C3 – Quantitative Chemistry

Conservation of Mass

- Atoms cannot be created or destroyed during reactions.
- **Mass of reactants = mass of products**.

To show mass is conserved in a reaction:
M_r on the left-side must be same as the right side.

$2Mg + O_2 \rightarrow 2MgO$
$(2 \times 24) + (2 \times 16) \rightarrow 2(24 + 16)$
$48 + 32 \rightarrow 2 \times 40$
$80 \rightarrow 80$

Reacting masses

Use conservation of mass to predict masses:

magnesium + oxygen → magnesium oxide
8g ? 10g

Both sides need to be equal:
10g – 8g = 4g of oxygen

Percentage Mass

- Percentage mass of an element in a compound

$$\frac{\text{Mass of the element in compound}}{\text{Total mass of compound}} \times 100$$

Example Question:
Find the percentage mass of oxygen in magnesium oxide (MgO).
A_r of magnesium = 24 A_r of oxygen = **16**

M_r of MgO = 24 + 16 = **40**

$$\% \text{ mass} = \frac{A_r}{M_r} = \frac{16}{40} = 0.4 \times 100 = 40\%$$

X 100 to make a %

40% of the mass of MgO is oxygen

Mass Changes

- Mass is always conserved in a reaction.
- Sometimes it may seem like the mass has increased/decreased.

- If a **reactant** is a gas – mass may **increase**.

magnesium + oxygen → magnesium oxide

Oxygen is in the air before it combines with magnesium – you cannot find the mass of oxygen on the balance.

It will look like the mass has increased when it is re-weighed at the end.

- If a **product** is a gas and the gas is able to escape the system – mass will **decrease**.

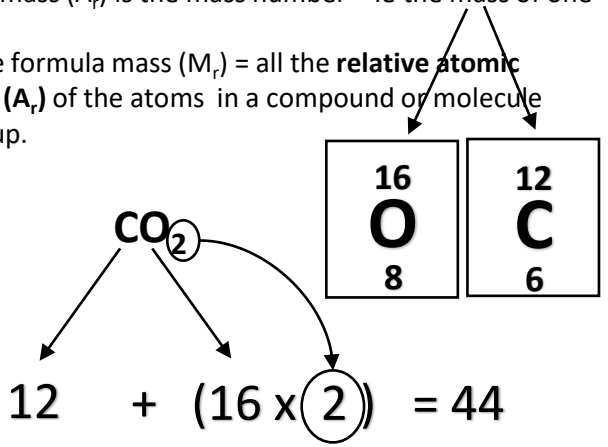
sodium carbonate → sodium oxide + carbon dioxide

It will look like the mass has decreased as some of the atoms have been given off as gas and have escaped – so cannot be re-weighed.

Atomic mass (A_r) and Relative Formula Mass (M_r)

- Atomic mass (A_r) is the mass number – ie the mass of one atom
- Relative formula mass (M_r) = all the **relative atomic masses (A_r)** of the atoms in a compound or molecule added up.

Example



The Mole (HT only)

- Avogadro constant – 6.02×10^{23}

- One mole contains 6.02×10^{23} atoms or molecules
- The mass, in g, of one mole is the Ar (if an element) or Mr if a compound or molecular element

Iron has a A_r of 56, so 1 mole of iron is 56 g and contains 6.02×10^{23} atoms of iron

Ammonia (NH_3) has an Mr of 17, so 1 mole of ammonia has a mass of 17g. and contains 6.02×10^{23} molecules of ammonia

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Concentrations of Solutions

- Concentration =mass of dissolved substance in specific volume (eg dm^3)
- More substance dissolved = more concentrated solution

Concentration = mass ÷ volume
(g/dm^3) (g) (dm^3)

Can be rearranged to find mass dissolved:

mass = concentration x volume
(g) (g/dm^3) (dm^3)

$1000cm^3 = 1dm^3$
cm^3 → dm^3 = divide by 1000.

Calculating mass in a given volume

If you have a known volume of a solution of known concentration then you can calculate the mass of dissolved solid.

E.g Calculate the mass of dissolved solid in $25cm^3$ of a $96g/dm^3$ solution

$96g/dm^3$ means 96g in every $1000cm^3$ → $25c\ m^3$

How do we get from 1000 to 25? (÷40)

Do the same to the other side (÷40) → 2.4g

Moles and Equations (HT only)

- You can use moles to help you write balanced symbol equations.

Example Question
18.4g of Sodium reacted with 6.4g of oxygen to give 24.8g sodium oxide. Use the masses to write the balanced equation.

Step	Example
Write the equation for the reaction (unbalanced)	$Na + O_2 \rightarrow Na_2O$
write down the mass or % <u>given in the question</u>	18.4 + 6.4 → 24.8
Write the mass of one mole of each element or compound	23 32 62 (e.g 18.4 ÷ 23)
Divide the mass given in question by the mass of one mole	0.8 0.2 0.4
Turn the answers into whole number simple ratio	8 2 4 (cancel down) 4 1 2
Put the numbers into the equation	$4Na + O_2 \rightarrow 2Na_2O$

Calculating reacting masses (HT)

Example Question
Calculate the mass of calcium needed to make 11.2g Calcium oxide

Step	Calculation
Write the balanced equation	$2Ca + O_2 \rightarrow 2CaO$
Write the masses of each substance	80 + 32 → 112
Write down the given mass in the question.	11.2
Work out the 'scale' factor (ie what did you have to do to the original number to get to the desired mass	÷ 10
Do the same to the other side	8g

Limiting Reactants (HT only)

- If one reactant runs out before the other, then the reaction will stop.
- The reactant that runs out first in a reaction is known as the limiting reactant.