

Combined Science  
PAPER 2  
Higher Tier

Total Marks
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Friday 17 May 2024 – Morning

Time: 1 hour 10 minutes

In the boxes below, write your name, centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

## **YOU MUST HAVE**

**Calculator, ruler, Periodic Table (enclosed)**

## **YOU WILL BE GIVEN**

**Diagram Booklet**

## **INSTRUCTIONS**

**Answer ALL questions.**

**Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – there may be more space than you need.**

**Calculators may be used.**

**Any diagrams may NOT be accurately drawn, unless otherwise indicated.**

**You must show all your working out with your answer clearly identified at the end of your solution.**

## **INFORMATION**

**The total mark for this paper is 60.**

**The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.**

**INFORMATION continued.**

**In questions marked with an *ASTERISK* (\*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.**

**A Periodic Table is provided as a separate insert.**

**There may be spare copies of some diagrams.**

**ADVICE**

**Read each question carefully before you start to answer it.**

**Try to answer every question.**

**Check your answers if you have time at the end.**

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**Answer ALL questions. Write your answers in the spaces provided.**

**Some questions must be answered with a cross in a box ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

**1 Barium hydroxide reacts with dilute hydrochloric acid to form barium chloride solution and water.**

**(a) (i) Look at the equation for Question 1(a)(i) in the Diagram Booklet. Complete the balanced equation for the reaction by adding a NUMBER in front of  $\text{HCl(aq)}$**   
**(1 mark)**

**(ii) State what you would SEE during the reaction.**  
**(1 mark)**

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**(continued on the next page)**

**1 continued.**

- (b) A student investigated how the pH of the mixture changed as barium hydroxide was added to dilute hydrochloric acid.**

**The student used this method.**

- STEP 1** measure out **50 cm<sup>3</sup>** of dilute hydrochloric acid into a beaker using a measuring cylinder
- STEP 2** use a glass rod to place a drop of the acid onto a piece of universal indicator paper and record the pH
- STEP 3** add one spatula measure of barium hydroxide to the acid in the beaker and stir
- STEP 4** use the glass rod to place a drop of the mixture onto a new piece of universal indicator paper and record the pH again
- STEP 5** repeat steps 3 and 4 until there is no further change in the pH.

**(continued on the next page)**

**1(b) continued.**

- (i) Name a piece of equipment that could be used to measure the pH of a substance more accurately than universal indicator paper.  
(1 mark)**

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- (ii) Explain why, in step 3, the mixture was stirred after adding the barium hydroxide.  
(2 marks)**

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**Turn over**

1(b) continued.

(iii) Figure 1 shows the student's results.

**FIGURE 1**

<b>number of spatula measures of barium hydroxide</b>	<b>pH of mixture</b>
<b>0</b>	<b>1</b>
<b>1</b>	<b>1</b>
<b>2</b>	<b>1</b>
<b>3</b>	<b>1</b>
<b>4</b>	<b>3</b>
<b>5</b>	<b>8</b>
<b>6</b>	<b>12</b>
<b>7</b>	<b>13</b>
<b>8</b>	<b>13</b>

Look at the graph for Question 1(b)(iii) in the Diagram Booklet. Plot a graph of the pH of the mixture against the number of spatula measures of barium hydroxide.  
(3 marks)

(continued on the next page)

**2(b) continued.**

- (iv) Use the graph to find the pH of the mixture when  $4.5$  spatula measures of barium hydroxide are added.  
(1 mark)**

**pH of the mixture = \_\_\_\_\_**

**(Total for Question 1 = 9 marks)**

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2 Sodium carbonate has the formula  $\text{Na}_2\text{CO}_3$

(a) Sodium carbonate contains  $\text{Na}^+$  ions and  $\text{CO}_3^{2-}$  ions.

(i) The atomic number of sodium is 11

What is the electronic configuration of the  $\text{Na}^+$  ion?  
(1 mark)

- ☐ A 1
- ☐ B 2.8
- ☐ C 2.8.1
- ☐ D 2.8.2

(continued on the next page)

**2(a) continued.**

- (ii) Explain why solid sodium carbonate CANNOT conduct electricity but a solution of sodium carbonate CAN conduct electricity.  
(3 marks)**

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**2 continued.**

**(b) Calculate the percentage by mass of sodium in sodium carbonate,  $\text{Na}_2\text{CO}_3$**

**percentage by mass of element =**

$$\frac{\text{total relative atomic mass of element}}{\text{relative formula mass of compound}} \times 100$$

**(relative atomic masses: C = 12, O = 16,  
Na = 23)  
(3 marks)**

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**percentage by mass of sodium = \_\_\_\_\_**

**(Total for Question 2 = 7 marks)**

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**Turn over**

**3 This question is about the extraction of metals.**

- (a) Give TWO advantages of obtaining metals by recycling rather than by extracting them from their metal ores.  
(2 marks)**

**1** \_\_\_\_\_

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\_\_\_\_\_

**2** \_\_\_\_\_

\_\_\_\_\_

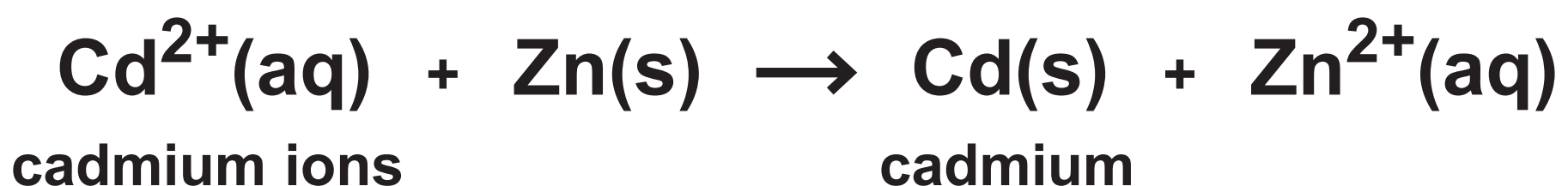
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### 3 continued.

**(b) (i) Small amounts of some metals are extracted using displacement reactions.**

**In one process, zinc dust is used to precipitate cadmium metal from a solution containing cadmium ions.**



**Explain why this displacement reaction can be described as a REDOX REACTION.**

**(3 marks)**

**Answer space continues on the next page.**

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**Turn over**

3(b)(i) continued.

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(ii) The formula of the cadmium ion is  $\text{Cd}^{2+}$   
The formula of the phosphate ion is  $\text{PO}_4^{3-}$

Which is the formula of cadmium phosphate?  
(1 mark)

☐ A  $\text{Cd}_2(\text{PO}_4)_3$

☐ B  $\text{Cd}_3\text{PO}_{12}$

☐ C  $\text{Cd}_3(\text{PO}_4)_2$

☐ D  $\text{Cd}_3\text{P}_2\text{O}_8$

(continued on the next page)

**3 continued.**

- (c) One of the alternative biological methods of extracting metals from very low-grade ores is bioleaching using bacteria.**

**Give one DISADVANTAGE of this method of extracting metals from low-grade ores.**

**(1 mark)**

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### 3 continued.

**(d) Lead is low in the reactivity series.**

**Describe how to obtain a sample of lead from some lead oxide in the laboratory.**

**(2 marks)**

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**(Total for Question 3 = 9 marks)**



- 4 (a) Water, acidified with dilute sulfuric acid, was electrolysed for **10 minutes** using inert electrodes.**

**Look at Figure 2 for Question 4(a) in the Diagram Booklet. It shows the apparatus used.**

- (i) In this electrolysis, the acidified water is an electrolyte.**

**Explain why acidified water is an electrolyte.  
(2 marks)**

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4(a) continued.

- (ii) Hydrogen collects at the negative electrode and oxygen collects at the positive electrode.

Look at the diagrams for Question 4(a)(ii) in the Diagram Booklet. Which of these shows the results after **10 minutes** of this electrolysis?  
(1 mark)

☐ A diagram **A**

☐ B diagram **B**

☐ C diagram **C**

☐ D diagram **D**

- (iii) Complete and balance the half equation for the formation of oxygen at the positive electrode in this electrolysis.  
(2 marks)



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**4 continued.**

- (b) Copper sulfate solution was electrolysed for 10 minutes using copper electrodes.**

**Look at Figure 3 for Question 4(b) in the Diagram Booklet. It shows the mass of the cathode and the appearance of the copper sulfate solution before electrolysis and after electrolysis.**

- (i) Describe what should be done to the copper cathode, after it has been removed from the copper sulfate solution, before its final mass is determined.**  
**(2 marks)**

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**4(b) continued.**

- (ii) Explain, in terms of ions, the change in mass of the cathode shown in Figure 3.  
(2 marks)**

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**4(b) continued.**

- (iii) Explain why the appearance of the copper sulfate solution did not change during the electrolysis.  
(2 marks)**

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**(Total for Question 4 = 11 marks)**

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**5 This question is about the properties of different substances.**

**(a) Silicon tetrachloride is a simple molecular covalent compound.**

**(i) A molecule of silicon tetrachloride is composed of a silicon atom and four chlorine atoms.**

- **a silicon atom has 4 outer electrons**
- **a chlorine atom has 7 outer electrons**

**Look at the blank page for Question 5(a)(i) in the Diagram Booklet. Draw a dot and cross diagram of a molecule of silicon tetrachloride,  $\text{SiCl}_4$**

**Show outer electrons only.  
(2 marks)**

**(continued on the next page)**

**5(a) continued.**

- (ii) Explain why simple molecular covalent compounds such as silicon tetrachloride have low melting and boiling points.  
(2 marks)**

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**(continued on the next page)**

**5 continued.**

**(b) Look at Figure 4 for Question 5(b) in the Diagram Booklet. Part of the structure of rubidium bromide is shown.**

**Which row shows the most likely melting point and boiling point of rubidium bromide?**

**(1 mark)**

	<b>melting point in °C</b>	<b>boiling point in °C</b>
<input type="checkbox"/> <b>A</b>	<b>6·93</b>	<b>134·0</b>
<input type="checkbox"/> <b>B</b>	<b>69·3</b>	<b>134·0</b>
<input type="checkbox"/> <b>C</b>	<b>69·3</b>	<b>1340</b>
<input type="checkbox"/> <b>D</b>	<b>693</b>	<b>1340</b>

**(continued on the next page)**



**5 continued.**

**\*(c) Diamond and graphite are two forms of carbon.**

**Look at Figure 5 for Question 5(c) in the Diagram Booklet. It shows how the carbon atoms are arranged in a part of the structure of each of these forms of carbon.**

- **diamond is one of the hardest known substances on Earth and is used in cutting tools.**
- **graphite is soft and flaky.**
- **diamond is a poor electrical conductor, but graphite is a good electrical conductor.**

**Explain, in terms of structure and bonding, these properties of diamond and graphite.  
(6 marks)**

**Answer space continues on the next 4 pages.**

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**5(c) continued.**

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**5(c) continued.**

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**5(c) continued.**

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**5(c) continued.**

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**(Total for Question 5 = 11 marks)**

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- 6 (a) An investigation was carried out on the reactivity of four metals, D, E, F and G.**

**Equal sized pieces of these metals were placed in excess dilute hydrochloric acid and left for three minutes.**

**Look at Figure 6 for Question 6(a) in the Diagram Booklet. It shows the observations of the reactions for metals D, E and F.**

**Look at Figure 7 for Question 6(a) in the Diagram Booklet. It shows the order of reactivity for these metals.**

- (i) Use the information in Figure 6 and Figure 7 to suggest the observations that would be made for metal G.**  
**(2 marks)**

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**6(a) continued.**

- (ii) The dilute hydrochloric acid used in this reaction is a strong acid.**

**Explain the meaning of the terms DILUTE and STRONG ACID.**

**(4 marks)**

**Answer space continues on the next page.**

**dilute**

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**6(a)(ii) continued.**

**strong acid**

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6 continued.

(b) The formula of lead ethanoate is  $\text{Pb}(\text{CH}_3\text{COO})_2$

Calculate the number of ATOMS that combine together to form **16.25 g** of lead ethanoate.

(relative atomic masses:  $\text{H} = 1.00$ ,  $\text{C} = 12.0$ ,  
 $\text{O} = 16.0$ ,  $\text{Pb} = 207$

Avogadro number =  $6.02 \times 10^{23}$ )  
(4 marks)

Answer space continues on the next page.

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**6(b) continued.**

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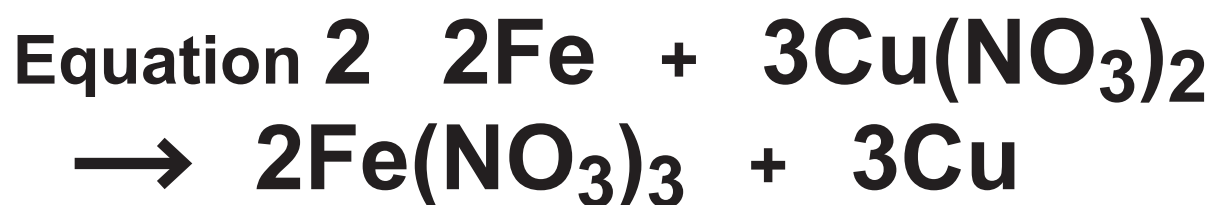
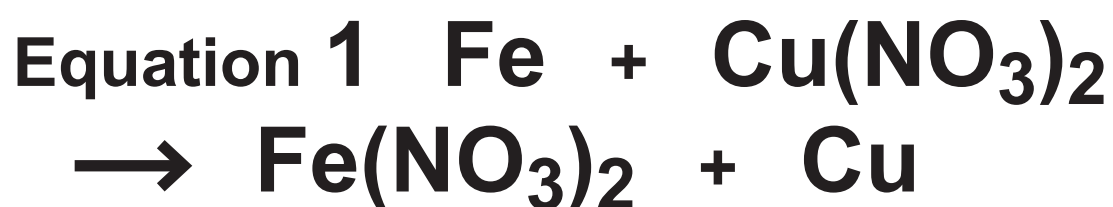
**number of atoms =** \_\_\_\_\_

**(continued on the next page)**

6 continued.

(c) Iron is more reactive than copper.

Iron will displace copper from copper nitrate solution. Two possible balanced equations for the reaction are



It was found that **2.24 g** of iron reacted with excess copper nitrate solution to form **3.81 g** of copper.

Carry out a calculation, using the information above, to show which equation represents the reaction taking place.

(relative atomic masses: **Fe = 56.0**, **Cu = 63.5**)  
(3 marks)

Answer space continues on the next page.

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**6(c) continued.**

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**(Total for Question 6 = 13 marks)**

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**TOTAL FOR PAPER = 60 MARKS**  
**END OF PAPER**