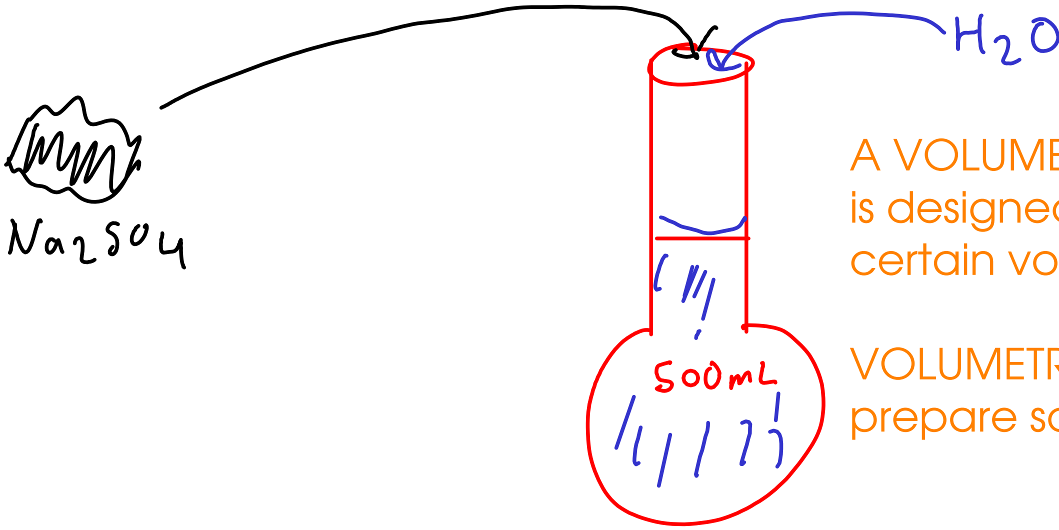
Example: How would we prepare 500. mL of 0.500 M sodium sulfate in water?

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

Start by finding moles of sodium sulfate required. Use the VOLUME and the MOLARITY.

0.500 mol Na_2SO_4 = L   mL = 10^{-3} L

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

Convert to grams

142.05 g Na_2SO_4 = mol Na_2SO_4

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

Put 35.5 grams sodium sulfate into a 500 mL volumetric flaks, then add distilled 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.

$$M \times V$$

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

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

$$M_1V_1 = M_2V_2$$

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?

$$M_1V_1 = M_2V_2$$

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

$$V_1 = 99.9\,mL \text{ of } 0.500\,M\ Na_2SO_4$$

$M_1 = 0.500\,M$

$V_1 = ?$

$M_2 = 0.333\,M$

$V_2 = 150.\,mL$

Measure out 99.9 mL of the 0.500 M sodium sulfate solution, then add water until the total volume is 150. mL..
(You can do this quickly in a 250 mL graduated cylinder!)

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

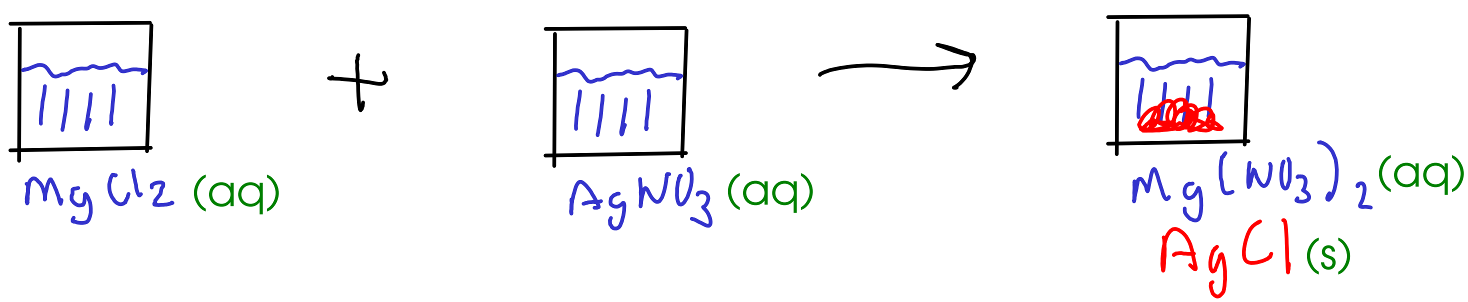
PHASE LABELS - give the physical state of a substance:

(s) -solid

(l) - liquid

(g) - gas

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



CHEMICAL EQUATIONS

$$2Mg(s) + O_2(g) \xrightarrow{\Delta} 2MgO(s)$$

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

- Δ 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

COEFFICIENTS

- Experimentally, we can usually determine the reactants and products of a reaction

- We can determine the proper ratios of reactants and products WITHOUT further experiments, using a process called BALANCING

  - BALANCING a chemical equation is making sure the same number of atoms of each element go into a reaction as come out of it.

- A properly balanced chemical equation has the smallest whole number ratio of reactants and products.

- There are several ways to do this, but we will use a modified trial-and-error procedure.

BALANCING

$$C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O$$ ✓

~~2~~ 10 | 6 + 4 = 10 oxygen

1. Pick an element. Avoid (if possible) elements that appear in more than one substance on each side of the equation.

2. Change the coefficients on substances containing this element so that the same number of atoms of the element are present on each side. CHANGE AS LITTLE AS POSSIBLE!

3. Repeat 1-2 until all elements are done.

4. Go back and quickly VERIFY that you have the same number of atoms of each element on each side, If you used any fractional coefficients, multiply each coefficient by the DENOMIMATOR of your fraction.

Use SMALLEST WHOLE NUMBER RATIOS!

BALANCING

$$3MgCl_2 + 2Na_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 6NaCl$$

$$C_2H_2 + 2\tfrac{1}{2}O_2 \longrightarrow 2CO_2 + H_2O$$

~~7~~ 5 ⋮ 4 + 1 = 5

We had to use a coefficient of 2 1/2 for oxygen on the reactant side. We can't leave it that way, since we're asked for small whole numbers. We can multiply out the fraction by multiplying by the denominator (2), but we have to do it to ALL the coefficents to maintain the right ratio!

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$$

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

1) Avoid H, balance S. (H appears in two compounds on the left)
2) Avoid O, balance Na. (O appears in all four compounds)
3) Balance H. (appears less than O)
4) Balance O.