

Combined Science
PAPER 2
Higher Tier

Total Marks

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.

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.

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

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

- 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 HCl(aq) (1 mark)**

(continued on the next page)

1(a) continued.

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

(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^3 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)

Turn over

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)**

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

1(b) continued.

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

FIGURE 1

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

(continued on the next page)

Turn over

1(b)(iii) continued.

**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)**

**(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)

2 Sodium carbonate has the formula Na_2CO_3

(a) Sodium carbonate contains Na^+ ions and CO_3^{2-} ions.

(i) The atomic number of sodium is 11

**What is the electronic configuration of the 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)**

(continued on the next page)

Turn over

2 continued.

(b) Look at the equation for Question 2(b) in the Diagram Booklet.

Calculate the percentage by mass of sodium in sodium carbonate, Na_2CO_3 (3 marks)

percentage by mass of sodium =

(Total for Question 2 = 7 marks)

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 _____

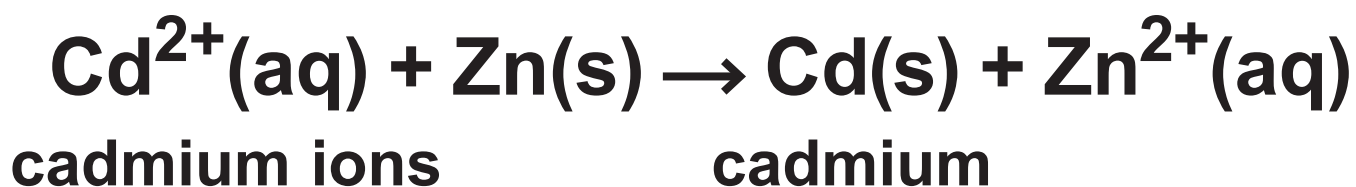
2 _____

(continued on the next page)

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.

Turn over

3(b)(i) continued.

(continued on the next page)

3(b) continued.

(ii) The formula of the cadmium ion
is Cd^{2+}

The formula of the phosphate ion
is 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)

Turn over

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)**

(continued on the next page)

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)

Answer space continues on the next page.

Turn over

3(d) continued.

(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)**

(continued on the next page)

Turn over

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**

(continued on the next page)

4(a) continued.

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



(continued on the next page)

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)**

Answer space continues on the next page.

Turn over

4(b)(i) continued.

(continued on the next page)

4(b) continued.

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

(continued on the next page)

4(b) continued.

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

(Total for Question 4 = 11 marks)

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, 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)**

(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)

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

(continued on the next page)

Turn over

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.

Turn over

5(c) continued.

[illegible]

Turn over

5(c) continued.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Turn over

5(c) continued.

[illegible]

Turn over

5(c) continued.

[illegible]

(Total for Question 5 = 11 marks)

Turn over

- 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.

(continued on the next page)

6(a) continued.

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

(continued on the next page)

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

6(a)(ii) continued.

strong acid

(continued on the next page)

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:

H = 1.00, C = 12.0,

O = 16.0, Pb = 207

**Avogadro number = 6.02×10^{23})
(4 marks)**

Answer space continues on the next page.

Turn over

6(b) continued.

number of atoms = _____

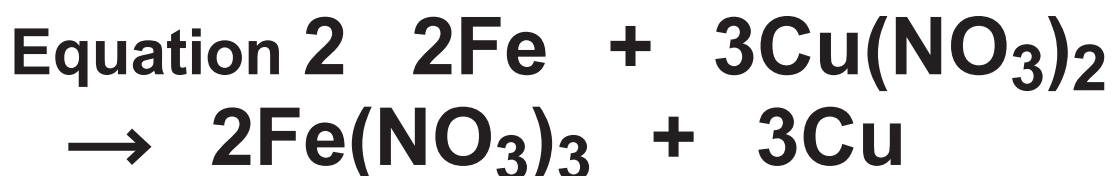
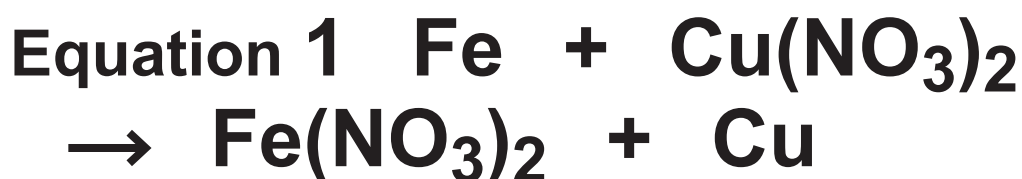
(continued on the next page)

Turn over

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: $\text{Fe} = 56.0$,
 $\text{Cu} = 63.5$)
(3 marks)

Answer space continues on the next page.

Turn over

6(c) continued.

(Total for Question 6 = 13 marks)

TOTAL FOR PAPER = 60 MARKS
END OF PAPER