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

* 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?

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

$159.80\ g\ Br_2 = mol\ Br_2$

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

(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 $Al = 26.98$

$26.98\ g\ Al = mol\ Al$

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

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

① $159.80\ g\ Br_2 = mol\ Br_2$ ② $2\ mol\ Al = 3\ mol\ Br_2$ ③ $26.98\ g\ Al = mol\ Al$

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

① ② ③

Things we can do:

If we have ...	... and we need ...	Use ...
MASS	MOLES	FORMULA WEIGHT
SOLUTION VOLUME	MOLES	MOLAR CONCETRATION (MOLARITY)
MOLES OF A	MOLES OF B	BALANCED CHEMICAL EQUATION

Example:

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

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

1 - Convert 25.0 g 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 solution. Use MOLARITY (6.00 M HCl)

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

$$25.0\ g\ Na_2CO_3 \times \frac{mol\ Na_2CO_3}{105.99\ g\ Na_2CO_3} = 0.235871308\ 6\ mol\ Na_2CO_3$$

② 2 mol HCl = mol Na_2CO_3

$$0.235871308\ 6\ mol\ Na_2CO_3 \times \frac{2\ mol\ HCl}{mol\ Na_2CO_3} = 0.471742617\ 2\ mol\ HCl$$

Example:

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

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

1 - Convert 25.0 g 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 solution. Use MOLARITY (6.00 M HCl)

③ $6.00\ mol\ HCl = L$

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

We currently have LITERS, but the answer's supposed to be in mL. Convert L to mL:

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

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

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?

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

1 - Convert 37.3 mL of NaOH solution to moles. User MOLARITY (0.150 M NaOH)
2 - Convert moles NaOH to moles acetic acid. User CHEMICAL EQUATION
3 - Divide moles acetic acid / volume of acid solution to get molarity.

$0.150\text{ mol NaOH} = 1\text{L} \mid \text{mL} = 10^{-3}\text{L} \mid \text{mol NaOH} = \text{mol } HC_2H_3O_2$

$$37.3\text{mL} \times \underbrace{\frac{10^{-3}\text{L}}{\text{mL}} \times \frac{0.150\text{ mol NaOH}}{\text{L}}}_{①} \times \frac{\text{mol } HC_2H_3O_2}{\text{mol NaOH}}_{②} = 0.00559\text{ mol } HC_2H_3O_2$$

③

$$M = \frac{\text{mol } HC_2H_3O_2}{\text{L solution}} = \frac{0.00559\text{ mol } HC_2H_3O_2}{0.0250\text{L}} = \boxed{0.224\text{ M } HC_2H_3O_2}$$

42.081 g/mol 53.064 g/mol

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

propylene 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. User FORMULA WEIGHT
2 - Convert moles propylene to moles acrylonitrile. Use CHEMICAL EQUATION
3 - Convert moles acrylonitrile to mass acrylonitrile. Use FORMULA WEIGHT.

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

$53.064\ g\ C_3H_3N = mol\ C_3H_3N$

$$651\ kg\ C_3H_6 \times \frac{10^3\ g}{Kg} \times \frac{mol\ C_3H_6}{42.081\ g\ C_3H_6} \times \frac{4\ mol\ C_3H_3N}{4\ mol\ C_3H_6} \times \frac{53.064\ g\ C_3H_3N}{mol\ C_3H_3N} =$$

① ② ③

$$= \boxed{821000\ g\ C_3H_3N}$$

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 grams 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 MOLARITY (0.250 M)

151.90 g FeSO4 = mol FeSO4	10 mol FeSO4 = 2 mol KMnO4

0.250 mol KMnO4 = L

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

(1) (2) (3)

$$= 0.0177\,L \text{ of } 0.250\,M\,KMnO_4$$

Let's convert L to mL so the answer's in the units we were asked for: $mL = 10^{-3}L$

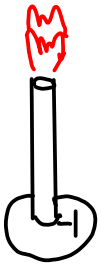
$$0.0177\,L \times \frac{mL}{10^{-3}L} = \boxed{17.7\,mL \text{ of } 0.250\,M\,KMnO_4}$$

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 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"