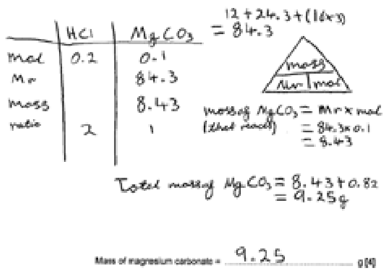
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1		i	**$MgCl_2$ (aq)** + H2O (l) + **CO_2 (g)** Both species ✓ Both state symbols ✓	2 (2 x AO 1.2)	**ALLOW** $MgCl_2$ (aq) / CO_2 (g) for 1 mark if no other mark awarded **<u>Examiner's Comments</u>** A common error was writing the state symbol for Mg*Cl*$_2$ as (s) but most correctly identified CO_2(g) as the other product. The most common incorrect formula given was MgC*l*.
		ii	**First check the answer on the answer line** **If answer = 9.25 (g) award 4 marks** 0.1 mol of $MgCO_3$ reacts with 0.2 mol of HC*l* / Idea of 1:2 mole ratio $MgCO_3$: HC*l* ✓ *M*r of $MgCO_3$ = 84.3 ✓ Mass of $MgCO_3$ that reacted = 0.1 x 84.3 = 8.43 g ✓ Mass of $MgCO_3$ used in the reaction = 8.43 + 0.82 = 9.25 g ✓	4 (4 x AO 2.2)	**ALLOW** ECF from incorrect *M*r and/or moles of $MgCO_3$ **ALLOW** ECF from incorrect mass of $MgCO_3$ **<u>Examiner's Comments</u>** Only the highest attaining candidates gained 4 marks, with most not appreciating the idea of a reagent being in excess and that its value should have been added to 8.43g. Common errors included subtracting the excess from 8.43 to give an answer of 7.61g, or not recognising that there was a 2:1 ratio of acid to carbonate. Many candidates set out their calculations in a table showing formula mass, number of moles (or mole ratio) and mass, which was extremely helpful to examiners when looking to give marks for error carried forward. Exemplar 3

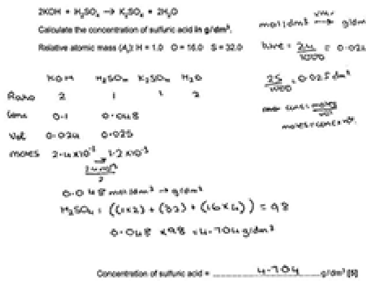
					 This candidate has clearly tabulated the data for HC*l* and $MgCO_3$. They understood that 0.2 mol of HCl react with 0.1 mol $MgCO_3$. They have calculated the Mr of $MgCO_3$ and hence the mass of $MgCO_3$ that reacted. Finally, the mass of $MgCO_3$ used in the reaction is calculated by adding the mass of $MgCO_3$ that reacted to the mass left unreacted to obtain the correct answer of 9.25g. They achieved all 4 marks for this response. Had the candidate made an error, their working out is set out very clearly which would have enabled the examiner to give marks for error carried forward.
			Total	**6**	
2			**B**	1 (AO 2.2)	**<u>Examiner's Comments</u>** The charges on the zinc ion and the iron ion were not well known, with examiners seeing all possible incorrect responses. Candidates could be encouraged to use the 'criss-cross/crossover' rule to work out the charges on the ions in an ionic compound from the formula.
			Total	**1**	
3			**C**	1 (AO 2.2)	**<u>Examiner's Comments</u>** Selecting option D was a common misconception in this question indicating that candidates did not recall that reduction occurs at the cathode and oxidation occurs at the anode.
			Total	**1**	
4			**B**	1 (AO 2.1)	

			Total	**1**	
5			**B**	1 (AO 2.1)	**<u>Examiner's Comments</u>** Selecting option D was a common misconception with candidates multiplying the relative atomic mass of beryllium by the Avogadro constant rather than dividing by the Avogadro constant.
			Total	**1**	
6			**D**	1 (AO 2.1)	
			Total	**1**	
7	a	i	(Gas) <u>syringe</u> / (upturned) burette ✓	1 (AO 2.2)	**<u>Examiner's Comments</u>** Most candidates correctly suggested using a gas syringe.
		ii	Idea that marble chips are left over at the end of the reaction / marble chips are in excess✓	1 (AO 2.2)	**IGNORE** idea that hydrochloric acid was used up first **<u>Examiner's Comments</u>** Many candidates stated that the acid would be all used up. Whilst this statement is correct it does not address the question and explain <u>how the student could tell</u> that the acid is the limiting reactant.
	b		Tangent drawn at 60 seconds ✓ Rate = $\frac{\text{y-step}}{\text{x-step}} = \frac{71 - 20}{120}$ ✓ = 0.425 / 0.43 / 0.4 (cm^3/s) ✓	3 (3 x AO 2.2)	**ALLOW ECF** for y-step and x-step from incorrect tangent / attempted tangent **ALLOW** answers in range 0.4 – 0.5 (cm^3/s) **ALLOW ECF** for correct rate from incorrect y-step and x-step **<u>Examiner's Comments</u>** Most candidates were able to construct a tangent at 60 seconds and were then able to use it to determine a rate within the acceptable range. Common errors included using x-step ÷ y-step for the rate or using a single point (usually 46,60) to calculate the rate.
	c	i	Stays the same / **AW** ✓	1 (AO 1.2)	**<u>Examiner's Comments</u>**

					Most candidates stated that the final volume would stay the same, but 'increase' was a common incorrect answer.
		ii	Stays the same / **AW** ✓	1 (AO 1.2)	**Examiner's Comments** Most candidates stated that the mass of the catalyst would stay the same, but 'decrease' was a common incorrect answer
			Total	**7**	
8		i	Copper oxide / CuO loses oxygen or copper oxide / CuO is reduced ✓ Carbon (atoms) / C gains oxygen or carbon (atoms) / C is oxidised ✓	2 (2 x AO 2.2)	**DO NOT ALLOW** copper loses oxygen **BUT ALLOW** copper gains electrons / copper (cat)ions are reduced (to form copper atoms) **ALLOW** carbon loses electrons **Examiner's Comments** Good responses to this question explained the redox reaction in terms of copper oxide losing oxygen and carbon gaining oxygen. Examiners also saw responses in terms of loss and gain of electrons. A frequent error was stating that copper loses oxygen.
		ii	**First check the answer on the answer line** **If answer = 12 (tonnes) award 3 marks** **If answer = 12,000,000 g award 3 marks** Mass of CuO = $15 \times \frac{63.5}{79.5}$ or $15 \times \frac{127}{159}$ ✓ = 11.98 ✓ To 2 **significant figures** = 12 (tonnes) ✓	3 (2 x AO 2.2) (1 x AO 1.2)	**ALLOW ECF** marks for e.g., $15 \times \frac{79.5}{63.5} = 18.78$ and (to 2 sig figs) 19 (tonnes) **ALLOW ECF** if significant figures are correct from an incorrect calculation of mass **Examiner's Comments** Candidates had been well prepared for reacting mass calculations, with most candidates gaining 3 marks. Some candidates did not express their answers to 2 significant figures. Errors that were made often arose from doubling only one of the A_r of Cu (from 63.5 to 127) or the M_r of CuO (from 79.5 to 159).
		iii	**Quantitative answer:** Pure copper is twice as conductive ✓ compared to 99% pure copper ✓	2 (2 x AO 3.2b)	**ALLOW** answers quoting 2 correct values from the graph for 2 marks e.g., 99% pure copper has relative

			BUT **Qualitative answer:** Pure copper is a better conductor than 99% pure / impure copper / ORA ✓		electrical conductivity of about 49, but 100% pure copper has relative electrical conductivity of 100 **OR** e.g., copper extracted from copper oxide has a relative electrical conductivity of about 49, but when purified by electrolysis has relative electrical conductivity of 100 **ALLOW** idea that copper with less impurities is a better conductor / ORA **Examiner's Comments** Lower attaining candidates misinterpreted the question and gave answers relating to the electrolysis reaction. Many candidates identified that the graph showed that impurities in copper brought about a decrease in its electrical conductivity. Higher attaining candidates were able to give a quantitative answer in terms of pure copper being twice as conductive as 99% pure copper or quoting two values from the graph to illustrate this relationship.
			Total	**7**	
9			$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ Formulae ✓ Balancing ✓	2 (2 x AO 2.1)	**ALLOW** any correct multiple, including fractions **ALLOW** = for → **DO NOT ALLOW** and / & instead of '+' **IGNORE** state symbols Balancing mark is dependent on the correct formulae but **ALLOW 1** mark for a balanced equation with a minor error in subscripts / formulae e.g. $Ch_4 + 2O_2 \rightarrow Co_2$ + 2H2O **Examiner's Comments** Most candidates were able to write the correct balanced symbol equation. The most common error was giving H_2, usually instead of H_2O, as a product.
			Total	**2**	

10			C ✓	1 (AO 2.1)	
			Total	**1**	
11	a		The measured volume will be greater than the actual volume. ☐ The measured volume will be smaller than the actual volume. ☑ ✓ The measured volume will be the same as the actual volume. ☐	1 (AO 3.2b)	**Examiner's Comments** 'The measured volume will be greater than the actual volume' was a commonly chosen distractor.
	b	i	**First check the answer on answer line** **If answer = 24.0 (cm^3) award 1 mark** Average titre = $\frac{24.1 + 23.9 + 24.0}{3}$ = 24.0 (cm^3) ✓	1 (AO 2.2)	**ALLOW** 24 (cm^3) **ALLOW** Average titre = $\frac{24.1 + 24.0}{2}$ = 24.05(cm^3) **ALLOW** Average titre = $\frac{23.9 + 24.0}{2}$ = 23.95(cm^3) **Examiner's Comments** Lower attaining candidates calculated the average of all 4 results, including the anomalous result in their calculation.
		ii	**First check the answer on answer line** **If answer = 4.7 / 4.70 / 4.704 / 4.71 / 4.7088 (g/dm^3) award 5 marks** Moles of KOH = $\frac{0.100 \times 24.0}{1000}$ / 0.100 x 0.024 / 0.0024 ✓ Moles of H_2SO_4 = $\frac{0.0024}{2}$ / 0.0012 ✓ Concentration of H_2SO_4 = $\frac{0.0012}{0.025}$ = 0.048 (mol/dm^3) ✓ M_r of H_2SO_4 = 98.0 / 98.1 ✓ Concentration of H_2SO_4 in g/dm^3 = 98 × 0.048 = 4.70 (g/dm^3) **or** Concentration of H_2SO_4 in g/dm^3 = 98.1 × 0.048	5 (5 × AO 2.2)	**ALLOW ECF** from average titre in part **(i)** **ALLOW ECF** from moles of KOH unit not needed **ALLOW ECF** from moles of alkali i.e., concentration = $\frac{moles}{0.025}$ / $\frac{moles \times 1000}{25}$ **ALLOW ECF** from concentration of H_2SO_4 **ALLOW ECF** from moles of H_2SO_4 **ALLOW ECF** from mass of H_2SO_4

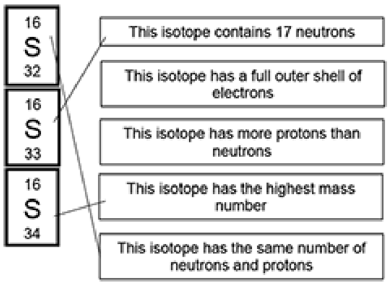
			= 4.71 (g/dm^3) ✓ **OR for MP3, 4 & 5:** Mr of H_2SO_4 = 98.0 / 98.1 ✓ Mass of H_2SO_4 = 98.0 × 0.0012 = 0.1176 g **or** Mass of H_2SO_4 = 98.1 × 0.0012 = 0.1177 g ✓ Concentration of H_2SO_4 in g/dm^3 = 0.1176 ÷ 0.025 =4.70 (g/dm^3) **or** Concentration of H_2SO_4 in g/dm^3 = 0.1177 ÷ 0.025 = 4.71 (g/dm^3)		Answer is 4.7138 (g/dm^3) if answer for **(b)(i)** is 24.05 cm^3 or 4.6942 (g/dm^3) if answer for **(b)(i)** is 23.95 cm^3 **<u>Examiner's Comments</u>** Around a quarter of candidates were given all 5 marks. Higher attaining candidates were able to calculate the concentration of sulfuric acid in g/dm^3. Error carried forward was given from an incorrect titre in part (b) (i). **Assessment for learning** Examiners use **bold type** to draw the candidates' attention to key aspects of a question. Despite the emboldening of '**in g/dm^3**' in this question, many candidates calculated the concentration in mol/dm^3. Exemplar 3  This response gained full marks for this titration calculation. The candidate has clearly set out their working out, making it easy for the examiner to follow. The candidate has calculated the moles of potassium hydroxide. They have appreciated the mole ratio and correctly calculated the moles of sulfuric acid, going on to use this to calculate the concentration of the acid. The candidate has then calculated the relative molecular mass of sulfuric

					acid and used this to convert the concentration in mol/dm³ to g/dm³.
			Total	**7**	
12		i	Electrons are gained ✓	1 (AO 1.1)	**Examiner's Comments** Most candidates correctly stated that electrons are gained.
		ii	$2Br^-$ - $2e^-$ → Br_2 **OR** $2Br^-$ → Br_2 + $2e^-$ Formulae ✓ Balancing ✓	2 (2 × AO 2.2)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' Balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g., $2br^-$ - $2e^-$ → Br2 **Examiner's Comments** Lots of candidates found it difficult to give the correct response for this question. Less successful responses gave the equation for the reverse reaction, i.e. Br_2 → $2Br^-$ - $2e^-$. **OCR support** When carrying out PAG C1 – Reactivity trends of halogens it would be appropriate to take time to reinforce the half equations involved too. This practical group can be used to reinforce the knowledge assessed in topics C3 and C4.
			Total	**3**	
13			($C_{28}H_{58}$ → $C_{12}H_{26}$ +) **$8C_2H_4$** Formula of ethene ✓ Balancing ✓	2 (2 × AO 2.2)	**ALLOW** any correct multiple, including fractions **ALLOW** $C_{16}H_{32}$ or $4C_4H_8$ for 2 marks **Examiner's Comments** $C_{16}H_{32}$ was the most common correct response.

			Total	**2**	
14			**First check the answer on answer line** **If answer = 96 (cm^3) award 4 marks** M_r of H_2 = 2.0 ✓ Moles of $H_2 = \frac{0.008}{2}$ / 0.004 ✓ Volume of H_2 = 0.004 × 24 / 0.096 dm^3 ✓ Volume of H_2 in cm^3 = 96 (cm^3) ✓	4 (3 × AO 2.2) (AO 1.2)	**ALLOW ECF** from incorrect M_r **ALLOW ECF** from incorrect moles calculation **ALLOW ECF** from volume in dm^3 **<u>Examiner's Comments</u>** This question proved to be a real discriminator, as did all the calculations on this paper. Only the highest attaining candidates worked this through to the correct answer. If candidates did not obtain an answer of 96 cm^3 examiners looked to award marks for working out and/or error carried forward. It is worth centres stressing to candidates that this is only possible when a response is clearly set out. **Misconception** Common errors/misconceptions in the calculation included: • taking the M_r of H_2 to be 1 • not converting dm^3 to cm^3 • not recalling the formula 'volume = mol x 24', with many candidates giving a mass of H_2 rather than the required volume. **Assessment for learning** Many candidates still forget to convert cm^3 to dm^3 before calculating moles or concentrations.

			Total	**4**	
15			$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ **OR** $C_4H_{10} + 6½O_2 \rightarrow 4CO_2 + 5H_2O$ Formulae ✓ Balancing ✓	2 (2 × AO 2.2)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' Balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g., $C_4h_{10} + 6½O_2 \rightarrow 4Co_2 + 5H2O$ **<u>Examiner's Comments</u>** Hydrogen, rather than water, was often seen as a product in this combustion reaction. Just over half of candidates gained some marks from this question.
			Total	**2**	
16			$2HCl + Mg \rightarrow MgCl_2 + H_2$ Formulae ✓ Balancing ✓	2 (2 × AO 2.2)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' Balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g., $2HCL + Mg \rightarrow MgCl2 + h_2$ **<u>Examiner's Comments</u>** Most candidates were able to write the correct balanced symbol equation for the reaction between hydrochloric acid and magnesium. 1 mark was given for the correct reactants and products and 1 mark for the correct balancing. The balancing mark was dependent on the correct formulae, but 1 mark was allowed for a balanced equation with minor errors in subscripts or formulae. For example, $2HCL + Mg \rightarrow MgCl2 + H_2$, would gain 1 mark. When candidates did not gain marks, it was often because they wrote the formula for magnesium chloride as $MgCl$.
			Total	**2**	

17		i	Idea that 2 electrons are lost to form a full outer shell ✓	1 (AO 2.1)	**ALLOW** idea that magnesium has (only) 2 outer shell electrons which are lost / idea that magnesium loses 2 electrons to become stable **IGNORE** just the idea that magnesium loses 2 electrons **Examiner's Comments** Many candidates did not give enough detail in their responses, for example stating that magnesium has 2 electrons on its outer shell but failing to explain that it loses them to become the 2+ion. Statements that magnesium loses two electrons were also seen, with no reference to the electrons being lost from the outer shell, or to allow the magnesium atom to become stable.
17		ii	$Mg^{2+} + 2OH^{-} \rightarrow Mg(OH)_2$ Correct formulae ✓ Balancing ✓	2 (2 × AO 2.1)	**ALLOW** any correct multiple, including fractions **ALLOW** = instead of → **DO NOT ALLOW** and / & instead of '+' **IGNORE** state symbols **DO NOT ALLOW** $Mg^{2+}(OH)^{-}_2$ **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g., Mg^{2+} + 2Oh⁻ → $Mg(OH)_2$ **Examiner's Comments** The formula for magnesium hydroxide was frequently incorrect despite many candidates correctly using Mg^{2+} and OH^- ions in the reactant side of their equations. Common errors were MgOH and $MgOH^2$. The GCSE Science Exam Hints for students highlighted that when writing the chemical formula of an ionic compound, candidates need to remember the charges have to balance in ionic formulas.
			Total	**3**	

18		i		2 (2 × AO 2.1)	All three correct = 2 marks Two correct = 1 mark **<u>Examiner's Comments</u>** Most candidates correctly matched the three isotopes to their descriptions.
		ii	**First check the answer on answer line** **If answer = 121.3 award 2 marks** 33 + (4 × 16) + 24.3 ✓ = 121.3 ✓	2 (2 × AO 2.2)	**<u>Examiner's Comments</u>** Most candidates correctly calculated the relative formula mass of magnesium sulfate. The most common incorrect response was 24.3 + 33 + 16 = 73.3.
		iii	Solvent / mobile phase ✓	1 (AO 3.3b)	**IGNORE** use a different liquid **IGNORE** change the concentration of the solvent **DO NOT ALLOW** (change) the stationary phase **<u>Examiner's Comments</u>** Many candidates correctly stated the need to change the solvent. The most common incorrect responses were: • use gas chromatography • melt the magnesium sulfate • increase the concentration of the solvent or use more solvent • change the stationary phase • add water.
	•	iv	Strong electrostatic attraction (between oppositely charged ions) / strong forces between oppositely charged ions / strong ionic bonds ✓ Lots of energy is required to overcome the forces / bonds ✓	2 (2 × AO 2.1)	**DO NOT ALLOW** references to intermolecular forces, covalent bonds or metallic bonds – scores 0 for question **<u>Examiner's Comments</u>** Successful responses to this question described the strong electrostatic

					attraction between oppositely charged ions, which needs lots of energy to overcome. Less successful responses referred to intermolecular forces, even after identifying the bonding in magnesium sulfate as ionic. **Assessment for learning** Candidates should be encouraged to use correct terminology. Many candidates attempted to explain the high melting point of magnesium sulfate in terms of covalent bonds or intermolecular forces. The term intermolecular forces appeared to be used by candidates without understanding of what they are or what type of structure possesses them.
			Total	**7**	
19		i	**First check the answer on answer line** **If answer = 7.2 (g) award 3 marks** Moles of oxygen = 0.45 ÷ 2 = 0.225 ✓ M_r of oxygen = 16 × 2 = 32 ✓ Mass of oxygen = 0.225 × 32 = 7.2 (g) ✓	3 (3 × AO 2.1)	**ALLOW ECF** from incorrect moles of oxygen and/or M_r of oxygen **<u>Examiner's Comments</u>** Many candidates correctly calculated the mass of oxygen as 7.2g. The most common incorrect response was 14.4g because while candidates had correctly calculated the formula mass of oxygen as 32, they hadn't used the mole ratio to determine that the number of moles would be 0.225. Some candidates calculated the M_r of O_2 as 64 because they multiplied 16 x 6.
		ii	**First check the answer on answer line** **If answer = 5.42 × 10^{23} award 3 marks**	3 (3 × AO 2.1)	

			Moles of NO_2 = 0.45 × 2 = 0.9 ✓ Molecules of NO_2 = 0.9 × (6.02 × 10^{23}) = 5.418 × 10^{23} ✓ **3 significant figures:** = 5.42 × 10^{23} ✓		**ALLOW ECF** from incorrect moles of NO_2 **ALLOW ECF** if significant figures correct from incorrect calculation of molecules of NO_2 **<u>Examiner's Comments</u>** The most common error was the incorrect calculation of moles of NO_2, but many candidates went on to multiply their value by Avogadro's number for error carried forward marks. Higher attaining candidates showed a good understanding of 3 significant figures. The most common incorrect answer was 2.71 x 10^{23} from multiplying the 2 numbers given in the question together. Some candidates incorrectly divided Avogadro's number by the number of moles of NO_2.
			Total	**6**	
20			$2Br^-$ - $\mathbf{2e^-}$ → $\mathbf{Br_2}$ Correct species ✓ Balancing ✓	2 (2 × AO 1.2)	Second MP is dependent on the first **<u>Examiner's Comments</u>** Most candidates correctly completed the half equation. The main error was not knowing that bromine is a diatomic molecule.
			Total	**2**	
21			C	1 (AO 2.2)	**<u>Examiner's Comments</u>** All possible incorrect responses were seen in this question.
			Total	**1**	
22			C	1 (AO 2.2)	
			Total	**1**	
23			D	1 (AO 2.1)	

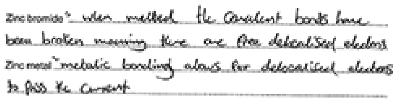
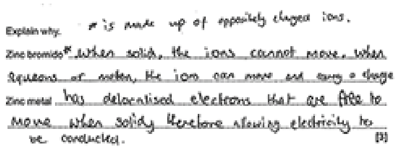
			Total	1	
24	a	i	(Catalyst) provides an alternative reaction pathway ✓ with a lower activation energy ✓	2(2 × 1.1)	**ALLOW** idea that reactants adsorb onto the surface of the catalyst to allow the molecules to react for 1 mark **ALLOW** idea that adsorption (onto catalyst surface) weakens bonds **IGNORE** references to larger surface area **Examiner's Comments** Many candidates gave a correct statement about what is meant by a catalyst in terms of a substance that speeds up a reaction (given in the stem of the question) but is not used up. The command word 'explain' required candidates to describe how catalysts speed up a reaction in terms of providing an alternative reaction pathway with a lower activation energy.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 102 (dm^3) award 4 marks** Moles of $CO_2 = \frac{187}{44.0}$ / 4.25 ✓ Moles of CO = moles of CO_2 / 4.25 ✓ Volume of CO = moles × 24 / 4.25 × 24 ✓ = 102 dm^3 ✓ **OR** 187g of CO2 produced from $187 \times \frac{28}{44} = 119$g CO ✓ 119g CO = $\frac{119}{28}$ = 4.25 moles CO ✓ Volume of 4.25 mol CO = 4.25 × 24 dm^3 ✓ = 102 dm^3 ✓	4(1 × 1.2)(3 ×2.2)	**ALLOW** ECF from incorrect moles of CO2 **ALLOW** ECF from incorrect moles of CO **ALLOW** ECF from incorrect mass of CO **ALLOW** ECF from incorrect moles of CO **Examiner's Comments** This question proved to be a real discriminator, as did all the calculations on this paper. Only the highest attaining candidates worked this through to the correct answer. If candidates did not obtain an answer of 102 dm^3 examiners looked to award marks for working out and/or error carried forward. It is worth centres stressing to candidates that this is only possible when working for the answer is clearly set out.

					Misconception Common errors / misconceptions in this calculation included • calculating the moles of CO_2 using the Mr as 88 rather than 44, giving the number of moles as 2.125 • not making the link that moles of CO_2 = moles of CO, so losing the opportunity to pick up an error carried forward mark • not recalling the formula 'vol = mol × 24', with many candidates multiplying 4.25 (or 2.125) mol of CO by 28 (or 56) to give a mass of CO, rather than the required volume of CO.
•	b		$C_2H_4 + 2O_2 \rightarrow 2CO + 2H_2O$ OR $C_2H_4 + O_2 \rightarrow 2C + 2H_2O$ OR $2C_2H_4 + 3O_2 \rightarrow 2C + 2CO + 4H_2O$ Formulae ✓ Balancing ✓	2(2 × 2.1)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g. C_2H_4 + 2O2 → 2Co + $2h_2O$ **ALLOW** any (balanced) equation that includes H_2O as the only hydrogen containing product and C and/or CO among the carbon containing products. Equation may also produce CO_2 in addition to C and/or CO. **IGNORE** state symbols **<u>Examiner's Comments</u>** Less successful candidates wrote an equation for complete, rather than incomplete, combustion. Hydrogen

					and methane were also often seen as incorrect products.
			Total	**8**	
25			B ✓	1 (AO1.1)	
			Total	**1**	
26		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 248 (g) award 2 marks** *M*r of P_4 = 4 × 31.0 = 124.0 ✓ Mass of P_4 = 124.0 × 2 = 248 (g) ✓	2(2 ×AO2.2)	**ALLOW** ECF from incorrect M_r (but not from A_r of 31.0, i.e. 2 × 31.0) **<u>Examiner's Comments</u>** Many candidates correctly calculated the relative formula mass of P_4 and then multiplied by 2.0 to calculate the mass of phosphorus. 62 was the most common incorrect answer (from 2 x 31.0).
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1100 (g) award 3 marks** Mole ratio P_4 : PCl_3 is 1 : 4 OR 2 moles of P_4 makes 8 moles of PCl_3 ✓ M_r PCl_3 = 31 + (35.5 × 3) = 137.5 ✓ Mass of PCl_3 = 137.5 × 8 = 1100 (g) ✓	3(3 ×AO2.2)	**ALLOW** ECF from incorrect mole ratio and/or M_r **<u>Examiner's Comments</u>** Most candidates recognised that they needed to calculate the relative formula mass of PCl_3 so gained at least 1 mark. Fewer candidates looked to state or apply the mole ratio from the equation to gain the remaining 2 marks.
		iii	Limiting reagent – phosphorus / P_4 ✓ Moles of Cl_2 = (866.2 ÷ 71.0 =) 12.2 ✓ Mole ratio of P_4 : Cl_2 is 1 : 6 or 2 : 12 ✓ There are 2 mol of P_4 to 12.2 mol of Cl_2 / stoichiometry of 1:6.1 / Idea that the ratio is higher than the stoichiometry of the equation / higher than 1:6 or 2:12 ✓	4 (1 ×AO2.2) (1 ×AO1.2) (2 ×AO2.2)	**ALLOW** idea that the mass of chlorine needed is 852g and there is 866.2g **ALLOW** 12.2 moles of Cl_2 means that Cl_2 is in excess **IGNORE** simply there is less phosphorus than chlorine **<u>Examiner's Comments</u>** Most candidates identified phosphorus as the limiting reactant. Many candidates calculated the moles of chlorine correctly as 12.2 and were able to state it in a ratio with 2 moles of phosphorus. Fewer compared this to the actual ratio of 1:6 (or 2:12), which was the mark most commonly

					not gained by candidates who gained 3 marks. Less successful candidates stated that phosphorus was the limiting reactant as it has the lower mass, without any attempt at a calculation.
			Total	**8**	
27	a		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.09 × 10^{-22} (g) award 3 marks** Moles of zinc = 1 ÷ 6.02 × 10^{23} = 1.66113 × 10^{-24} ✓ Mass of one atom = 65.4 × (1.66113 × 10^{-24}) = 1.086379 × 10^{-22} ✓ = 1.09 × 10^{-22} (g) (3 sig figures) ✓ IF CANDIDATE USES AVOGADRO CONSTANT AS 6.02 × 10^{-23} **FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.09 × 10^{24} (g) award 3 marks** Moles of zinc = 1 ÷ 6.02 × 10^{-23} = 1.6611296 × 10^{22} ✓ Mass of one atom = 65.4 × (1.66113 × 10^{22}) = 1.0863787 × 10^{24} ✓ = 1.09 × 10^{24} (g) (3 sig figures) ✓	3(3 ×AO2.1)	**ALLOW** ECF from incorrect moles of zinc **ALLOW** ECF if significant figures correct from incorrect calculation of mass of one atom **ALLOW** ECF from incorrect moles of zinc **ALLOW** ECF if significant figures correct from incorrect calculation of mass of one atom **<u>Examiner's Comments</u>** Avogadro's constant was incorrectly quoted. Our examiners reviewed the impact and found this did not seem to affect the candidates' approach to this question. However, to ensure no candidate was disadvantaged, full marks were given for answers using either 6.02 × 10^{23} or 6.02 × 10^{-23}.
	b	i	$Zn^{2+} + 2Br^{-} \rightarrow ZnBr_2$ Formulae ✓ Balancing ✓	2(2 ×AO2.1)	**ALLOW** any correct multiple, including fractions **ALLOW** = instead of → **DO NOT ALLOW** and / & instead of '+' **IGNORE** state symbols

					balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g. Zn^{2+} + 2BR $^{-}$ → ZnBr2 **<u>Examiner's Comments</u>** Higher achieving candidates were able to construct the correct balanced ionic equation for the formation of zinc bromide. One mark was given for the correct reactants and products and 1 mark for the correct balancing. The balancing mark was dependent on the correct formulae, but 1 mark was allowed for a balanced equation with a minor error in subscripts or formulae. The most common error was writing the formula of zinc bromide as ZnBr. **OCR support** Teachers might find the <u>Chemical reactions Delivery Guide</u> a useful resource for identifying common misconceptions and approaches to overcome them. In addition our <u>GCSE (9-1) Science Exam hints for candidates</u> is a useful resource to provide candidates with when revising to help them avoid this common issue. They can also be downloaded as an <u>A3 version</u> to display in classrooms.
		ii	**Zinc bromide** Idea that zinc bromide has ions that are free to move when zinc bromide is aqueous or molten / Idea that zinc bromide has ions that cannot move when zinc bromide is solid ✓ **Zinc metal** Has electrons ✓ (Electrons) can move / electrons can	3(3 ×AO1.1)	**IGNORE** just charged particles throughout the question **DO NOT ALLOW** electrons can move **IGNORE** bromine ions **DO NOT ALLOW** free ions **IGNORE** free (electrons) for idea of movement **IGNORE** electrons can carry the

			carry the charge ✓ **BUT** Delocalised electrons scores 2 marks		electricity **<u>Examiner's Comments</u>** Good responses to this question described that zinc metal contain delocalised electrons and that zinc bromide contains ions that can only move when the compound is dissolved in water or molten **Assessment for learning** Candidates should be encouraged to use correct terminology. Many candidates attempted to explain the electrical conductivity of zinc bromide in terms of electrons, while others described molten zinc bromide as containing free electrons or ions, a contradiction which did not gain a mark. Exemplar 3  Zinc bromide: when melted the covalent bonds have been broken meaning there are free delocalised electrons Zinc metal: metalic bonding alows for delocalised electrons to pass the current This response shows the answer, given 2 marks, which examiners saw most often. Exemplar 4  Explain why. is made up of oppositely charged ions. Zinc bromide: when solid, the ions cannot move. when aqueous or molten, the ions can move and carry a charge Zinc metal: has delocalised electrons that are free to move when solid, therefore allowing electricity to be conducted. [3] This response, however, illustrates correct use of key terminology and was given 3 marks.
			Total	**8**	
28			$H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$ Correct formulae ✓ Correct state symbols ✓	2(2 ×AO1.1)	**ALLOW** any correct multiple, including fractions **ALLOW** = instead of → **DO NOT ALLOW** and / & instead of

					‘+’ Second MP is dependent on the first **Examiner’s Comments** Many candidates were able to write the correct ionic symbol equation, but often did not gain the mark for the correct state symbols. The most common errors were $H^+(g)$ and/or $OH^-(g)$.
			Total	**2**	
29			B ✓	1(AO2.1)	**Examiner’s Comments** Many candidates incorrectly answered D as they did not make the link between 2g hydrogen and the number of moles, instead just multiplying 2g by $24dm^3$.
			Total	**1**	