Relative Formula masses (M_r) and Atomic Masses (A_r)

1. What is the M_r of the following

   a. MgO $\quad 24 + 16 = 40$

   b. CO_2 $\quad 12 + 16 + 16 = 44$

   c. $ZnCl_2$ $\quad 65 + 35.5 + 35.5 = 136$

   d. $FeCl_3$ $\quad 56 + (35.5 \times 3) = 162.5$

   e. Al_2O_3 $\quad (27 \times 2) + (16 \times 3) = 102$

   f. $Mg(NO_3)_2$ $\quad 24 + (14 \times 2) + (16 \times 6) = 148$

   g. $Al_2(SO_4)_3$ $\quad (27 \times 2) + (32 \times 3) + (16 \times 12) = 342$

   h. HNO_3 $\quad 1 + 14 + (16 \times 3) = 63$

   i. $CuCO_3$ $\quad 63.5 + 12 + (16 \times 3) = 123.5$

2. If a metal oxide has a M_r of 56 and a formula of XO, X being the unknown metal. What is X?

$XO = 56$
$O = 16$
$\therefore X = 40$

X= Ca

3. If a metal chloride has a M_r of 80 and a formula of XCl_2, X being the unknown metal. What is X?

$XCl_2 = 80$
$Cl_2 = 71$
$\therefore X = 9$

X= Be

Calculating Reacting Masses of Products and Reactants

1. When water is electrolysed it breaks down into hydrogen and oxygen:

   $2H_2O \longrightarrow 2H_2 + O_2$

   What mass of hydrogen is produced by the electrolysis of 6g of water?

Molar Ratio: 2 : 2 : 1

$$2H_2O \longrightarrow 2H_2 + O_2$$

$\frac{6g}{18} = 0.\dot{3}$ moles - - - - - - - → $0.\dot{3}$ moles

$0.\dot{3}$ moles × M_r

$0.\dot{3}$ moles × 2 = $0.\dot{6}$g

2. What mass of calcium oxide is produced when 10g of calcium burns?

$2Ca + O_2 \longrightarrow 2CaO$

$$\overset{2}{2Ca} + \overset{1}{O_2} \longrightarrow \overset{2}{2CaO}$$

$$\frac{10g}{40} = 0.25 \text{ moles} \dashrightarrow 0.25 \text{ moles}$$

$$0.25 \times 56 = 14g$$

3. What mass of aluminium is produced from 100g of aluminium oxide?

$2Al_2O_3 \longrightarrow 4Al + 3O_2$

$$\begin{array}{ccc} 2 & 4 & 3 \\ 2Al_2O_3 \longrightarrow & 4Al & + \; 3O_2 \end{array}$$

$\frac{100g}{102} = 0.98$ moles - - - - - - - → 1.96 moles

$1.96 \times 27 = 52.92g$

Maximum (Theoretical) Yield and percentage yield

Percentage yield	= actual yield / predicted yield	x 100

1. $Mg + Cl_2 \rightarrow MgCl_2$

a. What is the A_r of Mg?

24

b. What is the M_r of $MgCl_2$?

95

c. If 24g of Mg reacted what would the maximum mass of $MgCl_2$ be?

24g Mg = 1 mole Mg

Molar ratio is 1:1

∴ 1 mole $MgCl_2$ produced = 95g

← Assuming no side reactions or loss of reactants or products

If we only got 90g what is the percentage yield?

$$\% \text{ Yield} = \frac{90}{95} \times 100$$

$$= 94.7\%$$

d. If 48g of Mg reacted what would the maximum mass of $MgCl_2$ be?

48g Mg ------> 190g $MgCl_2$

2 moles   2 moles

If we only got 120g what would the percentage yield be?

$$\% \text{ Yield} = \frac{120}{190} \times 100$$

$$= 63.2\%$$

2. $O_2 + 2H_2 \longrightarrow 2H_2O$

a. What is the M_r of O_2?

32

b. What is the M_r of H_2O?

18

c. If 32g of O_2 reacted what would the maximum mass of H_2O be?

32g O_2 -------> 36g H_2O
1mole -------> 2moles

If we got 32g of water what is the percentage yield?

$$\% \text{ Yield} = \frac{32}{36} \times 100$$
$$= 88.9\%$$

d. If 12g of O_2 reacted what would the maximum mass of H_2O be?
If we got 10g of water what is the percentage yield?

12g O_2 -------> 13.5g H_2O
0.375moles -------> 0.75moles

$$\% \text{ Yield} = \frac{10}{13.5} \times 100$$
$$= 74.1\%$$

3. Why do we want a high percentage yield for a reaction?

So that we make as much product as we can from the mass of reactants that we started with.

Percentage Atom Economy

$$\text{Percentage atom economy} = \frac{\text{Mr of desired product}}{\text{total Mr of all products}} \times 100$$

1. Calcium oxide is made by the thermal decomposition of calcium carbonate This is shown in the equation below:

   $CaCO_3 \longrightarrow CaO + CO_2$

   a. What is the M_r of calcium carbonate ($CaCO_3$)?

   100

   b. What is the M_r of calcium oxide (CaO)?

   56

   c. What is the percentage atom economy in this reaction?

   $$\%\ \text{Atom Economy} = \frac{56}{100} \times 100$$
   $$= 56\%$$

2. Copper sulphate can be made in the following reaction

   Copper oxide + sulphuric acid ⟶ copper sulphate + water

   $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$

   Calculate the percentage atom economy of the reaction

   $$\%\ \text{Atom Economy} = \frac{159.5}{177.5}$$
   $$= 89.9\%$$

3. Why do we want a high atom economy in a reaction?

   More of the mass of the reactant ends up in the useful product. This means less reactant is needed and less waste product is produced. Making the process more sustainable.