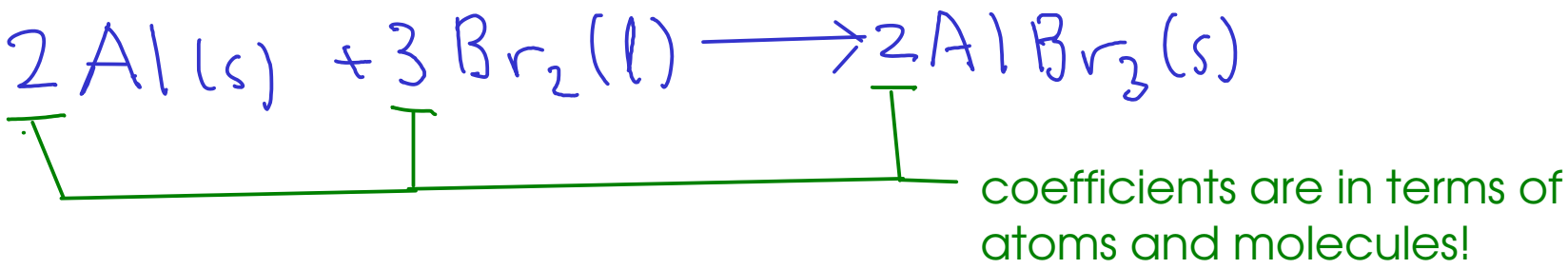
CHEMICAL CALCULATIONS CONTINUED: REACTIONS

- 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 $AlBr_3$

- To do chemical calculations, we need to:
  - Relate the amount of substance we know (mass or volume) to a number of moles
  - Relate the moles of one substance to the moles of another using the equation
  - 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?

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

$159.80\ g\ Br_2 = \text{mol}\ Br_2$

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

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

$2\ \text{mol}\ Al = 3\ \text{mol}\ Br_2$

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

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

$26.98\ g\ Al = \text{mol}\ Al$

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

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?

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

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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 solution. Use MOLARITY (6.00 M HCl)

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

$105.99\ g\ Na_2CO_3 = mol\ Na_2CO_3$

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

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② $2\ mol\ HCl = mol\ Na_2CO_3$

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

Example:

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

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

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 solution. Use MOLARITY (6.00 M HCl)

(3) $6.00\ mol\ HCl = L$

$$0.471\,7426172\ mol\ HCl \times \frac{L}{6.00\ mol\ HCl} = 0.0786\ L\ of\ 6.00\ M\ HCl$$

Since the problem asks for the volume in milliliters, we need to do a quick unit conversion.

$mL = 10^{-3} L$

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

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 g of propylene, assuming there is excess NO present.

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

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① $42.081\ g\ C_3H_6 = 1\ mol\ C_3H_6$ ② $4\ mol\ C_3H_6 = 4\ mol\ C_3H_3N$

③ $53.064\ g\ C_3H_3N = 1\ mol\ C_3H_3N$

$$651\ g\ C_3H_6 \times \frac{1\ mol\ C_3H_6}{42.081\ g\ C_3H_6} \times \frac{4\ mol\ C_3H_3N}{4\ mol\ C_3H_6} \times \frac{53.064\ g\ C_3H_3N}{1\ mol\ C_3H_3N} = \boxed{821\ g\ C_3H_3N}$$

① ② ③

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 solution. Use MOLARITY.

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① 151.90 g $FeSO_4$ = mol $FeSO_4$ ② 10 mol $FeSO_4$ = 2 mol $KMnO_4$

③ 0.250 mol $KMnO_4$ = L

$$3.36\,g\,FeSO_4 \times \frac{mol\,FeSO_4}{151.90\,g\,FeSO_4}\,(①) \times \frac{2\,mol\,KMnO_4}{10\,mol\,FeSO_4}\,(②) \times \frac{L}{0.250\,mol\,KMnO_4}\,(③) = 0.0177\,L$$

Convert answer to mL, as asked in problem statement ...

mL = 10^{-3} L

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