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

First, find out the FORMULA of the compound:

Ba^{2+} Cl^-

Cl^-

$BaCl_2$

Second, find the FORMULA WEIGHT:

$BaCl_2$: Ba - 1 x 137.3

Cl - 2 x 35.45

208.2 g $BaCl_2$ = mol $BaCl_2$

Finally, calculate the mass via dimensional analysis.

$$3.65 \text{ mol } BaCl_2 \times \frac{208.2 \text{ g } BaCl_2}{\text{mol } BaCl_2} = 76\bar{0} \text{ g } BaCl_2$$

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 x 137.3 = 137.3
Cl: 2 x 35.45 = 70.90

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

208.2 g $BaCl_2$ = mol $BaCl_2$

Ba: $\frac{137.3 \text{ g Ba}}{208.2 \text{ g total}} \times 100$ = 65.95 % Ba

Cl: $\frac{70.90 \text{ g Cl}}{208.2 \text{ g total}} \times 100$ = 34.05 % Cl

Note: These percentages should sum to 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 <--- this is how we express molarity as a conversion factor!

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

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

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

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

(11800 mL)

What if we used 6.00 M HCl?

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

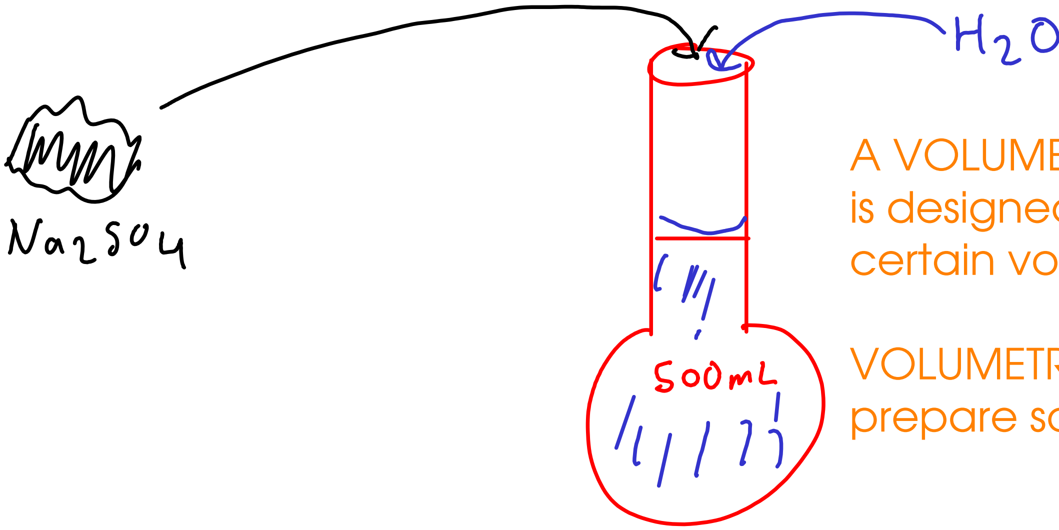
$$0.657 \text{ mol HCl} \times \frac{\text{L}}{6.00 \text{ mol HCl}} = \boxed{0.110 \text{ L}}$$

($11\bar{0}$ 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.



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

VOLUMETRIC FLASKS are used to prepare solutions.

volumetric flask

Find out the moles of sodium sulfate needed using MOLARITY. Then, change that number of moles to mass using FORMULA WEIGHT.

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

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

Now find the mass...

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

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

Add 35.5 grams sodium sulfate to 500 mL volumetric, then 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!

$M_1V_1 = M_2V_2$ ... the "DILUTION EQUATION"

M_1 = molarity of concentrated solution

V_1 = volume of concentrated solution

M_2 = molarity of dilute solution

V_2 = volume of dilute solution (total volume, not volume of added solvent!)

The volumes don't HAVE to be in liters, as long as you use the same volume UNIT for both volumes!

Example: Take the 0.500 M sodium sulfate we discussed in the previous example and dilute it to make 150. mL of 0.333 M solution. How many mL of the original solution will we need to dilute?

$M_1V_1 = M_2V_2$

$(0.500\ M)\ V_1 = (0.333\ M)(150.\ mL)$

$V_1 =$ 99.9 mL of 0.500 M stock

$M_1 = 0.500\ M$

$V_1 = ?$

$M_2 = 0.333\ M$

$V_2 = 150.\ mL$

Measure out 99.9 mL of the 0.500 M sodium sulfate solution. Then, add enough water to dilute the solution to a total volume of 150. mL.

CHEMICAL EQUATIONS

- are the "recipes" in chemistry
- show the substances going into a reaction, substances coming out of the reaction, and give other information about the process

"yields"

$$MgCl_2(aq) + 2AgNO_3(aq) \longrightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$$

REACTANTS - materials that are needed fot a reaction

PRODUCTS - materials that are formed in a reaction

COEFFICIENTS - give the ratio of molecules/atoms of one substance to the others

PHASE LABELS - give the physical state of a substance:
(s) -solid
(l) - liquid
(g) - gas
(aq) - aqueous. In other words, dissolved in water