Surname	Centre Number	Candidate Number
Other Names		0

GCSE – NEW

C410UA0-1

S18-C410UA0-1

CHEMISTRY – Component 1:
Concepts in Chemistry

HIGHER TIER

THURSDAY, 17 MAY 2018 – MORNING

2 hours 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**10**	
3.	**10**	
4.	**8**	
5.	**11**	
6.	**5**	
7.	**9**	
8.	**9**	
9.	**8**	
10.	**11**	
11.	**17**	
12.	**12**	
Total	**120**	

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ADDITIONAL MATERIALS

In addition to this paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **11**(*c*) is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table is printed on the back cover of this paper and the formulae for some common ions on the inside of the back cover.

Examiner only

Answer **all** *questions.*

1. *(a)* The table shows some information about particles found in atoms. Complete the table. [2]

Particle	Relative mass	Relative charge
proton	....	+1
electron	negligible	....
neutron	1	0

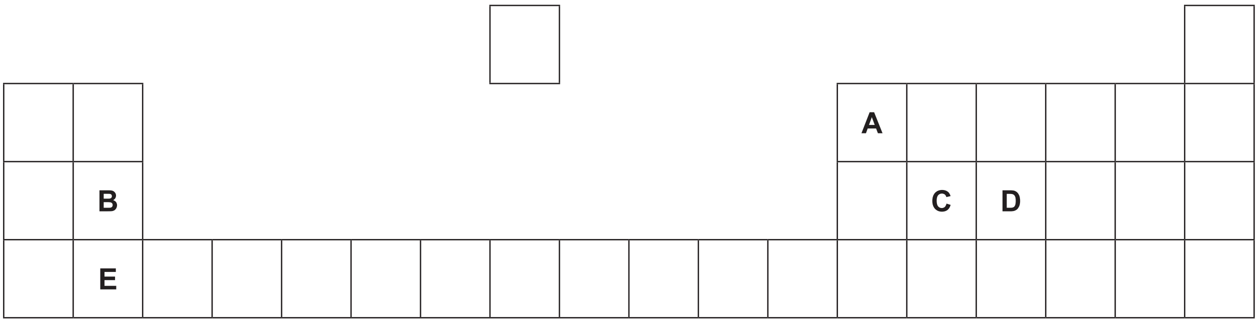
(b) Complete the following table that shows information about atoms of some elements. [3]

Element	Mass number	Atomic number	Number of protons	Number of neutrons	Number of electrons
fluorine	19	9	9	10	....
potassium	39	19	....	20	19
argon	....	18	18	22	18

Examiner only

(c) The following diagram shows an outline of part of the Periodic Table.

The letters shown are NOT the chemical symbols of the elements.



(i) Give the **letter** of the element in Group 2 and Period 3. [1]

....

(ii) Give the **letter** of the element which has 14 protons in its nucleus. [1]

....

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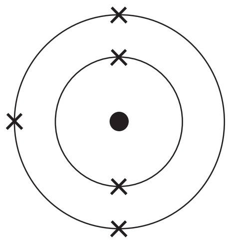
(d) The diagram shows the electronic structure of an element in the Periodic Table.



Draw the diagram which shows the electronic structure of the element which lies directly **below** it. [1]

Examiner only

(e) The definition of an element is:

"a substance that cannot be broken down into simpler substances by chemical methods".

In the 1700s a chemist named Antoine Lavoisier attempted to arrange substances in a pattern. The table shows some of the 'substances' which Lavoisier thought were elements. He divided the 'substances' into four groups. He published these groups in 1789. The modern names of some of the 'substances' are given in brackets.

Acid-making elements	Gas-like elements	Metallic elements	Earthy elements
sulfur phosphorus charcoal (carbon)	light caloric (heat) oxygen azote (nitrogen) hydrogen	mercury copper nickel gold iron zinc	lime (calcium oxide) magnesia (magnesium oxide) barites (barium sulfate) silex (silicon dioxide)

(i) Name **one** 'substance' in the table which is **not** a chemical element or compound. [1]

....

(ii) The 'earthy elements' are now known as compounds. Suggest why Lavoisier thought they were elements. [1]

....

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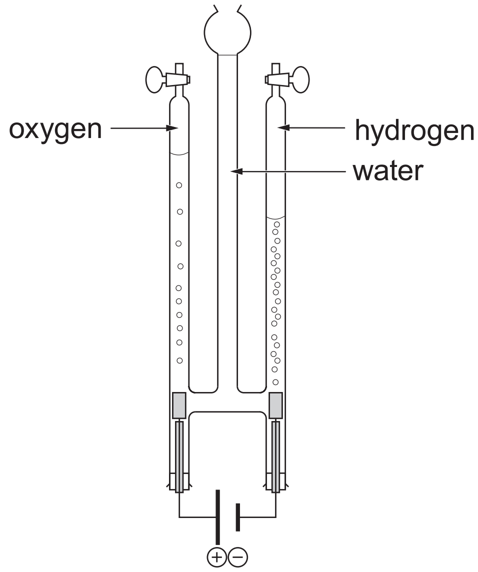
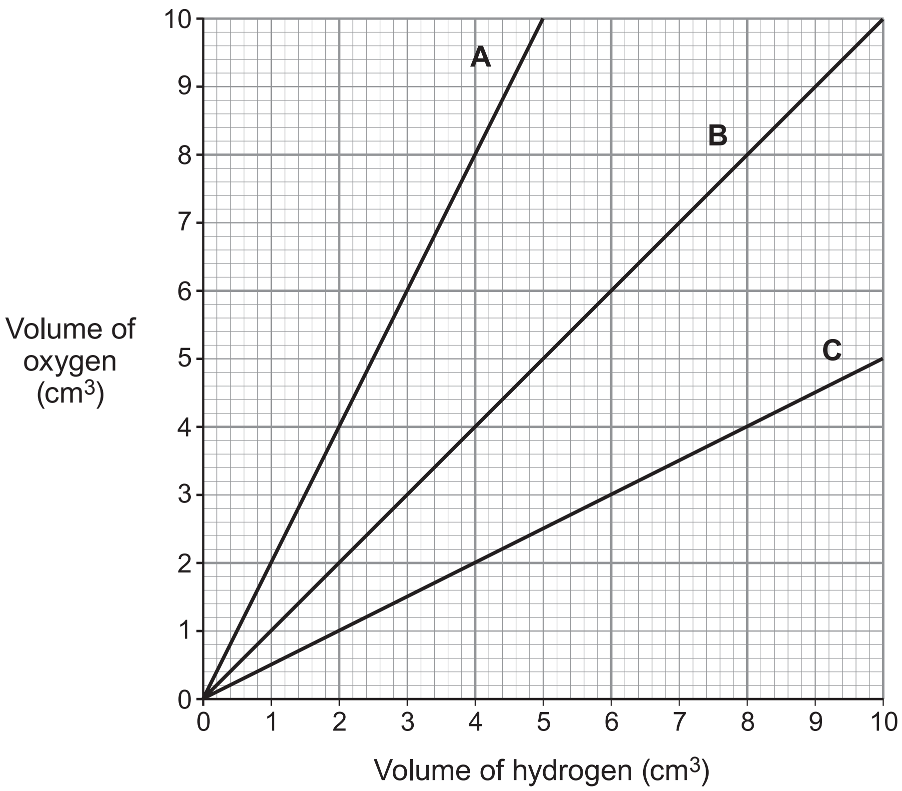
2. *(a)* The following apparatus is used to show the electrolysis of water.



(i) Choose the **letter** of the graph which shows the relationship between the volume of hydrogen and the volume of oxygen formed during the process. Give the reason for your choice. [2]



Letter ....

Reason ....

....

Examiner only

(ii) Explain the **movement** of H^+ ions and OH^- ions during the process. [2]

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....

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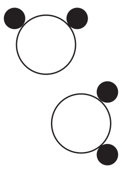
(iii) Complete the equation by drawing diagrams to represent **all** the molecules formed. [2]

water ⟶ hydrogen + oxygen

 ⟶ +

(b) The table below shows the symbols of the ions present in three electrolytes and the products formed during their electrolysis. **Complete the table.** [4]

Electrolyte	**Symbol** of ions present in electrolyte		**Name** of product formed	
	Positive ion(s)	Negative ion(s)	At the cathode (−)	At the anode (+)
molten lead(II) iodide	....	....	lead	iodine
aqueous copper(II) sulfate	Cu^{2+} H^+	SO_4^{2-} OH^-	....	oxygen
aqueous lithium chloride	Li^+ H^+	Cl^- OH^-	hydrogen	....

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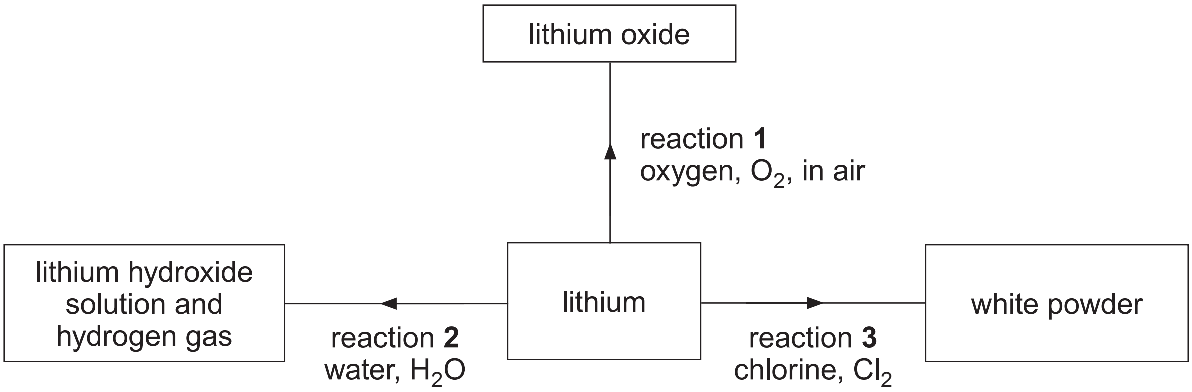
3. *(a)* The diagram shows three reactions of lithium.



(i) I Balance the symbol equation for reaction **1**. [1]

$$\square\, Li + O_2 \longrightarrow \square\, Li_2O$$

II Calculate the relative formula mass (M_r) of lithium oxide. [1]

$A_r(Li) = 7$ $\quad$ $A_r(O) = 16$

M_r = ...

III Describe how reaction **1** is prevented from happening when storing lithium in the laboratory. [1]

....

....

Examiner only

(ii) I Complete and balance the symbol equation for reaction **2**. [2]

$2Li + 2H_2O \longrightarrow$ .... + ...

II Explain the colour seen when a few drops of universal indicator are added to the solution formed in reaction **2**. [2]

....

....

(iii) Write a balanced symbol equation for reaction **3**. [2]

....

(b) Give the chemical formula of lithium carbonate. [1]

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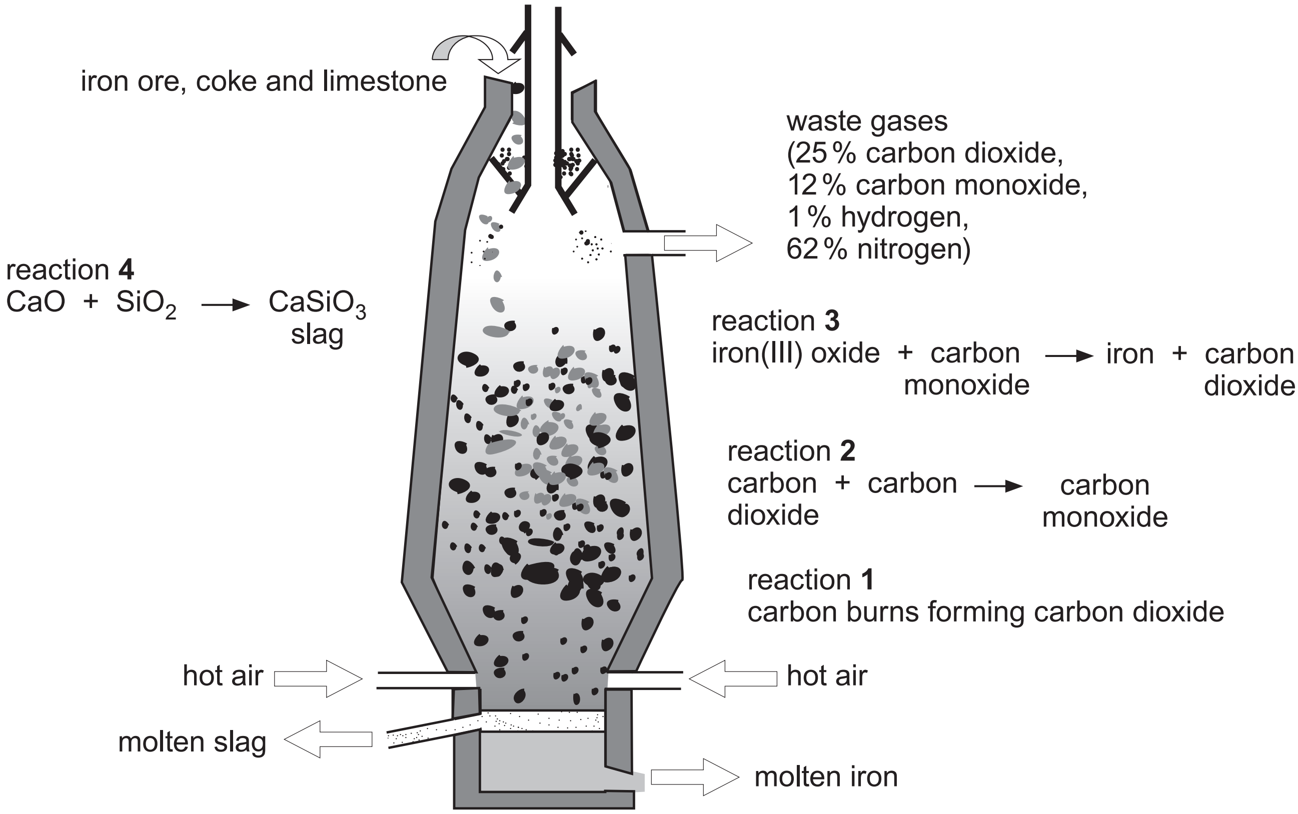
4. Iron is extracted from its ore in the blast furnace. The diagram shows the main reactions occurring in the furnace.



(a) (i) Complete and balance the symbol equation for reaction **3**. [2]

Fe_2O_3 + 3CO ⟶ .... + ...

(ii) Use this reaction to explain the term *reduction*. [1]

....

Examiner only

(b) Give the type of reaction taking place in the formation of slag. Give a reason for your answer. [2]

....

....

(c) Explain how calcium oxide is formed in the furnace. [2]

....

....

(d) Suggest how the cost of the process is reduced by using some of the waste gases. [1]

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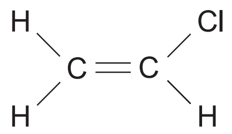
Examiner only

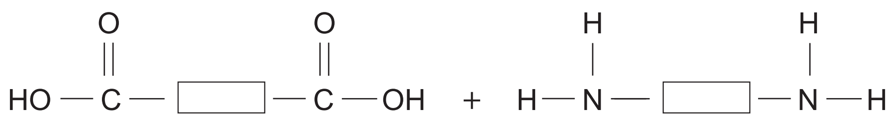
5. *(a)* Polymers are very large molecules made when many smaller molecules join together, end to end. The smaller molecules are called monomers. The process of small monomers joining together is called polymerisation. There are two types of polymerisation.

(i) Monomer **A** undergoes addition polymerisation. Complete the table. [2]

Monomer **A**	Functional group needed for addition polymerisation	Repeating unit
		

(ii) I Monomers **B** and **C** can undergo a condensation reaction.

Complete the diagram by showing how these two molecules join together forming two products. [2]



monomer **B** monomer **C**

II Explain, using monomers **B** and **C**, the principles of condensation polymerisation. [4]

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Examiner only

(b) When manufacturers produce soft drinks they often package the same product in different materials. Each type of disposable drink container has an environmental impact.

Scientists carried out a life cycle assessment (LCA) for three different disposable drinks' containers. The table shows some information from the life cycle assessment.

	Plastic bottle (PET)	Glass bottle	Aluminium can
Raw material(s)	petroleum	sand, sodium carbonate and limestone	bauxite
Mass of carbon dioxide emitted per container during production (g)	142	226	168
Mass of 330 ml container (g) *(mass impacts on truckload size and therefore fuel use)*	11	200	24
Recycling	25 % recycled into new bottles 75 % recycled into other products such as wheelie bins and eco-fleece due to degradation in properties	40 % recycled into new bottles no degradation of properties therefore can be recycled indefinitely	70 % recycled into new cans no degradation of properties therefore can be recycled indefinitely
Time to break down in the environment	400 years	400 years	80 years

Use the information from the table to state which material in your opinion has the least environmental impact.

Give **three** pieces of evidence to support your choice. [3]

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Examiner only

6. *(a)* The following tests were used to identify unknown compounds **A**, **B** and **C**.

add silver nitrate solution

add dilute hydrochloric acid, bubble gas given off into limewater

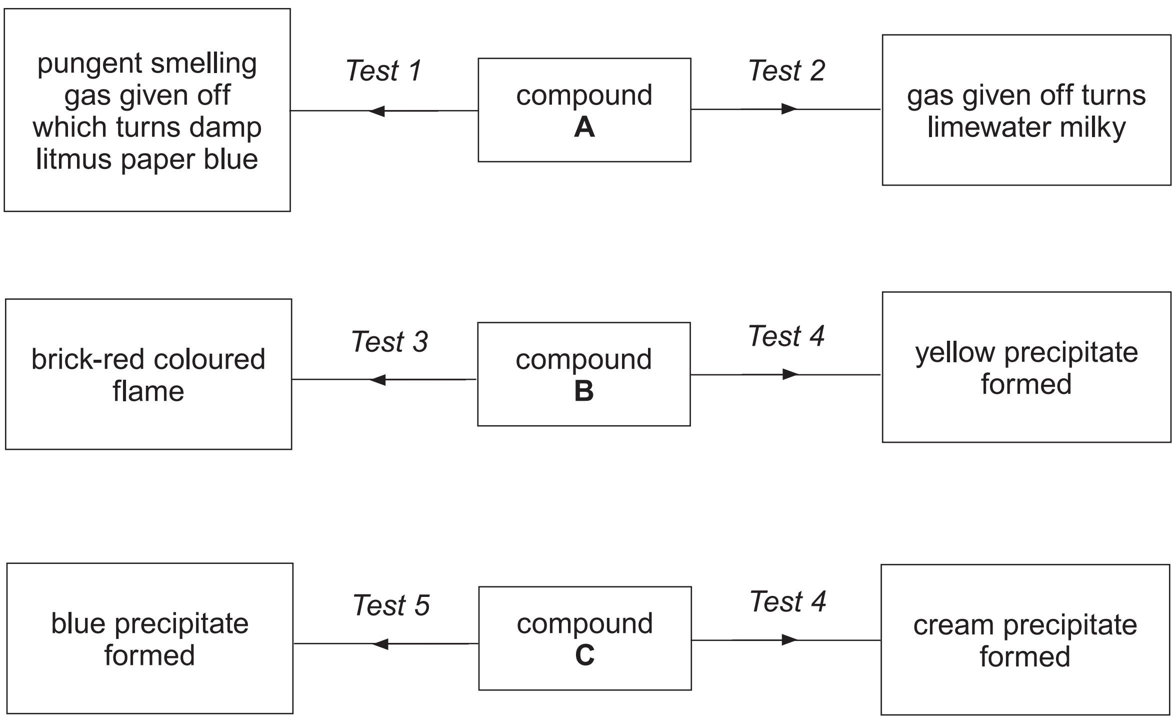
flame test

add sodium hydroxide solution

add sodium hydroxide solution and warm mixture, test gas given off with damp litmus paper

These are described below as tests **1** to **5** but **not** necessarily in that order.

The charts show the results obtained for each compound.



Deduce which test is which and hence identify compounds **A**, **B** and **C**. [3]

A ....

B ....

C ....

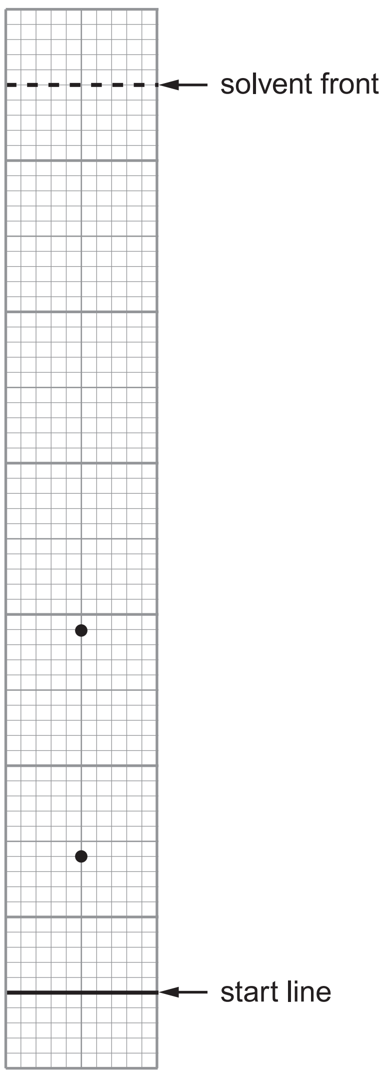
Examiner only

(b) Colourless aqueous solutions of amino acids can be separated by paper chromatography. Spots appear when the paper is sprayed with a 'locating agent'.

The table shows the R_f values for some amino acids.

Amino acid	R_f value
glycine	0.25
alanine	0.40
valine	0.70
proline	0.45
serine	0.30
lysine	0.15
cysteine	0.10

A student was given the chromatogram of a mixture of two unknown amino acids.



Use the information given to identify the **two** unknown amino acids in the mixture. [2]

.... and ....

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7. *(a)* Gareth and Caroline investigated the displacement reaction between iron filings and copper(II) sulfate solution. The equation for the reaction is as follows.

$$Fe(s) \;+\; CuSO_4(aq) \longrightarrow FeSO_4(aq) \;+\; Cu(s)$$

Both students carried out the following procedure.

0.56 g of iron fillings were added to excess aqueous copper(II) sulfate. Once all the iron filings had reacted, the copper formed was filtered, dried and weighed accurately.

The mass of copper expected was 0.64 g.

(i) Gareth obtained a value of 0.71 g. Suggest **one** possible reason for the higher than expected mass. State how this problem could be overcome. [2]

....

....

....

(ii) Caroline obtained a value of 0.61 g. Suggest **one** possible reason for the lower than expected mass. State how this problem can be overcome. [2]

....

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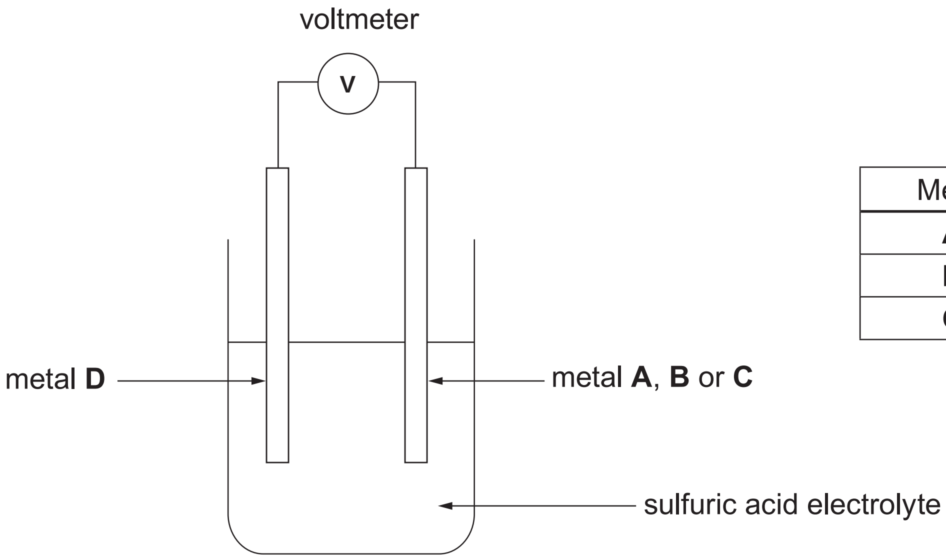
(b) The students were asked to find the relative positions in the reactivity series of four unknown metals, **A**, **B**, **C** and **D**.

Gareth measured the voltage formed in a simple chemical cell. He paired metals **A**, **B** and **C** in turn with metal **D**. Metal **D** is the least reactive of the metals. The voltage formed by each pair of metals is shown in the table.

In a chemical cell, the further apart the electrode metals are in the reactivity series the greater the voltage generated.



Metal	Voltage (V)
A	0.46
B	1.23
C	2.70

Caroline carried out a series of displacement reactions. She added metals **A**, **B**, **C** and **D** to separate solutions containing the nitrate of a different metal ion.

Complete the table below to show the results that would support Gareth's evidence. [2]

Use a tick (✓) to show that a reaction occurs and a cross (✗) to show that no reaction occurs.

Metal	Metal nitrate solution			
	metal **A** nitrate	metal **B** nitrate	metal **C** nitrate	metal **D** nitrate
A				
B				
C				
D				

Examiner only

(c) Suggest a reason why Gareth's is a better method than Caroline's for finding the relative positions of metals in the reactivity series. [1]

....

....

(d) Metal **D** has two main isotopes, ^{63}**D** and ^{65}**D**.

A sample of metal **D** contains 70 % ^{63}**D** atoms and 30 % ^{65}**D** atoms.

Calculate the relative atomic mass (A_r) of metal **D** to **three** significant figures. [2]

A_r = ...

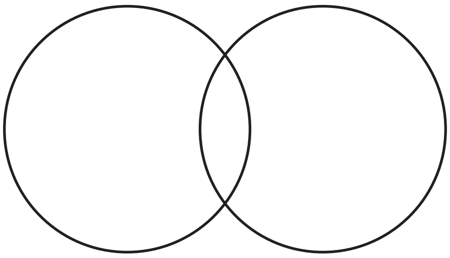
9

8. *(a)* (i) Calcium reacts with oxygen to form calcium oxide.

Using the electronic structures below, draw dot and cross diagrams to explain the bonding in calcium oxide. Show only outer shell electrons in your diagrams. [3]

calcium 2,8,8,2 oxygen 2,6

(ii) Complete the diagram showing the outer shell electrons in an oxygen molecule, O_2. [2]



(iii) Calcium oxide has an ionic structure and melts at 2572 °C. Oxygen has a simple covalent structure and melts at −219 °C.

Explain the difference in the melting points of calcium oxide and oxygen. [2]

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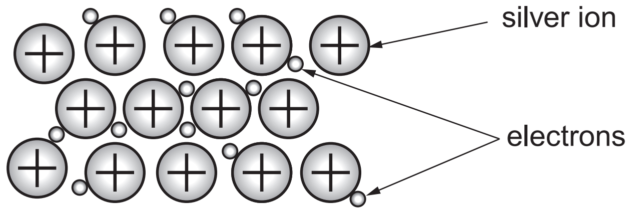
Examiner only

(b) The diagram shows the structure of metallic silver.



Explain why silver conducts electricity. [2]

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9. Alcohols can be used as fuels. **Table 1** shows the first five members of the alcohol homologous series. The theoretical values for the energy released when alcohols are burned are also shown. The value for ethanol is missing.

Alcohol	Molecular formula	Energy released (kJ)
methanol	CH_3OH	658
ethanol	C_2H_5OH	
propanol	C_3H_7OH	1894
butanol	C_4H_9OH	2512
pentanol	$C_5H_{11}OH$	3130

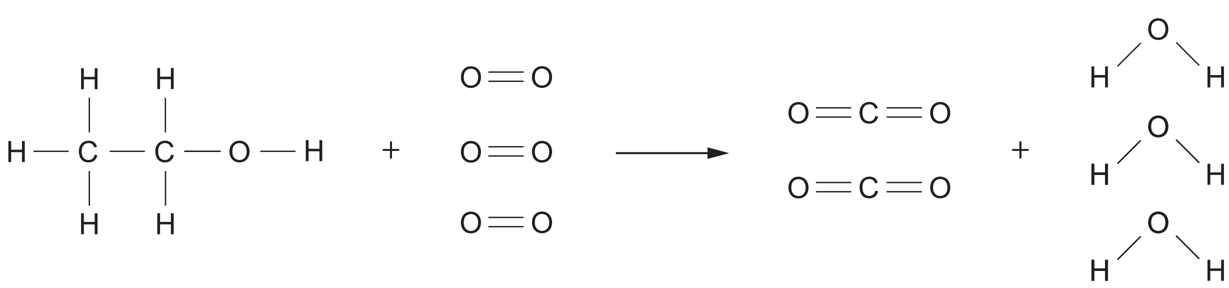
Table 1

The energies of the bonds broken and formed as alcohols burn are shown in **Table 2**.

Bond	Bond energy (kJ)
O—H	464
C—C	347
C—H	413
C—O	358
C=O	805
O=O	498

Table 2

The following equation shows the rearrangement of atoms as ethanol burns.



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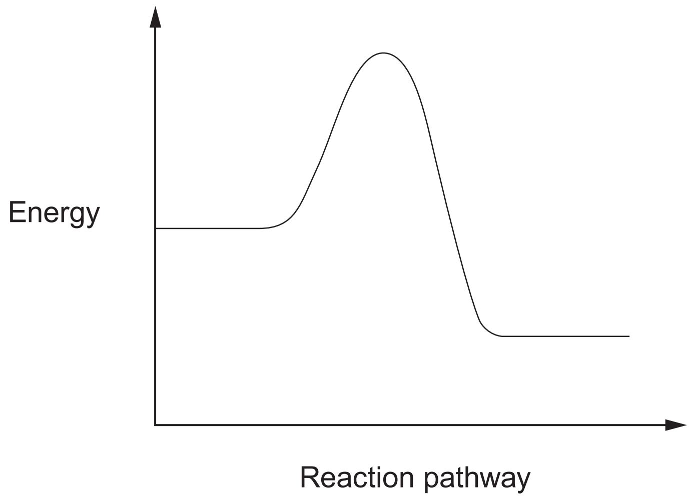
(a) Calculate the energy released for the burning of ethanol. [5]

Energy released = ... kJ

(b) Draw an arrow (↕) on the reaction profile to show the energy change calculated in part *(a)*. [1]



(c) Use your answer to part *(a)* and the information from **Table 1** to describe the relationship between the number of carbon atoms present in an alcohol and the energy released on burning. [2]

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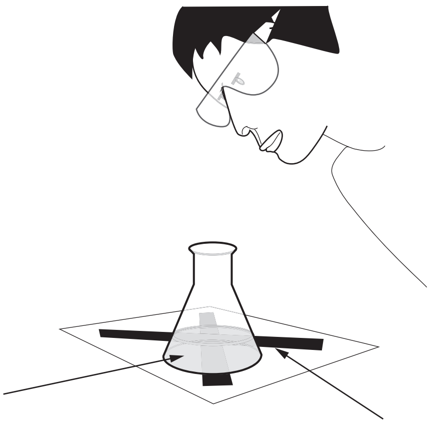
10. Sodium thiosulfate solution reacts with dilute hydrochloric acid forming a yellow precipitate. This reaction can be investigated using the 'disappearing cross' experiment.



50 cm^3 of sodium thiosulfate solution was heated in a water bath until a target temperature was reached. The flask was removed from the water bath and the actual temperature was recorded just before 10 cm^3 of hydrochloric acid was added. A stopwatch was started immediately. The time taken for the cross to disappear was recorded. This procedure was repeated at different temperatures. The concentrations of the acid and the sodium thiosulfate solutions were kept the same in each experiment.

The results are shown below.

Target temperature (°C)	Actual temperature recorded (°C)	Time for cross to disappear (s)	Rate 1/time × 10^{-3} (s^{-1})
20	19	250	4
30	27	167	6
40	39	62	15
50	49	33	30
60	59	17	59

(a) Suggest a reason for the difference between the target temperature and the actual temperature recorded for each reaction. [1]

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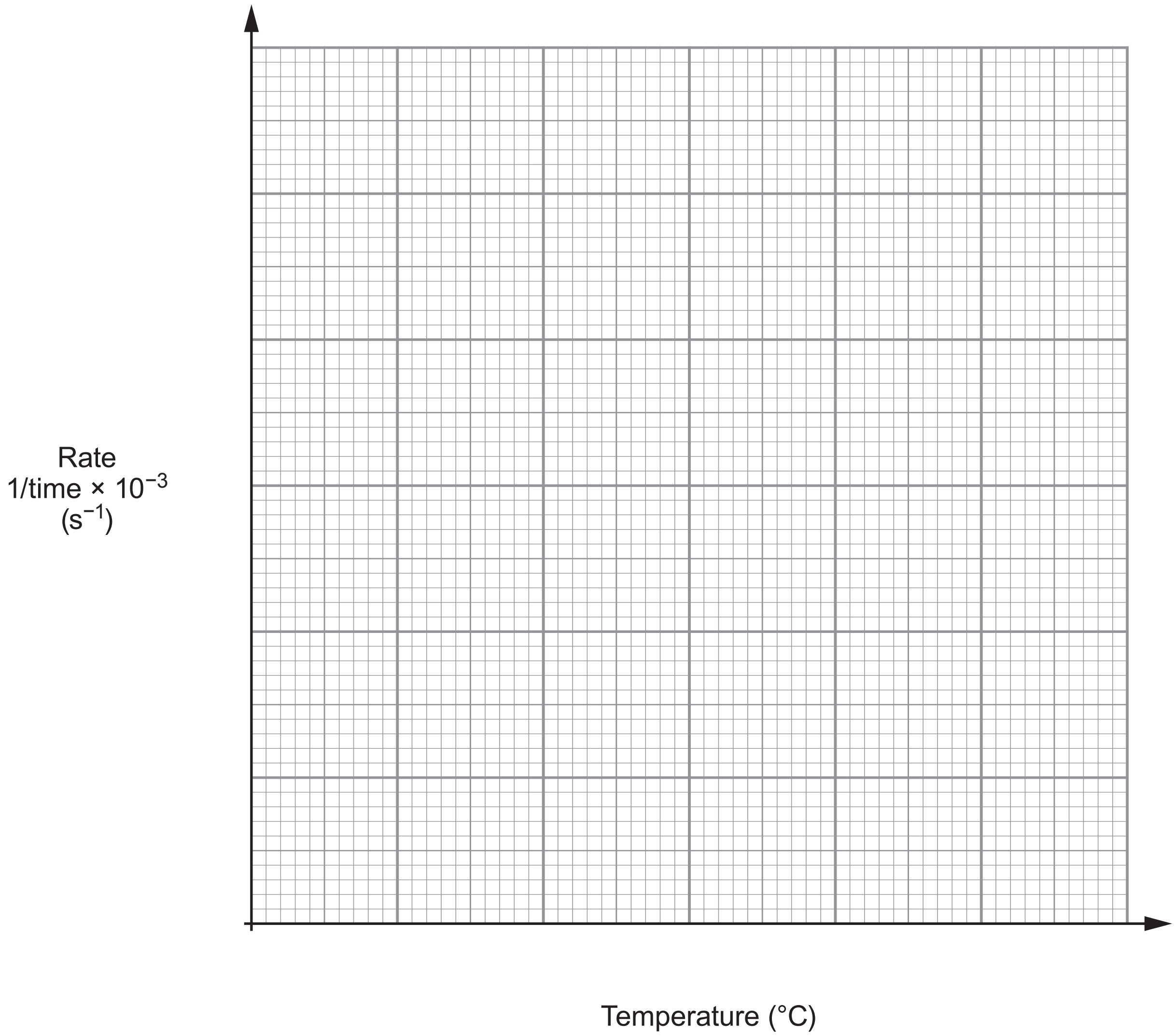
Examiner only

(b) Choose appropriate scales and plot the rate against the **actual** temperature recorded on the grid. Draw a suitable line. [4]



(c) (i) The following relationship is given in many text books.

"The rate of a reaction doubles for every 10°C rise in temperature."

Use your graph to show that this relationship is true. [2]

Examiner only

(ii) Using the relationship given in part (i) find the **time**, in seconds, it would take for the cross to disappear at 70 °C. Show your working. [3]

Time = ... s

(iii) At 80 °C the reaction would take less than 5 seconds. Explain why the time recorded at 80 °C would be a less accurate reading than at lower temperatures. [1]

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Examiner only

11. *(a)* Most of the hydrogen used in the Haber process is obtained by reacting methane with steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$$

The forward reaction is endothermic.

(i) Explain why a high temperature and a low pressure would give the maximum yield of hydrogen. [3]

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(ii) Calculate the atom economy for the manufacture of hydrogen using this reaction.

Give your answer to **three** significant figures. [2]

$A_r(H) = 1$ $A_r(C) = 12$ $A_r(O) = 16$

Atom economy = ... %

(iii) Calculate the maximum volume of hydrogen that could be formed at room temperature and pressure from 0.16 g of methane. The volume of 1 mol of gas at room temperature and pressure is 0.024 m^3.

Give your answer in m^3. [3]

Volume of hydrogen = ... m^3

Examiner only

(b) A three component fertiliser contains a mixture of ammonium nitrate, potassium chloride and ammonium phosphate.

Complete the table by identifying the **three** essential elements this fertiliser provides. State why each element is essential. [3]

Element	Benefit to plants

(c) Phosphoric acid contains hydrogen ions (H^+) and phosphate ions (PO_4^{3-}).

Ammonium phosphate is manufactured by reacting ammonium hydroxide solution with phosphoric acid, H_3PO_4. Describe a titration method for making pure crystals of ammonium phosphate in the laboratory. Include an equation in your answer. [6 QER]

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Examiner only

12. *(a)* The label shows the ingredients in 'Sparkling Apple Drink'.

Ingredients:
carbonic acid, apple juice, sugar, glucose syrup, malic acid, preservative (sodium benzoate), artificial sweetener (saccharin).

A student was asked to find the concentration of carbonic acid in 'Sparkling Apple Drink'. He decided to do this by titrating the drink against sodium hydroxide solution.

(i) He found that 25.0 cm^3 of 'Sparking Apple Drink' was neutralised by 15.0 cm^3 of sodium hydroxide solution of concentration 0.10 mol/dm^3. The relative formula mass of carbonic acid is 62.

$$H_2CO_3 \ + \ 2NaOH \longrightarrow Na_2CO_3 \ + \ 2H_2O$$

I Calculate the student's value for the concentration of carbonic acid in mol/dm^3. [3]

Concentration = ... mol/dm^3

II Write this concentration as a value in g/dm^3. [1]

Concentration = ... g/dm^3

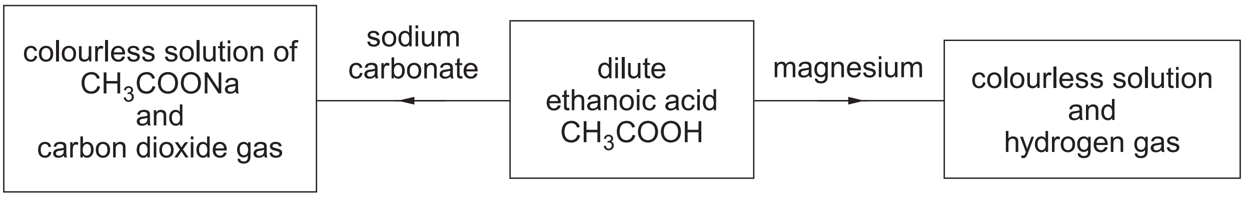
(ii) Suggest why the concentration of carbonic acid in 'Sparking Apple Drink' is actually less than that found by the student. [1]

....

....

Examiner only

(b) The flow diagram shows some reactions of ethanoic acid.



(i) Name the product with the formula CH_3COONa. [1]

....

(ii) Write a balanced symbol equation for the reaction between ethanoic acid and magnesium. [3]

....

(c) Dilute ethanoic acid (pH 3) reacts less vigorously with magnesium than dilute hydrochloric acid (pH 1) of equal concentration. Explain the reason for this difference in behaviour. [3]

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For continuation only.

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	Formula	Name	Formula
aluminium	Al^{3+}	bromide	Br^{-}
ammonium	NH_4^{+}	carbonate	CO_3^{2-}
barium	Ba^{2+}	chloride	Cl^{-}
calcium	Ca^{2+}	fluoride	F^{-}
copper(II)	Cu^{2+}	hydroxide	OH^{-}
hydrogen	H^{+}	iodide	I^{-}
iron(II)	Fe^{2+}	nitrate	NO_3^{-}
iron(III)	Fe^{3+}	oxide	O^{2-}
lithium	Li^{+}	sulfate	SO_4^{2-}
magnesium	Mg^{2+}		
nickel	Ni^{2+}		
potassium	K^{+}		
silver	Ag^{+}		
sodium	Na^{+}		
zinc	Zn^{2+}		

THE PERIODIC TABLE

1	2					Group						3	4	5	6	7	0
						1 H Hydrogen 1											4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

A_r — relative atomic mass
Symbol
Name
Z — atomic number