

The sum of all the elements in the compound should be 100% ... within roundoff error.

So far, we have

- looked at how to determine the composition by mass of a compound from a formula
- converted from MASS to MOLES (related to the number of atoms/molecules)
- converted from MOLES to MASS

Are we missing anything?

- What about SOLUTIONS, where the desired chemical is not PURE, but found DISSOLVED IN WATER?
- How do we deal with finding the moles of a desired chemical when it's in solution?

# MOLAR CONCENTRATION

- unit: MOLARITY (M): moles of dissolved substance per LITER of solution

dissolved substance

$$M = \text{molarity} = \frac{\text{moles of SOLUTE}}{\text{L SOLUTION}}$$

6.0 M HCl solution: $\frac{6.0 \text{ mol HCl}}{\text{L}}$

If you have 0.250 L (250 mL) of 6.0 M HCl, how many moles of HCl do you have?

6.0 mol HCl = L

$$0.250 \text{ L} \times \frac{6.0 \text{ mol HCl}}{\text{L}} = \boxed{1.5 \text{ mol HCl}}$$

If you need 0.657 moles of hydrochloric acid, how many liters of 0.0555 M HCl do you need to measure out?

$0.0555 \text{ mol HCl} = \text{L}$

$$0.657 \text{ mol HCl} \times \frac{\text{L}}{0.0555 \text{ mol HCl}} = \boxed{11.8 \text{ L of } 0.0555 \text{ M HCl}}$$

11800 mL

What if we used 6.00 M HCl?

$6.00 \text{ mol HCl} = \text{L}$

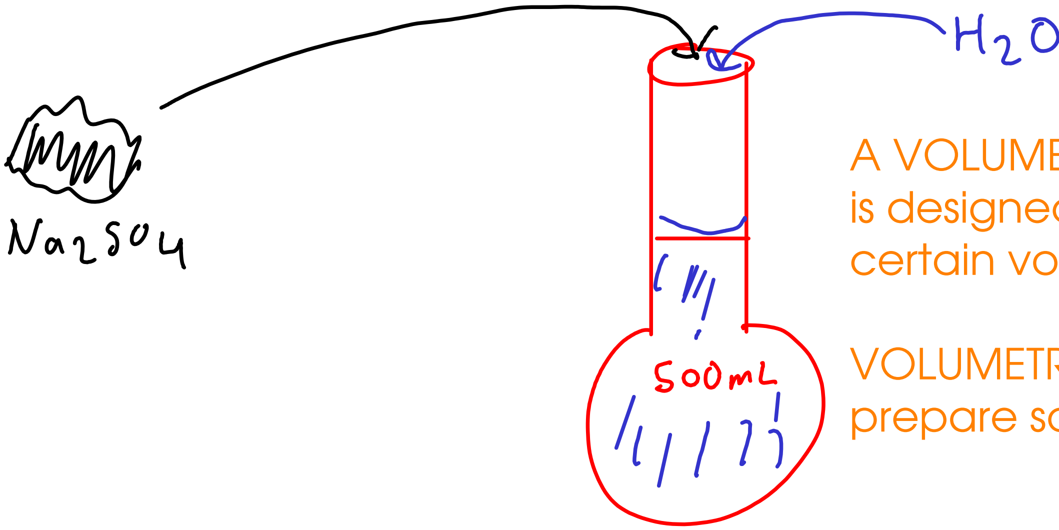
$$0.657 \text{ mol HCl} \times \frac{\text{L}}{6.00 \text{ mol HCl}} = \boxed{0.110 \text{ L of } 6.00 \text{ M HCl}}$$

110 mL

Example: How would we prepare 500. mL of 0.500 M sodium sulfate in water?

$Na_2SO_4$ : 142.05 g/mol

Dissolve the appropriate amount of sodium sulfate into enough water to make 500. mL of solution.




volumetric flask

A VOLUMETRIC FLASK is a flask that is designed to precisely contain a certain volume of liquid.

VOLUMETRIC FLASKS are used to prepare solutions.

Find the moles of sodium sulfate in the solution using the volume and molarity.

$0.500 \text{ mol } Na_2SO_4 = L \qquad mL = 10^{-3} L$

$$500.\,mL \times \frac{10^{-3}\,L}{mL} \times \frac{0.500 \text{ mol } Na_2SO_4}{L} = 0.250 \text{ mol } Na_2SO_4$$

Find the mass of sodium sulfate using moles and formula weight.

$142.05 \text{ g } Na_2SO_4 = \text{mol } Na_2SO_4$

$$0.250 \text{ mol } Na_2SO_4 \times \frac{142.05 \text{ g } Na_2SO_4}{\text{mol } Na_2SO_4} = \boxed{35.5 \text{ g } Na_2SO_4}$$

Weigh 35.5 grams of sodium sulfate into a 500. mL volumetric flask, and add water to the mark.

# More on MOLARITY

To prepare a solution of a given molarity, you generally have two options:

1. Weigh out the appropriate amount of solute, then dilute to the desired volume with solvent (usually water)

"stock solution"

2. Take a previously prepared solution of known concentration and DILUTE it with solvent to form a new solution

- Use DILUTION EQUATION

The dilution equation is easy to derive with simple algebra.

$$M \times V$$

$$\frac{mol}{L} \times L = \text{moles solute}$$

... but when you dilute a solution, the number of moles of solute REMAINS CONSTANT. (After all, you're adding only SOLVENT)

$$M_1V_1 = M_2V_2$$

before diution

after dilution

Since the number of moles of solute stays the same, this equality must be true!