

1.1	hydrogen or H ₂	allow hydrogen gas ignore H without the 2 subscript	1	AO1 5.4.2.1
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Metals - AQA past paper mark scheme

1.2	filtration / filter	allow magnet or decant ignore heating	1	AO1 5.1.1.2
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2.1	FeS ₂	do not accept equations	1	AO2 4.2.1.3
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2.2	26 30 26	must be this order	1 1 1	AO2 4.1.1.4 4.1.1.5
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2.3	carbon is more reactive (than nickel)	allow converse	1	AO1 4.4.1.2 4.4.1.3
	(so) carbon will displace / replace nickel (from nickel oxide)	allow (so) nickel ions gain electrons	1	
	or (so) carbon will remove oxygen (from nickel oxide)	allow (so) carbon transfers electrons to nickel (ions)		

3.1	all 4 metals labelled and suitable scale on y-axis	magnesium value must be at least half the height of the grid	1	AO2 4.4.1.2 4.5.1.1
	all bars correctly plotted	allow a tolerance of $\pm \frac{1}{2}$ a small square ignore width and spacing of bars allow 1 mark if copper not included and other 3 bars plotted correctly	1	

3.2	suitable method described		1	AO3
	the observations / measurements required to place in order	dependent on a suitable method	1	4.4.1.2 4.5.1.1
	an indication of how results would be used to place the unknown metal in the reactivity series		1	
	a control variable to give a valid result		1	
approaches that could be used				
approach 1:				
add the unknown metal to copper sulfate solution (1)				
measure temperature change (1)				
place the metals in order of temperature change (1)				
any one from (1):				
• same volume of solution • same concentration of solution • same mass / moles of metal • same state of division of metal				
approach 2:				
add the metal to salt solutions of the other metals				
or				
heat the metal with oxides of the other metals (1)				
measure temperature change (only if salt solutions used)				
or				
observe whether a chemical change occurs (1)				
place the metals in order of temperature change or				
compare whether there is a reaction to place in correct order (1)				
any one from (1):				
• same volume of salt solutions • same concentration of salt solutions • same (initial) temperature of salt solutions • same mass / moles of metal or metal oxide • same state of division of metal or metal oxide				

3.2 cont. cont.	approach 3: add all of the metals to an acid (1) measure temperature change or means of comparing rate of reaction (1) place the metals in order of temperature change or rate of reaction (1) any one from (1): • same volume of acid • same concentration of acid • same (initial) temperature of acid • same mass / moles of metal • same state of division of metal approach 4: set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1) measure the voltage of the cell (1) place the metals in order of voltage (1) any one from (1): • same electrolyte • same concentration of electrolyte • same temperature of electrolyte		
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4.1	any one from: • very exothermic reaction • produces a corrosive solution • produces hydrogen, which is explosive / flammable	allow explosive allow violent reaction ignore vigorous reaction ignore sodium is very reactive allow caustic for corrosive ignore alkaline allow flames produced ignore sodium burns	1	AO3 4.1.2.5 4.4.1.3
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4.2	sodium (atoms) lose electrons	do not accept references to oxygen	1	AO1 4.4.1.4
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0 5.1	a Mg Zn Cu		1	AO3 5.4.1.2

0 5.2	by two from: • mass (of metal / element) • surface area (of metal / element) • concentration (of acid) • volume (of acid) • temperature (of acid)	allow weight ignore size ignore length ignore pH ignore strength ignore room temperature	2	AO3 5.4.1.2

0 5.3	Type of metal / element		1	AO2 5.4.1.2
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0 6.1	metal is too reactive to be extracted using carbon or metal reacts with carbon	allow metal is more reactive than carbon	1	AO1 5.4.3.3

0!	7.1	electron transfer		1	AO2 5.11
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8.1	13	this order only	1	AO2 5.1.1.4 5.1.1.5
	14		1	

8.2	loss of oxygen	allow (Al^{3+}) gain of electrons allow aluminium oxide loses oxygen	1	AO1 5.4.1.1 5.4.1.3
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9.1	temperature (change)		1	AO2 5.4.1.2 5.5.1.1 RPA 10
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9.2	to reach a constant temperature	allow to reach room temperature	1	AO3 5.4.1.2 5.5.1.1 RPA 10
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9.3

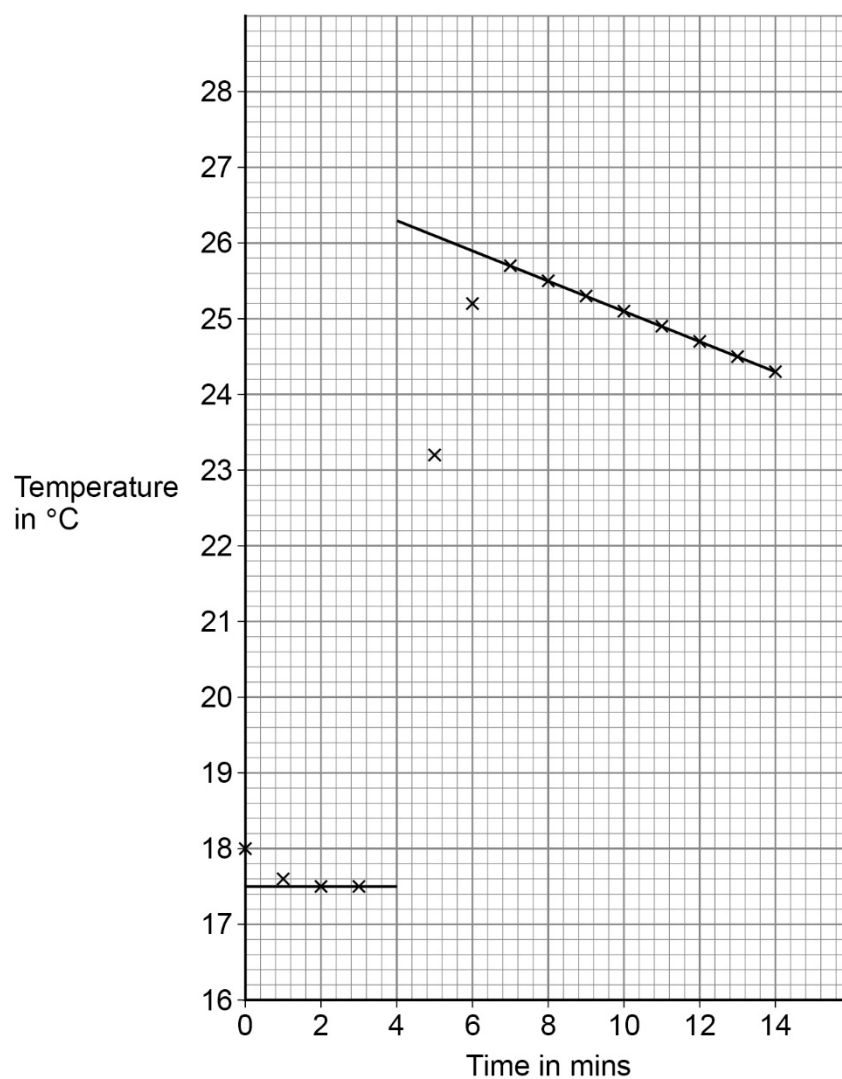
line of best fit after 7 minutes

extends line back to 4 minutes

ignore extension of line beyond
4 minutes

1

1

AO2
5.4.1.2
5.5.1.1
RPA 10the diagram below scores **2** marks

9.4	(maximum and minimum values at 4 minutes) 26.3 (°C) and 17.5 (°C)	allow ecf from 05.3	1	AO3 5.4.1.2 5.5.1.1 RPA 10
	(temperature change at 4 minutes) = 8.8 (°C)		1	

9.5	aluminium / zinc / iron / beryllium	allow Al / Zn / Fe / Be do not accept copper, silver MP2 dependent on a correct answer to MP1	1	AO3
	metal Q is less reactive (than magnesium) or metal Q is lower in reactivity series	allow converse	1	AO2 5.4.1.2 5.5.1.1 RPA 10

10.1		max 3 marks if reference to incorrect particles / bonding / structure		
	caesium atom loses one electron		1	AO1 5.1.2.5 5.2.1.2
	(and) oxygen atom gains two electrons		1	
	(so) two caesium atoms react with one oxygen atom	allow (to produce) Cs_2O	1	
	any one from: • (to form) Cs^+ and O^{2-} • (to form) caesium ion(s) and oxide ion(s) • (to form) ions with full outer shells / levels		1	

11.1	the (grey) crystals are silver		1	AO3 4.4.1.2
	the copper ions (produced) are blue	allow the copper nitrate / compound (produced) is blue	1	
	(because) copper displaces silver		1	

11.2	Level 2: The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	3–4	AO1 AO3 4.4.1.2 4.5.1.1 RPA 4
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content Key steps • add the metals to (dilute) hydrochloric acid • measure temperature change or compare rate of bubbling or compare colour of resulting solution for copper: • no reaction • shown by no temperature change or shown by no bubbles for magnesium and iron: • magnesium increases in temperature more than iron or magnesium bubbles faster than iron or magnesium forms a colourless solution and iron forms a coloured solution Control variables • same concentration / volume of hydrochloric acid • same mass / moles of metal • same particle size of metal • same temperature (of acid if comparing rate of bubbling)		

12.1	magnesium (atoms) are oxidised because they lose electrons		1	AO2 4.4.1.4
	(and) zinc (ions) are reduced because they gain electrons	if no other marks awarded allow 1 mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons	1	

Total			9
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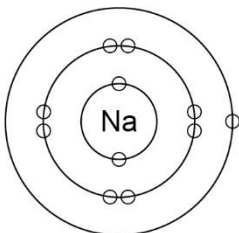
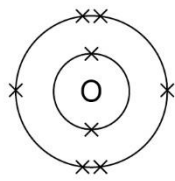
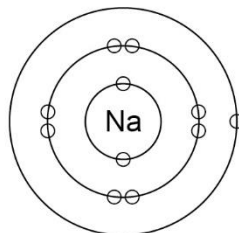
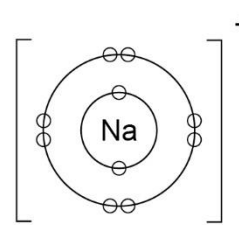
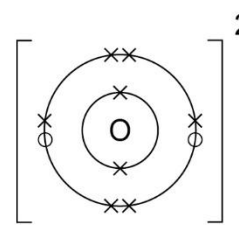
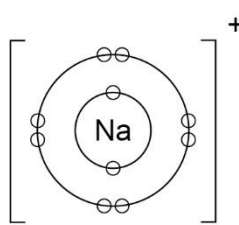
13.1	(without a lid the) mass of magnesium oxide was less		1	AO3 5.4.1.1
	(because) products escaped	allow magnesium oxide escaped	1	

13.2	(mass of copper oxide =) $\frac{79.5}{63.5} \times 0.5$ = 0.62598 (g) = 0.626 (g)		1 1 1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.3.2.2 5.3.2.3 5.4.1.1
		allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question		

14.1	Level 2: Some logically linked reasons are given. There may also be a simple judgement.	3-4	AO3 4.4.1.3
	Level 1: Relevant points are made. They are not logically linked.	1-2	
	No relevant content	0	
	Indicative content • carbon and iron are the cheapest reactants • hydrogen is the most expensive reactant • separating solid products is expensive • separating solid products is time consuming • in method 1, tungsten needs to be separated from tungsten carbide • in method 1, some tungsten is lost as tungsten carbide • in method 1, the carbon dioxide produced will escape • in method 2, the water vapour produced will escape • in method 2, no separation of solids is needed • in method 3, tungsten needs to be separated from iron oxide		
Total			10

15.1	any two from: • (potassium) floats • (potassium) melts • (potassium) moves around • potassium becomes smaller • (lilac) flame • effervescence	allow potassium disappears allow fizzing	2	AO1 4.1.2.5 4.4.1.2
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15.2	$2\text{K} + 2\text{H}_2\text{O} \rightarrow 2\text{KOH} + \text{H}_2$	allow multiples allow 1 mark for KOH and H ₂	2	AO1 AO2 4.1.1.1 4.1.2.5

15.3	(dot and cross diagram to show) sodium atom and oxygen atom two sodium atoms to one oxygen atom (to produce) sodium ion with a + charge (to produce) oxide ion with a 2- charge	allow use of outer shells only allow two sodium ions to one oxide ion	1 1 1 1	AO2 4.2.1.1 4.2.1.2
  				
  				
scores 4 marks				

Metals - AQA past paper mark scheme

15.4	(oxygen) gains electrons		1	AO1 4.4.1.4
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16.1	C		1	AO3 4.2.2.7 4.2.2.8
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16.2	measure temperature change	allow measure the temperature before and after the reaction	1	AO1
	when each metal is added to silver nitrate solution		1	AO1
	same concentration / volume of solution or same mass / moles of metal	allow same initial temperature (of silver nitrate solution)	1	AO2
	the greater the temperature change the more reactive		1	AO3
				4.4.1.2 4.5.1.1 RPA4
Total			8	

17.1	Level 3: The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO3
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	AO3
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	AO1
	No relevant content.	0	
	Indicative Content • measure volume of (hydrochloric) acid • into a suitable container eg polystyrene cup • measure the initial temperature (of hydrochloric acid) • with a thermometer • add stated mass of one metal • stir • measure the highest temperature reached of the solution or measure temperature reached after a set time period • determine the temperature difference • repeat • repeat for each metal • with same mass • in same physical state (powder, lump, etc) • with the same volume and / or concentration of (hydrochloric) acid • use results to arrange metals in order of reactivity • most reactive metal has the largest temperature change to access level 3 there must be an indication of how the temperature change is determined with the same mass of the 3 different metals reacted with the same volume of (hydrochloric) acid		5.1.4.2 RPA2
Total Question 3		6	

18.1	electrolysis of molten compound (of metal Y) OR displacement (1) by heating with a more reactive metal or by heating with potassium / magnesium (1)	allow liquid for molten	1 1	AO3 5.4.1.3 5.4.3.2 5.4.3.3

18.2	$4 \text{ Na} + \text{TiCl}_4 \rightarrow 4 \text{ NaCl} + \text{Ti}$	allow multiples allow 1 mark for NaCl and Ti with incorrect / no balancing	2	AO2 5.1.1.1 5.3.1.1

19.1	ionic		1	AO1 4.2.1.1
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19.2	magnesium (atom) loses electrons		1	AO2 4.2.1.1 4.2.1.2
	oxygen (atom) gains electrons		1	
	two electrons (are transferred)		1	
	magnesium ions and oxide ions are formed	allow Mg^{2+} (ions) and O^{2-} (ions) are formed allow magnesium forms positive ions and oxygen forms negative ions allow (both) form a complete outer shell	1	

Total Question 1		13
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20.1	zinc (atoms) lose (2) electrons	do not accept references to oxygen	1	AO2 4.4.1.2 4.4.1.4
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21.1	any one from: • more vigorous bubbling (for rubidium) • bigger / brighter flame (for rubidium)	allow converse statements for potassium allow (rubidium) catches fire more quickly allow (rubidium) moves around more quickly allow (rubidium) explodes allow (rubidium) disappears more quickly allow (rubidium) melts more quickly	1	AO3 4.1.2.5
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21.2	$2 \text{ Rb} + 2 \text{ H}_2\text{O} \rightarrow 2 \text{ RbOH} + \text{H}_2$	ignore state symbols allow multiples allow 1 mark for H_2 allow 1 mark for RbOH	3	AO2 4.1.1.1 4.1.2.5 4.3.1.1
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22.1	silicon is less reactive than carbon	ignore references to hydrogen allow converse allow silicon is below carbon (in the reactivity series)	1	AO3 4.4.1.3
	(because) carbon displaces silicon (from silicon dioxide)	ignore (because) carbon reduces silicon dioxide	1	

22.2	more energy is needed (to obtain aluminium)	ignore references to electricity	1	AO3 4.4.1.3 4.4.3.3
	(because) aluminium is obtained (from aluminium oxide) by electrolysis		1	

22.3	both products are solid		1	AO3 4.4.1.3
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23.1	$4 \text{ Na} + \text{O}_2 \rightarrow 2 \text{ Na}_2\text{O}$	allow multiples	1	AO2 5.1.1.1 5.1.2.5 5.3.1.1 5.4.1.1
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23.2	sodium atom loses one electron		1	AO1
	(and) oxygen atom gains two electrons		1	5.1.1.7 5.1.2.3 5.1.2.5 5.2.1.2
	(so) two sodium atoms to one oxygen atom		1	
	any one from: • (to form) Na^+ and O^{2-} • (to form) sodium ion(s) and oxide ion(s) • (to form) ions with full outer shells / levels.		1	

23.3	yellow flame	allow orange flame	1	AO1 5.1.2.5
	any one from: • sodium melts • white smoke / solid / powder		1	

24.1	filter (to remove excess magnesium)		1	AO1
	(then) crystallisation (of magnesium chloride solution)	allow (then) evaporation (of water from magnesium chloride solution)	1	5.1.1.2 5.4.2.1 5.4.2.3 RPA8

24.2	(magnesium atoms are) oxidised		1	AO2
	(because the atoms) lose (two) electrons		1	5.4.1.4 5.4.2.1 5.4.2.3 RPA8

25.1	Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	3–4	AO3 4.2.2.7 4.2.2.8 4.4.1.2
	Level 1: Relevant points are made. They are not logically linked.	1–2	
	No relevant content	0	
	Indicative content relevant points • silver is the best electrical conductor • aluminium is the least dense • aluminium is the least expensive • copper is a better conductor than aluminium or copper is almost as good a conductor as silver • copper is much less expensive than silver • overhead power cables need a low density metal • wiring in homes needs to be affordable • printed circuit boards only require small amounts of material judgements • use aluminium for overhead wires because of aluminium's low density and/or lower cost • use copper for domestic wiring because copper is a very good conductor and not too expensive • use silver only for small uses such as circuit boards due to high cost • copper is a good compromise between electrical conductivity and cost		

26.1	any two from: • effervescence / fizzing / bubbles • barium disappears • forms a colourless solution • temperature increases	ignore references to floating / flames ignore produces a gas allow barium gets smaller allow barium moves around	2	AO3 4.1.2.1 4.4.1.2 4.4.2.1
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26.2	$\text{Ba} + 2 \text{HCl} \rightarrow \text{BaCl}_2 + \text{H}_2$	allow multiples allow 1 mark for BaCl_2 allow 1 mark for H_2 ignore state symbols	3	AO2 4.1.1.1 4.4.1.2 4.4.2.1
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Total Question 8	10
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27.1	(substance reduced) Fe_2O_3	allow iron oxide	1	AO2 4.4.1.1
	(reason) (Fe_2O_3) loses oxygen	MP2 is dependent upon MP1 being awarded	1	
		ignore Fe^{3+} gains electrons		

27.2	A loses electrons and B ⁺ gains electrons		1	AO2 4.4.1.4

27.3	D		1	AO3 4.4.1.2