

Chemistry
UNIT: 4CH1
PAPER: 2CR

Total Marks

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 Look at the diagram for Question 1 in the Diagram Booklet. It shows the sub-atomic particles in an atom of an element.

**(a) (i) Give the name of each of the sub-atomic particles labelled P, Q and R.
(3 marks)**

P _____

Q _____

R _____

(continued on the next page)

Turn over

1 continued.

**(ii) Give the name of the part of the atom
labelled S.
(1 mark)**

**(b) Give the name of this element.
(1 mark)**

(Total for Question 1 = 5 marks)

2 Look at the diagram for Question 2 in the Diagram Booklet.

A potassium permanganate crystal is placed in a beaker of water.

After several days a coloured solution forms.

**(a) Give the names of the two processes that cause the coloured solution to form.
(2 marks)**

1 _____

2 _____

(continued on the next page)

2 continued.

(b) The formula of potassium permanganate is KMnO_4

**(i) How many different types of atom are
in KMnO_4 ?
(1 mark)**

☐ **A 3**

☐ **B 4**

☐ **C 6**

☐ **D 7**

(continued on the next page)

2 continued.

- (ii) Calculate the relative formula mass (M_r) of KMnO_4 (1 mark)**

$M_r =$ _____

- (c) Potassium permanganate can be used as an oxidising agent.**

**State what is meant by the term
OXIDISING AGENT.
(1 mark)**

(Total for Question 2 = 5 marks)

Turn over

3 This question is about alkanes.

(a) (i) Which of these is the MOLECULAR formula of an alkane?

(1 mark)

- ☐ **A** C_2H_5
- ☐ **B** C_4H_{10}
- ☐ **C** CH_2CH_2
- ☐ **D** $\text{CH}_3\text{CH}_2\text{CH}_3$

(ii) Which of these has the same empirical formula and molecular formula?

(1 mark)

- ☐ **A** CH_2
- ☐ **B** C_2H_6
- ☐ **C** C_3H_8
- ☐ **D** C_4H_{10}

(continued on the next page)

Turn over

3 continued.

(b) In the presence of ultraviolet radiation, methane reacts with bromine to form bromomethane and hydrogen bromide.

**(i) State the name of this type of reaction.
(1 mark)**

**(ii) Give a chemical equation for this reaction.
(1 mark)**

(continued on the next page)

3 continued.

(c) One mole of an alkane burns completely in oxygen.

The equation represents the reaction.



The numbers x, y and z are used to balance the equation.

(continued on the next page)

3 continued.

- (i) The complete combustion of one mole of the alkane produces 220 g of carbon dioxide and 108 g of water.**

Calculate the values of y and z.

**[M_r of CO_2 = 44 M_r of H_2O = 18]
(2 marks)**

y = _____

z = _____

(continued on the next page)

3 continued.

- (ii) Determine the molecular formula of the alkane and the value of x.
(2 marks)**

molecular formula = _____

x = _____

(continued on the next page)

Turn over

3 continued.

(d) When an alkane burns in a limited supply of air, incomplete combustion occurs.

Explain why incomplete combustion of an alkane could be harmful to humans.

(2 marks)

(Total for Question 3 = 10 marks)

- 4 (a) Look at the diagram for Question 4(a) in the Diagram Booklet. It represents the structure of copper metal.**

**Explain three properties of copper that make it a suitable metal to use in electrical wiring.
(5 marks)**

(continued on the next page)

Turn over

4 continued.

(continued on the next page)

4 continued.

- (b) Look at the diagram for Question 4(b) in the Diagram Booklet. It shows the electrolysis of copper(II) sulfate solution, using graphite electrodes.**

Copper forms at the negative electrode and oxygen forms at the positive electrode.

- (i) Give the formula of the copper ion and the formula of the sulfate ion in copper(II) sulfate. (1 mark)**

copper ion

sulfate ion

(continued on the next page)

4 continued.

**(ii) State what would be seen at the positive electrode.
(1 mark)**

**(iii) Give a test for oxygen.
(1 mark)**

**(iv) Give an ionic half-equation for the formation of oxygen at the positive electrode.
(2 marks)**

(continued on the next page)

Turn over

4 continued.

- (v) Suggest why the copper(II) sulfate solution contains some OH^- ions.
(1 mark)**

(Total for Question 4 = 11 marks)

5 This question is about alcohols, carboxylic acids and esters.

(a) Ethanol can be manufactured by the fermentation of a solution of glucose.

**(i) Write a word equation for this reaction.
(1 mark)**

**(ii) State the substance that needs to be added for the reaction to occur.
(1 mark)**

(continued on the next page)

5 continued.

(iii) State two conditions needed for this reaction.
(2 marks)

1 _____

2 _____

(b) In the presence of an acid catalyst, ethanoic acid is heated with butanol to form an ester.

(i) Which of these is the formula of the ester?
(1 mark)

☐ A $\text{CH}_3\text{COOC}_3\text{H}_7$

☐ B $\text{CH}_3\text{COOC}_4\text{H}_9$

☐ C $\text{C}_2\text{H}_5\text{COOC}_4\text{H}_9$

☐ D $\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5$

(continued on the next page)

Turn over

5 continued.

- (ii) State how you would know that an ester has formed.
(1 mark)**

- (iii) Give one use of an ester.
(1 mark)**

(continued on the next page)

5 continued.

(c) Aspirin is a compound used to reduce pain.

Aspirin contains a carboxylic acid functional group and an ester functional group.

**(i) State what is meant by the term
FUNCTIONAL GROUP.
(1 mark)**

(ii) Look at the diagram for Question 5(c)(ii) in the Diagram Booklet. It is the structural formula of aspirin.

**Draw a circle around the carboxylic acid functional group.
(1 mark)**

(continued on the next page)

5 continued.

(iii) Aspirin has this percentage composition by mass.

C = 60.00 % H = 4.44 % O = 35.56 %

**Show by calculation that the empirical formula of aspirin is $\text{C}_9\text{H}_8\text{O}_4$
(3 marks)**

(Total for Question 5 = 12 marks)

Turn over

6 A student uses this method to do a titration.

- **use a measuring cylinder to obtain 25 cm³ of sodium hydroxide solution**
- **transfer the solution to a conical flask**
- **add a few drops of universal indicator to the flask**
- **fill a burette with dilute sulfuric acid and record the initial burette reading**
- **add the acid to the flask, swirling the flask continuously**
- **add the acid slowly near the end-point**
- **record the final burette reading at the end-point**

The student repeats the titration until at least two concordant results are obtained.

(continued on the next page)

6 continued.

- (a) State what is meant by concordant results.
(1 mark)**

- (b) Explain two improvements to the student's method
so that more accurate results are obtained.
(4 marks)**

(continued on the next page)

Turn over

6 continued.

(continued on the next page)

6 continued.

- (c) The student makes the improvements and repeats the titration.**

The sulfuric acid has a concentration of 0.600 mol/dm^3 .

The sodium hydroxide solution has a concentration of 1.50 mol/dm^3 .

This is the equation for the reaction.



**Calculate the volume, in cm^3 , of sulfuric acid that the student needs to completely react with 25.0 cm^3 of the sodium hydroxide solution.
(3 marks)**

volume of sulfuric acid = _____ cm^3

(continued on the next page)

Turn over

6 continued.

- (d) The student plans to obtain pure dry crystals of hydrated sodium sulfate.**

They add the calculated volume of sulfuric acid to 25.0 cm^3 of the sodium hydroxide solution to form sodium sulfate solution.

Describe what the student should do to obtain pure dry crystals of hydrated sodium sulfate from the solution.

(4 marks)

(continued on the next page)

Turn over

6 continued.

(Total for Question 6 = 12 marks)

- 7 In the presence of an iron catalyst, nitrogen reacts with hydrogen to form ammonia.

The reaction conditions used are a temperature of 450 °C and a pressure of 200 atmospheres.

This is the equation for the reaction.



- (a) (i) State what the symbol \rightleftharpoons represents.
(1 mark)

- (ii) Give the reason for using a catalyst.
(1 mark)

(continued on the next page)

7 continued.

- (b) (i) The reaction mixture is kept at a pressure of 200 atmospheres, but the temperature is increased to 550 °C.**

**Explain the effect of this change on the yield of ammonia at equilibrium.
(2 marks)**

(continued on the next page)

7 continued.

- (ii) The reaction mixture is kept at a temperature of 450 °C, but the pressure is increased to 300 atmospheres.**

**Explain the effect of this change on the yield of ammonia at equilibrium.
(2 marks)**

(continued on the next page)

7 continued.

(c) Look at the diagram for Question 7(c) in the Diagram Booklet.

Draw an energy level diagram for the reaction between nitrogen and hydrogen.

Include the reactants, products and ΔH in your diagram.

(3 marks)

(continued on the next page)

7 continued.

- (d) At the start of the reaction, 48 dm³ of nitrogen is added to 120 dm³ of hydrogen at rtp.**



[molar volume of any gas at rtp = 24 dm³]

- (i) Show by calculation that the nitrogen is in excess.
(3 marks)**

(continued on the next page)

Turn over

7 continued.

(ii) The yield of ammonia at equilibrium is 20%.

**Calculate the volume, in dm^3 , of ammonia
formed from 120 dm^3 of hydrogen.
(3 marks)**

volume of ammonia = _____ dm^3

(Total for Question 7 = 15 marks)

**TOTAL FOR PAPER = 70 MARKS
END OF PAPER**