

# **Chemistry**

**UNIT: 4CH1**

**Science (Double Award) 4SD0**

**PAPER: 1CR**

**Total Marks**

**Time: 2 hours**

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

<b>Surname</b>					
<b>Other names</b>					
<b>Centre Number</b>					
<b>Candidate Number</b>					

## **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 (a) Look at the diagram and table for Question 1(a) in the Diagram Booklet. The diagram represents an atom of an element.**

**Use numbers from the list to complete the table.**

**You may use each number once, more than once or not at all.**

**(4 marks)**

**2**

**4**

**5**

**9**

**10**

**(continued on the next page)**

**1 continued.**

- (b) In terms of sub-atomic particles, state a similarity and a difference for isotopes of the same element. (2 marks)**

**similarity**

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**difference**

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**(Total for Question 1 = 6 marks)**

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**2 This question is about apparatus used in the laboratory.**

**(a) Look at the table for Question 2(a) in the Diagram Booklet. Complete the table by giving the name of each piece of apparatus and a unit used for the quantity it measures.**

**(2 marks)**

**(b) Look at the diagram for Question 2(b) in the Diagram Booklet. It shows apparatus used to obtain pure water from sodium chloride solution by simple distillation.**

**(i) Explain why it is necessary for water to flow continuously in and out of the apparatus.**

**(2 marks)**

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**2 continued.**

- (ii) Describe a chemical test to show that the sodium chloride solution contains chloride ions.  
(2 marks)**

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**2 continued.**

- (iii) Describe a physical test to show that the liquid in the conical flask is pure water.  
(2 marks)**

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**(Total for Question 2 = 8 marks)**

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**3 Look at the diagram for Question 3 in the Diagram Booklet. It shows a chromatogram of the food dyes in four different food colourings, A, B, C and D.**

**(a) (i) Give the letter of the food colouring that contains three different food dyes.  
(1 mark)**

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**(ii) Give the letters of the two food colourings that contain the same dye.  
(1 mark)**

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**3 continued.**

- (iii) Using the scale on the diagram, determine the  $R_f$  value of the dye in food colouring C. (2 marks)**

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

- (iv) Give a reason why the dye in food colouring D moves the furthest from the start line. (1 mark)**

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**3 continued.**

**(b) Describe how a student could obtain a chromatogram similar to the one shown in the diagram.**

**(4 marks)**

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**3 continued.**

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

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- 4 Look at the diagram for Question 4 in the Diagram Booklet. It shows the positions of some elements in part of the Periodic Table.**

**(a) (i) Give the symbol of a metal from the diagram.  
(1 mark)**

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**(ii) Give the symbol of an element from the diagram that forms an acidic oxide.  
(1 mark)**

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**(b) Give a similarity in the electron configurations of Al and In.  
(1 mark)**

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**Turn over**

**4 continued.**

- (c) Explain which element in the diagram is unreactive.  
(2 marks)**

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4 continued.

- (d) A teacher adds a small piece of sodium to a glass trough containing water and universal indicator.

The universal indicator changes colour.

The equation for the reaction is



- (i) Explain the final colour of the universal indicator.  
(2 marks)

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**4 continued.**

- (ii) The teacher repeats the experiment with potassium instead of sodium.**

**Give one similarity and one difference observed with potassium.**

**(2 marks)**

**similarity**

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**difference**

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**4 continued.**

**(iii) The reaction with sodium produces 0.036 g of hydrogen gas.**

**One mole of hydrogen gas contains  
 $6.0 \times 10^{23}$  molecules.**

**Calculate the number of molecules of hydrogen gas produced in the reaction with sodium.**

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

**number of molecules of hydrogen gas = \_\_\_\_\_**

**(Total for Question 4 = 12 marks)**

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**Turn over**

**5 This question is about metal carbonates.**

**When heated, some metal carbonates decompose to form a metal oxide and carbon dioxide gas.**

- (a) Look at the diagram for Question 5(a) in the Diagram Booklet. A student is given three solid metal carbonates, a timer, some limewater and this apparatus.**

**Describe a method the student can use to find out which metal carbonate decomposes fastest when heated.**

**(4 marks)**

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**5 continued.**

- (b) A student is given a solid metal carbonate with the formula  $\text{XCO}_3$**

**X represents the symbol of a Group 2 metal.**

**Look at the diagram for Question 5(b) in the Diagram Booklet. A student uses this apparatus to heat a sample of  $\text{XCO}_3$  until it all decomposes.**

**The equation for the decomposition of  $\text{XCO}_3$  is**



**The student records the mass of  $\text{XCO}_3$  and the mass of carbon dioxide that escapes through the cotton wool plug.**

**These are the student's results.**

**mass of  $\text{XCO}_3$  = 7.40 g**

**mass of  $\text{CO}_2$  = 2.20 g**

**(continued on the next page)**

**5 continued.**

- (i) Give a reason why the student uses a cotton wool plug.  
(1 mark)**

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- (ii) Calculate the amount, in mol, of carbon dioxide produced.  
(1 mark)**

**[for carbon dioxide  $M_r = 44$ ]**

**amount of carbon dioxide = \_\_\_\_\_ mol**

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5 continued.

- (iii) Use the equation to determine the amount, in mol, of  $\text{XCO}_3$  that decomposed.  
(1 mark)

amount of  $\text{XCO}_3$  = \_\_\_\_\_ mol

- (iv) Use the mass of  $\text{XCO}_3$  and your answer to (b)(iii) to calculate the relative formula mass ( $M_r$ ) of  $\text{XCO}_3$   
(2 marks)

$M_r$  of  $\text{XCO}_3$  = \_\_\_\_\_

(continued on the next page)

**5 continued.**

- (v) Use your answer to (b)(iv) and the Periodic Table on the separate sheet provided to determine the identity of the Group 2 metal X.**

**Show your working.  
(2 marks)**

**identity of X = \_\_\_\_\_**

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

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- 6 Silicon hydride ( $\text{SiH}_4$ ) and silicon dioxide ( $\text{SiO}_2$ ) both contain covalent bonds but they have different structures.**

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

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**(b) Look at the diagram for Question 6(b) in the Diagram Booklet. Complete the diagram to show the outer shell electrons in a molecule of silicon hydride ( $\text{SiH}_4$ ).  
(1 mark)**

**(continued on the next page)**



**6 continued.**

**(c) Look at the diagram for Question 6(c) in the Diagram Booklet. It represents part of the structure of silicon dioxide ( $\text{SiO}_2$ ).**

**(i) State how the diagram shows that the atom labelled A is oxygen, not silicon.  
(1 mark)**

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**6 continued.**

- (ii) Silicon hydride has a simple molecular structure.**

**Silicon dioxide has the same type of structure as diamond.**

**Explain why silicon dioxide has a much higher melting point than silicon hydride.**

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

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**6 continued.**

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**6 continued.**

- (d) Silicon hydride reacts with oxygen to form silicon dioxide and water.**

**Write a chemical equation for the reaction between silicon hydride and oxygen.**

**(1 mark)**

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**(Total for Question 6 = 9 marks)**

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**7 Look at the diagram for Question 7 in the Diagram Booklet. It shows some important conversion processes used in the oil industry.**

**(a) Describe how kerosene is produced from crude oil in process 1.  
(5 marks)**

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**7 continued.**

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7 continued.

(b)  $\text{C}_{12}\text{H}_{26}$  is present in kerosene.

In process 2,  $\text{C}_{12}\text{H}_{26}$  is cracked to produce two molecules of ethene and one molecule of another hydrocarbon.

(i) Complete the equation for the cracking of  $\text{C}_{12}\text{H}_{26}$   
(1 mark)



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**7 continued.**

**(ii) Explain why cracking is a useful process in the oil industry.**  
**(4 marks)**

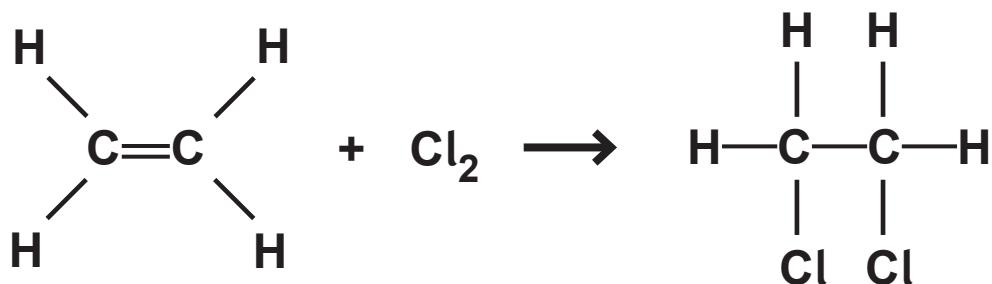
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(c) This is the equation for one of the reactions that may occur during process 3.



What is the name of this type of reaction?  
(1 mark)

- ☐ A addition
- ☐ B combustion
- ☐ C decomposition
- ☐ D substitution

(continued on the next page)

**7 continued.**

**(d) (i) Look at the equation for Question 7(d)(i) in the Diagram Booklet. Complete the equation for the polymerisation of chloroethene in process 4.**

**(2 marks)**

**(ii) Explain why the disposal of polymers such as poly(chloroethene) is difficult.**

**(2 marks)**

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**(Total for Question 7 = 15 marks)**

**Turn over**

**8 This question is about exothermic reactions.**

**(a) Look at the diagram for Question 8(a) in the Diagram Booklet. A student uses this apparatus to measure the temperature increase when an excess of zinc powder is added to copper(II) sulfate solution.**

**(i) Complete the word equation for the reaction.  
(1 mark)**

**zinc + copper(II) sulfate →**

\_\_\_\_\_ +  
\_\_\_\_\_

**(ii) Give a reason why the student uses a polystyrene cup inside a glass beaker.  
(1 mark)**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

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**Turn over**

**8 continued.**

**(iii) State why zinc reacts with  
copper(II) sulfate solution.  
(1 mark)**

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8 continued.

(iv) The temperature at the start of the reaction is  $19.7^{\circ}\text{C}$ .

The temperature at the end of the reaction is  $48.3^{\circ}\text{C}$ .

Calculate the heat energy change, in joules, for the reaction.

(2 marks)

[for the mixture,  $c = 4.2 \text{ J/g/}^{\circ}\text{C}$ ]

heat energy change = \_\_\_\_\_ J

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8 continued.

- (b) (i) The reaction between zinc and silver nitrate solution is exothermic.

A mass of 0.65 g of zinc is added to excess silver nitrate solution.

The heat energy change is 800 J.

Calculate the molar enthalpy change,  $\Delta H$ , in kJ/mol.

Include a sign in your answer.  
(3 marks)

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

(continued on the next page)

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8 continued.

- (ii) This is the ionic equation for the reaction between zinc and silver nitrate solution.



Explain, in terms of electrons, why this is a redox reaction.

(2 marks)

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(Total for Question 8 = 10 marks)

Turn over



**9 This question is about rates of reaction.**

**(a) A student uses this method to investigate the rate of reaction between iron(III) nitrate solution and sodium thiosulfate solution.**

- **pour  $50\text{ cm}^3$  of iron(III) nitrate solution into a conical flask**
- **add one drop of catalyst solution**
- **add  $50\text{ cm}^3$  of sodium thiosulfate solution to the conical flask**
- **record the time for the mixture to become colourless**

**The student repeats the method using different catalysts and also with no catalyst.**

**Look at the table for Question 9 in the Diagram Booklet. It shows the student's results.**

- (i) Explain which is the best catalyst for the reaction.  
(2 marks)**

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**9 continued.**

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- (ii) Explain how a catalyst increases the rate of a reaction.  
(2 marks)**

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**9 continued.**

**(b) The rate of a reaction can also be altered by changing the temperature or by changing the concentration of solutions.**

**(i) Explain, using the particle collision theory, how increasing the temperature affects the rate of a reaction.  
(4 marks)**

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**Turn over**

**9 continued.**

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**9 continued.**

- (ii) Explain why using a solution of a lower concentration decreases the rate of reaction.  
(2 marks)**

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**(Total for Question 9 = 10 marks)**

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- 10 A student investigates how the electrical conductivity changes as dilute sulfuric acid is added to barium hydroxide solution.**

**This is the student's method.**

**STEP 1 add  $50.0\text{ cm}^3$  of barium hydroxide solution to beaker**

**STEP 2 measure the electrical conductivity of the solution**

**STEP 3 add  $10.0\text{ cm}^3$  of dilute sulfuric acid to the beaker**

**STEP 4 stir the mixture**

**STEP 5 measure the electrical conductivity of the mixture**

**STEP 6 repeat steps 3 to 5 until a total of  $100\text{ cm}^3$  of dilute sulfuric acid has been added**

**Look at the table for Question 10 in the Diagram Booklet. It shows the student's results.**

**(continued on the next page)**

**10 continued.**

- (a) (i) Name a piece of apparatus the student could use to add  $10.0\text{ cm}^3$  of dilute sulfuric acid to the beaker.**

**(1 mark)**

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- (ii) Look at the graph for Question 10(a) in the Diagram Booklet. The first four points have been plotted for you. Plot the rest of the student's results.**

**(2 marks)**

- (iii) Ignoring the anomalous result, draw two lines of best fit, making sure that the two lines cross.**

**(1 mark)**

**(continued on the next page)**

**10 continued.**

- (iv) Give the trend shown on the graph for the first 50 cm<sup>3</sup> of acid added.  
(1 mark)**

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- (v) Suggest a mistake the student could have made to cause the anomalous result.  
(1 mark)**

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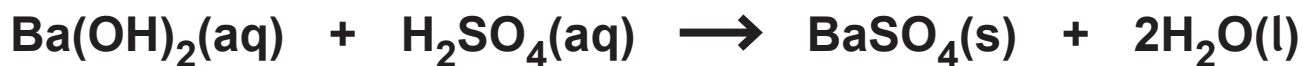
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10 continued.

(b) This is the equation for the reaction.



- (i) When  $50 \text{ cm}^3$  of dilute sulfuric acid have been added, only barium sulfate and water are present in the mixture.

Explain why this mixture does not conduct electricity.

Refer to the type of bonding in barium sulfate and in water in your answer.

(3 marks)

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**10 continued.**

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- (ii) Name a technique the student could use to separate barium sulfate from the mixture after  $100\text{ cm}^3$  of dilute sulfuric acid has been added. (1 mark)

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

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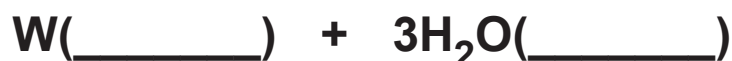
**11 This question is about the reduction of tungsten oxide,  $\text{WO}_3$**

**(a) Look at the diagram for Question 11(a) in the Diagram Booklet. A teacher uses this apparatus to reduce tungsten oxide.**

**This is the teacher's method.**

- **record the mass of a weighing boat**
- **add tungsten oxide and record the mass again**
- **heat the weighing boat and tungsten oxide strongly for two minutes and then allow to cool**
- **record the mass of the weighing boat and its contents**

**(i) Complete the equation by adding the state symbols.  
(2 marks)**



**(continued on the next page)**

**11 continued.**

- (ii) Give an addition to the method to check that the tungsten oxide has been completely reduced.  
(1 mark)**

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**11 continued.**

**(iii) Look at the table for Question 11(a)(iii) in the Diagram Booklet. It shows the teacher's results.**

**Use the teacher's results to show that the empirical formula of tungsten oxide is  $\text{WO}_3$  (3 marks)**

**[for tungsten,  $A_r = 184$       for oxygen,  $A_r = 16$ ]**

**11 continued.**

**(iv) The teacher wears eye protection and a lab coat during the experiment.**

**Give one other safety precaution the teacher should take.**

**(1 mark)**

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**(continued on the next page)**

**11 continued.**

- (b) In industry, tungsten oxide is reduced on a large scale using hydrogen.**

**The percentage yield of tungsten is 73.5%**

**This is the equation for the reaction.**



**On page 56 calculate the mass, in tonnes, of tungsten that is produced when 2784 tonnes of tungsten oxide are reacted with an excess of hydrogen.**

**(3 marks)**

**(continued on the next page)**

11 continued.

$$[1 \text{ tonne} = 1 \times 10^6 \text{ g}]$$

[for tungsten,  $A_r = 184$       for oxygen,  $A_r = 16$ ]

mass of tungsten = \_\_\_\_\_ tonnes

(Total for Question 11 = 10 marks)

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**TOTAL FOR PAPER = 110 MARKS**

**END OF PAPER**