

Chemistry
UNIT: 4CH1
PAPER: 2C

Total Marks

Monday 20 November 2023 – Morning

Time: 1 hour 15 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.

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

INFORMATION

The total mark for this paper is 70.

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.

A periodic table is provided as a separate insert.

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.

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 Group 7, the halogens.

**(a) What is the total number of electrons in one fluorine atom?
(1 mark)**

☐ **A 7**

☐ **B 9**

☐ **C 10**

☐ **D 19**

(continued on the next page)

1 continued.

(b) What is the charge on a bromide ion?
(1 mark)

☐ **A 1–**

☐ **B 1+**

☐ **C 2–**

☐ **D 2+**

(c) Which of these describes the element iodine at room temperature?
(1 mark)

☐ **A brown liquid**

☐ **B brown solid**

☐ **C grey solid**

☐ **D purple gas**

(continued on the next page)

1 continued.

- (d) When a halogen is added to a solution containing halide ions, a displacement reaction may occur.**

Look at the table for Question 1(d) in the Diagram Booklet. It shows whether a reaction occurs.

Using information from the table, explain the order of reactivity of the three halogens.

(3 marks)

Answer space continues on the next page.

Turn over

1(d) continued.

(Total for Question 1 = 6 marks)

2 This question is about gases in the atmosphere.

Look at the apparatus for Question 2 in the Diagram Booklet. A teacher uses this apparatus to determine the percentage of oxygen in air.

The teacher removes the stopper, ignites the magnesium ribbon and immediately replaces the stopper.

The magnesium reacts with oxygen to form magnesium oxide.

During the reaction the water level in the bell jar rises.

When the flame goes out, some magnesium remains in the basin.

**(a) (i) Give the appearance of the magnesium oxide.
(1 mark)**

(continued on the next page)

2(a) continued.

- (ii) Give a chemical equation for the reaction of magnesium with oxygen.
(1 mark)**

- (iii) Explain why the water in the bell jar rises.
(2 marks)**

(continued on the next page)

2 continued.

- (b) The volume of air in the bell jar at the start of the reaction is 2000 cm^3 .**

When the reaction ends, the apparatus cools down to room temperature.

Calculate the expected volume of gas in the bell jar at room temperature.

(3 marks)

volume of gas = _____ cm^3

(continued on the next page)

Turn over

2 continued.

- (c) State why the gas remaining in the bell jar at the end of the reaction is approximately 99% nitrogen.
(1 mark)**

(Total for Question 2 = 8 marks)

3 This question is about aluminium.

- (a) State why aluminium cannot be extracted by heating aluminium oxide with carbon.
(1 mark)**

(continued on the next page)

3 continued.

(b) Aluminium is a metal with many uses.

Aluminium is malleable, a good conductor of heat and electricity, and has a low density compared to most other metals.

Explain two uses of aluminium that are related to its properties.

(4 marks)

1 _____

2 _____

3 continued.

- (c) Look at the diagram for Question 3(c) in the Diagram Booklet. It represents the structure of pure aluminium, and the structure of an alloy of aluminium.**

Use the diagram to explain why the alloy is harder than pure aluminium.

(3 marks)

Answer space continues on the next page.

Turn over

3(c) continued.

(Total for Question 3 = 8 marks)

4 A student uses this method to investigate the reaction between sodium hydroxide solution and dilute hydrochloric acid.

- **pour 25 cm^3 of dilute hydrochloric acid into a glass beaker**
- **measure the temperature of the acid**
- **add 5 cm^3 of sodium hydroxide solution and stir the mixture**
- **record the highest temperature reached**
- **continue to add further 5 cm^3 portions of sodium hydroxide solution until a total of 40 cm^3 has been added**
- **record the temperature after adding each 5 cm^3 portion of sodium hydroxide solution**

**(a) State two factors that the student must keep constant to make this a valid investigation.
(2 marks)**

1 _____

2 _____

(continued on the next page)

Turn over

4 continued.

- (b) Explain how using a polystyrene cup, instead of a glass beaker, would increase the accuracy of the results.**

(2 marks)

- (c) Look at the graph for Question 4(c) in the Diagram Booklet. It shows the student's results.**

- (i) Use the graph to determine the maximum temperature change in °C.**

(1 mark)

maximum temperature change = _____ °C

(continued on the next page)

Turn over

4(c) continued.

**(ii) Explain the shape of the graph.
(3 marks)**

[illegible]

4 continued.

- (d) The student repeats the experiment using a polystyrene cup.**

Look at the table for Question 4(d) in the Diagram Booklet. These are the student's results.

**Calculate the heat energy change (Q) in kJ.
(4 marks)**

**[for the solution, 1.0 cm^3 has a mass of 1.0 g
 $c = 4.2 \text{ J/g/}^\circ\text{C}$]**

Q = _____ kJ

(Total for Question 4 = 12 marks)

Turn over

5 This question is about carboxylic acids and esters.

(a) Ethanoic acid reacts with magnesium to form two products.

**(i) Complete the equation for this reaction.
(2 marks)**

_____ + _____ →

$(\text{CH}_3\text{COO})_2\text{Mg}$ + _____

**(ii) Give two observations that could be made during this reaction.
(2 marks)**

1 _____

2 _____

(continued on the next page)

5 continued.

(b) Propanoic acid reacts with methanol to form an ester.

**(i) Give the name of a suitable catalyst for this reaction.
(1 mark)**

**(ii) What is the structural formula of the ester that forms?
(1 mark)**

☐ **A $\text{HCOOCH}_2\text{CH}_2\text{CH}_3$**

☐ **B $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3$**

☐ **C $\text{CH}_3\text{CH}_2\text{COOCH}_3$**

☐ **D $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_3$**

(continued on the next page)

5 continued.

- (c) A polyester can be made by reacting ethanedioic acid with ethanediol.**

Look at the formulae for Question 5(c) in the Diagram Booklet. These are the displayed formulae of the two reactants.

- (i) Give the name for this type of polymerisation.
(1 mark)**

- (ii) Give the name of the other product of this reaction.
(1 mark)**

(continued on the next page)

5(c) continued.

**(iii) Draw the displayed formula for the repeat unit of the polyester that forms.
(2 marks)**

**(d) State what is meant by the term BIOPOLYESTER.
(1 mark)**

(Total for Question 5 = 11 marks)

Turn over

- 6 (a) Look at the diagram for Question 6(a) in the Diagram Booklet. It shows two pieces of apparatus used in a titration.**

**Give the names of these pieces of apparatus.
(2 marks)**

X _____

Y _____

- (b) Give the name of a suitable indicator that can be used in an acid-alkali titration.
(1 mark)**

(continued on the next page)

6 continued.

- (c) A student does a titration using sodium carbonate solution and dilute nitric acid.**

This is the equation for the reaction.



Look at the table for Question 6(c) in the Diagram Booklet. It shows the concentrations of the two solutions and the volume of sodium carbonate used in the titration.

Use the equation and the data in the table to answer these questions.

(continued on the next page)

6(c) continued.

- (i) Calculate the volume of dilute nitric acid that the student would need to neutralise the sodium carbonate solution.
(3 marks)**

volume of nitric acid = _____ cm³

(continued on the next page)

6(c) continued.

- (ii) Calculate the volume, in cm^3 , of carbon dioxide gas at rtp that would be produced from the 25.0 cm^3 of the sodium carbonate solution.
(2 marks)**

[at rtp, molar volume = $24\,000 \text{ cm}^3$]

volume of carbon dioxide = _____ cm^3

(continued on the next page)

6 continued.

- (d) Describe a test to show that sodium carbonate solution contains carbonate ions.
(3 marks)**

(Total for Question 6 = 11 marks)

7 (a) Sodium chloride is an ionic compound.

Explain why sodium chloride conducts electricity when it is molten or in solution, but not when it is solid.

(2 marks)

(continued on the next page)

7 continued.

(b) Look at the diagram for Question 7(b) in the Diagram Booklet. A solution of sodium chloride can be electrolysed using this apparatus.

(i) If the solution is dilute, a significant amount of oxygen collects at P.

Complete the ionic half-equation for this reaction.

(1 mark)



(ii) If the solution is concentrated, chlorine is the main product that collects at P.

This is the ionic half-equation for the reaction.



State why this is an oxidation reaction.

(1 mark)

7 continued.

(c) The gas that collects at Q is hydrogen.

**(i) Give a test for hydrogen.
(1 mark)**

(continued on the next page)

7(c) continued.

- (ii) Explain how hydrogen gas forms at the negative electrode.
(3 marks)**

Answer space continues on the next page.

Turn over

7(c)(ii) continued.

(continued on the next page)

7 continued.

(d) Hydrogen reacts with oxygen to form water.

The equation shows the covalent bonds in the molecules.



Look at the table for Question 7(d)(i) in the Diagram Booklet. It gives the bond energies.

(i) Use the equation and the values in the table to calculate the enthalpy change, ΔH , for the reaction.

**Include a sign in your answer.
(3 marks)**

$\Delta H =$ _____ **kJ**

7(d) continued.

- (ii) Look at the diagram for Question 7(d)(ii) in the Diagram Booklet. Complete the diagram to show the energy levels of the reactants and products, and the enthalpy change, ΔH .
(3 marks)**

(Total for Question 7 = 14 marks)

TOTAL FOR PAPER = 70 MARKS

END OF PAPER