

Combined Science
PAPER 2
Higher Tier

Total Marks

Monday 22 May 2023 – 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

YOU WILL BE GIVEN

Diagram Booklet, Periodic Table

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.

Turn over

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 the question 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.**

There is a periodic table 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 ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

- 1 In an experiment, powdered calcium hydroxide was added to dilute hydrochloric acid and the pH was measured.**

The method used was

STEP 1 measure 200 cm³ dilute hydrochloric acid into a beaker

STEP 2 add 0.1 g of powdered calcium hydroxide to the beaker

STEP 3 find the pH of the mixture

STEP 4 repeat steps 2 and 3 until the pH stops changing.

(continued on the next page)

1 continued.

- (a) State what should be done after
STEP 2 to make sure that any reaction
is complete.
(1 mark)**

- (b) Complete the word equation for
the reaction.
(2 marks)**

calcium hydroxide + hydrochloric acid →

(continued on the next page)

1 continued.

- (c) Which row of the table shows the state symbols for powdered calcium hydroxide and dilute hydrochloric acid in the balanced chemical equation?
(1 mark)**

	calcium hydroxide	hydrochloric acid
<input type="checkbox"/> A	aq	l
<input type="checkbox"/> B	l	aq
<input type="checkbox"/> C	s	aq
<input type="checkbox"/> D	s	l

(continued on the next page)

Turn over

1 continued.

(d) Look at Figure 1 for Question 1(d) in the Diagram Booklet. The results of the experiment are shown in Figure 1.

- (i) Using Figure 1, give the pH of the acid at the start of the experiment.
(1 mark)**

pH = _____

- (ii) Using Figure 1, give the mass of calcium hydroxide required to make a neutral mixture.
(1 mark)**

**mass of calcium hydroxide =
_____ g**

(continued on the next page)

Turn over

1(d) continued.

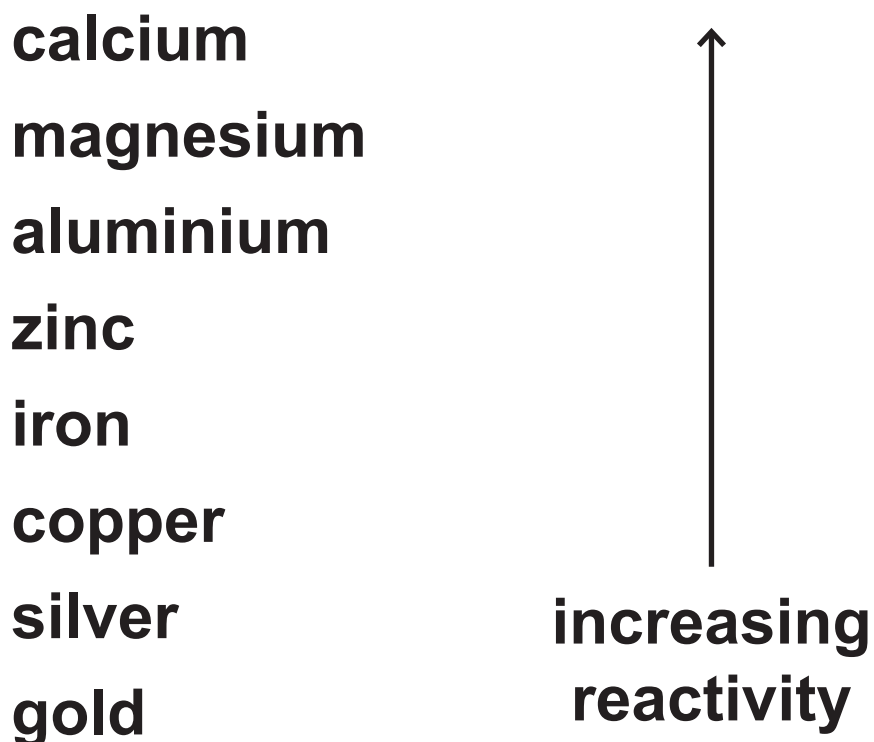
**(iii) Explain why the pH starts at a low value and ends at a higher value.
(3 marks)**

(Total for Question 1 = 9 marks)

Turn over

- 2 Figure 2 shows part of the reactivity series of metals.

FIGURE 2



- (a) Which metal reacts when added to cold water?
(1 mark)

- ☐ A calcium
- ☐ B copper
- ☐ C gold
- ☐ D silver

2 continued.

- (b) A student investigates the reactivity of four different metals.**

The student adds an equal-sized piece of each metal to separate test tubes containing dilute hydrochloric acid.

Look at Figure 3 for Question 2(b) in the Diagram Booklet. The student's observations for zinc and copper are recorded in Figure 3.

- (i) Use the information in Figure 2 and in Figure 3 to predict the observations for the reactions of magnesium and of iron with dilute hydrochloric acid.
(2 marks)**

Answer space continues on the next page.

2(b)(i) continued.

magnesium

iron

(continued on the next page)

2(b) continued.

**(ii) When metals react with acids,
hydrogen gas is produced.**

**Describe the test to show that the
gas is hydrogen.
(2 marks)**

(continued on the next page)

2(b) continued.

(iii) When magnesium reacts with hydrochloric acid, magnesium chloride and hydrogen are formed.

**Complete the balanced equation for the reaction.
(2 marks)**



(c) An excess of magnesium is added to some dilute hydrochloric acid of pH 2.

The mass of hydrogen gas produced is measured.

The experiment is repeated with excess magnesium but with the same volume of dilute hydrochloric acid of pH 1.

2(c) continued.

- (i) State how many times greater the concentration of hydrogen ions is in the acid of pH 1 than in the acid of pH 2.
(1 mark)**

(continued on the next page)

2(c) continued.

- (ii) With the acid of pH 2, the mass of hydrogen gas produced when the reaction is complete is 0.005 g.**

**Predict the mass of hydrogen gas produced in the reaction with acid of pH 1.
(1 mark)**

mass = _____ g

(Total for Question 2 = 9 marks)

3 (a) Ammonia is manufactured in the Haber process by the reversible reaction between nitrogen and hydrogen.

**(i) Write the balanced equation for the reversible reaction between nitrogen and hydrogen to make ammonia, NH_3 .
(3 marks)**

(continued on the next page)

3(a) continued.

- (ii) Which row shows the typical conditions of temperature and pressure used in the Haber process?
(1 mark)**

	temperature in °C	pressure in atmospheres
<input type="checkbox"/> A	250	100
<input type="checkbox"/> B	250	200
<input type="checkbox"/> C	450	500
<input type="checkbox"/> D	450	200

(continued on the next page)

3(a) continued.

(iii) In the Haber process, iron is added to the vessel where the nitrogen and hydrogen react.

**State the purpose of the iron.
(1 mark)**

(continued on the next page)

3(a) continued.

(iv) The reaction between nitrogen and hydrogen to make ammonia can reach dynamic equilibrium.

The reaction gives out heat.

**Explain how the position of equilibrium changes if the temperature is decreased.
(2 marks)**

(continued on the next page)

Turn over

3 continued.

(b) Compound A is a dark brown gas.

Compound B is a colourless gas.

**Two molecules of A combine
to form one molecule of B in a
reversible reaction.**

You are given

- **a sealed glass tube containing an equilibrium mixture of A and B**
- **a beaker**
- **a kettle**
- **some ice**

(continued on the next page)

Turn over

3(b) continued.

At room temperature, the equilibrium mixture is a pale brown colour.

Devise an experiment to show how the position of equilibrium of this reaction is affected by temperature.

**The sealed tube must NOT be opened.
(3 marks)**

Answer space continues on the next page.

Turn over

3(b) continued.

(Total for Question 3 = 10 marks)

- 4 A student investigates the mass of copper produced when copper chloride solution in a beaker is electrolysed using inert electrodes.**

**(a) Where is copper formed during the electrolysis?
(1 mark)**

- ☐ **A at the anode**
- ☐ **B at the bottom of the beaker**
- ☐ **C at the cathode**
- ☐ **D on the surface of the electrolyte**

(continued on the next page)

4 continued.

- (b) The student investigated the change in the mass of copper formed when the current was altered.**

Look at Figure 4 for Question 4(b) in the Diagram Booklet. The results are shown in Figure 4.

- (i) State and explain the trend shown in these results.
(3 marks)**

Answer space continues on the next page.

Turn over

4(b)(i) continued.

(continued on the next page)

4(b) continued.

(ii) Describe how, after the power supply has been switched off, the mass of copper formed can be measured.

(2 marks)

(continued on the next page)

4 continued.

(c) In another experiment, 74 mg of copper is formed.

Calculate the number of copper atoms in 74 mg of copper.

**(relative atomic mass Cu = 63.5;
Avogadro constant = 6.02×10^{23})
(3 marks)**

number of atoms = _____

(Total for Question 4 = 9 marks)

Turn over

5 Crystals of copper sulfate are prepared by reacting copper oxide, a base, with dilute sulfuric acid.

**(a) Name the other product of this reaction.
(1 mark)**

(b) During the experiment, a spatula measure of copper oxide, a black powder, is added to warm, dilute sulfuric acid in a beaker.

When the mixture is stirred, the black powder disappears and the mixture turns pale blue.

The student then adds more copper oxide until the maximum amount of copper sulfate is formed without wasting copper oxide.

(continued on the next page)

5(b) continued.

**Explain how the student knows when
to stop adding copper oxide.
(3 marks)**

(continued on the next page)

5 continued.

(c) The reaction produces an aqueous solution of copper sulfate.

**What is the best way to obtain crystals of copper sulfate from an aqueous solution?
(1 mark)**

- ☐ **A pour the solution through filter paper in a funnel**
- ☐ **B heat the solution with a Bunsen burner until dry**
- ☐ **C heat the solution using a water bath**
- ☐ **D leave the solution in a cold, damp place**

(continued on the next page)

Turn over

5 continued.

(d) When some water is removed from the aqueous solution of copper sulfate, crystals of copper sulfate are made.

**Describe how the arrangement and movement of the particles change as crystals are formed from a solution.
(3 marks)**

Answer space continues on the next page.

Turn over

5(d) continued.

(e) In this reaction, copper oxide, CuO , forms copper sulfate, CuSO_4

**Explain, in terms of electrons, whether the copper in copper oxide has been oxidised, has been reduced, or has not been oxidised or reduced.
(2 marks)**

5 continued.

- (f) In another experiment, a copper sulfate solution with a concentration of 39.875 g dm^{-3} is used.**

Calculate the mass of copper sulfate dissolved in 0.300 dm^3 of this solution.

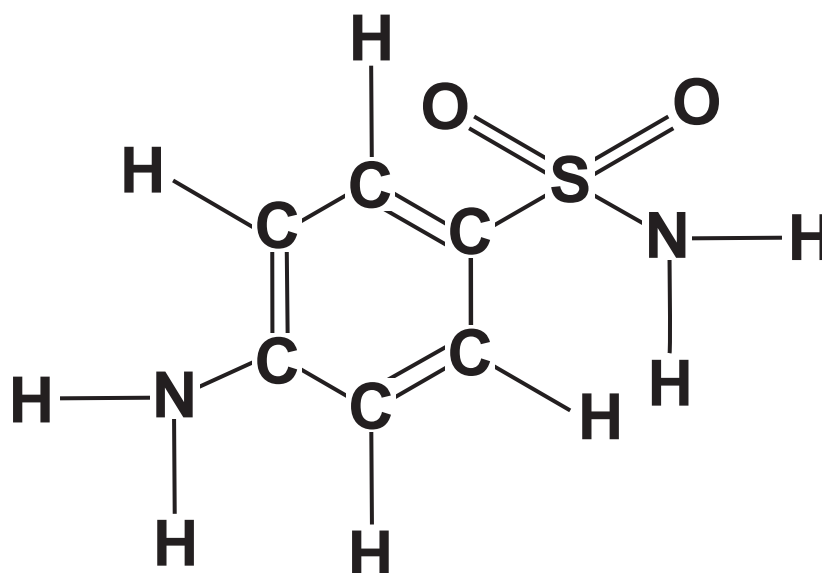
(1 mark)

mass = _____ g

(Total for Question 5 = 11 marks)

- 6 (a) Figure 5 shows the structure of a molecule of compound S.

FIGURE 5



- (i) Use Figure 5 to deduce the empirical formula of compound S.
(1 mark)

(continued on the next page)

6(a) continued.

- (ii) Look at Figure 6 for Question 6(a) (ii) in the Diagram Booklet. The melting points of three samples of S are shown in Figure 6.**

**State whether each of these samples, A, B and C, is pure or impure and justify your answers using the information in Figure 6.
(3 marks)**

Answer space continues on the next page.

Turn over

6(a)(ii) continued.

(continued on the next page)

6 continued.

(b) A scientist uses chromatography in an investigation of compound S.

In the conditions used, compound S has an R_f value of 0.22

**Calculate the distance the spot of compound S moves if the solvent front has moved by 2.4 cm.
(2 marks)**

distance = _____ cm

(continued on the next page)

Turn over

6 continued.

- *(c) A solution of sodium chloride in water needs to be separated to obtain a sample of pure, dry sodium chloride and a sample of pure water.**

Look at Figure 7 for Question 6(c) in the Diagram Booklet. It shows the boiling points of sodium chloride and water.

**Explain this difference in boiling points in terms of the structure and bonding of sodium chloride and water and how this difference is used to choose a method to separate sodium chloride solution into pure, dry sodium chloride and pure water.
(6 marks)**

Answer space continues on the next 5 pages.

Turn over

6(c) continued.

Turn over

6(c) continued.

Turn over

6(c) continued.

Turn over

6(c) continued.

Turn over

6(c) continued.

(Total for Question 6 = 12 marks)

TOTAL FOR PAPER = 60 MARKS
END OF PAPER