So far, we have

ch 8

- 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?

Sec 15.4 p483-488

- 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

solute = dissolved substance

$$M = \text{MOLARITY} = \frac{\text{moles of solute}}{\text{L solution}}$$

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

There are 6.0 moles of hydrochloric acid in each liter of this solution, so you can write this relationship another way:

6.0 mol HCl = 1 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

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

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

$0.0555\ \text{mol HCl} = \text{L}$ $\qquad$ $\text{mL} = 10^{-3}\ \text{L}$

$$0.657\ \text{mol HCl} \times \frac{\text{L}}{0.0555\ \text{mol HCl}} \times \frac{\text{mL}}{10^{-3}\ \text{L}} = \boxed{11800\ \text{mL of } 0.0555\ \text{M HCl}}$$

Thisi is an impractical volume for lab-scale work - it;s much too large! Solution: use a MORE CONCENTRATED solution (like the 6.00 M HCl below)

What if we used 6.00 M HCl?

$6.00\ \text{mol HCl} = \text{L}$ $\qquad$ $\text{mL} = 10^{-3}\ \text{L}$

$$0.657\ \text{mol HCl} \times \frac{\text{L}}{6.00\ \text{mol HCl}} \times \frac{\text{mL}}{10^{-3}\ \text{L}} = \boxed{110.\ \text{mL of } 6.00\ \text{HCl}}$$

This is a more reasonable volume to use for lab-scale work! Measure this with a 250 mL greaduated cylinder!

If you're preparing a solution by dissolving a solid in water, you can easily calculate the molarity of the solution. How?

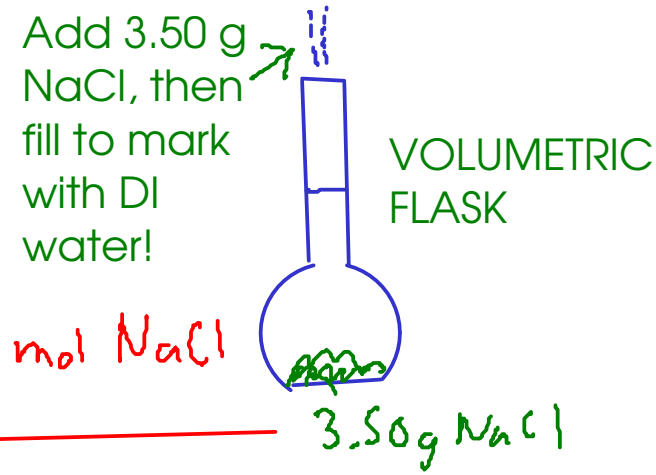
Just find the number of moles of solid you dissolved, then divide by the volume of the solution (expressed in liters!)

What is the molarity of a solution made by dissolving 3.50 g of NaCl in enough water to make 250. mL of solution?

$$M = \frac{\text{mol NaCl}}{\text{L solution}}$$

1 - Convert 3.50 g of NaCl to moles. Use formula weight.
2 - Divide moles NaCl / LITERS of solution we intend to make. (Convert 250 mL to L)

NaCl: Na: 1×22.99
Cl: 1×35.45
$58.44\ g\ NaCl = mol\ NaCl$



① $3.50\ g\ NaCl \times \frac{mol\ NaCl}{58.44\ g\ NaCl} = 0.05989\,0486\ mol\ NaCl$

② $mL = 10^{-3} L$

$250.\ mL \times \frac{10^{-3} L}{mL} = 0.250\ L$

$$M = \frac{0.05989\,0486\ mol\ NaCl}{0.250\ L}$$

$$= \boxed{0.240\ M\ NaCl}$$

A few more examples...

Use FORMULA WEIGHT when relating mass and moles

You have a 250.g bottle of silver(I) chloride (AgCl). How many moles of AgCl do you have?

AgCl: Ag: 1 x 107.9

Cl: 1 x 35.45

143.35 g AgCl = mol AgCl

$$250.\text{g AgCl} \times \frac{\text{mol AgCl}}{143.35\ \text{g AgCl}} = \boxed{1.74\ \text{mol AgCl}}$$

How many moles of NaOH are present in 155 mL of 1.50 M NaOH?

When relating moles and VOLUME, we need to use CONCENTRATION (usually MOLARITY - M)

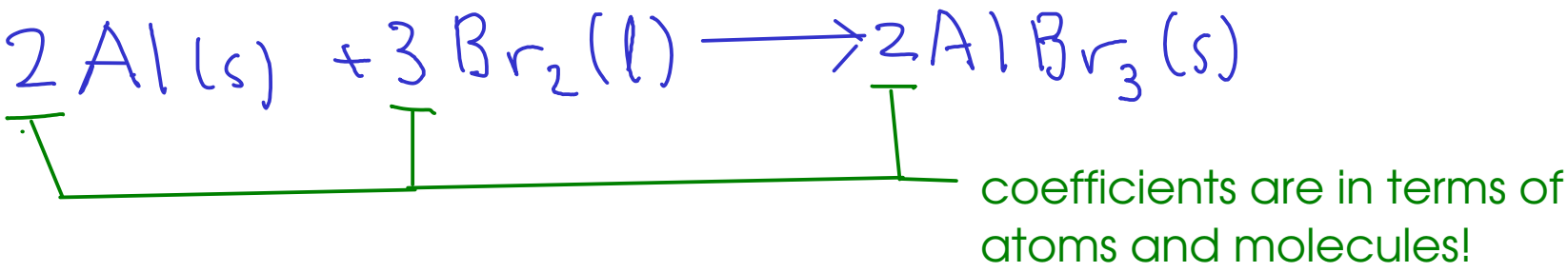
1.50 mol NaOH = L mL = 10^{-3} L

$$155\ \text{mL} \times \frac{10^{-3}\ \text{L}}{\text{mL}} \times \frac{1.50\ \text{mol NaOH}}{\text{L}} = \boxed{0.233\ \text{mol NaOH}}$$

CHEMICAL CALCULATIONS CONTINUED: REACTIONS

- Chemical reactions proceed on an ATOMIC basis, NOT a mass basis!

- To calculate with chemical reactions (i.e. use chemical equations), we need everything in terms of ATOMS ... which means MOLES of atoms



2 atoms Al = 3 molecules Br_2 = 2 formula units $AlBr_3$

2 mol Al = 3 mol Br_2 = 2 mol $AlBr_3$ *

- To do chemical calculations, we need to:

① - Relate the amount of substance we know (mass or volume) to a number of moles

② - Relate the moles of one substance to the moles of another using the equation

③ - Convert the moles of the new substance to mass or volume as desired

$$2\,Al(s) + 3\,Br_2(l) \longrightarrow 2\,AlBr_3(s)$$

* Given that we have 25.0 g of liquid bromine, how many grams of aluminum would we need to react away all of the bromine? How many grams of aluminum bromide would be produced?

① Convert the 25.0 g of bromine to moles. Use formula weight. $Br_2: 2 \times 79.90 = 159.8$

$159.8\ g\ Br_2 = mol\ Br_2$

$$25.0\ g\ Br_2 \times \frac{mol\ Br_2}{159.8\ g\ Br_2} = 0.156445 6\ mol\ Br_2$$

---

② Convert the moles bromine to moles aluminum. Use chemical equation.

$2\ mol\ Al = 3\ mol\ Br_2$

$$0.156445 6\ mol\ Br_2 \times \frac{2\ mol\ Al}{3\ mol\ Br_2} = 0.104297038\ mol\ Al$$

---

③ Convert the moles aluminum to mass. Use formula weight. $Al: 26.98$

$26.98\ g\ Al = mol\ Al$

$$0.104297038\ mol\ Al \times \frac{26.98\ g\ Al}{mol\ Al} = \boxed{2.81\ g\ Al}$$

You can combine all three steps on one line if you like!

$$25.0\text{ g } Br_2 \times \frac{\text{mol } Br_2}{159.8\text{ g } Br_2} \times \frac{2\text{ mol Al}}{3\text{ mol } Br_2} \times \frac{26.98\text{ g Al}}{1\text{ mol Al}} = \boxed{2.81\text{ g Al}}$$

① ② ③

$$\begin{array}{r} 25.0\text{ g } Br_2 \\ +\ 2.81\text{ g Al} \\ \hline 27.8\text{ g } AlBr_3 \end{array}$$

Conservation of mass!

But ...
...what would you have done to calculate the mass of aluminum bromide IF you had NOT been asked to calculate the mass of aluminum FIRST?

Calculating the mass of aluminum bromide directly:

$$25.0\text{ g } Br_2 \times \frac{1\text{ mol } Br_2}{159.8\text{ g } Br_2} \times \frac{2\text{ mol } AlBr_3}{3\text{ mol } Br_2} \times \frac{266.68\text{ g } AlBr_3}{1\text{ mol } AlBr_3} = 27.8\text{ g } AlBr_3$$

$AlBr_3$: Al : 1×26.98

Br : 3×79.90

266.68