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

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

coefficients are in terms of atoms and molecules!

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 grams of bromine to moles: Need formula weight $Br_2 : 2 \times 79.90 = 159.80$

$$159.80\ g\ Br_2 = 1\ mol\ Br_2$$

$$25.0\ g\ Br_2 \times \frac{1\ mol\ Br_2}{159.80\ g\ Br_2} = 0.15645\ mol\ Br_2$$

(2) Use the chemical equation to relate moles of bromine to moles of aluminum

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

$$0.15645\ mol\ Br_2 \times \frac{2\ mol\ Al}{3\ mol\ Br_2} = 0.10430\ mol\ Al$$

(3) Convert moles aluminum to mass: Need formula weight $Al : 26.98$

$$26.98\ g\ Al = 1\ mol\ Al$$

$$0.10430\ mol\ Al \times \frac{26.98\ g\ Al}{1\ mol\ Al} = \boxed{2.81\ g\ Al}$$

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

$$25.0\text{ g } Br_2 \times \frac{1\text{ mol } Br_2}{159.80\text{ g } Br_2} \times \frac{2\text{ mol Al}}{3\text{ mol } Br_2} \times \frac{26.98\text{ g Al}}{1\text{ mol Al}} = \boxed{2.81\text{ g Al}}$$

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?

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

1. - Convert mass of sodium carbonate to moles using formula weight
2. - Convert moles of sodium carbonate to moles hydrochloric acid using chemical equation
3. - Convert moles of hydrochloric acid to volume using concentration (M = moles/L)

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1. - Convert mass of sodium carbonate to moles using formula weight

$105.99\ g\ Na_2CO_3 = 1\ mol\ Na_2CO_3$

Na : 22.99 x 2
C : 12.01 x 1
O : 16.00 x 3
105.99

$$25.0\ g\ Na_2CO_3 \times \frac{1\ mol\ Na_2CO_3}{105.99\ g\ Na_2CO_3} = 0.2359\ mol\ Na_2CO_3$$

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

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

② - Convert moles of sodium carbonate to moles hydrochloric acid using chemical equation

$$2 \text{ mol } HCl = 1 \text{ mol } Na_2CO_3$$

$$0.2359 \text{ mol } Na_2CO_3 \times \frac{2 \text{ mol } HCl}{1 \text{ mol } Na_2CO_3} = 0.4717 \text{ mol } HCl$$

②

③ - Convert moles of hydrochloric acid to volume using concentration (M = moles/L)

$$6.00 \text{ mol } HCl = 1 \text{ L}$$

$$0.4717 \text{ mol } HCl \times \frac{1 \text{ L}}{6.00 \text{ mol } HCl} = 0.0786 \text{ L } HCl \text{ solution}$$

③

$$1 \text{ mL} = 10^{-3} \text{ L}$$

Convert L to mL, since the problem statement asks us to find the mL of acid solution required.

$$0.0786 \text{ L} \times \frac{\text{mL}}{10^{-3} \text{ L}} = \boxed{78.6 \text{ mL of } 6.00 \text{ M } HCl}$$