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 grams sodium carbonate to moles. Use FORMULA WEIGHT.

2 - Convert moles sodium carbonate to moles HCl. Use CHEMICAL EQUATION

3 - Convert moles HCl to volume HCl. Use MOLAR CONCENTRATION (6.00 M HCl)

(1) Na_2CO_3: Na: 2×22.99

C: 1×12.01

O: 3×16.00

$105.99\,g\ Na_2CO_3 = mol\ Na_2CO_3$

FORMULA WEIGHT of sodium carbonate

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

(2) $2\ mol\ HCl = mol\ Na_2CO_3$

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

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(3) 6.00 mol HCl = L

$$0.4717426172 \text{ mol HCl} \times \frac{\text{L}}{6.00 \text{ mol HCl}} = 0.0786 \text{ L of } 6.00 \text{ M HCl}$$

Notice that the problem statement asks us for MILLILITERS HCl. We have liters, so we'll need to do a quick unit conversion to give them the units they want!

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

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

25.0 mL of acetic acid solution requires 37.3 mL of 0.150 M sodium hydroxide for complete reaction. The equation for this reaction is:

$$NaOH + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2O$$

What is the molar concentration of the acetic acid?

$$\frac{mol\ HC_2H_3O_2}{L\ solution} \leftarrow = 25.0\ mL \text{ or } 0.0250\ L$$

Since we already know the VOLUME of the acetic acid solution, we need to find the MOLES OF ACETIC ACID if we want to calculate concentration. How do we find moles acid? We start with the sodium hydroxide.

$0.150\ mol\ NaOH = L$ | $mL = 10^{-3}\ L$ | $mol\ NaOH = mol\ HC_2H_3O_2$

$$37.3\ mL \times \frac{10^{-3}\ L}{mL} \times \frac{0.150\ mol\ NaOH}{L} \times \frac{mol\ HC_2H_3O_2}{mol\ NaOH} =$$

$$= 0.05595\ mol\ HC_2H_3O_2$$

$$M = \frac{mol\ HC_2H_3O_2}{L\ solution} = \frac{0.05595\ mol\ HC_2H_3O_2}{0.0250\ L} = 0.224\ M\ HC_2H_3O_2$$

NOTE FOR LATER: This is how the main calculation for EXPERIMENT 4C is done!

$42.081\ g/mol$ $\qquad\qquad$ $53.064\ g/mol$

$$4\,C_3H_6 + 6\,NO \longrightarrow 4\,C_3H_3N + 6\,H_2O + N_2$$

propylene $\qquad$ acrylonitrile

Calculate how many grams of acrylonitrile could be obtained from 651 kg of propylene, assuming there is excess NO present.

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1 - Convert mass propylene to moles. Use FORMULA WEIGHT. (Also kg -> g conversion)
2 - Convert moles propylene to moles acrylonitrile. Use CHEMICAL EQUATION
3 - Convert moles acrylonitrile to mass acrylonitrile. Use FORMULA WEIGHT

$42.081\ g\ C_3H_6 = mol\ C_3H_6$	$kg = 10^3\ g$	$4\ mol\ C_3H_6 = 4\ mol\ C_3H_3N$

$53.064\ g\ C_3H_3N = mol\ C_3H_3N$

$$651\ kg\ C_3H_6 \times \underbrace{\frac{10^3\ g}{kg} \times \frac{mol\ C_3H_6}{42.081\ g\ C_3H_6}}_{①} \times \underbrace{\frac{4\ mol\ C_3H_3N}{4\ mol\ C_3H_6}}_{②} \times \underbrace{\frac{53.064\ g\ C_3H_3N}{mol\ C_3H_3N}}_{③} =$$

$$= \boxed{821000\ g\ C_3H_3N} \quad (821\ kg)$$

151.90 g/mol

$$10\,FeSO_4 + 2\,KMnO_4 + 8\,H_2SO_4 \rightarrow 5\,Fe_2(SO_4)_3 + 2\,MnSO_4 + K_2SO_4 + 8\,H_2O$$

How many mL of 0.250M potassium permangenate are needed to react with 3.36 g of iron(II) sulfate?

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1 - Convert 3.36 g iron(II) sulfate to moles. Use FORMULA WEIGHT.
2 - Convert moles iron(II) sulfate to moles potassium permangenate. Use CHEMICAL EQUATION
3 - Convert moles potassium permangenate to volume. Use MOLAR CONCENTRATION (0.250 M)

151.90 g $FeSO_4$ = mol $FeSO_4$	10 mol $FeSO_4$ = 2 mol $KMnO_4$
0.250 mol $KMnO_4$ = L	mL = 10^{-3} L

$$3.36\,g\,FeSO_4 \times \underbrace{\frac{mol\,FeSO_4}{151.90\,g\,FeSO_4}}_{①} \times \underbrace{\frac{2\,mol\,KMnO_4}{10\,mol\,FeSO_4}}_{②} \times \underbrace{\frac{L}{0.250\,mol\,KMnO_4}}_{③} =$$

$$= 0.0177\,L$$

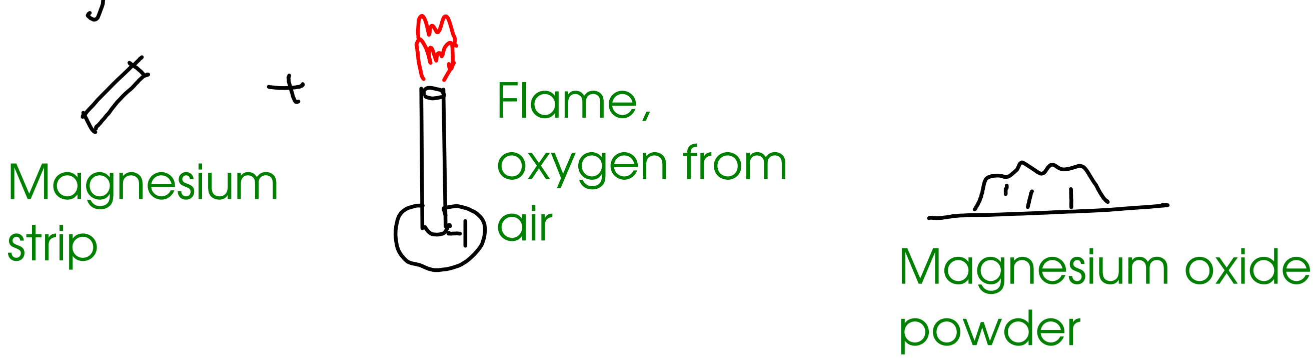
$$0.0177\,L \times \frac{mL}{10^{-3}\,L} = 17.7\,mL \text{ of } 0.250\,M\,KMnO_4$$

Unit conversion. We want answer in mL, not L

CONCEPT OF LIMITING REACTANT

- When does a chemical reaction STOP?

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



- 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 amount of OTHER reactants remaining. We do chemical calculations in part to minimize these "leftovers".

These are often called "excess" reactants, or reactants present "in excess"