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Tuesday 10 June 2014 – Afternoon

GCSE TWENTY FIRST CENTURY SCIENCE CHEMISTRY A/ADDITIONAL SCIENCE A

A172/02 Modules C4 C5 C6 (Higher Tier)

Candidates answer on the Question Paper.
A calculator may be used for this paper.

OCR supplied materials:
None

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: 1 hour

A172/02

3137558416

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with a pencil (✎).
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- This document consists of **24** pages. Any blank pages are indicated.
- A list of qualitative tests for ions is printed on page **2**.
- The Periodic Table is printed on the back page.

TWENTY FIRST CENTURY SCIENCE DATA SHEET

Qualitative analysis

Tests for ions with a positive charge

Ion	Test	Observation
calcium Ca^{2+}	add dilute sodium hydroxide	a white precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
copper Cu^{2+}	add dilute sodium hydroxide	a light blue precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
iron(II) Fe^{2+}	add dilute sodium hydroxide	a green precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
iron(III) Fe^{3+}	add dilute sodium hydroxide	a red-brown precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
zinc Zn^{2+}	add dilute sodium hydroxide	a white precipitate forms; the precipitate dissolves in excess sodium hydroxide

Tests for ions with a negative charge

Ion	Test	Observation
carbonate CO_3^{2-}	add dilute acid	the solution effervesces; carbon dioxide gas is produced (the gas turns lime water from colourless to milky)
chloride Cl^-	add dilute nitric acid, then add silver nitrate	a white precipitate forms
bromide Br^-	add dilute nitric acid, then add silver nitrate	a cream precipitate forms
iodide I^-	add dilute nitric acid, then add silver nitrate	a yellow precipitate forms
sulfate SO_4^{2-}	add dilute acid, then add barium chloride or barium nitrate	a white precipitate forms

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Question 1 begins on page 4

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Answer **all** the questions.

1 Johann Döbereiner was one of the first chemists to organise elements by their properties.

He found out that some sets of three elements seem to fit together because they have similar properties.

He called these sets of elements 'triads'.

(a) One triad contained the three elements, lithium, sodium and potassium.

All three elements react with water to give similar products.

Give **two** ways that the products of the reaction of the three elements with water are similar.

.....

.....

..... **[2]**

(b) The table shows some elements that could be considered to be triads.

Triad A	lithium	sodium	potassium
Triad B	calcium	strontium	barium
Triad C	chlorine	bromine	iodine
Triad D	carbon	nitrogen	oxygen

Most of these triads now fit into groups in the modern Periodic Table.

Which triad does not?

Explain your answer.

triad .....

explanation .....

.....

[2]

(c) Döbereiner looked at the relative atomic masses of the elements in some triads.

He noticed that the relative atomic mass of the 'middle' element was close to the mean relative atomic mass of the other two.

The table shows some examples of elements that appear to fit his pattern.

	Element and relative atomic mass			**Mean relative atomic mass of first and third element**
Triad A	lithium 7	***sodium*** ***23***	potassium 39	***23***
Triad B	calcium 40	***strontium*** ***88***	barium 137	***89***
Triad C	chlorine 35.5	***bromine*** ***80***	iodine 127	***81***

(i) Döbereiner asked other scientists to evaluate his data and ideas.

What **two** things would Döbereiner expect the other scientists to do?

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.....

..... **[2]**

(ii) Döbereiner found that some elements with similar properties did **not** fit the atomic mass pattern.

Three of these elements are copper, silver and gold.

Element and relative atomic mass		
copper 63.5	***silver*** ***108***	gold 197

How does this data show that copper, silver and gold do **not** fit Döbereiner's atomic mass pattern?

Use a calculation to support your answer.

.....

..... **[2]**

[Total: 8]

2 Chlorine reacts with metals in many groups of the Periodic Table to make metal chlorides.

(a) **Table 1** shows some information about metals and metal chlorides.

Metal	Number of electrons in outer shell of atom	Formula of metal ion	Formula of metal chloride
lithium	1	Li^+	$LiCl$
sodium	1	Na^+	$NaCl$
beryllium	2	Be^{2+}	$BeCl_2$
magnesium	2	Mg^{2+}	$MgCl_2$
aluminium	3	Al^{3+}	$AlCl_3$

Table 1

There are links between the information in the columns in the table.

Describe **two** of these links.

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.....

.....

..... **[2]**

(b) **Table 2** shows information about other metals and metal chlorides.

Complete the table by filling in the boxes.

Metal	Number of electrons in outer shell of atom	Formula of metal chloride
potassium	1	
calcium	2	$CaCl_2$
gallium	3	

Table 2

[2]

(c) Iron reacts with chlorine to form iron chloride, $FeCl_3$.

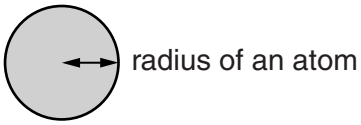
What are the symbols for the two ions in this compound?

..... and ..... **[2]**

[Total: 6]

3 Joe does some research about atoms of Group 1 elements.

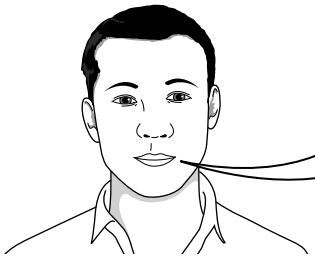
He finds data about the radius of each atom.



He also finds data about the energy needed to remove one electron from the outer shell (energy level) of each atom.

Element name	Total number of electrons in each atom	Radius of the atom in pm	Energy needed to remove one outer shell electron in arbitrary units
lithium	3	152	520
sodium	11	186	490
potassium	19	231	420

Joe works out the number of electron shells in each atom and puts forward a hypothesis.



I can see trends in both the radius of each atom and in the energy needed to remove an electron from its outer shell.

I think both trends are linked to the number of electron shells in each atom.

Joe

What trends does the table show? How does the number of **electron shells** in each atom link to these trends?

You may use diagrams to show the electron shells in each atom to support your answer.

The quality of written communication will be assessed in your answer.

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..... **[6]**

[Total: 6]

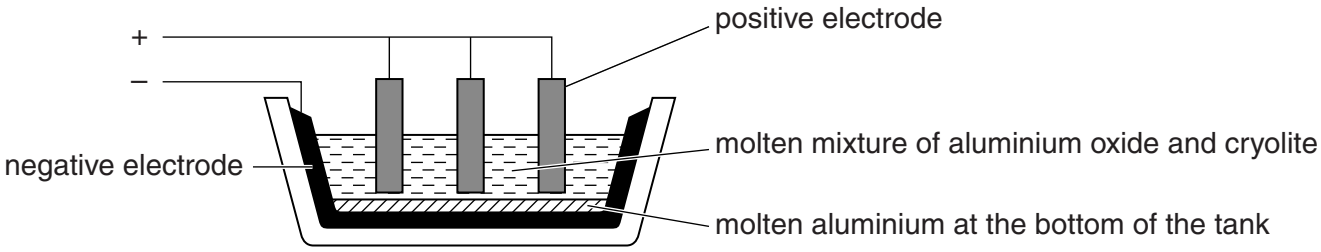
4 This question is about extracting metals.

(a) Aluminium is extracted from aluminium oxide by electrolysis.

The melting point of **pure** aluminium oxide is about 2000 °C.

In the industrial process, aluminium oxide is mixed with cryolite. The **mixture** melts at 900 °C.

The process works at about 1000 °C. Molten aluminium collects at the bottom of the electrolysis tank.



(i) Which of the following statements about electrolysing aluminium oxide are **true** and which are **false**?

Put a tick (✓) in one box in each row.

	true	**false**
Melting pure aluminium oxide uses more energy than melting a mixture of aluminium oxide and cryolite.		
After the mixture melts, it contains ions arranged in a regular lattice.		
The melting point of aluminium is above 1000 °C.		
A gas is made at the positive electrode.		
Below 900 °C the mixture does not conduct electricity.		

[2]

(ii) Aluminium ions (Al^{3+}) are attracted to the negative electrode.

Explain what happens to aluminium ions at the negative electrode.

You may use an equation to support your answer.

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..... **[2]**

(b) Copper can be extracted by heating copper oxide, CuO, with carbon.

The products of the reaction are carbon dioxide and copper.

(i) Write a balanced, symbol equation for the reaction.

[2]

(ii) The reaction between copper oxide and carbon involves **reduction**.

What does reduction mean?

..... **[1]**

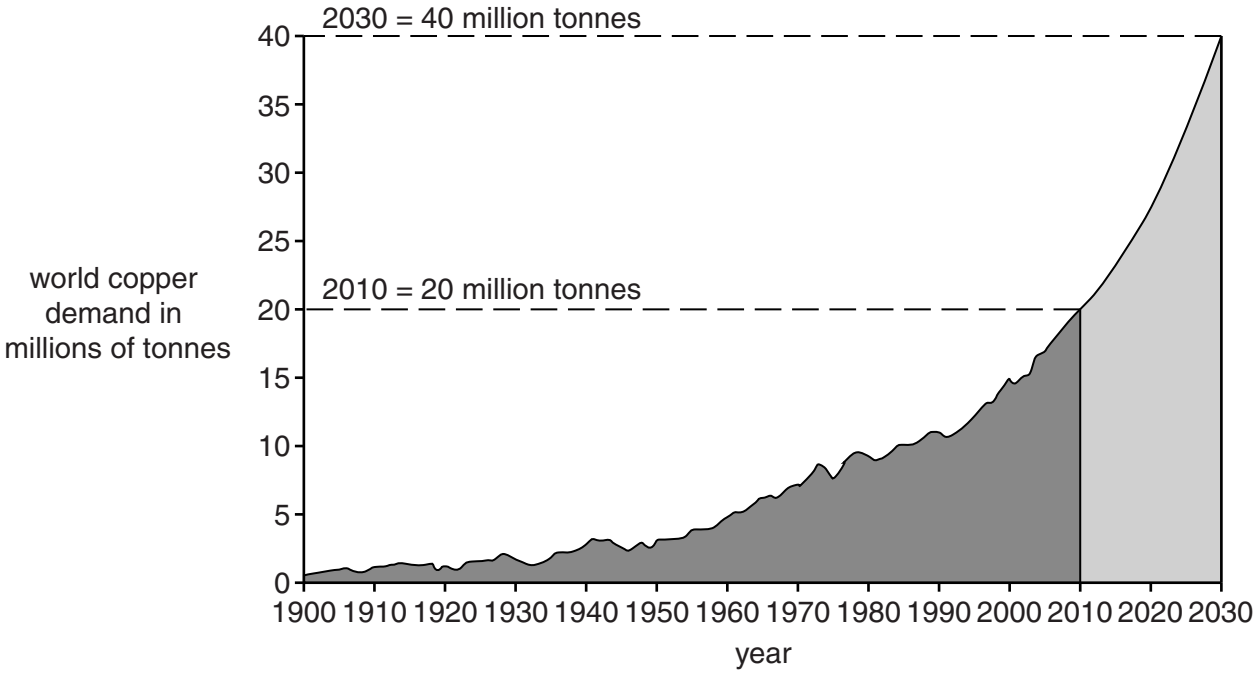
(iii) Why is it **not** possible to extract aluminium from aluminium oxide by heating with carbon?

..... **[1]**

[Total: 8]

5 Scientists are concerned about how the demand for copper is changing and how this will affect the supply of copper for the future.

The graph shows how the total world **demand** for copper has changed since 1900. The graph also shows the predicted demand for copper between 2010 and 2030.



The **supplies** of copper in the world come from four main countries. The copper deposits left in these countries are shown in the table.

Country	**Estimated copper deposits in millions of tonnes**
Chile	140
United States	90
Canada	23
Poland	36

Even if all scrap copper is recycled, this meets less than 50% of the world demand for copper.

(a) Scientists are very concerned about the balance between the supply and demand for copper from 2010 onwards.

Use the information about copper to discuss why they are so concerned.

The quality of written communication will be assessed in your answer.

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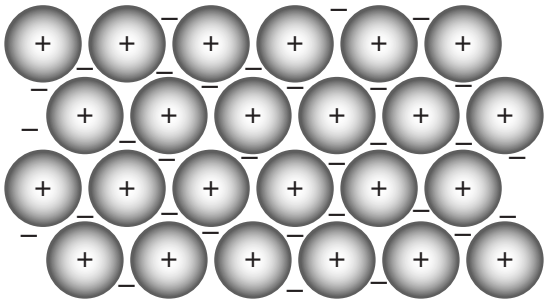
..... **[6]**

(b) The diagram shows how the particles in copper metal are arranged.



Complete the key to the diagram by filling in the boxes.

Key

+	
–	

Choose words from this list.

electron

negative ion

neutron

copper atom

copper ion

proton

[2]

(c) One reason why copper is useful is because it is malleable.

Which statement explains why copper is malleable?

Put a tick (✓) in the box next to the correct answer.

Copper is a good electrical conductor.	☐
Particles in copper can slide over each other.	☐
Bonds in the metal structure are strong.	☐
Metal particles are arranged in a regular crystal.	☐

[1]

(d) People living near a copper mine are worried about the water that runs out of the mine.

They think that the water might contain copper ions or other metal ions.

A scientist tests for metal ions by adding dilute sodium hydroxide to the water.

Why is dilute sodium hydroxide used to test for metal ions?

Put ticks (✓) in the boxes next to the **two** correct answers.

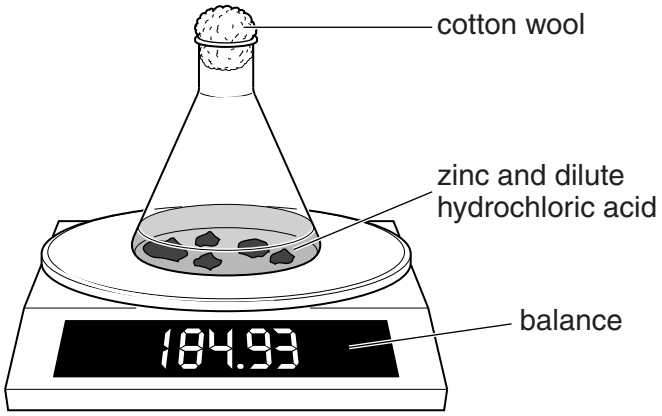
Many metal hydroxides are insoluble.	☐
The metals can be identified by the gases given off in the reactions.	☐
Different metal ions react at different rates with sodium hydroxide.	☐
Dilute sodium hydroxide is neutralised by the metal ions.	☐
Precipitates of metal compounds have characteristic colours.	☐

[2]

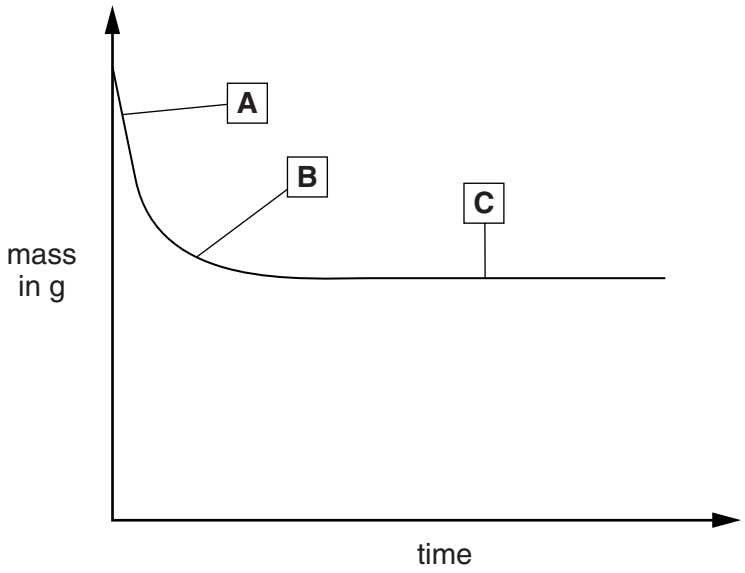
[Total: 11]

6 Liz does an experiment to investigate the rate of reaction between zinc and dilute hydrochloric acid.

She measures the mass of the flask during the reaction.



Liz plots her results on the graph below.



(a) Explain how and why the rate of reaction changes between points **A**, **B** and **C**, using ideas about the collisions between particles.

The quality of written communication will be assessed in your answer.

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..... **[6]**

(b) What is the name of the salt that is made when zinc reacts with hydrochloric acid?

..... **[1]**

(c) Liz reads an article on the internet which says that copper acts as a catalyst for this reaction.

She does an investigation to find out if this is true.

How should she do the investigation, and what results should she expect?

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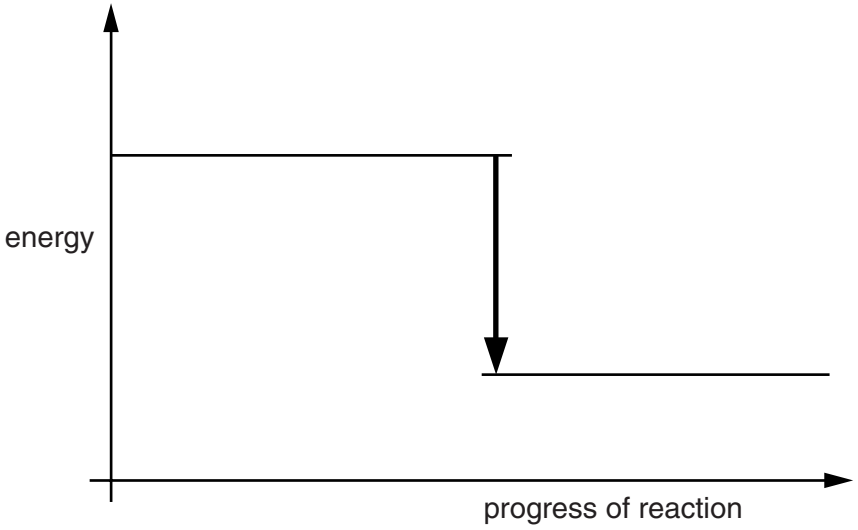
..... **[3]**

(d) This is the energy level diagram for the reaction between zinc and hydrochloric acid.



Which statements about the diagram are **true** and which are **false**?

Put a tick (✓) in one box in each row.

	true	**false**
The products are at a lower energy level than the reactants.		
The reaction is endothermic.		
The chemicals give out energy during the reaction.		
There is a temperature change during the reaction.		

[1]

[Total: 11]

7 Eve has two beakers of dilute acid.

One contains dilute hydrochloric acid, one contains dilute sulfuric acid.

(a) Complete the boxes to show which ions are in each acid.

Choose from this list. You may use each symbol once, more than once or not at all.

H_2 H^+ OH^- Cl^- ClO^- S^{2-} SO_4^{2-}

ions in dilute hydrochloric acid	ions in dilute sulfuric acid

[2]

Question 7(b) begins on page 20

(b) Eve does tests **A**, **B**, **C** and **D** on each acid.

A test pH using a pH meter
B add magnesium ribbon
C add a few drops of dilute silver nitrate (see data sheet page 2)
D add a few drops of dilute barium chloride (see data sheet page 2)

(i) Two tests give the **same** result with both hydrochloric acid and sulfuric acid.

Which two tests give the same result?

What will she **see** when she does each of these tests?

test .....

result .....

.....

test .....

result .....

.....

[3]

(ii) Two tests give a **different** result with hydrochloric acid and sulfuric acid.

Which two tests give a different result?

What will she **see** when she does each test?

test .....

result for each acid .....

.....

test .....

result for each acid .....

.....

[3]

(c) Both dilute hydrochloric acid and dilute sulfuric acid are neutralised when they react with dilute sodium hydroxide.

Complete the table to show the name and formula of the salt that is made from each acid.

Acid	**Salt formed with dilute sodium hydroxide**	
	Name	**Formula**
dilute hydrochloric acid		
dilute sulfuric acid		

[2]

[Total: 10]

END OF QUESTION PAPER

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The Periodic Table of the Elements

1	2											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
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **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	178 **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	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.