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

1. What is the M_r of the following
   a. MgO $24 + 16 = 40$
   b. CO_2 $12 + 16 + 16 = 44$
   c. $ZnCl_2$ $65 + 35.5 + 35.5 = 136$
   d. $FeCl_3$ $56 + (35.5 \times 3) = 162.5$
   e. Al_2O_3 $(27 \times 2) + (16 \times 3) = 102$
   f. $Mg(NO_3)_2$ $24 + (14 \times 2) + (16 \times 6) = 148$
   g. $Al_2(SO_4)_3$ $(27 \times 2) + (32 \times 3) + (16 \times 12) = 342$
   h. HNO_3 $1 + 14 + (16 \times 3) = 63$
   i. $CuCO_3$ $63.5 + 12 + (16 \times 3) = 123.5$

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: $\overset{2}{2H_2O} \longrightarrow \overset{2}{2H_2} + \overset{1}{O_2}$

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

$0.\dot{3}moles \times Mr$

$0.\dot{3}moles \times 2 = 0.\dot{6}g$

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

   $2Ca + O_2 \longrightarrow 2CaO$

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

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

$0.25 \times 56 = 14g$

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

   $2Al_2O_3 \longrightarrow 4Al + 3O_2$

$\overset{2}{2Al_2O_3} \longrightarrow \overset{4}{4Al} + \overset{3}{3O_2}$

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

$1.96 \times 27 = 52.92g$

Maximum (Theoretical) Yield and percentage yield

Percentage yield = $\frac{\text{actual yield}}{\text{predicted yield}} \times 100$

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 + 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 (2 moles) ------> 190g $MgCl_2$ (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

   1 mole ------> 2 moles

   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?

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

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

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.