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 25.0 g of 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 molarity (6.00 mol HCl = L)

① Na_2CO_3: Na : 2 × 22.99
C : 1 × 12.01
O : 3 × 16.00

$105.99 \text{ g } Na_2CO_3 = \text{mol } Na_2CO_3$

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

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

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

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(3) 6.00 mol HCl = L   mL = 10^{-3} L

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

If you like, you can solve this problem on one line!

105.99 g Na_2CO_3 = mol Na_2CO_3 2 mol HCl = mol Na_2CO_3

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

Conversion factors!

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

EXAMPLE PROBLEM:

$$2\,Na(s) + Cl_2(g) \rightarrow 2\,NaCl(s)$$

How many grams of sodium metal is required to completely react with 2545 grams of chlorine gas?

1 - Convert 2545 g of chlorine gas to moles. Use formula weight.
2 - Convert moles chlorine gas to moles sodium using chemical equation
3 - Convert moles sodium to grams using formula weight.

(1) Cl_2: $2 \times 35.45 = 70.90\ g\ Cl_2 = mol\ Cl_2$

(2) $2\ mol\ Na = mol\ Cl_2$

(3) Na: $22.99\ g\ Na = mol\ Na$

$$2545\ g\ Cl_2 \times \frac{mol\ Cl_2}{70.90\ g\ Cl_2} \times \frac{2\ mol\ Na}{mol\ Cl_2} \times \frac{22.99\ g\ Na}{mol\ Na} = \boxed{1650.\ g\ Na}$$

 EXAMPLE PROBLEM:

$$H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

How many mL of 0.250 M sodium hydroxide is required to completely react with 15.0 mL of 2.00 M sulfuric acid?

1 - Convert volume of sulfuric acid to moles using concetration (2.00 M)
2 - Convert moles sulfuric acid to moles sodium hydroxide. Use chemical equation.
3 - Convert moles sodium hydroxide to volume. Use concentration (0.250 M)

(1) 2.00 mol H_2SO_4 = L mL = 10^{-3} L | (2) mol H_2SO_4 = 2 mol NaOH

(3) 0.250 mol NaOH = L mL = 10^{-3} L

$$15.0\ \text{mL} \times \frac{10^{-3}\ \text{L}}{\text{mL}} \times \frac{2.00\ \text{mol}\ H_2SO_4}{\text{L}} \times \frac{2\ \text{mol NaOH}}{\text{mol}\ H_2SO_4} \times \frac{\text{L}}{0.250\ \text{mol NaOH}} \times \frac{\text{mL}}{10^{-3}\ \text{L}} = 240.\ \text{mL}\ 0.250\ M\ \text{NaOH}$$

(1) (2) (3)

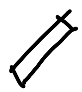
Shortcut to this problem ... use millimoles instead of moles!

$$15.0\ \text{mL} \times \frac{2.00\ \text{mol}\ H_2SO_4}{\text{L}} \times \frac{2\ \text{mol NaOH}}{\text{mol}\ H_2SO_4} \times \frac{\text{L}}{0.250\ \text{mol NaOH}} = 240.\ \text{mL}$$

CONCEPT OF LIMITING REACTANT

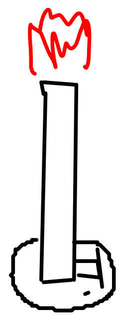
- When does a chemical reaction STOP?

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



Magnesium strip

+



Flame, oxygen from air

Magnesium oxide powder

- When does this reaction stop? When burned in open air, this reaction stops when all the MAGNESIUM STRIP is gone. We say that the magnesium is LIMITING.

- This reaction is controlled by the amount of available magnesium

- At the end of a chemical reaction, the LIMITING REACTANT will be completely consumed, but there may be some amount of OTHER reactants remaining. We do chemical calculations in part to minimize these "leftovers".

- Reactants that are left at the end of a chemical reaction (in other words, they are NOT the limiting reactant) are often called "excess". So reacting magnesium with "excess oxygen" means that magnesium is limiting.