

## 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.

$$\text{BaCl}_2 : \text{Ba} : 1 \times 137.3 = 137.3$$

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

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

$$208.2 \text{ g BaCl}_2 = \text{mol BaCl}_2$$

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

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

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

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

↙ dissolved substance

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

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

$$6.0 \text{ mol HCl} = \text{L}$$

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

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

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

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

(11800 mL)

What if we used 6.00 M HCl?

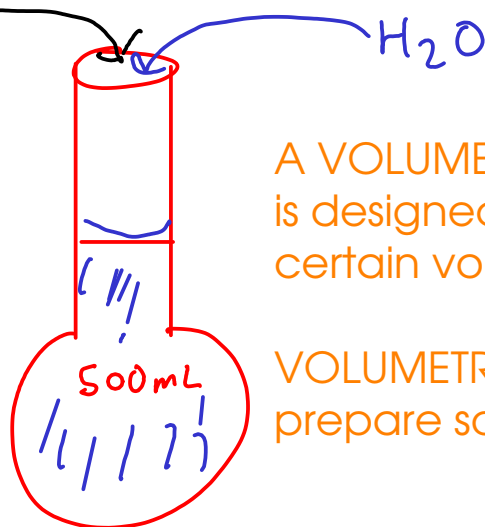
$$6.00 \text{ mol HCl} = L$$

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

(110 mL)

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

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

Take the volume of solution needed and use MOLARITY to change that volume to moles of sodium sulfate. Then, use the FORMULA WEIGHT to change moles sodium sulfate to mass.

$$\textcircled{1} 0.500 \text{ mol Na}_2\text{SO}_4 = \text{L} \quad \text{mL} = 10^{-3} \text{L}$$

$$500. \text{ mL} \times \frac{10^{-3} \text{ L}}{\text{mL}} \times \frac{0.500 \text{ mol Na}_2\text{SO}_4}{\text{L}} = 0.250 \text{ mol Na}_2\text{SO}_4$$

Next, find the mass.

$$142.05 \text{ g Na}_2\text{SO}_4 = \text{mol Na}_2\text{SO}_4$$

$$0.250 \text{ mol Na}_2\text{SO}_4 \times \frac{142.05 \text{ g Na}_2\text{SO}_4}{\text{mol Na}_2\text{SO}_4} = \boxed{35.5 \text{ g Na}_2\text{SO}_4}$$

Add 35.5 grams sodium sulfate to 500 mL volumetric flask, then add water to the line and shake to dissolve.

## 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)

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

"stock solution"

- Use DILUTION EQUATION

The dilution equation is easy to derive with simple algebra.

$$M \times V$$

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

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

$$M_1 V_1 = M_2 V_2$$

before  
dilution

after  
dilution

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

$$M_1 V_1 = M_2 V_2 \quad \dots \text{the "DILUTION EQUATION"}$$

$M_1$  = 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?

$$M_1 V_1 = M_2 V_2$$

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

$$V_1 = 99.9\text{ mL of } 0.500\text{M} \text{ stock solution}$$

$$M_1 = 0.500\text{M}$$

$$V_1 = ?$$

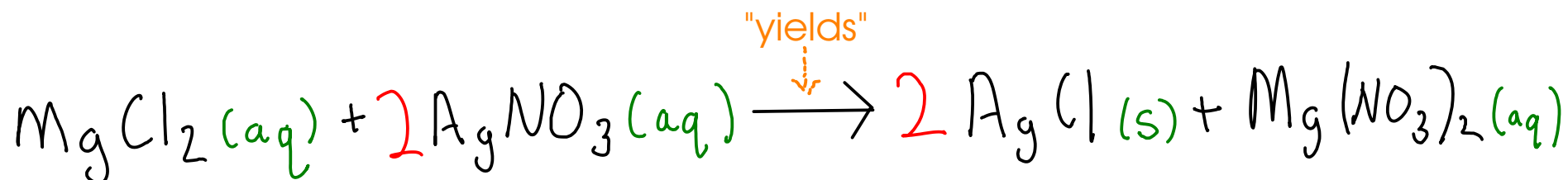
$$M_2 = 0.333\text{M}$$

$$V_2 = 150.\text{mL}$$

Measure out 99.9 mL of 0.500 M sodium sulfate, then add enough water to make the total volume equal 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



REACTANTS - materials that are needed for a reaction

PRODUCTS - materials that are formed in a reaction

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

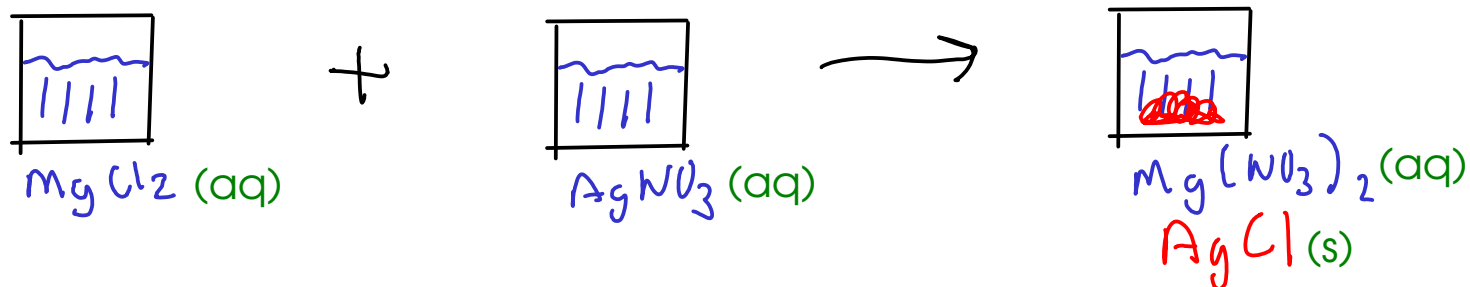
PHASE LABELS - give the physical state of a substance:

(s) - solid

(l) - liquid

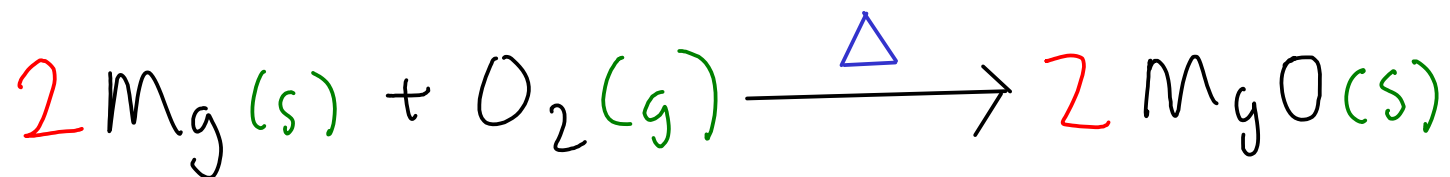
(g) - gas

(aq) - aqueous. In other words, dissolved in water





## CHEMICAL EQUATIONS



REACTION CONDITIONS - give conditions necessary for chemical reaction to occur. May be:

- $\Delta$  apply heat
  - catalysts - substances that will help reaction proceed faster
  - other conditions, such as required temperatures
- Reaction conditions are usually written above the arrow, but may also be written below if the reaction requires several steps or several different conditions