

Chemistry

UNIT: 4CH1

Science (Double Award) 4SD0

PAPER: 1CR

Total Marks
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Friday 17 May 2024 – Morning

Time: 2 hours

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**

**Periodic Table**

**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.**

**Show all the steps in any calculations and state the units.**

## **INFORMATION**

**The total mark for this paper is 110.**

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

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

**ADVICE**

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

**Write your answers neatly and in good English.**

**Try to answer every question.**

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

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**Answer ALL questions.**

**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 This question is about atomic structure.**

- (a) Look at the table for Question 1(a) in the Diagram Booklet. It shows the number of protons, neutrons and electrons in five species, V, W, X, Y and Z.**

**The letters represent the species but are NOT symbols from the Periodic Table.**

**Choose letters from the table to answer these questions.**

**Each letter may be used once, more than once or not at all.**

- (i) Which species is an atom?  
(1 mark)**

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**(continued on the next page)**

**Turn over**

**1(a) continued.**

**(ii) Which species is an ion with a positive charge?  
(1 mark)**

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**(iii) Which species is an ion with a 3<sup>−</sup> charge?  
(1 mark)**

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**(b) (i) State what is meant by the term  
ATOMIC NUMBER.  
(1 mark)**

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**(continued on the next page)**

**1(b) continued.**

- (ii) State what is meant by the term  
MASS NUMBER.  
(1 mark)**

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**(Total for Question 1 = 5 marks)**

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**2 This question is about methane,  $\text{CH}_4$**

**Look at the diagram for Question 2 in the Diagram Booklet. It shows a Bunsen burner that uses methane.**

- (a) During combustion, methane reacts with a gas in the air.**

**Give the name of this gas.  
(1 mark)**

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- (b) Give the two products of the complete combustion of methane.  
(2 marks)**

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**(continued on the next page)**

**2 continued.**

**(c) During the incomplete combustion of methane, carbon monoxide forms.**

**(i) Give a reason why carbon monoxide forms during incomplete combustion.  
(1 mark)**

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**(ii) State why carbon monoxide is poisonous.  
(1 mark)**

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**(continued on the next page)**



**2 continued.**

- (d) The equation shows the reaction of methane with bromine.**



**Give the name of this type of chemical reaction.  
(1 mark)**

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**(Total for Question 2 = 6 marks)**

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**3 This question is about elements, mixtures and compounds.**

**(a) Look at the list of words for Question 3(a) in the Diagram Booklet. It gives some methods used to separate mixtures.**

**Choose methods from the list to answer these questions.**

**(i) Identify a method to remove sand from a mixture of sand and seawater.  
(1 mark)**

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**(ii) Identify a method to separate a mixture of liquids with different boiling points.  
(1 mark)**

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**(continued on the next page)**

**3 continued.**

- (b) Look at the diagram for Question 3(b) in the Diagram Booklet. It shows part of the structure of silicon dioxide.**

**Explain why silicon dioxide is a compound.  
(2 marks)**

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**(continued on the next page)**

**3 continued.**

**(c) The molecular formula of the compound insulin is  $\text{C}_{257}\text{H}_{383}\text{N}_{65}\text{O}_{77}\text{S}_6$**

**(i) Determine the number of different elements in  $\text{C}_{257}\text{H}_{383}\text{N}_{65}\text{O}_{77}\text{S}_6$**   
**(1 mark)**

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**(continued on the next page)**

**3(c) continued.**

- (ii) Determine the number of atoms in a molecule  
of  $\text{C}_{257}\text{H}_{383}\text{N}_{65}\text{O}_{77}\text{S}_6$   
(1 mark)**

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

**(continued on the next page)**

**3 continued.**

- (d) Magnalium is a mixture of magnesium atoms and aluminium atoms.**

**Look at the diagram for Question 3(d) in the Diagram Booklet. It shows a sample of magnalium.**

**Calculate the percentage of magnesium atoms in this sample.**

**(2 marks)**

**percentage = \_\_\_\_\_ %**

**(Total for Question 3 = 8 marks)**

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**4 This question is about the alkali metals.**

**A teacher demonstrates the reaction between sodium and water.**

**Look at the diagram for Question 4 in the Diagram Booklet. The teacher fills a trough with water and then adds a piece of sodium.**

**(a) The sodium reacts with the water, forming bubbles of hydrogen gas and a colourless solution.**

**State two other observations that would be made.  
(2 marks)**

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

\_\_\_\_\_

\_\_\_\_\_

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

\_\_\_\_\_

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**(continued on the next page)**

**4 continued.**

- (b) Give a test to show that, at the end of the reaction, the solution contains sodium ions.  
(2 marks)**

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- (c) Lithium, sodium and potassium react in a similar way when added to water.**

- (i) State, with reference to the electronic configurations of atoms, why these elements have similar reactions.  
(1 mark)**

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**(continued on the next page)**

**Turn over**



4(c) continued.

- (ii) The table shows the atomic radius of a lithium atom, a sodium atom and a potassium atom.

Atom	Atomic radius in cm
lithium	$1.82 \times 10^{-12}$
sodium	$2.27 \times 10^{-12}$
potassium	$2.80 \times 10^{-12}$

Deduce the relationship between the atomic radius and the reactivity of the metals.  
(1 mark)

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(Total for Question 4 = 6 marks)

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**5 Chromatography is used to separate the components in a mixture.**

**(a) Look at Diagram 1 for Question 5(a) in the Diagram Booklet. It shows the apparatus used to separate the different dyes in a food colouring.**

**(i) Complete the missing labels below.  
(3 marks)**

**A** \_\_\_\_\_

\_\_\_\_\_

**B** \_\_\_\_\_

\_\_\_\_\_

**C** \_\_\_\_\_

\_\_\_\_\_

**(continued on the next page)**

**5(a) continued.**

- (ii) Give a reason why the baseline is drawn in pencil.  
(1 mark)**

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- (b) Look at Diagram 2 for Question 5(b) in the Diagram Booklet. It shows a chromatogram produced from four different food colourings, **W**, **X**, **Y** and **Z**.**

- (i) Which two food colourings contain the same dye?  
(1 mark)**

☐ **A    W and X**

☐ **B    W and Y**

☐ **C    X and Z**

☐ **D    Y and Z**

**(continued on the next page)**

5(b) continued.

- (ii) Calculate the  $R_f$  value of the dye in food colouring **W**.  
(2 marks)

$R_f =$  \_\_\_\_\_

(Total for Question 5 = 7 marks)

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- 6 Look at the diagram for Question 6(a) in the Diagram Booklet. A student uses the apparatus to find the heat energy released by the combustion of liquid fuels.**

**(a) Explain what is meant by the term FUEL.  
(2 marks)**

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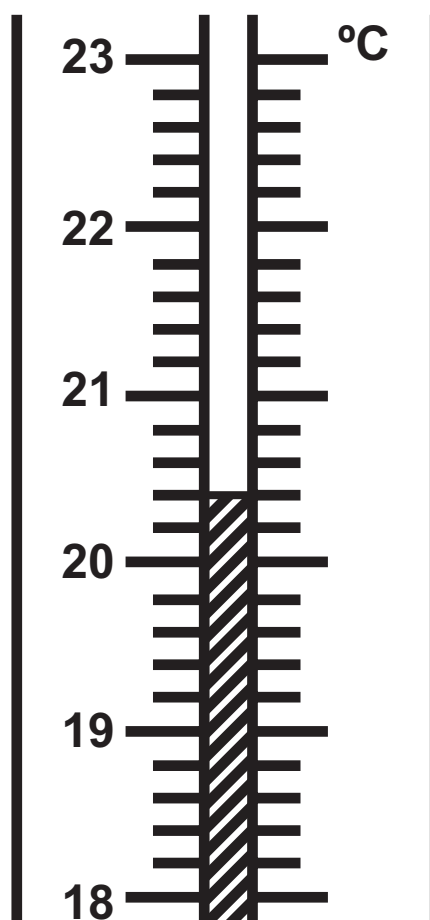
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**(continued on the next page)**

6 continued.

- (b) (i) In one experiment, the student uses liquid ethanol as the fuel.

The thermometer shows the temperature of the water at the start of the experiment.



Look at the table for Question 6(b)(i) in the Diagram Booklet. Complete the table by giving the temperatures to the nearest  $0.1^{\circ}\text{C}$  (2 marks)

(continued on the next page)

6(b) continued.

(ii) The metal can contains water of mass **150 g**.

Show, by calculation, that the heat energy change (**Q**) for this reaction is approximately **36 000 J**  
(2 marks)

[for water, **c = 4.2 J/g/°C**]

**Q = \_\_\_\_\_ J**

(continued on the next page)

**6(b) continued.**

- (iii) In the experiment, 2.3 g of ethanol ( $M_r = 46$ ) is burned.**

**Calculate the molar enthalpy change ( $\Delta H$ ),  
in  **$\text{kJ/mol}$** , for the combustion of ethanol,  
 **$\text{C}_2\text{H}_5\text{OH}$****

**Include a sign in your answer.**

**Give your answer to two significant figures.  
(4 marks)**

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



**6(b)(iii) continued.**

**$\Delta H =$  \_\_\_\_\_ **kJ/mol****

**(continued on the next page)**

**6 continued.**

- (c) In this experiment, the calculated value of  $\Delta H$  is less than the value given in a data book.**

**Give a possible reason for the difference in values.  
(1 mark)**

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**(Total for Question 6 = 11 marks)**

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- 7** Look at the diagram for Question 7 in the Diagram Booklet. A student uses the apparatus to investigate the rate of reaction between dilute sulfuric acid and an excess of small pieces of zinc.

This is the student's method.

**Step 1** use **50 cm<sup>3</sup>** of dilute sulfuric acid

**Step 2** add approximately **5 g** of small zinc pieces to the sulfuric acid

**Step 3** quickly connect the gas syringe

**Step 4** record the reading on the gas syringe every 30 seconds until the reaction stops

- (a) (i)** Name a suitable piece of apparatus to measure the volume of sulfuric acid.  
(1 mark)
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(continued on the next page)

**7(a) continued.**

- (ii) Give a reason why the mass of zinc pieces does not need to be measured accurately.  
(1 mark)**

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- (iii) Give a reason why the student quickly connects the gas syringe in step 3  
(1 mark)**

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- (iv) State how the student would know when the reaction stops.  
(1 mark)**

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**7 continued.**

**(b) Look at the graph for Question 7(b) in the Diagram Booklet. It shows the volume of gas collected in the syringe during the experiment.**

**(i) A tangent to the curve has been drawn at a time of 80 s**

**Use the tangent to calculate the rate of reaction at 80 s**

**Show your working on the graph.**

**Give the unit.  
(3 marks)**

**rate of reaction = \_\_\_\_\_**

**unit \_\_\_\_\_**

**(continued on the next page)**

**7(b) continued.**

- (ii) Explain the shape of the graph in these regions.  
(6 marks)**

**Answer space continues on the next 2 pages.**

**from 0 s to 60 s**

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7(b)(ii) continued.

from **60 s** to **150 s**

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7(b)(ii) continued.

from **150 s** to **240 s**

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**(Total for Question 7 = 13 marks)**

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**8 This question is about crude oil.**

**(a) Describe how crude oil is separated into fractions by fractional distillation.**  
**(4 marks)**

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

[illegible]

**8(a) continued.**

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**(continued on the next page)**

8 continued.

- (b) Some of the products of fractional distillation are then cracked.

This equation represents a reaction that occurs during cracking.



Explain why cracking is an important process in the oil industry.

(4 marks)

Answer space continues on the next page.

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Turn over

**8(b) continued.**

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**(continued on the next page)**

**8 continued.**

- (c) Fuels obtained from crude oil may contain impurities.**

**Explain how an impurity found in fuels can cause an environmental problem.**

**(3 marks)**

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**(Total for Question 8 = 11 marks)**

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9 (a) Look at the table for Question 9(a) in the Diagram Booklet. It shows the formulae of some positive and negative ions, and the formulae of some compounds containing these ions.

(i) Complete the table by giving the formulae of the missing compounds.

(3 marks)

(ii) Give the name of the compound with the formula **ZnSO<sub>4</sub>**

(1 mark)

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(continued on the next page)

**9 continued.**

**(b) Hydrogen chloride and magnesium chloride have different types of bonding and have different structures.**

**(i) Look at the diagram for Question 9(b)(i) in the Diagram Booklet. Complete the dot-and-cross diagram to show the outer shell electrons in a molecule of hydrogen chloride.**

**(2 marks)**

**(ii) Look at the diagrams for Question 9(b)(ii) in the Diagram Booklet. They show the electronic configuration of a magnesium atom and of a chlorine atom.**

**Draw the electronic configuration of a magnesium ion and of a chlorine ion on page 17 of the Diagram Booklet.**

**Show the charge on each ion.**

**(3 marks)**

**(continued on the next page)**

**9(b) continued.**

- (iii) Explain why magnesium chloride has a much higher melting point than hydrogen chloride.**

**Refer to structure and bonding in your answer.  
(5 marks)**

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

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**Turn over**



**9(b)(iii) continued.**

[illegible]

**(Total for Question 9 = 14 marks)**

- 10 This is the equation for the decomposition of hydrogen peroxide.



The rate of reaction increases when a catalyst of manganese(IV) oxide is added.

- (a) Describe how a catalyst increases the rate of a reaction.  
(2 marks)

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(continued on the next page)

**10 continued.**

- (b) A student adds  $50\text{ cm}^3$  of hydrogen peroxide solution to a glass container and then adds  $1.0\text{ g}$  of manganese(IV) oxide.**

**Look at the diagram for Question 10(b) in the Diagram Booklet. It shows the apparatus the student uses.**

- (i) Name the glass container the student uses.  
(1 mark)**

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**(continued on the next page)**

**10(b) continued.**

- (ii) The student waits until the hydrogen peroxide solution completely decomposes.**

**Describe how the student could then show that the manganese(IV) oxide was a catalyst and not a reactant.**

**(3 marks)**

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**(Total for Question 10 = 6 marks)**

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- 11 Diamond and graphite are both forms of the element carbon.**

**Diamond and graphite both have covalent bonds and giant covalent structures.**

**Look at the diagram for Question 11 in the Diagram Booklet. It represents the structure of diamond and the structure of graphite.**

- (a) Give a reason why diamond is an element.  
(1 mark)**

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**(continued on the next page)**

**11 continued.**

**(b) Describe the forces of attraction in a covalent bond.  
(2 marks)**

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**(continued on the next page)**

**11 continued.**

- (c) (i) Explain why graphite conducts electricity.  
(2 marks)**

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**(continued on the next page)**

**11(c) continued.**

- (ii) Explain why diamond is hard but graphite is soft.  
(4 marks)**

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**(continued on the next page)**

**Turn over**



11 continued.

- (d) Another form of carbon has molecules with the formula  $\text{C}_x$

$x$  represents the number of carbon atoms in each molecule.

Each molecule of  $\text{C}_x$  has a mass of  $1.40 \times 10^{-21} \text{ g}$

One mole of  $\text{C}_x$  contains  $6.02 \times 10^{23}$  molecules.

Calculate the  $M_r$  of  $\text{C}_x$  and the value of  $x$   
(3 marks)

[for carbon,  $A_r = 12$ ]

Answer space continues on the next page.

11(d) continued.

$M_r =$  \_\_\_\_\_

$X =$  \_\_\_\_\_

(Total for Question 11 = 12 marks)

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Turn over

**12 This question is about the metal tantalum, Ta**

**Tantalum metal can be produced by heating tantalum chloride ( $\text{TaCl}_5$ ) and hydrogen gas in a furnace.**

**The other product of the reaction is hydrogen chloride.**

- (a) Look at the equation for Question 12(a) in the Diagram Booklet. Complete the equation for the reaction.  
(1 mark)**

**(continued on the next page)**

**12 continued.**

- (b) As tantalum chloride is heated, the mass of solid in the furnace decreases leaving tantalum as the only solid product.**

**Look at the table for Question 12(b) in the Diagram Booklet. It shows the mass of solid in the furnace at one-hour intervals.**

- (i) State how the data in the table shows that the reaction is complete.**  
**(1 mark)**

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**(continued on the next page)**

12(b) continued.

- (ii) Use the data to show that the formula of tantalum chloride is  $\text{TaCl}_5$   
(3 marks)

[for tantalum,  $A_r = 181$   
for chlorine,  $A_r = 35.5$ ]

Answer space continues on the next page.

12(b)(ii) continued.

[for tantalum,  $A_r = 181$   
for chlorine,  $A_r = 35.5$ ]

12 continued.

- (c) Another method of extracting tantalum is by reacting tantalum(V) oxide with carbon.

This is the equation for the reaction.



- (i) Explain why this is a redox reaction.  
(2 marks)

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(continued on the next page)

12(c) continued.

- (ii) **2000 mol** of tantalum(V) oxide is heated with **500 000 g** of carbon.

Show by calculation that the carbon is in excess.  
(2 marks)

[for carbon,  $A_r = 12$ ]

(continued on the next page)

Turn over



12(c) continued.

- (iii) Calculate the maximum mass, in grams, of tantalum that can be obtained from **2000 mol** of tantalum(V) oxide.  
(2 marks)

[for tantalum,  $A_r = 181$ ]

mass = \_\_\_\_\_ g

(Total for Question 12 = 11 marks)

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**TOTAL FOR PAPER = 110 MARKS**

**END OF PAPER**