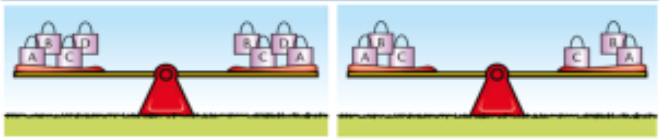
QUANTITATIVE CHEMISTRY

CONSERVATION OF MASS AND BALANCED CHEMICAL EQUATIONS

- **LAW OF CONSERVATION OF MASS:** No atoms are lost or made during a chemical reaction. $\textbf{MASS}_{\textbf{Products}} = \textbf{MASS}_{\textbf{Reactants}}$
- **CHEMICAL REACTIONS:** Represented by balanced symbol equations → numbers of atoms of each element are the same on each side



$\textbf{MASS}_{\textbf{Products}} = \textbf{MASS}_{\textbf{Reactants}}$	Numbers of atoms of the formulae are balanced

Relative atomic mass, A_r	The average mass of the atoms of an element compared with carbon-12 (which is given a mass of exactly 12). The average mass must take into account the proportions of the naturally occurring isotopes of the element.
Relative formula mass, M_r	The total of the relative atomic masses, added up in the ratio shown in the chemical formula of a substance. E.G. $M_r(NaCl) = Na + Cl = 23 = 35.5 = 58.5$ E.G. $M_r(MgF_2) = Mg + (2xF) = 24 + (2 \times 19) = 62$

MASS CHANGES WHEN A REACTANT OR PRODUCT IS A GAS

- **LOSING MASS:** In thermal decompositions of metal carbonates, CO_2 is produced → escapes into the atmosphere
- **GAINING MASS:** When a metal reacts with oxygen, mass of oxide produced is greater than the mass of the metal.

PERCENTAGE COMPOSITION BY MASS

- **% Z = (Number of atoms of Z) x (A_r of Z) / M_r of the compound x 100**
- E.G. % of oxygen in CO_2 (A_r of C = 12 and A_r of O = 16)
  % of oxygen = (2 x A_r of O) / M_r of CO_2
  % of oxygen = (2 x 16) / 12 + (2x16) = (32 / 44) x 100 = **72.7 %**

Empirical formula	The simplest ratio of elements in a compound.

EMPIRICAL FORMULA

- E.G. **5.5g** of manganese reacted with **3.2g** of oxygen. What is the **empirical formula** of the oxide of manganese that was formed? **(A_r of Mn = 55 and A_r of O = 16)**

ELEMENTS	Mn	O
mass (g)	5.5	3.2
Ar	55	16
Mass / Ar	5.5/55 = 0.10	3.2/16 = 0.20
Ratio (DIVIDE BY SMALLEST)	0.10/0.10 = **1**	0.20/0.10 = **2**
EMPIRICAL FORMULA	**MnO_2**	

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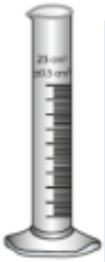

CHEMICAL MEASUREMENTS

- Whenever a measurement is made, there is always some **UNCERTAINTY** about the result obtained.
- A measuring cylinder has an **uncertainty of ±0.5 cm³.** 15 cm³ should be written as 15.0 cm³±0.5 cm³.

- **TRUE MEASUREMENT:** between 14.5 cm³ and 15.5 cm³.
- **RANGE** = highest measurement – lowest measurement
- **MEAN** = sum of the measurements divided by the number of measurements

- **PERCENTAGE UNCERTAINTY = range of measurements / mean x 100**

NUMERACY IN SCIENCE

1. Equation
2. Identify variables
3. Substitute
4. Rearrange
5. Answer
6. Units

CONCENTRATION

- Most chemical reactions take place in solutions.
- Concentration can be measured in **grams per dm³** (g/dm³).

- **Concentration (g/dm³) = mass (g) / volume (dm³)**

- **1 dm^3 = 1000cm^3 (1 litre)**

- E.G. What is the concentration in g/dm³ of **2.4g** sodium chloride dissolved in **0.5dm^3** of water?
- Concentration = mass / volume
- Concentration = 2.4g / 0.5dm^3 = **4.8 g/dm^3**

CONCENTRATION

- The **concentration increases** as the number of solute **particles** in a **fixed volume increases.**

QUANTITATIVE CHEMISTRY: MOLES [HIGHER TIER]

THE MOLE [HIGHER TIER]

- A mole of an element = **6.02×10^{23}** atoms **(AVOGADRO CONSTANT)**.
- If the atoms are larger, then 1 mole of that atom will be heavier.
- To CALCULATE MOLE: mole = mass (g) / A_r
- **$n = m / A_r$, OR $n = m / M_r$**
- E.G. How many moles in 6g of C? 6 / 12 = 0.5 moles
- E.G. How many moles in 30g of MgO? 30 / (24 + 16) = 30/40 = 0.75 moles

- The **mass of 1 mole of a substance in grams** is numerically equal to its **relative formula mass.**
- E.G. Calculate the mass of 3 moles of KBr: m = n x M_r,
  m = 3 x (39 + 80) = 357g
- **MOLAR MASS:** Mass of 1 mole (unit: g/mol or $gmol^{-1}$)
- E.G. Molar mass of $Mg(NO_3)_2$ = 24 + (2 x 14) + 2 (3 x 16) = 148 g/mol

AMOUNTS OF SUBSTANCES IN EQUATIONS [HIGHER TIER]

- Masses of REACTANTS and PRODUCTS can be calculated from balanced symbol equations.
- E.G. $Mg + 2HCl \rightarrow MgCl_2 + H_2$
- This equation shows that **1 mole** of Mg reacts with **2 moles** of HCl to produce **1 mole** of $MgCl_2$ and **1 mole** of H_2 gas.

THE MOLE [HIGHER TIER]

- If the mass of each reactant and product is known, a balanced equation can be calculated.
- E.G. **Calculate the balanced equation** when **12g of Mg** reacts completely with **38.5g of HCl** to make **49.5g of $MgCl_2$** and **1g of H_2**. **Symbol equation:** $Mg + HCl \rightarrow MgCl_2 + H_2$

Elements / Compounds	**Mg**	**HCl**	**$MgCl_2$**	**H_2**
Moles (m / Mr)	12/24 = 0.5	38.5/38.5 = 1	49.5/99 = 0.5	1/2 = 0.5
÷ by smallest number	0.5/0.5 = **1**	1/0.5 = **2**	0.5/0.5 = **1**	0.5/0.5 = **1**
BALANCED EQUATION:	**$Mg + 2HCl \rightarrow MgCl_2 + H_2$**			

CALCULATING MASSES IN REACTIONS [HIGHER TIER]

- **E.G. 1 :** What mass of magnesium chloride is made from **5g** of magnesium?
- **$Mg + 2HCl \rightarrow MgCl_2 + H_2$**
  1 : 1

	Mg	**$MgCl_2$**
Mass (g)	5 **STEP 1**	**19.8**
Ar or Mr	24 ÷	24 + (2 x 35.5) = **95** **STEP 3** x
n = m / Mr	5/24 = **0.21** → **STEP 2**	**0.21**
RATIO from the balanced equation	**1**	**RATIO** **1**

- **E.G. 2 :** What mass of carbon dioxide is formed when **100g** of C_7H_{16} is burned?
- **$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$**
  1 : 7

	C_7H_{16}	**CO_2**
Mass (g)	100 ÷	**308**
Mr	(7 x 12) + (16 x 1) = **100**	12 + (2 x 16) = **44** x
n = m / Mr	100/100 = **1** →	1 x 7 = **7**
RATIO from the balanced equation	**1**	**7**

QUANTITATIVE CHEMISTRY: MOLES [HIGHER TIER]

CALCULATING MASSES IN REACTIONS [HIGHER TIER]

- **E.G. 1 :** What mass of magnesium chloride is made from **5g** of magnesium?
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n = m / Mr	100/100 = **1**	1 x 7 = **7**
RATIO from the balanced equation	**1**	**7**

LIMITING REACTANTS [HIGHER TIER]

- In a chemical reaction involving 2 reactants, an EXCESS of one of the reactants is used → ensures all of the other reactant is used.
- Reactant that is COMPLETELY USED UP = **LIMITING REACTANT**
- The amount of product formed is DIRECTLY PROPORTIONAL to the amount of limiting reactant → If the limiting reactant is DOUBLED, then the amount of product formed is also DOUBLED.