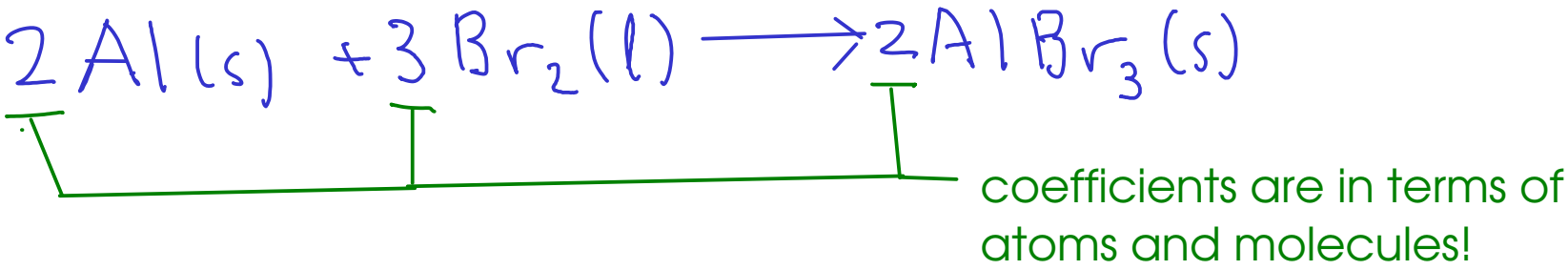
CHEMICAL CALCULATIONS CONTINUED: REACTIONS

- 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 $AlBr_3$ *

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. $Br_2: 2 \times 79.90 = 159.8$

$159.8\ g\ Br_2 = mol\ Br_2$

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

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

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

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

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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!

$$5.0\text{ g } Br_2 \times \frac{1\text{ mol } Br_2}{159.8\text{ g } Br_2} \times \frac{2\text{ mol Al}}{3\text{ mol } Br_2} \times \frac{26.98\text{ g Al}}{1\text{ mol Al}} = \boxed{2.81\text{ g Al}}$$

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?

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

$AlBr_3$: Al : 1×26.98

Br : 3×79.90

266.68

Example:
How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?

$$2HCl(aq) + Na_2CO_3(s) \longrightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$$

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1 - Convert mass sodium carbonate to moles. Use formula weight.
2 - Convert moles sodium carbonate to moles hydrochloric acid. Use chemical equation.
3 - Convert moles hydrochloric acid to volume. Use concentration (6.00 M)

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① Na_2CO_3: Na : 2 x 22.99
C : 1 x 12.01
O : 3 x 16.00
105.99 g Na_2CO_3 = mol Na_2CO_3

$$25.0\ g\ Na_2CO_3 \times \frac{mol\ Na_2CO_3}{105.99\ g\ Na_2CO_3} = 0.2358713086\ mol\ Na_2CO_3$$

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② 2 mol HCl = 1 mol Na_2CO_3

$$0.2358713086\ mol\ Na_2CO_3 \times \frac{2\ mol\ HCl}{1\ mol\ Na_2CO_3} = 0.4717426172\ mol\ HCl$$

Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?

$$2HCl(aq) + Na_2CO_3(s) \longrightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$$

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

$$0.4717426172\ mol\ HCl \times \frac{L}{6.00\ mol\ HCl} \times \frac{mL}{10^{-3} L} = \boxed{78.6\ mL}$$

You can put all of this on one line if you like.

$$25.0\ g\ Na_2CO_3 \times \underbrace{\frac{mol\ Na_2CO_3}{105.99\ g\ Na_2CO_3}}_{①} \times \underbrace{\frac{2\ mol\ HCl}{1\ mol\ Na_2CO_3}}_{②} \times \underbrace{\frac{L}{6.00\ mol\ HCl} \times \frac{mL}{10^{-3} L}}_{③} = \boxed{78.6\ mL}$$