PERCENTAGE COMPOSITION

- sometimes called "percent composition" or "percent composition by mass"
- the percentage of each element in a compound, expressed in terms of mass

Example: Find the percentage composition of ammonium nitrate.

NH_4^+ NO_3^-

NH_4NO_3:

N: $2 \times 14.01 = 28.02$

H: $4 \times 1.008 = 4.032$

O: $3 \times 16.00 = 48.00$

80.052 g NH_4NO_3 = mol NH_4NO_3

$$\%N: \frac{28.02\ g\ N}{80.052\ g\ NH_4NO_3} \times 100\% = 35.00\ \%N$$

$$\%H: \frac{4.032\ g\ H}{80.052\ g\ NH_4NO_3} \times 100\% = 5.04\ \%H$$

$$\%O: \frac{48.00\ g\ O}{80.052\ g\ NH_4NO_3} \times 100\% = 59.96\ \%O$$

These percentages should sum to 100% ... within roundoff error.

A few more examples...

Use FORMULA WEIGHT when relating mass and moles

You have a 250.g bottle of silver(I) chloride (AgCl). How many moles of AgCl do you have?

$AgCl$: $Ag: 1 \times 107.9$

$Cl: 1 \times 35.45$

$143.35\ g\ AgCl = mol\ AgCl$

$$250.\ g\ AgCl \times \frac{mol\ AgCl}{143.35\ g\ AgCl} = \boxed{1.74\ mol\ AgCl}$$

How many grams of NaOH are present in a 1.50 mole sample of NaOH?

$NaOH$ $Na: 1 \times 22.99$

$O: 1 \times 16.00$

$H: 1 \times 1.008$

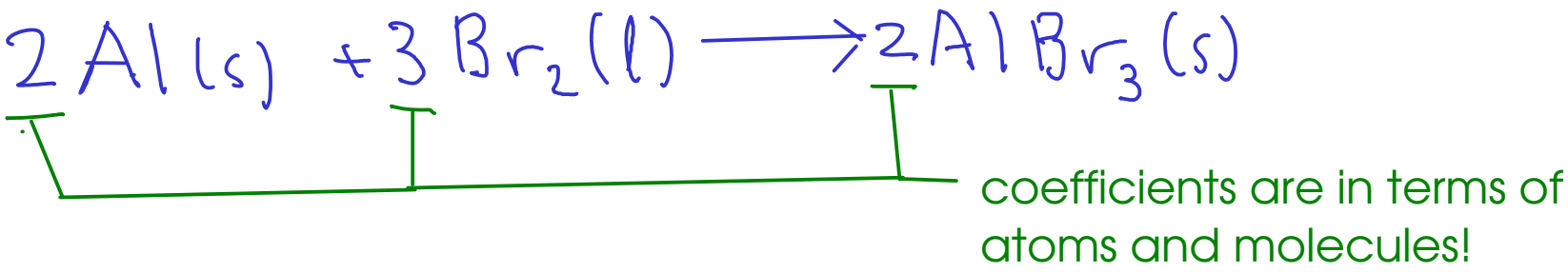
$39.998\ g\ NaOH = mol\ NaOH$

$$1.50\ mol\ NaOH \times \frac{39.998\ g\ NaOH}{mol\ NaOH} = \boxed{60.0\ g\ NaOH}$$

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:

① - Relate the amount of substance we know (mass or volume) to a number of moles

② - Relate the moles of one substance to the moles of another using the equation

③ - 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 the 25.0 g of bromine to moles. Use formula weight. Br_2: 2×79.90

159.8

$159.8\ g\ Br_2 = 1\ mol\ Br_2$

$$25.0\ g\ Br_2 \times \frac{1\ mol\ Br_2}{159.8\ g\ Br_2} = 0.156445559\ mol\ Br_2$$

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② Convert the moles bromine to moles aluminum. Use chemical equation.

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

$$0.156445559\ mol\ Br_2 \times \frac{2\ mol\ Al}{3\ mol\ Br_2} = 0.104297038\ mol\ Al$$

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③ Convert the moles aluminum to mass. Use formula weight. Al: 26.98

$26.98\ g\ Al = 1\ mol\ Al$

$$0.104297038\ mol\ Al \times \frac{26.98\ g\ Al}{1\ mol\ Al} = \boxed{2.81\ g\ Al}$$

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

1 - Convert the 25.0 g of bromine to moles. Use formula weight.
2 - Convert the moles bromine to moles aluminum. Use chemical equation.
3 - Convert the moles aluminum to mass. Use formula weight.

① $159.8\ g\ Br_2 = mol\ Br_2$

② $2\ mol\ Al = 3\ mol\ Br_2$

③ $26.98\ g\ Al = mol\ Al$

$$25.0\ g\ Br_2 \times \underset{①}{\frac{mol\ Br_2}{159.8\ g\ Br_2}} \times \underset{②}{\frac{2\ mol\ Al}{3\ mol\ Br_2}} \times \underset{③}{\frac{26.98\ g\ Al}{mol\ Al}} = \boxed{2.81\ g\ Al}$$

Example:

How many grams of sodium carbonate is needed to make 15.5 grams of sodium chloride, assuming there is sufficient hydrochloric acid for the reaction

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

1 - Convert 15.5 g NaCl to moles. Use FORMULA WEIGHT.
2 - Convert moles NaCl to moles sodium carbonate. Use CHEMICAL EQUATION
3 - Convert moles sodium carbonate to grams. Use FORMULA WEIGHT

$NaCl: 1 \times 22.99$
1×35.45
$58.44\ g\ NaCl = mol\ NaCl$

① $15.5\ g\ NaCl \times \frac{mol\ NaCl}{58.44\ g\ NaCl} = 0.265229295\ mol\ NaCl$

$mol\ Na_2CO_3 = 2\ mol\ NaCl$

② $0.265229295\ mol\ NaCl \times \frac{mol\ Na_2CO_3}{2\ mol\ NaCl} = 0.132614647\ mol\ Na_2CO_3$

Example:

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

1 - Convert 15.5 g NaCl to moles. Use FORMULA WEIGHT.
2 - Convert moles NaCl to moles sodium carbonate. Use CHEMICAL EQUATION
3 - Convert moles sodium carbonate to grams. Use FORMULA WEIGHT

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

(3)

$$0.132614647\ mol\ Na_2CO_3 \times \frac{105.99\ g\ Na_2CO_3}{mol\ Na_2CO_3} = \boxed{14.1\ g\ Na_2CO_3}$$

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 chlorine gas to moles. Use FORMULA WEIGHT.
2 - Convert moles chlorine gas to moles sodium metal. Use CHEMICAL EQUATION
3 - Convert moles sodium metal to grams. Use FORMULA WEIGHT.

① Cl_2: $\frac{2 \times 35.45}{70.90\ g\ Cl_2 = mol\ Cl_2}$

② $mol\ Cl_2 = 2\ mol\ Na$

③ Na: $22.99\ g\ Na = mol\ Na$

$$2545\ g\ Cl_2 \times \frac{mol\ Cl_2}{70.90\ g\ Cl_2}\ (①) \times \frac{2\ mol\ Na}{mol\ Cl_2}\ (②) \times \frac{22.99\ g\ Na}{mol\ Na}\ (③) = \boxed{1650.\ g\ Na}$$