FOR OFFICIAL USE

N5

National Qualifications 2026

Mark

X813/75/01

Chemistry
Section 1 — Answer grid and Section 2

TUESDAY, 12 MAY

1:00 PM – 3:30 PM

X8137501

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

Scottish candidate number

Total marks —100

SECTION 1 — 25 marks

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 75 marks

Attempt ALL questions.

You may refer to the Chemistry Data Booklet for National 5.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Do not remove any exam materials. You must leave this booklet on your desk; if you do not, you could lose all the marks for this paper.

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SECTION 2 — 75 marks

Attempt ALL questions

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1. Hydrogen is the only element in the periodic table that has isotopes with unique names.

(a) State what is meant by the term isotope. **1**

(b) The nuclide notation for two of the isotopes of hydrogen are shown.

$^{1}_{1}H$	$^{2}_{1}H$
protium	deuterium

(i) A third isotope of hydrogen has two neutrons.

Write the nuclide notation for the third isotope of hydrogen. **1**

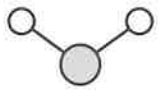
(ii) A sample of hydrogen containing all three isotopes has a relative atomic mass of 1.008

State why the relative atomic mass is not a whole number. **1**

1. (b) (continued)

(iii) A water molecule containing deuterium isotopes is known as heavy water.

The structure of a heavy water molecule is shown.



○ = deuterium

◯ = oxygen

(A) Calculate the mass, in grams, of one mole of heavy water, H_2O. 1

(B) Draw a diagram, showing all the outer electrons, for a molecule of heavy water, H_2O. 1

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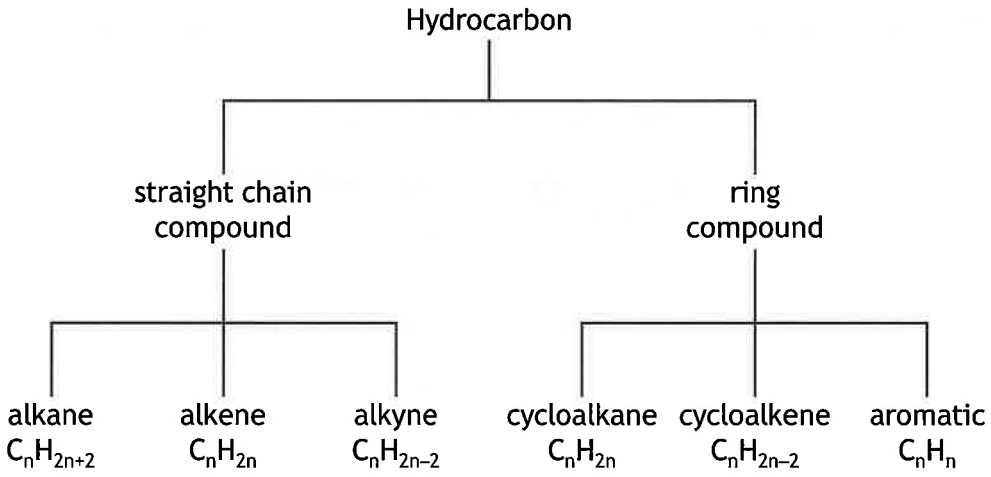
MARKS | DO NOT WRITE IN THIS MARGIN

2. The diagram shows the name and general formula of some families of hydrocarbons.



(a) (i) Ethyne is a member of the alkyne family.

Write the molecular formula for ethyne. **1**

(ii) Identify any **two** families, from the diagram, with molecules that can be isomers of each other. **1**

(iii) The formula of a ring compound is C_6H_{10}.

Name the family of hydrocarbons to which this molecule belongs. **1**

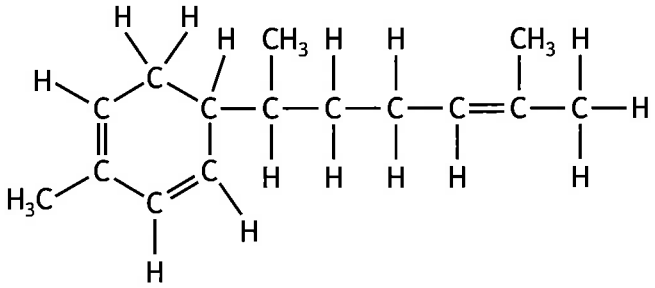
(b) Aromatic hydrocarbons do not rapidly decolourise bromine solution.

Suggest what this indicates about the structure of aromatic hydrocarbons. **1**

2. (continued)

(c) Isoprene is a hydrocarbon with the molecular formula C_5H_8. Isoprene molecules can combine to form terpenes, a family of compounds commonly found in essential oils.

A molecule of zingiberene, a terpene found in ginger oil, is shown.



zingiberene

(i) The number of isoprene molecules combined to form a specific terpene is determined by counting the number of carbon atoms in the terpene molecule and dividing by 5.

Calculate the number of isoprene molecules that combine to form a molecule of zingiberene. **1**

(ii) One mole of zingiberene can react fully with three moles of hydrogen, H_2, to form a product with only single carbon-carbon bonds.

The mass of one mole of zingiberene is 204 g.

Calculate the mass, in grams, of the product formed when zingiberene reacts fully with hydrogen, H_2. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

3. Calcium chloride can be produced by reacting limestone, $CaCO_3$, with hydrochloric acid, HCl.

(a) State the chemical name for limestone, $CaCO_3$. **1**

(b) The chemical equation for the reaction of limestone and hydrochloric acid is shown.

$$CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Balance this equation. **1**

(c) A student measured the volume of carbon dioxide gas produced when lumps of limestone were added to excess dilute hydrochloric acid.

(i) Suggest how the student would know when the reaction had finished. **1**

(ii) The student's results are shown.

Time (s)	0	10	20	30	40	50	60	70
Volume of carbon dioxide (cm^3)	0	48	62	66	74	79	80	80

Calculate the average rate, in $cm^3\,s^{-1}$, for the first 30 seconds. **2**

Show your working clearly.

3. (c) (continued)

(iii) Suggest a different measurement that could be used to follow the progress of this chemical reaction over time. **1**

(iv) Suggest why the rate of a chemical reaction decreases over time. **1**

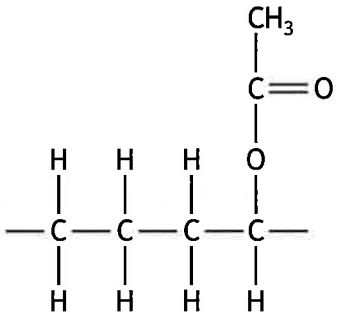
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

4. Read the passage and answer the questions that follow.

Copolymers

Copolymers are formed from the polymerisation of two different monomers. The plastic polyethylene-vinyl acetate (PEVA) is a copolymer formed from the monomers ethylene and vinyl acetate.

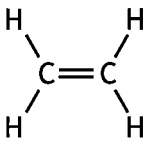


PEVA

One of the most useful properties of PEVA is that it can be elastic. How elastic the polymer is depends on the percentage of vinyl acetate used. This is known as the 'elastic modulus' and is measured in GPa. When the percentage of vinyl acetate is 12% the elastic modulus is 91 GPa. PEVA with a vinyl acetate percentage of 18% has an elastic modulus of 33 GPa which changes to 12 GPa when the percentage is 28%.

(a) State what must be used in the polymerisation to form a copolymer. **1**

(b) One of the monomers used to make PEVA is shown.



Draw the structure of the **other** monomer used to make PEVA. **1**

4. (continued)

(c) Complete the table to show the percentage of vinyl acetate used in PEVA and its elastic modulus. **2**

(An additional table, if required, can be found on *page 33*.)

(d) PEVA is often used in place of polyvinyl chloride.

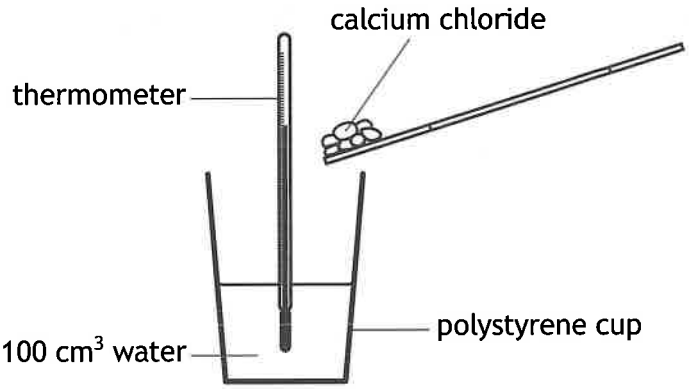
Name the monomer used to make polyvinyl chloride. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

5. When calcium chloride is dissolved in water, heat energy is released causing the temperature of the solution formed to increase.

(a) A student investigated how changing the mass of calcium chloride dissolved affected the temperature of the solution formed.



The results of the experiment are shown.

Mass of calcium chloride dissolved (g)	Temperature of the solution (°C)
0	20
5	27
10	35
15	43
20	50
25	57

The starting temperature of the water was 20 °C.

Calculate the energy absorbed by the water, in kJ, when 15 g of calcium chloride was dissolved. **3**

Show your working clearly.

5. (continued)

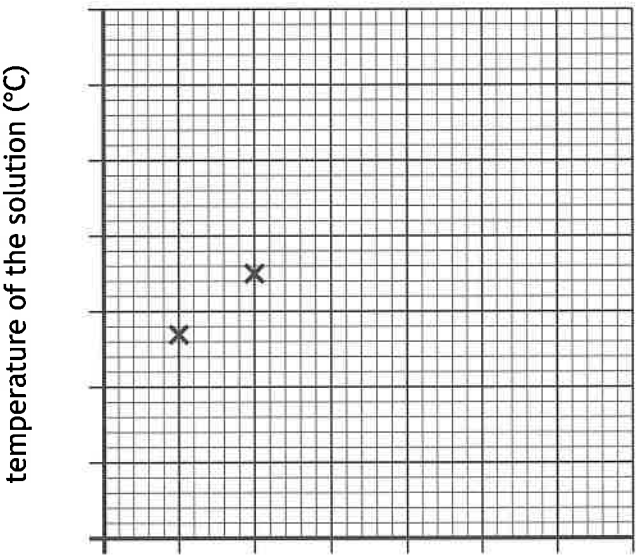
(b) The student used a polystyrene cup rather than a glass beaker to make the results more accurate.

Suggest why using a polystyrene cup makes the results more accurate. **1**

(c) Complete the graph to show the student's results. **2**

Two of the points have been plotted for you.

(An additional graph, if required, can be found on *page 33*.)



(d) Predict the temperature of the solution, in °C, if 30 g of calcium chloride was dissolved in the water. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

6. English physicist JJ Thomson discovered the electron in 1897.

Using your knowledge of chemistry, comment on the role of electrons in chemistry. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

7. Alkanes are hydrocarbons which are commonly used as fuels.

(a) Fuels are substances which burn in a plentiful supply of oxygen gas to release energy.

(i) State the test, including the result, used to identify oxygen gas. 1

(ii) State the products formed when an alkane is burned in a plentiful supply of oxygen gas. 1

(b) The efficiency of a fuel is given a rating known as the octane number.

The higher the octane number, the more efficient the fuel.

The octane numbers for some fuels are shown.

Fuel	Octane number
Octane	−19
2-methylheptane	22
2,4-dimethylhexane	64
2,2,4-trimethylpentane	100

(i) Using the information in the table, describe the relationship between the number of branches present and the octane number. 1

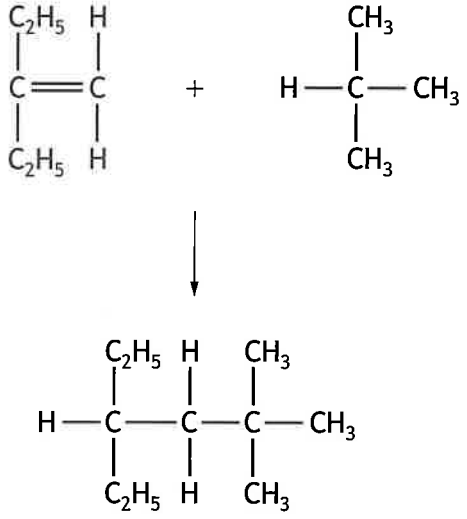
(ii) Name the most efficient fuel in the table. 1

[Turn over

7. **(continued)**

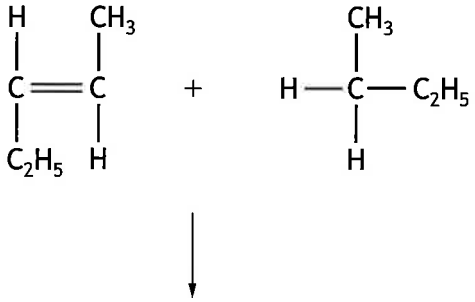
MARKS | DO NOT WRITE IN THIS MARGIN

(c) Alkanes can be reacted with alkenes to produce longer chain alkanes.



(i) Name the type of chemical reaction taking place. **1**

(ii) Draw the structural formula of the alkane formed in the following reaction. **1**



8. Read the passage and answer the questions that follow.

MARKS | DO NOT WRITE IN THIS MARGIN

Marie Curie — Elements of inspiration

In 1911, Polish scientist Marie Curie was the first female recipient of any Nobel prize. She was awarded the Nobel prize in chemistry for the discovery of the elements radium and polonium.

At that time, uranium and thorium were the only elements known to exhibit radioactivity. Marie found that an ore named pitchblende, containing the compound uranium(IV) oxide, was more radioactive than pure uranium. From this, she concluded that it contained other radioactive elements. After a series of experiments these elements were isolated and given the names radium and polonium.

The most common radioisotope of radium has a mass number of 226 and has a half-life of 1600 years. The most common radioisotope of polonium has a mass number of 210 and has a half-life of 138 days.

(a) Name the only **two** elements known to exhibit radioactivity before the discovery of radium and polonium. **1**

(b) Write the chemical formula for the compound found in the ore named pitchblende. **1**

(c) Calculate the time taken for a sample of polonium-210 to have decayed to 25% of its original radioactivity. **3**

Your answer must include an appropriate unit.

MARKS | DO NOT WRITE IN THIS MARGIN

8. (continued)

(d) Radium and polonium are both formed when uranium undergoes radioactive decay.

Explain why the formation of radium and polonium from uranium **must** include alpha decay. 1

You may wish to use the data booklet to help you.

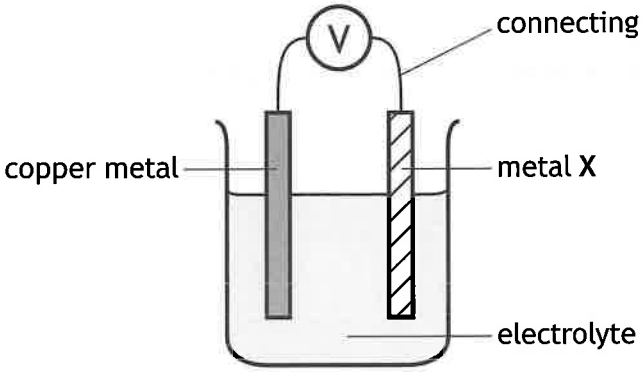
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

9. A student carried out a series of experiments using electrochemical cells.

(a) The student set up an experiment to measure the voltage produced by different metals when paired with copper in an electrochemical cell.

Their experimental set up and results are shown.



Metal X	Voltage (V)
Aluminium	0.6
Iron	0.4
Magnesium	1.6
Zinc	0.9

(i) The trend shown by the student's results is not correct.

Suggest **one** way in which this trend is not correct. **1**

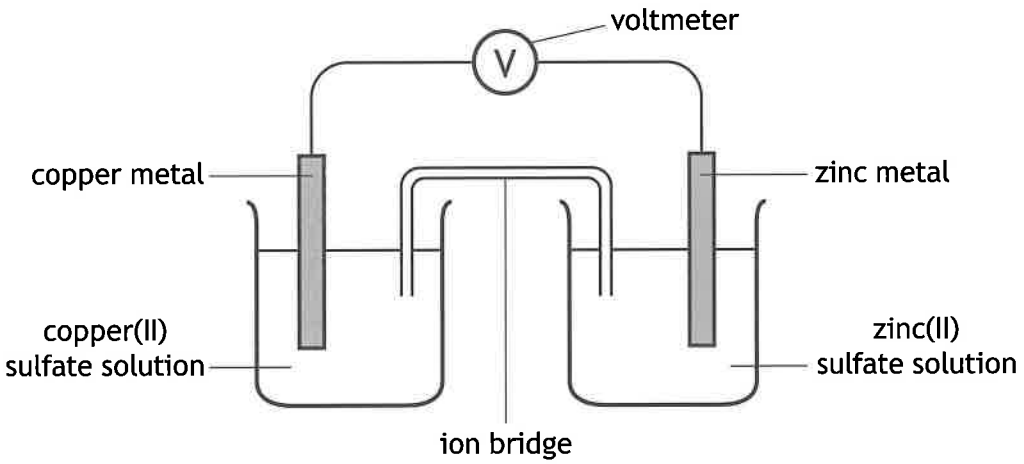
You may wish to use the data booklet to help you.

(ii) The electrolyte used in the cell must be an ionic solution because ionic solutions can conduct electricity.

State why an ionic solution can conduct electricity. **1**

9. (continued)

(b) The student set up another experiment using the apparatus shown.



(i) Draw an arrow on the diagram to show the path and direction of electron flow. **1**

You may wish to use the data booklet to help you.

(An additional diagram, if required, can be found on *page 34*.)

(ii) State the purpose of the ion bridge. **1**

[Turn over

9. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(c) The standard cell potential, E^0_{cell}, is a value that predicts the voltage produced by a cell using the E^0 values for the oxidation and reduction reactions in the cell.

The relationship used is shown.

$$E^0_{cell} = E^0\,(\text{reduction}) - E^0\,(\text{oxidation})$$

The E^0 values for some common metals are shown in the table.

Metal	E^0 (V)
Zinc	–0.76
Tin	–0.14
Copper	0.34
Silver	0.80

In one cell, silver ions are reduced whilst the tin atoms are oxidised.

The standard cell potential, E^0_{cell}, can be calculated as shown.

$$\begin{aligned} E^0_{cell} &= E^0\,(\text{reduction}) - E^0\,(\text{oxidation}) \\ &= E^0 \text{ for silver} - E^0 \text{ for tin} \\ &= 0.80 - (-0.14) \\ &= 0.94 \text{ V} \end{aligned}$$

In a cell containing zinc and copper, the ion-electron equations for the two reactions are shown.

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$
$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

(i) Calculate the standard cell potential, E^0_{cell}, in volts, for this cell. **2**

(ii) Write the redox equation for the overall reaction. **1**

9. (c) (continued)

(iii) To measure a standard cell potential the concentration of the solution used in the cell must be 1.0 mol l^{-1}.

Calculate the mass, in grams, of copper(II) sulfate, $CuSO_4$, required to prepare 250 cm^3 of 1.0 mol l^{-1} solution. **3**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

10. Alcohols are a homologous series commonly used in food and drink.

(a) (i) State what is meant by the term homologous series. 1

(ii) Name the functional group found in all alcohols. 1

(b) Ethanol is the alcohol used to make alcoholic drinks.

A 700 cm^3 bottle of whisky contains 224 g of ethanol.

Calculate the mass, in grams, of ethanol present in a 35 cm^3 glass of whisky. 1

(c) Alcohols can react with carboxylic acids to make a family of compounds called esters.

(i) The ester methyl ethanoate, $C_3H_6O_2$, is formed when methanol, CH_3OH, reacts with ethanoic acid, CH_3COOH. Water is also formed in the reaction.

This reaction is reversible.

Write an equation, using symbols and formulae, which shows that the reaction is reversible. 2

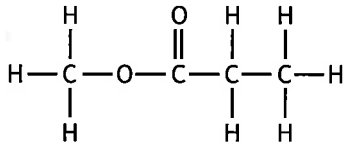
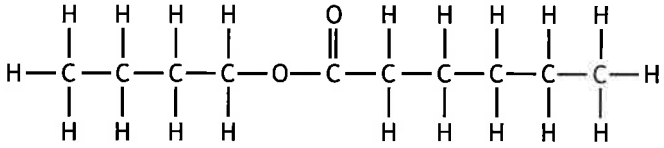
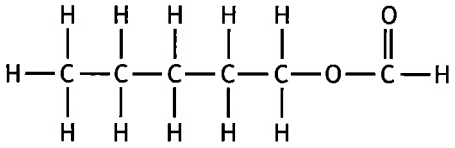
10. (c) (continued)

(ii) When making an ester, the reaction mixture must be heated.

The reaction mixture is flammable and so a Bunsen burner should not be used.

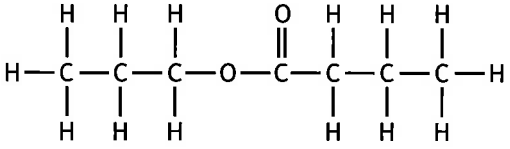
Suggest a more appropriate way to heat the reaction mixture. **1**

(iii) The structure of an ester depends upon the alcohol and carboxylic acid used.

Alcohol	Carboxylic acid	Ester
methanol	propanoic acid	
butan-1-ol	hexanoic acid	
pentan-1-ol	methanoic acid	

Complete the table below to show the name of the alcohol and carboxylic acid used to produce the ester shown. **2**

(An additional table, if required, can be found on *page 34*.)

Alcohol	Carboxylic acid	Ester
		

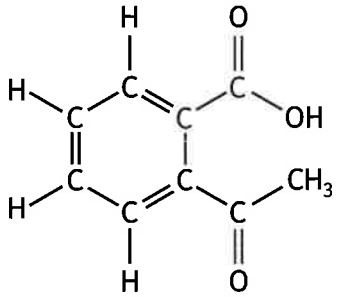
[Turn over

10. (c) (continued)

(iv) Aspirin is an ester, used in the treatment of pain, that dissolves in water to form a solution with a pH of less than 7.

Circle the functional group on the aspirin molecule that would be responsible for the pH of the solution being less than 7. **1**

(An additional diagram, if required, can be found on *page 34*.)



aspirin

11. Potassium permanganate can be used in many chemical reactions.

(a) Potassium permanganate, $KMnO_4$, reacts violently with glycerol, $C_3H_8O_3$.

The reaction releases heat energy, catches fire with a coloured flame and produces white smoke.

(i) State the term used to describe a chemical reaction that releases heat energy. **1**

(ii) State the colour of the flame that is observed in this reaction. **1**

You may wish to use the data booklet to help you.

(b) Potassium permanganate can also be used to find the quantity of iron present in an iron tablet.

The equation for this reaction is shown.

$$\underset{\text{permanganate ions}}{MnO_4^-(aq)} + 8H^+(aq) + 5e^- \rightarrow \underset{\text{manganese ions}}{Mn^{2+}(aq)} + 4H_2O(\ell)$$

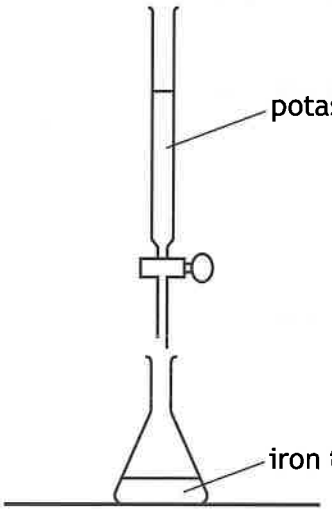
The reaction must be carried out in the presence of an acid.

Describe how the equation above shows that an acid is present in the reaction. **1**

[Turn over

(c) A student carried out a titration experiment to find the quantity of iron in an iron tablet.

Their experimental set up and results are shown.



	1st titre	2nd titre	3rd titre
Initial burette reading (cm^3)	0.0	21.9	0.0
Final burette reading (cm^3)	21.9	43.2	21.5
Volume used (cm^3)	21.9	21.3	21.5

(i) Using the results from the table, calculate the average volume, in cm^3, of potassium permanganate used to react completely with the iron tablet solution. **1**

(ii) The redox equation for the reaction is shown including the colour of the ions involved.

$$5Fe^{2+} + \underset{\text{purple}}{MnO_4^-} + 8H^+ \rightarrow 5Fe^{3+} + \underset{\text{colourless}}{Mn^{2+}} + 4H_2O$$

(A) Using your answer to part (i), calculate the concentration, in mol l^{-1}, of iron(II) ions in the iron tablet solution. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

11. (c) (ii) (continued)

(B) This titration does not require the use of an indicator to see the end-point of the titration.

Suggest why the use of an indicator is not required. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

12. Sodium chloride, NaCl, is commonly known as table salt. It has several uses and is also a product in some common chemical reactions.

Using your knowledge of chemistry, comment on the chemistry of sodium chloride. 3

[END OF QUESTION PAPER]