

1.1	copper, zinc, sodium chloride solution		1	AO2 4.5.2.1
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1.2	a reactant is used up	allow the reaction stops allow electrolyte / electrode / ions / metal / metal hydroxide / alkali for reactant	1	AO1 4.5.2.1
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1.3	the reaction is not reversible		1	AO1 4.5.2.1
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1.4	$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$	allow fractions / multiples allow 1 mark for O_2	2	AO1 AO2 4.1.1.1 4.5.2.2
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1.5	Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	5–6	AO3								
	Level 2: Some logically linked reasons are given. There may also be a simple judgement.	3–4	AO3								
	Level 1: Relevant points are made. This is not logically linked.	1–2	AO2								
	No relevant content	0									
	Indicative content reasons why fuel cells could be judged as better <table><tr><td>from the table</td><td>from other knowledge</td></tr><tr><td> - time for refuelling a fuel cell is faster than recharging or - a fuel cell does not need to be recharged - a fuel cell has a greater range </td><td> - hydrogen can be renewable if made by electrolysis using renewable energy - lithium-ion batteries can catch fire - produces only water or - no pollutants produced - lithium-ion batteries may release toxic chemicals on disposal - lithium-ion batteries (eventually cannot be recharged so) have a finite life </td></tr></table> reasons why the lithium-ion battery could be judged as better <table><tr><td>from the table</td><td>from other knowledge</td></tr><tr><td> - lithium-ion uses energy more efficiently - cost of lithium-ion car much less - cost of recharging much less than refuelling with hydrogen </td><td> - hydrogen is often made from fossil fuels so is not renewable - charging points are more widely available than hydrogen filling stations - hydrogen takes up a lot of space or - is difficult to store - hydrogen can be highly flammable / explosive - no emissions produced (catalyst in the hydrogen fuel-cell eventually becomes poisoned so) have a finite life </td></tr></table>			from the table	from other knowledge	- time for refuelling a fuel cell is faster than recharging or - a fuel cell does not need to be recharged - a fuel cell has a greater range	- hydrogen can be renewable if made by electrolysis using renewable energy - lithium-ion batteries can catch fire - produces only water or - no pollutants produced - lithium-ion batteries may release toxic chemicals on disposal - lithium-ion batteries (eventually cannot be recharged so) have a finite life	from the table	from other knowledge	- lithium-ion uses energy more efficiently - cost of lithium-ion car much less - cost of recharging much less than refuelling with hydrogen	- hydrogen is often made from fossil fuels so is not renewable - charging points are more widely available than hydrogen filling stations - hydrogen takes up a lot of space or - is difficult to store - hydrogen can be highly flammable / explosive - no emissions produced (catalyst in the hydrogen fuel-cell eventually becomes poisoned so) have a finite life
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2.1	450 °C	allow values in the range 400– 500 °C	1	AO1 4.10.4.1
	200 atm / atmospheres	allow values in the range 150– 250 atm / atmospheres allow 1 mark if both values within range but no units given	1	

3.1	(melamine is a) thermosetting (polymer)		1	AO3 4.10.3.3
	(which) contains crosslinks / bonds (between polymer chains)	do not accept reference to intermolecular forces allow (so) it decomposes	1	AO2 4.10.3.3

4.1	order: (most reactive) magnesium cobalt nickel tin copper (least reactive) silver	allow 1 mark for magnesium, cobalt, nickel, tin in order at top allow 1 mark for copper and silver in order at the bottom	2	AO3 4.4.1.2 4.5.2.1
	justification: the higher the (positive) voltage, the more reactive (the metal)	allow the most reactive (metal) has the highest voltage	1	
	silver has a negative voltage because silver is less reactive than copper		1	

4.2	magnesium and tin		1	AO3 4.5.2.1
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4.3	(in a fuel cell) hydrogen is oxidised (to produce water)	allow (in a fuel cell) hydrogen reacts with oxygen (to produce water)	1	AO3 4.5.2.2
	water is produced / released as gas / vapour / steam	if no other mark awarded, allow 1 mark for fuel cells produce water	1	

5.1	Tube 1: (nail) rusts because air / oxygen and water present		1	AO1
	Tube 2: (nail) does not rust because no water	allow Tube 2: (nail) does not rust because only air / oxygen	1	AO1
	Tube 3: (nail) does not rust because no air / oxygen	allow Tube 3: (nail) does not rust because only water	1	AO1
	Tube 4: (nail) does not rust because paint is a barrier (to water / air / oxygen)	allow Tube 4: (nail) does not rust because paint is a protective layer / coating (against water / air / oxygen)	1	AO1
	Tube 5: (nail) does not rust because stainless steel resistant to corrosion	or allow Tube 4: (nail) does not rust because paint protects it from water / air / oxygen allow Tube 5: (nail) does not rust because stainless steel does not corrode allow Tube 5: (nail) does not rust because stainless steel contains nickel / chromium If no other mark awarded allow 1 mark for correct rusting pattern in all 5 tubes	1	AO2 4.10.3.1 4.10.3.2

5.2	magnesium is more reactive (than iron) (so magnesium) provides sacrificial protection	allow converse	1	AO2 4.10.3.1
		allow magnesium is more reactive (than steel) allow (so magnesium) corrodes / reacts instead of iron / steel allow (so magnesium) corrodes / reacts before iron / steel ignore references to protective layers ignore references to magnesium rusting		

5.3	(aluminium has a coating of) aluminium oxide	allow (so aluminium oxide) prevents water / air / oxygen from reaching the metal	1	AO1 4.10.3.1
	(so the aluminium oxide) protects the metal (from further corrosion)		1	

6.1	(polyester is) thermosoftening	allow (polyester is) thermoplastic ignore thermoforming	1	AO1
	(polyester has) no cross-links	allow intermolecular forces are weak do not accept references to breaking covalent bonds or breaking chains	1	AO3 4.10.3.3

6.2		allow for 1 mark:	1 1	AO3 4.10.3.3
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6.3	any two from: (to make the board) • harder • stronger • tougher • more rigid } • waterproof	must be implied comparative statements	2	AO3 4.10.3.3
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7.1	any one from: • the energy costs would be high(er) • the equipment would need to be strong(er) • high(er) pressures are (more) dangerous	allow converse arguments in terms of low(er) pressure ignore energy / cost unqualified allow the equipment would be (more) expensive (to build / maintain) allow (more) dangerous because (greater) risk of explosion	1	AO1 4.10.4.1
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8.1	any two from: (hydrogen fuel cells) • no toxic chemicals to dispose of at the end of the cell's life • take less time to refuel (than to recharge rechargeable cells) • travel further before refuelling (than before recharging rechargeable cells) • no loss of efficiency (over time)	allow converse arguments for a rechargeable cell allow has a greater range allow does not lose capacity / range in cold weather	2	AO1 4.5.2.2
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8.2	any one from: • $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ • $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$ • $\text{H}_2 + 2\text{OH}^- \rightarrow 2\text{H}_2\text{O} + 2\text{e}^-$ • $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$	allow multiples allow $\text{H}_2 - 2\text{e}^- \rightarrow 2\text{H}^+$ allow $\text{H}_2 + 2\text{OH}^- - 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$	1	AO1 4.5.2.2
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9.1	electrolysis uses electricity to produce a chemical reaction	allow voltage for electricity allow potential difference for electricity allow (electrical) current for electricity allow electrolysis uses electricity to decompose a compound / electrolyte	1	AO1 4.4.3.1 4.5.2.1
	(but) cells use a chemical reaction to produce electricity		1	

10.1	(poly(ethene)) melts	allow converse statements about thermosetting polymers	1	AO1
	(so) can be reshaped (into new products)	allow thermosoftening polymers melt	1	AO3 4.10.3.3

10.2		allow converse statements about LDPE		AO3 4.10.3.3
	(in HDPE) polymer chains / molecules are closer together	allow (HDPE has) unbranched polymer chains / molecules	1	
	(so) more atoms per unit volume	allow (so) more molecules per unit volume	1	

11.1	ammonium phosphate		1	AO2 4.10.4.2
	potassium nitrate		1	

11.2	(nitric acid) calcium nitrate		1	AO1 4.10.4.2
	(phosphoric acid) (calcium) triple superphosphate or calcium dihydrogenphosphate		1	

12.1	Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.6.1.3 4.6.1.4 4.6.2.6 4.6.2.7 4.10.4.1
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content rate • higher temperature gives higher rate because of more frequent collisions • higher temperature gives higher rate because more particles have the activation energy • higher pressure gives higher rate because of more frequent collisions • use of catalyst gives higher rate because the activation energy is lowered equilibrium • higher temperature shifts the position of equilibrium to the left because reaction is exothermic • higher pressure shifts the position of equilibrium to the right because more molecules on left-hand side • use of catalyst has no effect on the position of equilibrium other factors • higher temperature (than 450°C) uses more energy so increases costs • higher pressure (than 200 atmospheres) uses more energy so increases costs • higher pressure (than 200 atmospheres) requires stronger reaction vessels so increases costs • use of a catalyst reduces energy costs compromise • the temperature chosen is a compromise between rate of reaction and position of equilibrium • the temperature chosen is a compromise between rate and cost • the pressure chosen is a compromise between yield / rate and cost		

13.1	composites		1	AO1 4.10.3.3
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14.1	Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	3–4	AO3 4.10.1.1 4.10.2.2 4.10.4.2
	Level 2: Some logically linked reasons are given. There may also be a simple judgement.	1–2	
	No relevant content	0	
	Indicative content reasons - compound A (potassium chloride) only contains potassium - compound A (potassium chloride) is the only source of potassium so is needed. - compound B (ammonium nitrate) only contains nitrogen - compound B (ammonium nitrate) contains more nitrogen than compound C (diammonium hydrogen phosphate) so is preferable - compound B (ammonium nitrate) contains more nitrogen and is cheaper than compound C (diammonium hydrogen phosphate) and so is more cost effective - compound C (diammonium hydrogen phosphate) contains phosphorus which is not needed judgement - none of the compounds contain both nitrogen and potassium so a mixture is needed (both) compound A (potassium chloride) and B (ammonium nitrate) should be used (both) compound A (potassium chloride) and C (diammonium phosphate) could be used		

14.2	mining	allow quarrying	1	AO1 4.10.4.2
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14.3	potassium sulfate	ignore potassium chloride allow potassium nitrate allow any other named potassium salt	1	AO1 4.10.4.2
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14.4	ammonia	allow water	1	AO1 4.10.4.2
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14.5	(phosphate rock is) insoluble (in water)	allow (phosphate rock) cannot be absorbed as a solid	1	AO3 4.10.4.2
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14.6	(sulfuric acid) calcium sulfate	allow single superphosphate allow calcium phosphate	1	AO1 4.10.4.2
	(phosphoric acid) calcium phosphate	allow triple superphosphate	1	