1(a). This question is about making copper.

Copper is made using a displacement reaction.

Magnesium is added to copper sulfate solution, $CuSO_4$.

Copper and magnesium sulfate solution, $MgSO_4$, are made.

Write a balanced symbol equation for this reaction.

---

[1]

(b).

(i) In the reaction magnesium atoms become magnesium ions, Mg^{2+}, and copper ions, Cu^{2+}, become copper atoms.

Write **a balanced ionic equation** for this reaction.

---

[2]

(ii) Write a **balanced half equation** to show what happens to magnesium in this reaction.

Use e^- to represent an electron.

---

[2]

2. Magnesium chloride, $MgCl_2$, can be made by reacting hydrochloric acid, HCl, with magnesium carbonate, $MgCO_3$.

Look at the equation for the reaction.

$$2HCl + MgCO_3 \rightarrow MgCl_2 + H_2O + CO_2$$

Helen uses 2.8g of magnesium carbonate.

Calculate how much magnesium chloride she should make.

Give your answer to **two significant figures**.

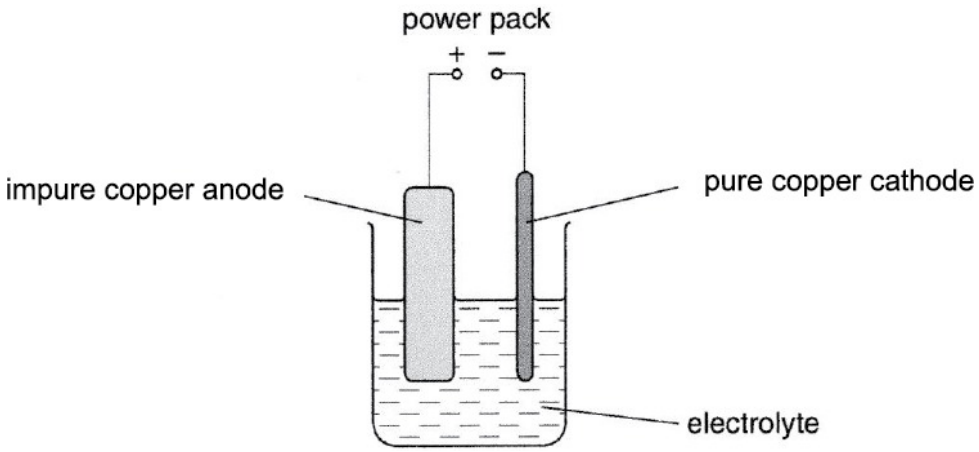
Relative formula mass of magnesium carbonate = 84.3

Relative formula mass of magnesium chloride = 95.3

answer _____ g

[2]

3. Copper obtained from copper oxide is purified by **electrolysis**.



At the cathode, copper ions, Cu^{2+}, gain electrons.

Copper atoms are formed.

Write a **balanced half equation** for the reaction.

Use e^- to represent an electron.

---------- **[2]**

4(a). Sodium, Na, reacts with oxygen, O_2, to make sodium oxide.

Sodium oxide contains the ions, Na^+ and $O^{2?}$.

Explain how you can tell that O_2 is a **molecule** but $O^{2?}$ is an **ion**.

---[2]

(b). Use the charges of the ions in sodium oxide to work out the formula of sodium oxide.

---[1]

5(a). Soldiers use ‘flameless heaters’ to heat their meals.

The ‘flameless heater’ heats the food safely and quickly without using a flame.

The heater uses a chemical reaction between magnesium metal and water.

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

Look at the equation.

Write down the formula for one **reactant** in this reaction.

---

[1]

(b). The reaction is **exothermic**.

What is meant by an exothermic reaction?

---

[1]

(c). A scientist is trying to improve the 'flameless heaters' so that they heat the food more quickly.

Look at her results.

Heater	Temperature rise in the heater in °C	Time taken in minutes
A	40	8
B	42	7
C	24	6
D	50	10

Which heater heats up quickest?

Explain your answer using the temperature rise and time taken.

---

[2]

6. Pete and Helen investigate the reaction between marble chips (calcium carbonate) and nitric acid.

Calcium nitrate, carbon dioxide and water are made.

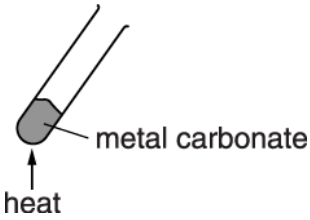
Write the **word** equation for this reaction.

---

[1]

7(a). Sam investigates what happens when she heats different metal carbonates.

Look at the apparatus she uses.



Sam measures the mass of metal carbonate then heats it.

She measures the mass of solid left in the test tube after it has cooled down.

Look at her results in Table 8.

Metal carbonate	Mass of metal carbonate in g	Mass of solid in test tube after heating in g
copper carbonate	2.50	1.61
iron(II) carbonate	2.50	1.55
manganese carbonate	2.50	1.54
potassium carbonate	1.25	1.25
sodium carbonate	2.50	2.50
zinc carbonate	2.50	1.62

Table 8

Some metal carbonates decompose when heated.

metal carbonate → metal oxide + carbon dioxide

(i) Calculate the mass of carbon dioxide made when manganese carbonate is heated.

mass of carbon dioxide = _____ g

[1]

(ii) Manganese carbonate produces the greatest percentage by mass of carbon dioxide.

How can you tell from the results?

---

[2]

(b). Manganese carbonate has the formula $MnCO_3$.

Write the **balanced symbol** equation for the decomposition of manganese carbonate.

---

[1]

8. Sodium, Na, reacts with water, H_2O.

Sodium hydroxide, NaOH, and hydrogen, H_2, are made.

Write a **balanced symbol** equation for this reaction.

---

[2]

9. Sodium reacts with iodine.

Sodium iodide is made.

Write the **word** equation for this reaction.

---

[1]

10. Ethanol has the formula C_2H_6O.

Ethanol burns in oxygen, O_2.

Carbon dioxide and water are made.

Write a **balanced symbol** equation for this reaction.

---

[2]

11. Jan and Mike investigate the reaction between magnesium lumps and hydrochloric acid, HC*l*.

Magnesium chloride solution, $MgCl_2$, and hydrogen gas, H_2, are made.

Write a **balanced symbol** equation for this reaction.

[2]

12. Harneet and Mike investigate the reaction between sodium thiosulfate, $Na_2S_2O_3$, and hydrochloric acid, HC*l*.

Sodium chloride NaC*l*, sulfur dioxide SO_2, sulfur S and water H_2O are made.

Write a **balanced symbol** equation for this reaction.

[2]

13. Aspirin is a painkiller used to treat headaches and reduce fevers.

A pharmaceutical company makes aspirin using the following reaction.

salicylic acid + ethanoic anhydride → aspirin + ethanoic acid

A scientist reacts 6.9 g salicylic acid with 5.1 g of ethanoic anhydride.

She makes 3.0 g of ethanoic acid and some aspirin.

Calculate the mass of aspirin that she makes. Use the principle of conservation of mass.

---

[2]

mass of aspirin _____ g

14. Sodium chloride is found in sea water.

It is an important raw material used in the chemical industry.

Sodium chloride solution can be chemically changed into:

- sodium hydroxide
- chlorine
- hydrogen.

Look at the symbol equation for this reaction. It is not balanced.

$$Nacl + H_2O \text{ ? } NaOH + H_2 = Cl_2$$

Write down the **balanced symbol** equation for this reaction.

[1]

15. The air may contain different pollutants.

Look at the table.

It shows the relative concentration of pollutants found in the air in two places.

Pollutant	Molecular formula	Relative concentration in the air	
		in a city centre	near a volcano
carbon monoxide	CO	0.3	0.01
hydrogen sulfide	H_2S	0.01	210
nitrogen dioxide	NO_2	1.5	0.1
sulfur dioxide	SO_2	200	1500
trichlorofluoromethane	$CFCl_3$	0.01	0.005

Write down the names of **two** of the pollutants that have molecules with only **three** atoms.

_____ and _____ **[1]**

16(a) Duncan investigates the combustion of four different fuels.

.

He burns the same amount of fuel in each experiment.

Look at his results.

Fuel	Is carbon dioxide made?	Is carbon monoxide made?	Is soot made?	Energy given out in J
A	✓	✗	✗	4200
B	✓	✓	✗	2800
C	✗	✓	✓	1100
D	✓	✗	✗	3400

In each experiment Duncan tests to see if **carbon dioxide** is made.

Write about how Duncan tests for carbon dioxide.

---

[2]

(b). Fuel **A** is ethanol.

Ethanol burns in oxygen.

Carbon dioxide and water are made.

Write the **word equation** for this reaction.

---

[1]

17. Look at this equation. It shows the complete combustion of ethanol.

$$C_2H_5OH + xO_2 \rightarrow yCO_2 + zH_2O$$

What are the numbers **x, y** and **z** that balance this equation?

x = _____

y = _____

z = _____

[1]

18(a) Chris is a gardener.

.

He uses different compounds in his garden.

Look at the table. It shows information about some of these compounds

Compound	Formula	Solubility in water	Use
calcium hydroxide	$Ca(OH)_2$	slightly soluble	soil conditioner
glyphosate	$C_3H_8NO_5P$	highly soluble	weedkiller
ammonium phosphate	$(NH_4)_3PO_4$	highly soluble	fertiliser
sodium nitrate	$NaNO_3$	highly soluble	fertiliser

How many different **elements** are in glyphosate?

answer _____ [1]

(b). What is the **total** number of **atoms** in the formula for sodium nitrate?

answer _____ [1]

19. Magnesium reacts with hydrochloric acid.

Hydrogen and magnesium chloride are made.

Write down the **word** equation for this reaction.

____ [1]

20. Hydrogen peroxide solution breaks down to make water and oxygen.

hydrogen peroxide → water + oxygen

In an experiment 6.8 g of hydrogen peroxide makes 3.2 g of oxygen.

(i) Use the principle of conservation of mass to predict the mass of water made.

mass of water = ____________________ g [1]

(ii) What mass of oxygen can be made from 680 g of hydrogen peroxide?

mass of oxygen = ____________________ g [2]

21. Look at the **balanced symbol** equation for the combustion of propane.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

(i) Write down the **formula** for a **product** in this reaction.

____ [1]

(ii) Explain how you can tell that the equation is balanced.

____

____ [1]

22. The table shows some common ions.

Negative ions		Positive ions	
Nitrate	NO_3 –	Aluminium	Al^{3+}
Oxide	O^{2-}	Magnesium	Mg^{2+}

Write the formula for **aluminium oxide**.

---------- [1]

23(a) The table shows some common ions.

.

Negative ions		Positive ions	
Nitrate	NO_3 –	Aluminium	Al^{3+}
Oxide	O^{2-}	Magnesium	Mg^{2+}

Write the formula for **aluminium oxide**.

---------- [1]

(b). A teacher wrote the formula for magnesium nitrate as:

$MgNO_3$

A student says that the formula is incorrect.

Who is right? Explain your answer.

---------- [1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		$Mg + CuSO_4 \longrightarrow Cu + MgSO_4$ (1)	1	
	b	i	$Mg + Cu^{2+} \longrightarrow Mg^{2+} + Cu$ (2)	2	**ALLOW** $Mg + Cu^{2+}$ (1) (reactants) **ALLOW** $Mg^{2+} + Cu$ (1) (products)
		ii	$Mg \longrightarrow Mg^{2+} + 2e^-$ / $Mg - 2e^- \longrightarrow Mg^{2+}$ (2)	2	**ALLOW** $Mg \longrightarrow Mg^{2+}$ (1)
			Total	**5**	
2			2.8 ÷ 84.3 = 0.033 moles used so 0.033 moles $MgCl_2$ made (1) 0.033 × 95.3 = 3.2 (1) **but** mass is 3.2 (g) (2)	2	**ALLOW** idea that 84.3g of magnesium carbonate makes 95.3g of magnesium chloride for one mark unit not needed **ALLOW** 3.17 (g) for 1 mark if no other mark awarded **DO NOT ALLOW** 3.16 (g) Award 2 marks if answer on answer line = 3.2 (g)
			Total	**2**	
3			$Cu^{2+} + 2e^- \rightarrow Cu$ formulae (1) balancing (1)	2	balancing mark is conditional on correct formulae **ALLOW** any correct multiple e.g. $2Cu^{2+} + 4e^- \rightarrow 2Cu$ **ALLOW** = or ⇌ for arrow **DO NOT ALLOW** 'and' or & for + **ALLOW** one mark for correct balanced equation with incorrect use of upper and lower case formulae e.g. Cu2+ + 2e⁻ → CU
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
4	a		O_2 contains two (oxygen) atoms (1) $O^{2?}$ has a charge / has a negative charge / has a 2? (1)	2	**ignore** does not have a charge **allow** is negative / has gained electrons (1) **Examiner's Comments** Candidates were asked how they knew that O_2 was a molecule and $O^{?2}$ was an ion. Few candidates stated that the molecule had two oxygen atoms but the majority of candidates were able to say the ion could be identified because it was charged.
	b		Na_2O / ONa_2 (1)	1	**allow** $(Na^{+})_2O^{2?}$ **allow** answer on right hand side of equation (the equation does not need to be balanced) e.g. Na + O_2 ? Na_2O (1) **not** Na2O / Na^2O **Examiner's Comments** In this question candidates were asked to work out the formula of sodium oxide. Correct answers were rare and candidates did not realise they needed to balance the charges.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
5	a		Mg / H_2O (1)	1	**any incorrect formula is zero** **allow** $2H_2O$ / Mg + H_2O / Mg + $2H_2O$ **allow** correct answer ticked, circled or underlined in equation if answer line is blank **ignore** magnesium and water **Examiner's Comments** Most candidates did not score here. If they could identify a reactant they usually named it rather than giving the formula. Of those that got it correct, Mg was much a more common response than H_2O.
	b		energy given out or heat given out (1)	1	**allow** temperature increase **allow** heat or energy produced / made / exits / released **allow** energy or heat is lost (limit of acceptability) **ignore** gives more energy **NOT** energy or heat is created **Examiner's Comments** Many candidates knew this, or if not, left it blank.
	c		B (1) largest temperature rise per minute (1)	2	**allow** all correct calculations of temperature rise per minute in table (A ? 5°/min; B ? 6°/min; C ? 4°/min; D ? 5°/min) **Examiner's Comments** Of the candidates that scored on this question many candidates got B but few gave the correct reason. Those that got the second mark normally got it for a correct column of numbers against the table, but most struggled to manipulate data to make a comparison.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
6			calcium carbonate + nitric acid → calcium nitrate + carbon dioxide + water (1)	1	**allow** = instead of → **not** and / & / instead of + **allow** correct formulae but equation does not need to balance e.g. $CaCO_3$ + HNO_3 → $Ca(NO_3)_2$ + CO_2 + H_2O **allow** mix of correct formulae and words **Examiner's Comments** Most candidates answered this well. Most put the arrow and plus signs in the correct place. However, a few missed off water at the end.
			Total	**1**	
7	a	i	0.96 (g) (1)	1	
		ii	all metal carbonates (that decomposed) had the same starting mass (1) idea that this is the least amount of solid left / most mass lost (so the greatest amount of gas produced) (1)	2	**allow** decomposed the most lowest mass of solid left in relation to mass of carbonate (2) **allow** four correct percentage calculations (2) **Examiner's Comments** Most candidates could calculate the mass of carbon dioxide and explain how you could tell which carbonate produced the most but explaining the concept of percentage change was very challenging.
	b		$MnCO_3$? $MnO + CO_2$ (1)	1	**allow** any correct multiple **not** heat in the equation rather than over the equation all formulae must be completely **correct** **Examiner's Comments** There were a significant minority of candidates that confused manganese with magnesium.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
8			$2Na + 2H_2O$? $2NaOH + H_2$ correct reactants and products (1) correct balancing (1)	2	**allow** any correct multiple, including fractions e.g. $4Na + 4H_2O$? $4NaOH + 2H_2$ (2) **allow** = / ^ instead of ? **not** and or & 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. 2Na + 2H2O ? 2NAOH + H^2 (1) **Examiner's Comments** This question required candidates to write a balanced symbol equation for the reaction of sodium with water. One mark was awarded 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. When candidates did not gain marks it was often because they tried to balance the equation by changing the formulae given, e.g. $NaOH_2$.
			Total	2	
9			sodium + iodine ? sodium iodide (1)	1	**not** sodium + iodine ? sodium iod**ine** **allow** = instead of ? **not** and / & / instead of + **allow** correct formulae but equation does not need to balance eg Na + I_2 ? NaI **allow** mix of correct formulae and words **Examiner's Comments** Although candidates were told in the question that the product of the reaction between sodium and iodine is sodium iodide, many gave 'sodium iodine' as the product of the reaction.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
10			$C_2H_6O + 3O_2$? $2CO_2 + 3H_2O$ formulae (1) balancing (1)	2	**allow** C_2H_5OH as formula for ethanol **allow** any correct multiple, including fractions eg $2C_2H_6O + 6O2$? $4CO_2 + 6H_2O$ (2) **allow** = or ? instead of ? **not** and or & balancing mark is dependent on the correct formulae but **allow** 1 mark for a balanced equation with a minor error in subscripts or case eg $C_2H_6O + 3O_2$? $2CO_2 + 3H_2O$ (1) **Examiner's Comments** Better candidates scored both marks on this question and balanced the equation successfully. Weaker candidates often scored 1 mark for placing the correct formulae in an equation. There were numerous examples of failed attempts to balance the equation which scored 1 mark because the formulae were correct. The presence of an oxygen atom in ethanol was overlooked by a number of candidates.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
11			$Mg + 2HCl \rightarrow MgCl_2 + H_2$ formulae (1) balancing (1)	2	balancing mark is conditional on correct formulae **but** **allow** one mark for balanced equation with minor errors of subscripts, superscripts, etc eg MG + 2HC*l*? MgC*l*2+ H^2 **not** and or & for + **allow** = instead of ? **allow** correct multiples eg 2Mg + 4HC*l*? $2MgCl_2 + 2H_2$ **Examiner's Comments** Candidates are certainly getting better at writing equations, with fewer candidates losing marks through poor presentation, being unclear about capitalisation and using superscripts.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
12			$Na_2S_2O_3$ + 2HC*l* ? 2NaC*l* + SO_2 + S + H_2O formulae (1) balancing (1)	2	**allow** any correct multiple, including fractions **allow** = / ⇌ instead of ? **not** and / & 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. $Na2S_2O_3$ + 2HCL ? S + SO2 + 2NaCL + H_2O **allow** HOH for H_2O **allow** NaC*l* Examiner's Comments The majority of candidates were able to write a symbol equation for the reaction. Some candidates missed out S on the right hand side of the equation and a few more struggled to balance the equation. A few candidates tried to add formulae together, S2O2, or used incorrect formulae, Na2Cl2.
			Total	**2**	
13			1.0 (g) (2) **BUT** idea that mass of reactants equals mass of products / 6.9 + 5.1 = 3.0 + mass of aspirin / 12.0 = 3.0 + mass of aspirin (1)	2	Examiner's Comments Often both marks were scored for 9, but working out was surprisingly missing in many.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
14			$2NaCl + 2H_2O$? $2NaOH + H_2 + Cl_2$	1	**allow** any correct multiple including fractions **allow** = instead of ? **allow** balanced equation on the line or on the original equation. If there is a **contradiction** take the answer on the answer line. **not** & **or** and instead of + **ignore** poor use of case or subscript **Examiner's Comments** Only a minority of candidates were able to balance the equation correctly.
			Total	1	
15			**any two from:** hydrogen sulfide, sulfur dioxide or nitrogen dioxide (1)	1	if any **other** gas included then award 0 marks **allow** H_2S, SO_2, NO_2 **Examiner's Comments** Most candidates got the mark, but there was also a few gases named that weren't in the table.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
16	a		(use) limewater / calcium hydroxide (1) **then** (which goes) cloudy (1)	2	**The second marking point is dependent on the correct chemical** **ignore any reference to method** **ignore** use of an indicator / litmus paper **ignore** reference to blowing through a straw **allow** goes milky / goes white (1) **allow** a white solid or white precipitate or white suspension is formed (1) **ignore** put out lighted splint **Examiner's Comments** Many candidates referred back to the results table and suggested that the amount of energy given out would indicate whether carbon dioxide was made. Answers in terms of the colour of the flame also did not gain credit.
	b		ethanol + oxygen ? carbon dioxide + water	1	**allow** = or ? instead of ? **not** and / & / instead of + **not** '+ heat' in equation, but **allow** heat above arrow **allow** correct formulae but equation does not need to balance e.g. $C_2H_5OH + O_2$? $CO_2 + H_2O$ **allow** mix of correct formulae and words **not eg** ethan**al** / ethon**al** + oxygen ? carbon dioxide + water **Examiner's Comments** Many candidates were able to write a correct word equation for the combustion of ethanol. When candidates did not gain credit it was often because they used 'and' or an ? instead of '+'. Omitting oxygen as a reactant was also a common error.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
17			**x** = 3 **y** = 2 **z** = 3 (1)	1	all three required for the mark Examiner's Comments Only the more able students could balance the equation. Some candidates thought that value of **x** was carbon turning the oxygen into carbon dioxide. This suggests they had not clearly read the question that states that x, y and z are all numbers.
			Total	1	
18	a		5 (1)	1	Examiner's Comments Very few candidates understood how to count the number of elements and atoms in the compounds. Many thought NO was one element and so gave the answer for atoms in $C_3H_8NO_5P$ as 4 or they calculated the actual number of atoms. For $NaNO_3$ they neglected to include three oxygen or they multiplied everything by 3.
	b		5 (1)	1	Examiner's Comments Very few candidates understood how to count the number of elements and atoms in the compounds. Many thought NO was one element and so gave the answer for atoms in $C_3H_8NO_5P$ as 4 or they calculated the actual number of atoms. For $NaNO_3$ they neglected to include three oxygen or they multiplied everything by 3.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
19			magnesium + hydrochloric (acid) → magnesium chloride + hydrogen (1)	1	**allow** = or ⇌ instead of arrow (1) **not** 'and' or '&' instead of + **allow** correct formulae instead of names – the equation does not have to be balanced. $Mg + HCl \rightarrow MgCl_2 + H_2$ **allow** a mixture of names and correct formulae **ignore** 'hydrolic'
			Total	1	
20		i	3.6 (g)	1	
		ii	320 (g) (2) **BUT if answer is incorrect then** use of 680/6.8 or idea that 100 × more hydrogen peroxide used (1)	2	**allow** full marks for correct answer even with incorrect working out
			Total	3	
21		i	CO_2 / H_2O (1)	1	**allow** $3CO_2$ / $4H_2O$ (1) **allow** CO2 / CO^2 / H2O / H^2O (1) (as mark is for identifying a product) **allow** carbon dioxide / water (1) if two answers given and one incorrect = 0 marks
		ii	idea of same number of each type of atom on LHS and RHS (1)	1	**allow** same number of each different element on LHS and RHS (1) **ignore** same number of atoms on LHS and RHS
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
22			Al_2O_3 ✓	1 (AO2.1)	ALLOW O_3 Al_2 DO NOT ALLOW Al^2O^3 Examiner's Comments A few candidates deduced that the correct formula for aluminium oxide was Al2O3, but a few wrote Al3O2. Most included charges on the ions and some attempted to write a word or symbol equation.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
23	a		Al_2O_3 ✓	1 (AO 2.1)	**ALLOW** O_3Al_2 **DO NOT ALLOW** Al^2O_3 Examiner's Comments Only higher ability candidates were credited credit here. There were a variety of answers that were not awarded credit including Al_3O_2, $2AlO_3$ and AlO. Candidates also quoted ions rather than formula without the charges. Exemplar 2  This was a common incorrect response. The candidate perhaps knows the number of each atom present in the formula but has incorrectly expressed the formula so cannot be given credit.
	b		Teacher is wrong / student is right (no mark) Any one from: Formula should be $Mg(NO_3)_2$✓ Idea that charges do not balance as Mg ion is 2+ and NO_3 is 1- ✓ The ratio of ions is 1:2 ($Mg:NO_3$) ✓	1 (AO 3.1b)	**Mark is for explanation** – Who is right or wrong can be implied in response. **ALLOW** MgNO3 would be charged (+) Examiner's Comments A large number of candidates realised that the candidate was correct and not the teacher. This was not creditworthy. The reason for their decision was where the mark was credited. Candidates could either say why the teacher was wrong or give the correct formula. There was a variety of incorrect responses mainly around the candidate's inability to communicate the lack of balance of the charges of the ions in the formula as well as the incorrect idea of transfer of electrons.

Question			Answer/Indicative content	Marks	Guidance
			Total	2	