

Mark schemes compress a calculation to “C1 A1”. These are written the way you should write them: convert to moles first, use the *BALANCED* equation for the ratio, then convert back – and show every step, because the method marks survive an arithmetic slip. C1 A1; :

Moles and masses

| Calculate the mass of magnesium oxide formed when 4.8 g of magnesium burns completely in oxygen. (M_r : Mg = 24, O = 16) [4]

The equation is $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$. Moles of Mg = $\frac{4.8}{24} = 0.20$ mol. From the equation the ratio Mg : MgO is 2 : 2, so moles of MgO = 0.20 mol. $M_r(\text{MgO}) = 24 + 16 = 40$, so mass = $0.20 \times 40 = 8.0$ g.

Commentary: Convert to moles FIRST. Working with masses in the ratio gives 4.8 g and is the standard error.

Commentary: The ratio comes from the balanced equation, not from the formula. Writing the equation is itself a mark.

| 25.0 cm³ of 0.100 mol/dm³ sodium hydroxide is neutralised by 20.0 cm³ of hydrochloric acid. Calculate the concentration of the acid. [4]

Moles of NaOH = $c \times \frac{V}{1000} = 0.100 \times \frac{25.0}{1000} = 2.50 \times 10^{-3}$ mol. The equation $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ gives a 1 : 1 ratio, so moles of HCl = 2.50×10^{-3} mol. Concentration = $\frac{n}{V} = \frac{2.50 \times 10^{-3}}{20.0/1000} = 0.125$ mol/dm³.

Commentary: Divide the volume in cm³ by 1000 to get dm³. Forgetting this is worth two marks and gives an answer out by a factor of 1000.

Commentary: State the 1 : 1 ratio explicitly – in a titration question it is a mark, even though it looks obvious.

| A sample of copper(II) sulfate crystals, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, has mass 5.00 g. Calculate the mass of water it contains. (M_r : $\text{CuSO}_4 = 160$, $\text{H}_2\text{O} = 18$) [3]

M_r of the hydrated salt = $160 + (5 \times 18) = 160 + 90 = 250$. The fraction that is water = $\frac{90}{250} = 0.36$. Mass of water = $0.36 \times 5.00 = 1.8$ g.

Commentary: Multiply the water's M_r by 5 BEFORE adding – using 18 alone gives 178 and everything after is wrong.

Commentary: The fraction method avoids a second mole calculation and is less error-prone under time pressure.

Yield, gases and electrolysis

| In a reaction the theoretical yield of product is 12.0 g but only 9.0 g is obtained. Calculate the percentage yield, and give one reason it is less than 100%. [3]

Percentage yield = $\frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{9.0}{12.0} \times 100 = 75\%$. It is less than 100% because some product is lost during transfer and filtration.

Commentary: Actual over theoretical, not the reverse – an answer above 100% always signals this error.

Commentary: ‘The reaction did not finish’ is also accepted, but ‘human error’ is not; name a specific loss.

I Calculate the volume of carbon dioxide, at room temperature and pressure, produced when 10.0 g of calcium carbonate decomposes completely. (Molar gas volume = 24 dm³/mol; $M_r(\text{CaCO}_3) = 100$) [4]

$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. Moles of $\text{CaCO}_3 = \frac{10.0}{100} = 0.100$ mol. The ratio is 1 : 1, so moles of $\text{CO}_2 = 0.100$ mol. Volume = $0.100 \times 24 = 2.4 \text{ dm}^3$.

Commentary: The molar gas volume is given on the paper; using 22.4 (the value at STP) instead is a common substitution error.

Commentary: Give the unit as dm³ – an answer in cm³ needs multiplying by 1000 and must say so.

I During the electrolysis of molten lead(II) bromide, write the equation for the reaction at each electrode. [4]

At the cathode (negative), lead ions gain electrons: $\text{Pb}^{2+} + 2e^- \rightarrow \text{Pb}$. At the anode (positive), bromide ions lose electrons: $2\text{Br}^- \rightarrow \text{Br}_2 + 2e^-$.

Commentary: Cathode is reduction (gain of electrons), anode is oxidation. Reversing them loses both marks.

Commentary: Balance the charges as well as the atoms – the electrons must make each side’s total charge equal.