

Section A: Vocabulary
Tier 3 Vocabulary

empirical formula	The formula showing the simplest whole number ratio of atoms of each element in a compound.
molecular formula	The formula showing the actual number of atoms of each element in a molecule of a compound.
relative formula mass	The sum of the relative atomic masses of all the atoms in a formula.
precipitate	An insoluble substance that is formed when two soluble substances react together in solution.
closed system	When substances cannot enter or leave an observed environment, e.g. a stoppered test tube.
conservation of mass	The idea that mass is never lost or gained during a chemical reaction or physical change.
non-enclosed system	When substances can enter or leave an observed environment e.g. stoppered test tube
Avogadro constant	This is the number of particles in one mole of a substance ($6.02 \times 10^{23} \text{ mol}^{-1}$).
limiting reactant	The reactant that determines the amount of product formed in a chemical reaction. Any other reactants will be present in excess.
mole	The mass of a mole of a substance is the relative formula mass expressed in grams.
stoichiometry	The molar ratio of the reactants and products in a chemical reaction.

Tier 2 Vocabulary

solute	A substance that dissolves in a liquid to make a solution.
solvent	Describes the liquid in which a substance dissolves to make a solution.

Section B: Relative Formula Mass, Empirical and Molecular Formula
Relative Formula Mass (M_r)

Calculate the M_r of carbon dioxide (CO_2).

$$= A_r(\text{C}) + (2 \times A_r(\text{O})) \\ = 12 + (2 \times 16)$$

So, M_r of $\text{CO}_2 = 44$

Calcium nitrate has a giant lattice structure. Its formula is $\text{Ca}(\text{NO}_3)_2$ (for each calcium ion there are two nitrate ions). Calculate the M_r of calcium nitrate.

$$= A_r(\text{Ca}) + 2(A_r(\text{N}) + (3 \times A_r(\text{O}))) \\ = 40 + 2(14 + (3 \times 16))$$

So, M_r of $\text{Ca}(\text{NO}_3)_2 = 164$

Calculate the relative formula masses of:

a N_2 **b** NaCl **c** NH_3 **d** H_2SO_4 **e** $(\text{NH}_4)_2\text{SO}_4$.

Finding an Empirical Formula

Symbol for element	Ca	Cl
Mass (g)	10.0	17.8
Relative atomic mass, A_r	40	35.5
Divide the mass of each element by its relative atomic mass	$\frac{10.0}{40} = 0.25$	$\frac{17.8}{35.5} = 0.5$
Divide the answers by the smallest number to find the simplest ratio	$\frac{0.25}{0.25} = 1$	$\frac{0.5}{0.25} = 2$
Empirical formula	CaCl_2	

Calculate the empirical formula of magnesium carbonate (1.2g Mg, 0.6g C, 2.4g O)

Finding a Molecular Formula

The empirical formula for glucose is CH_2O and its relative formula mass is 180. Determine the molecular formula for glucose.

- Find empirical formula mass $A_r(\text{C}) + (2 \times A_r(\text{H})) + A_r(\text{O})$
 $= 12 + (2 \times 1) + 16 = 30$

- Divide M_r by empirical formula mass $\frac{180}{30} = 6$

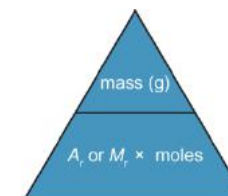
The molecular formula is six times the empirical formula, so the molecular formula is $\text{C}_6\text{H}_{12}\text{O}_6$.

Determine the molecular formula of hydrogen peroxide, with empirical formula HO and M_r 34.

Section C: Conservation of Mass and Moles

Calculate the mass of chlorine needed to make 53.4 g of aluminium chloride.

Write the balanced equation	$2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$
Calculate relative formula masses of the substances needed	$M_r \text{Cl}_2 = 2 \times 35.5 = 71$ $M_r \text{AlCl}_3 = 27 + (3 \times 35.5) = 133.5$
Calculate ratio of masses (multiply M_r values by the balancing numbers shown in the equation).	3Cl_2 makes 2AlCl_3 so $3 \times 71 = 213 \text{ g Cl}_2$ makes $2 \times 133.5 = 267 \text{ g AlCl}_3$
Work out the mass for 1 g of reactant or product. (Here we want 1 g of the product because that's the mass we know already.)	$\frac{213}{267} \text{ g Cl}_2$ makes $\frac{267}{267} \text{ g AlCl}_3$ $+ 267$ (under 213) $+ 267$ (under 267)
Scale up or down (from 1 g to the mass you are given)	$\times 53.4$ (under 1) 0.798 g Cl_2 makes 1 g AlCl_3 $\times 53.4$ (under 1) 42.6 g Cl_2 makes 53.4 g AlCl_3



1.50 g of ammonium chloride and 4.00 g of calcium hydroxide are heated together to form ammonia.



a Which is the limiting reactant?

b Calculate the mass of ammonia formed.

a The equation shows that 2 mol of NH_4Cl reacts with 1 mol of $\text{Ca}(\text{OH})_2$.

number of moles of $\text{Ca}(\text{OH})_2 = 4.00 \text{ g} / (40 + 2(16 + 1)) = 0.0541 \text{ mol}$

We need: $2 \times 0.0541 = 0.108 \text{ mol NH}_4\text{Cl}$ to react with 0.0541 mol of $\text{Ca}(\text{OH})_2$.

We have: $1.50 \text{ g} / (14 + (4 \times 1) + 35.5) = 0.0280 \text{ mol}$

We have less than the 0.0541 mol of NH_4Cl needed; $\text{NH}_4\text{Cl} = \text{limiting reactant}$.

b The equation shows that the number of moles of NH_3 made equals the number of moles of NH_4Cl used.

So, 0.0280 mol of NH_4Cl forms 0.0280 mol of NH_3

mass of NH_3 formed = $\text{mol} \times M_r = 0.0280 \times (14 + (3 \times 1)) = 0.476 \text{ g}$