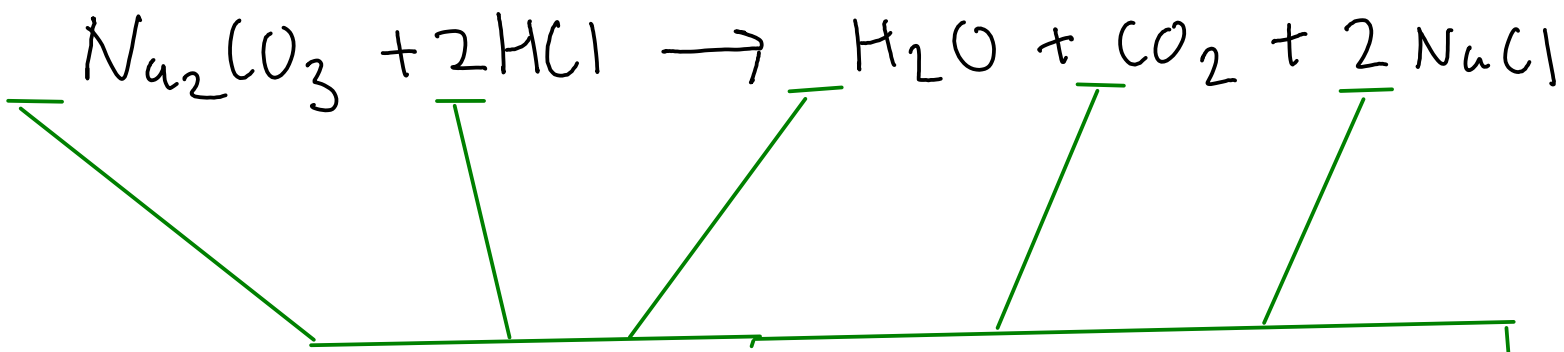
CHEMICAL CALCULATIONS - RELATING MASS AND ATOMS



Chemical equations are written and balanced in terms of ATOMS and MOLECULES

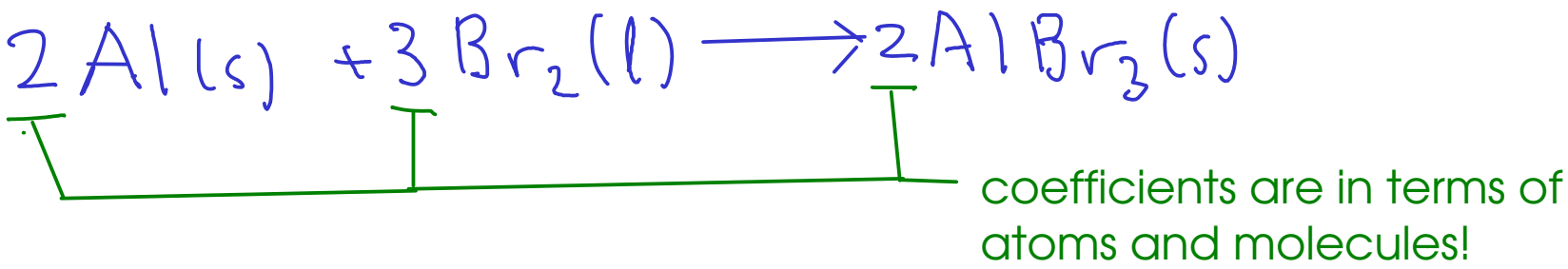
- While chemical equations are written in terms of ATOMS and MOLECULES, that's NOT how we often measure substances in lab!

- measurements are usually MASS (and sometimes VOLUME), NOT number of atoms or molecules!

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 $Br_2 = 2 \times 79.90 = 159.80$

$159.80\ g\ Br_2 = mol\ Br_2$

$$25.0\ g\ Br_2 \times \frac{mol\ Br_2}{159.80\ g\ Br_2} = 0.156445569\ mol\ Br_2$$

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

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

$$0.156445569\ mol\ Br_2 \times \frac{2\ mol\ Al}{3\ mol\ Br_2} = 0.104297038\ mol\ Al$$

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

$26.98\ g\ Al = mol\ Al$

$$0.104297038\ mol\ Al \times \frac{26.98\ g\ Al}{mol\ Al} = \boxed{2.81\ g\ Al}$$

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?

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

1 - Convert 25.0 g of sodium carbonate to moles. Use FORMULA WEIGHT.
2 - Convert moles sodium carbonate to moles HCl. Use CHEMICAL EQUATION
3 - Convert moles HCl to volume. Use MOLARITY (6.00M HCl)

① Na_2CO_3: Na - 2×22.99
C - 1×12.01
O - 3×16.00
$105.99\ g\ Na_2CO_3 = mol\ Na_2CO_3$

$$25.0\ g\ Na_2CO_3 \times \frac{mol\ Na_2CO_3}{105.99\ g\ Na_2CO_3} = 0.2358713066\ mol\ Na_2CO_3$$

② $2\ mol\ HCl = mol\ Na_2CO_3$

$$0.2358713066\ mol\ Na_2CO_3 \times \frac{2\ mol\ HCl}{mol\ Na_2CO_3} = 0.4717426172\ mol\ HCl$$

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 of sodium carbonate to moles. Use FORMULA WEIGHT. .
2 - Convert moles sodium carbonate to moles HCl. Use CHEMICAL EQUATION
3 - Convert moles HCl to volume. Use MOLARITY (6.00M HCl)

③ $6.00\ mol\ HCl = L$

$$0.471742617\ 2\ mol\ HCl \times \frac{L}{6.00\ mol\ HCl} = 0.0786\ L\ of\ 6.00M\ HCl$$

We need to convert our final answer from liters to milliliters (specified in problem statement)

$mL = 10^{-3} L$

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