FOR OFFICIAL USE

National Qualifications
2021 ASSESSMENT RESOURCE

Mark

X813/75/01

Chemistry
Section 1 — Answer grid and Section 2

Duration — 2 hours 30 minutes

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.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

X8137501 01

SECTION 1 — 25 marks

The questions for Section 1 are contained in the question paper X813/75/02.

Read these and record your answers on the answer grid on *page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

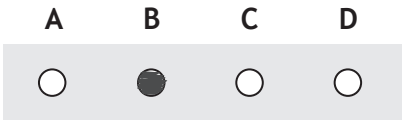
A fractional distillation

B chromatography

C fractional crystallisation

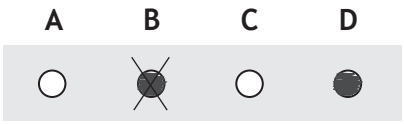
D filtration.

The correct answer is **B** — chromatography. The answer **B** bubble has been clearly filled in (see below).

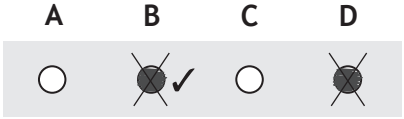


Changing an answer

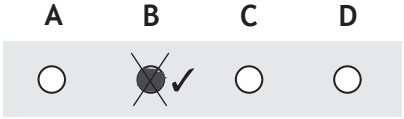
If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



or



SECTION 1 — Answer grid

OBJ25AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○
21	○	○	○	○
22	○	○	○	○
23	○	○	○	○
24	○	○	○	○
25	○	○	○	○

X8137501103

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X8137501O4

SECTION 2 — 75 marks

Attempt ALL questions

1. The element tin has the chemical symbol Sn.

(a) A sample of tin contains three different isotopes. The nuclide notation for each is shown.

$^{116}_{50}Sn$ $^{118}_{50}Sn$ $^{120}_{50}Sn$

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

(ii) This sample of tin has an average atomic mass of 119·4.

State the mass number of the most common type of atom in the sample of tin. **1**

(b) Another isotope of tin exists with 74 neutrons.

Write the nuclide notation for this isotope of tin. **1**

(c) Tin(IV) chloride can be formed by reacting tin with chlorine.

Some properties of tin(IV) chloride are shown in the table.

Melting point	−33 °C
Boiling point	114 °C
Electrical conductivity as a solid	Does not conduct
Electrical conductivity as a liquid	Does not conduct

Using the information in the table, state the **type of bonding** present in tin(IV) chloride. **1**

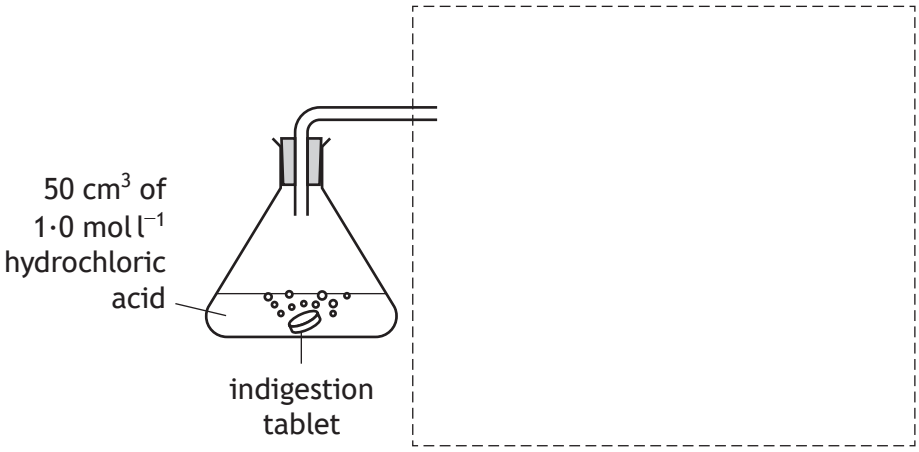
[Turn over

2. A student carried out an investigation into reaction rates using dilute hydrochloric acid and indigestion tablets which contain calcium carbonate.

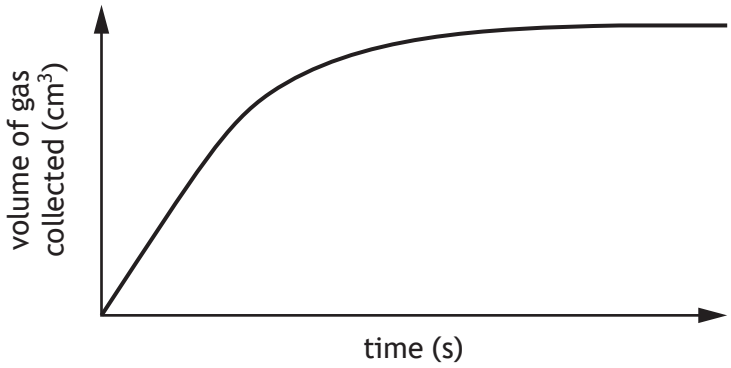
$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(\ell) + CO_2(g)$$

(a) Complete the diagram to show the apparatus required to **collect** and **measure** the volume of gas produced. **1**

(An additional diagram, if required, can be found on *page 29*.)



(b) The student recorded the volume of gas produced over a period of time. A graph of the results of this experiment is shown.



(i) **Add a curve to the graph** to show the results that would be expected if the experiment was repeated using a crushed indigestion tablet. **1**

(An additional diagram, if required, can be found on *page 29*.)

(ii) As these reactions proceed the rate of reaction decreases.

Suggest a reason why the rate of reaction decreases. **1**

2. (continued)

(c) The student carried out another three experiments, recording the time taken for 50 cm^3 of gas to be collected at different temperatures.

The results are shown.

Experiment	Temperature of acid (°C)	Time taken for 50 cm^3 of gas to be collected (s)
1	15	230
2	25	145
3	35	76

(i) Calculate the average rate of reaction, in $cm^3 s^{-1}$, for **experiment 1**. **2**

(ii) State the relationship between temperature of acid and time taken to collect 50 cm^3 of gas. **1**

(iii) **Experiment 1** was repeated using 1·0 mol l^{-1} sulfuric acid, $H_2SO_4(aq)$, instead of 1·0 mol l^{-1} hydrochloric acid, HCl(aq).

The time taken to collect 50 cm^3 of gas decreased.

Explain why the time taken decreased. **1**

[Turn over

3. Ammonia is a starting material for the commercial production of nitric acid.

(a) A catalyst is used in the production of nitric acid.

State what is meant by the term catalyst. **1**

(b) Ammonia and nitric acid react together to form ammonium nitrate.

Ammonium nitrate is commonly used as a fertiliser because it contains the element nitrogen, which is essential for healthy plant growth.

(i) Name another element essential for healthy plant growth. **1**

(ii) Describe another property of ammonium nitrate that makes it suitable for use as a fertiliser. **1**

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

(c) Another common fertiliser is urea, $(NH_2)_2CO$.

(i) Calculate the percentage by mass of nitrogen in urea, $(NH_2)_2CO$. **3**

Show your working clearly.

(ii) Urea dissolving in water is an endothermic process.

Suggest a piece of apparatus that could be used to confirm this process is endothermic. **1**

[Turn over for next question

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X8137501 09

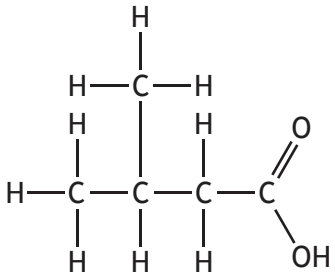
4. Read the passage below and answer the questions that follow.

Air Fresheners

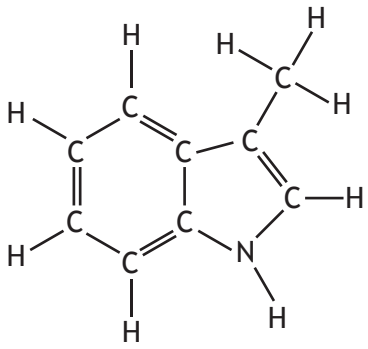
There are three ways an air freshener can remove an unpleasant smell. These are:

- Overpower it with a stronger smell
- Disguise it by mixing it with molecules to create a pleasant smell
- Absorb it

The following molecules are often found in unpleasant toilet smells.



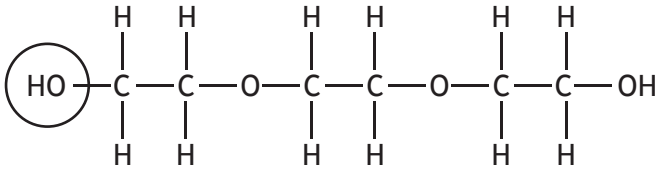
3-methylbutanoic acid



skatole

Some other molecules that make up these bad smells can contain sulfur atoms. For example, hydrogen sulfide (H_2S) is the gas associated with the smell of rotten eggs.

Air fresheners can contain molecules such as cyclodextrins that can absorb bad smells. Another molecule which is added for the same purpose is triethylene glycol.



triethylene glycol

Adapted from an article by John Emsley in Education in Chemistry, *September 2007*

(a) Cyclodextrin molecules absorb bad smells.

Name another molecule added to air fresheners to absorb bad smells. **1**

4. (continued)

(b) Draw a diagram, showing all outer electrons, of the molecule associated with the smell of rotten eggs. **1**

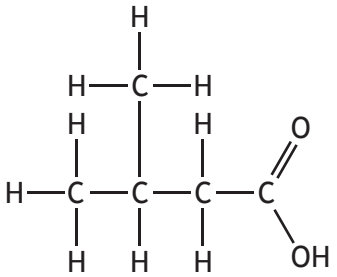
(c) Calculate the mass, in grams, of one mole of skatole. **1**

(d) Name the functional group circled on the triethylene glycol molecule. **1**

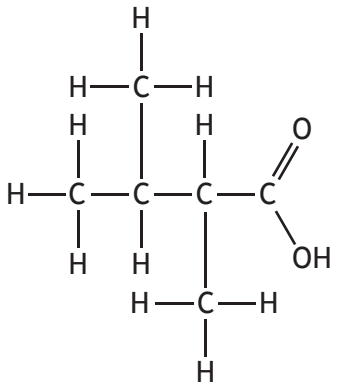
[Turn over

4. (continued)

(e) Two branched carboxylic acid molecules are shown.



3-methylbutanoic acid



2,3-dimethylbutanoic acid

(i) Draw the structure of 2,4-dimethylpentanoic acid. **1**

MARKS

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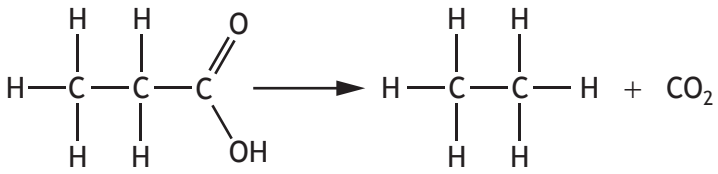
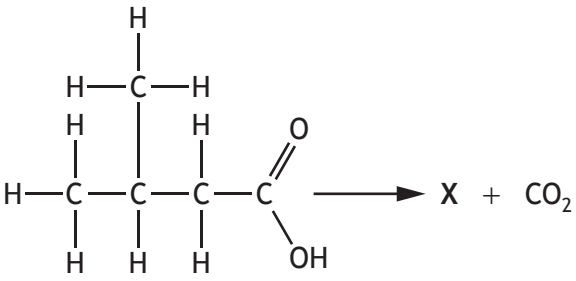
(ii) Carboxylic acids can be used to produce alkanes by a reaction that involves the loss of carbon dioxide.



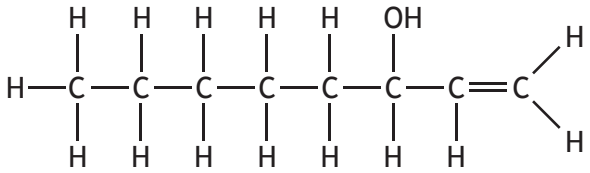
3-methylbutanoic acid produces alkane **X** as shown.



3-methylbutanoic acid

Draw the structure of alkane **X**. **1**

(f) The molecule shown is associated with the smell of wet dogs. It will decolourise bromine solution quickly.



State the term used to describe molecules that decolourise bromine solution quickly. **1**

[Turn over

5. Metal elements make up over three-quarters of the periodic table.

Using your knowledge of chemistry, comment on the chemical reactions and properties of metals. **3**

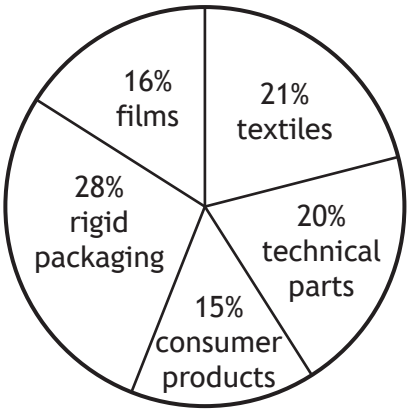
MARKS | DO NOT WRITE IN THIS MARGIN

6. Poly(propene) is an addition polymer with many uses.

(a) (i) Draw the monomer used to make poly(propene). **1**

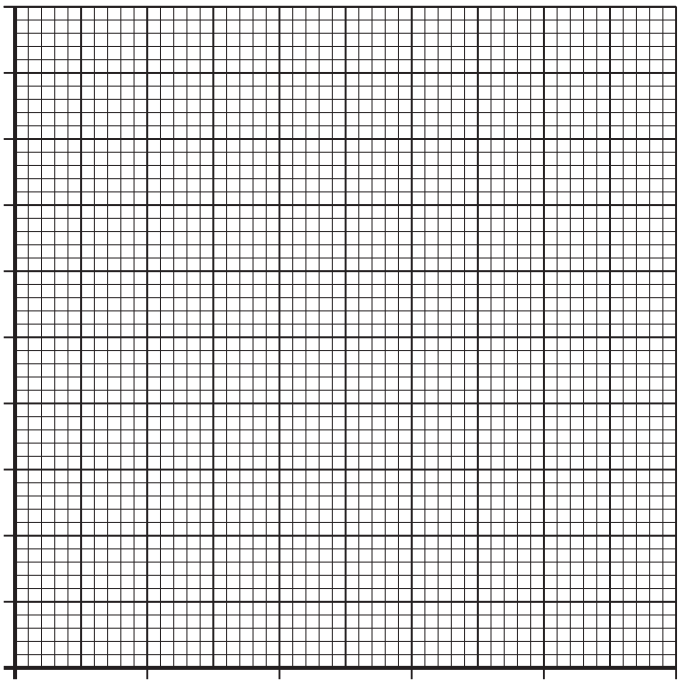
(ii) Poly(propene) is one of the most widely used polymers.

Uses of poly(propene)



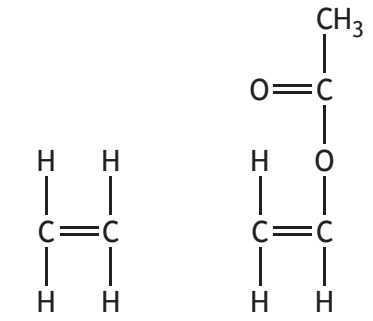
Draw a graph showing the information in the pie chart. **4**

(Additional graph paper, if required, can be found on *page 30*.)



6. (continued)

(b) Co-polymers are polymers made using more than one type of monomer. Poly(ethylene-vinyl acetate) is a co-polymer used to make shower curtains and football studs. The monomers used to make it are shown.



monomer A monomer B

(i) These monomer units join together by addition polymerisation.

State why these monomers can take part in addition polymerisation. **1**

(ii) Draw the repeating unit formed when one molecule of **monomer A** joins with one molecule of **monomer B**. **1**

7. When an acid and a base react together, water and a salt are formed.

(a) Acids and bases can be classified as strong or weak.

The salts formed, if soluble, will have a pH that depends on the strength of the acid and base used.

strong acid + strong base → neutral salt + water

strong acid + weak base → acidic salt + water

weak acid + strong base → alkaline salt + water

Examples of strong and weak acids and bases are shown in the tables.

Acids	
Strong acid	**Weak acid**
hydrochloric acid	methanoic acid

Bases	
Strong base	**Weak base**
sodium hydroxide	ammonium hydroxide

(i) Methanoic acid reacts with sodium hydroxide.

Name the salt formed. **1**

(ii) Predict the pH of the salt solution formed when hydrochloric acid reacts with ammonium hydroxide. **1**

[Turn over

7. (continued)

(b) (i) The volume of an acid required to neutralise an accurately measured volume of a base can be measured as follows.

1. Pipette 10 cm^3 of a base into a conical flask
2. Add 3 drops of indicator solution
3. Add 0·1 mol l^{-1} of an acid from a burette until the indicator changes colour

State the name of this technique. **1**

(ii) To determine the concentration of a base, the titre volumes must be concordant.

State what is meant by the term concordant. **1**

(c) Salts have a wide variety of uses.

(i) The salt strontium chloride is used in fireworks.

State the colour of the flame that would be seen when a firework containing the salt strontium chloride is burned. **1**

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

(ii) Another salt, barium sulfate, is used in some medical procedures.

Write the formula, showing the charge on each ion, for barium sulfate. **1**

8. Camping gas contains a mixture of the hydrocarbons propane and butane. When propane and butane are burned, carbon dioxide and water are produced.

(a) (i) Name the chemical used to confirm that carbon dioxide has been produced. **1**

(ii) Propane and butane are members of the alkane homologous series.

State what is meant by the term homologous series. **1**

(iii) Balance the equation for the combustion of butane. **1**

$$C_4H_{10} \quad + \quad O_2 \quad \rightarrow \quad CO_2 \quad + \quad H_2O$$

(b) During a camping trip a can of baked beans was heated by burning camping gas.

Specific heat capacity of baked beans	3·6 kJ kg^{-1} $°C^{-1}$
Energy absorbed by the baked beans	76·32 kJ
Temperature of baked beans before being heated	17 °C
Mass of baked beans	400 g

Calculate the **final** temperature, in °C, of the baked beans using the information in the table. **4**

9. Aluminium is a metal that cannot be extracted from its ore by heat alone.

(a) The first step in the extraction of aluminium is to obtain aluminium oxide from the ore bauxite.

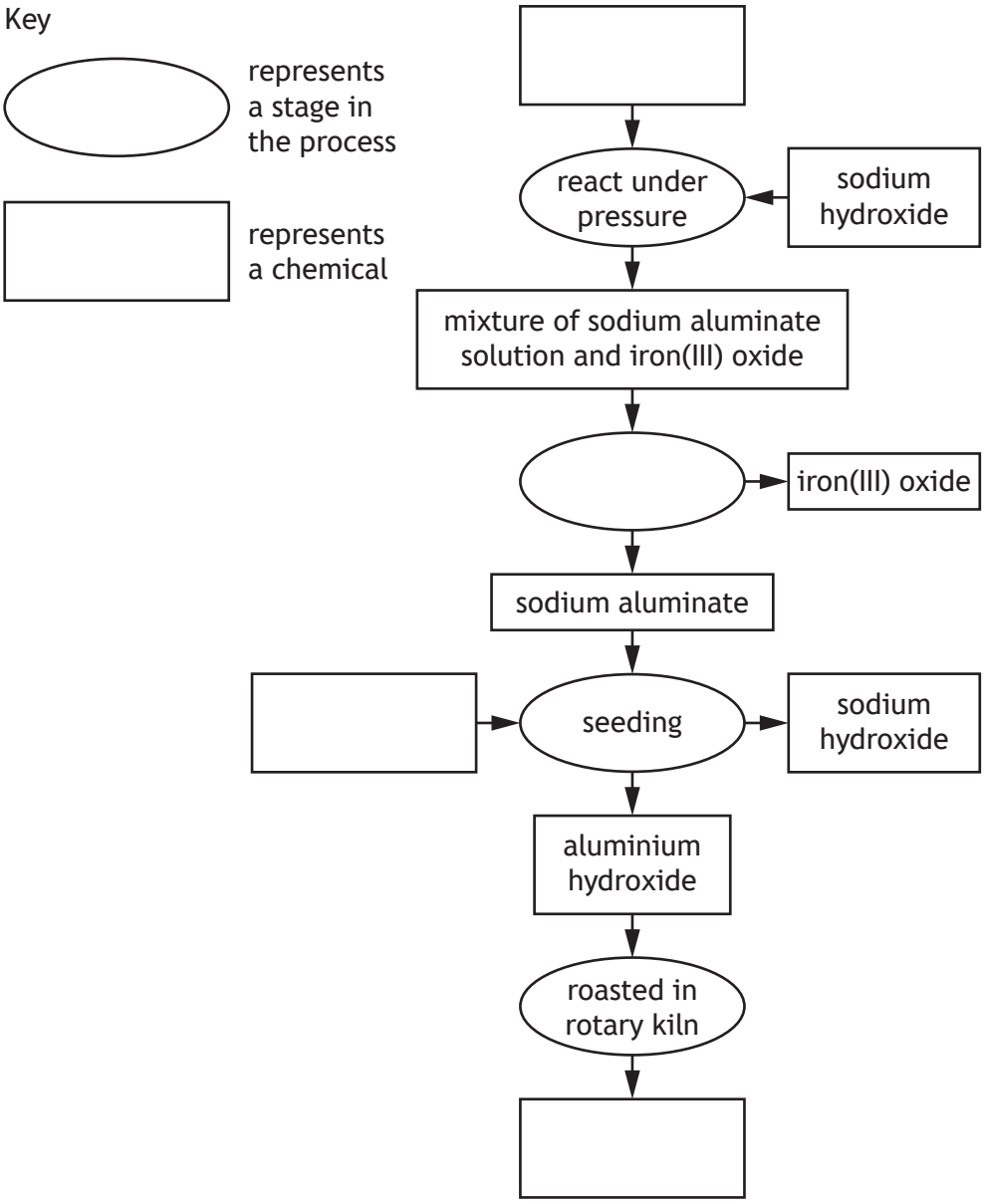
The ore is reacted with sodium hydroxide solution under pressure. This produces a mixture of sodium aluminate solution and the impurity iron(III) oxide which is removed by filtration.

A small amount of aluminium hydroxide is added to the filtrate to produce larger amounts of aluminium hydroxide in a process called 'seeding'. Sodium hydroxide solution is also formed.

The aluminium hydroxide then passes to a rotary kiln where it is roasted to form aluminium oxide.

(i) Complete the **flow diagram**, to summarise the production of aluminium oxide. **2**

(An additional diagram, if required, can be found on *page 31*.)

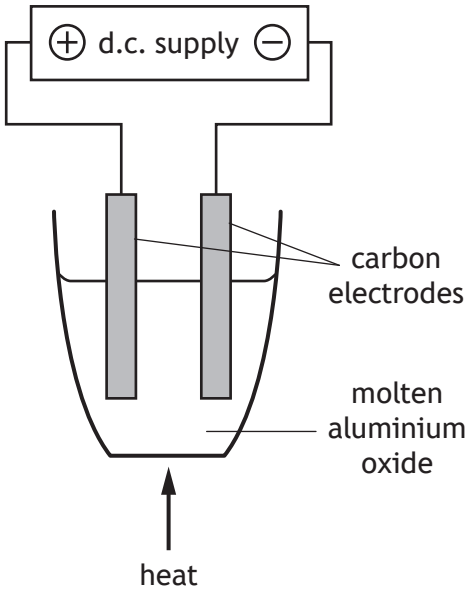


9. (a) (continued)

(ii) **On the flow diagram**, draw an arrow to show how the process could be made more economical. **1**

(b) Aluminium can be extracted from aluminium oxide by electrolysis.

A simple electrolysis set up is shown.



(i) State what is meant by the term electrolysis. **1**

(ii) Explain why a d.c. supply **must** be used. **1**

[Turn over

9. (b) (continued)

(iii) State why ionic compounds, like aluminium oxide, conduct electricity when molten. **1**

(iv) During electrolysis, the following reactions take place.

$$Al^{3+} + 3e^- \rightarrow Al$$

$$2O^{2-} \rightarrow O_2 + 4e^-$$

Write the redox equation for the overall reaction. **1**

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

MARKS | DO NOT WRITE IN THIS MARGIN

Tungsten carbide

Tungsten has the chemical symbol W. It can be traced back to the 18th century when it was first extracted from the ore wolframite. Tungsten has a very high melting point of 3422 °C.

Tungsten carbide, a compound of tungsten, was accidentally made by chemist Henri Moissan in 1896. In an attempt to make artificial diamond, he heated sugar and tungsten(III) oxide in a furnace. The sugar reacted with the tungsten oxide to produce liquid tungsten carbide.

Tungsten carbide has a melting point of 2870 °C and a boiling point of 6000 °C and is three and a half times as dense as titanium.

Adapted from
https://eic.rsc.org/magnificent-molecules/tungsten-carbide/3008556.article

(a) State the name of the ore from which tungsten was first extracted. **1**

(b) Write the formula for the compound that was heated with sugar, in a furnace, to produce tungsten carbide. **1**

(c) Suggest a temperature, in °C, that Henri Moissan's furnace could have been operating at when tungsten carbide was accidentally made. **1**

(d) Calculate the density of tungsten carbide, in $g\,cm^{-3}$. **2**

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

[Turn over

11. Carbon-14 is an isotope of carbon that can be used to determine the age of materials.

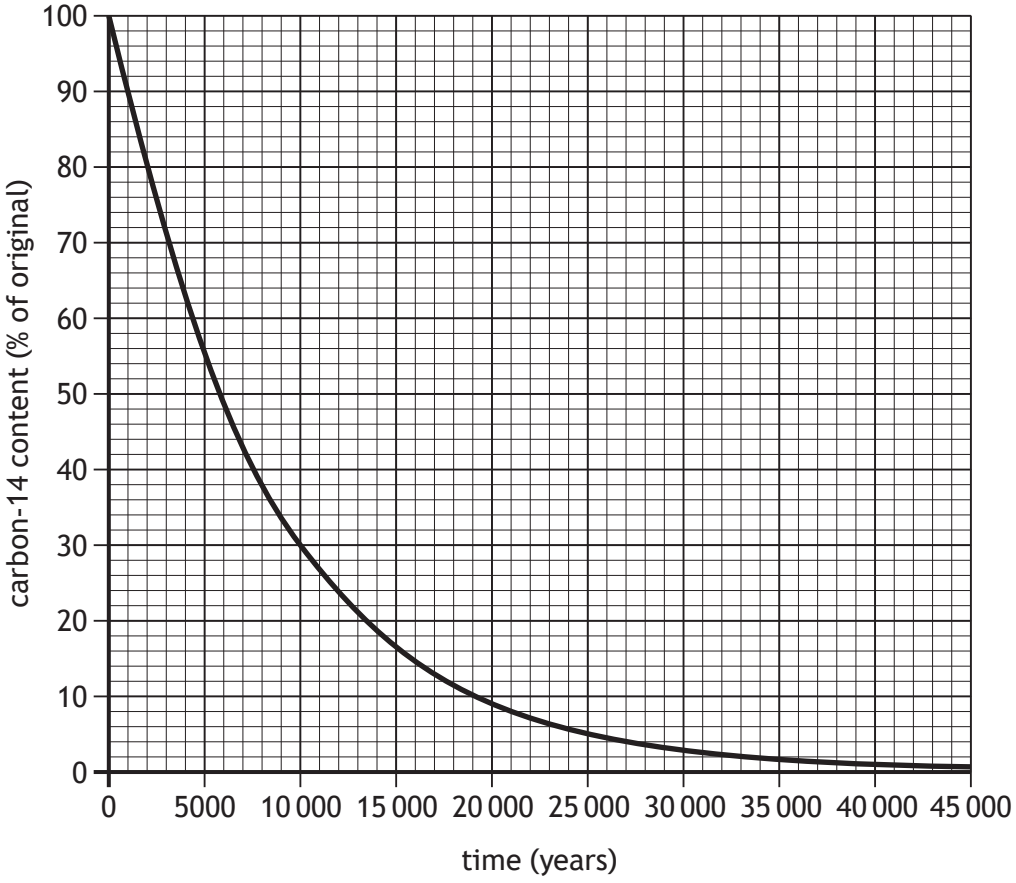
(a) When a neutron is absorbed by a nitrogen-14 nucleus, a carbon-14 isotope is produced along with one other particle, **X**.

An equation for this is shown

$$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C + X$$

Name particle **X**. **1**

(b) The graph shows how the percentage of carbon-14 in a sample changes over a period of time.



(i) Use the graph to calculate the half-life, in years, of carbon-14. **1**

11. (b) (continued)

(ii) Use your answer to part (b) (i) to calculate the age, in years, of a bone found to contain $\frac{1}{16}$ of the original carbon-14 content. **2**

(iii) Another bone, believed to be over 100 000 years old, cannot be dated using levels of carbon-14.

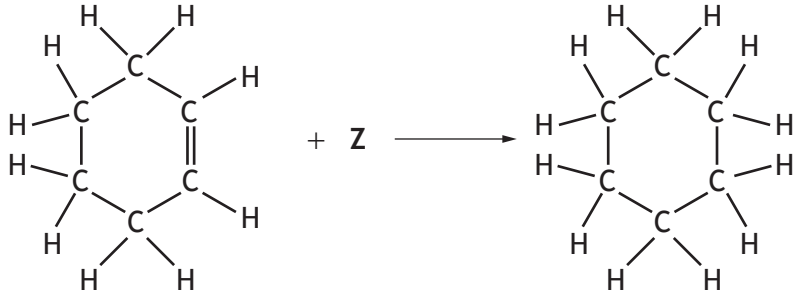
Suggest why carbon-14 is unsuitable for dating this bone. **1**

[Turn over

12. Cycloalkanes are an important family of hydrocarbons found in jet fuels.

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

(b) Cycloalkanes can be made in a number of ways. One method is shown.



cyclohexene compound **Y**

(i) Name the type of addition reaction taking place when cyclohexene reacts with **Z**. **1**

(ii) Draw an isomer of compound **Y** that belongs to a different homologous series to compound **Y**. **1**

MARKS

DO NOT WRITE IN THIS MARGIN

(c) Another method for making cycloalkanes is shown.

$$\underset{\text{1,5-dibromopentane}}{C_5H_{10}Br_2} + \underset{\text{sodium}}{2Na} \rightarrow \underset{\text{cyclopentane}}{C_5H_{10}} + \underset{\text{sodium bromide}}{2NaBr}$$

Calculate the mass, in grams, of sodium required to produce 175 g of cyclopentane. **3**

(d) Cycloalkanes can experience ring strain within their rings. The ring strain of some cycloalkanes is shown.

Cycloalkane	Total ring strain (kJ)
cyclopropane	132
cyclopentane	25
cycloheptane	28

$$\text{Ring strain per carbon} = \frac{\text{total ring strain}}{\text{number of carbons in the cycloalkane}}$$

Calculate the ring strain per carbon, in kJ, for cycloheptane. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

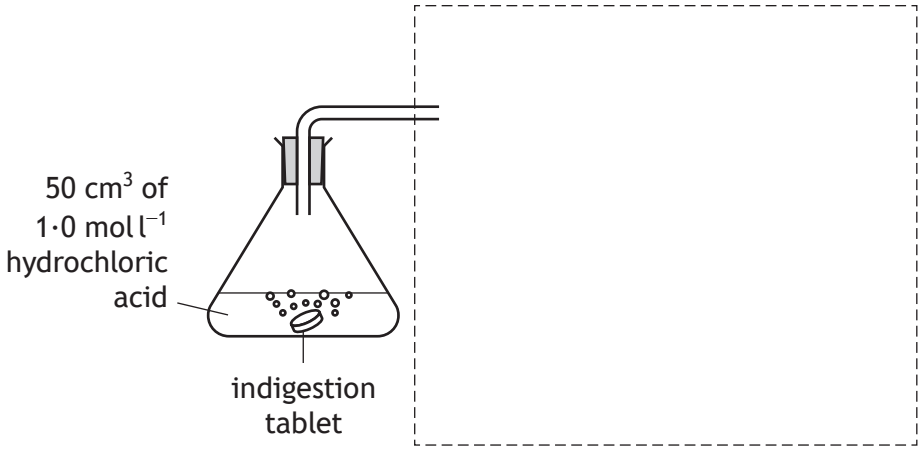
13. Vinegar is a solution of ethanoic acid in water. Different types of vinegar can contain different concentrations of ethanoic acid.

Using your knowledge of chemistry, suggest how a student could determine which type of vinegar had the highest concentration of ethanoic acid. **3**

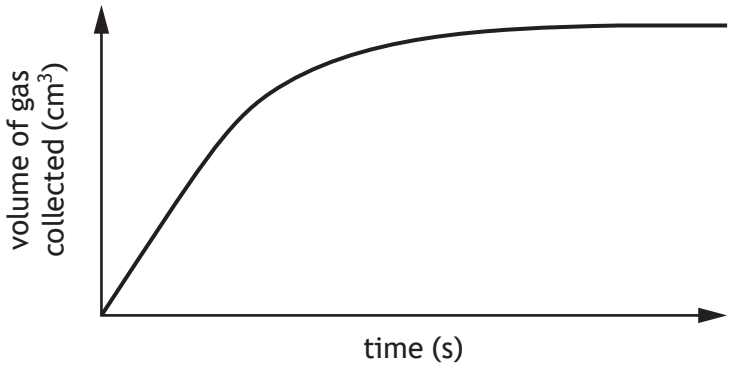
[END OF QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional diagram for question 2 (a)

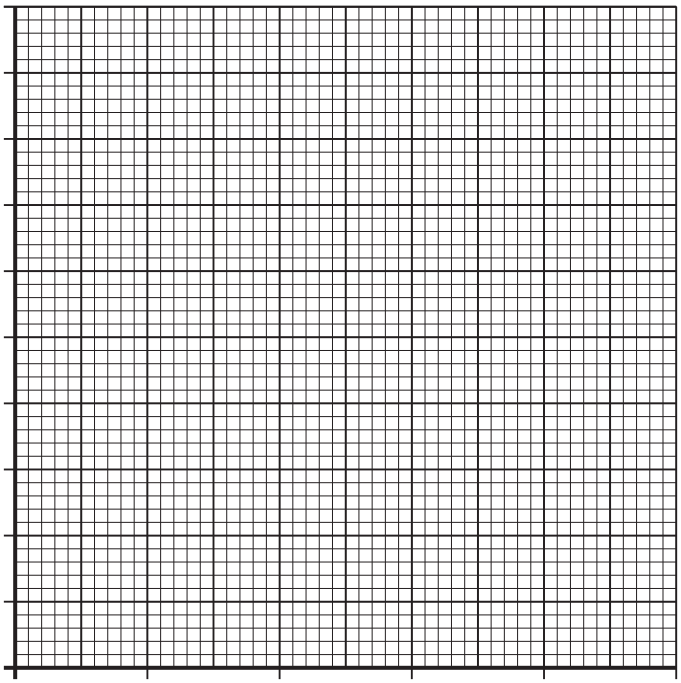


Additional diagram for question 2 (b) (i)



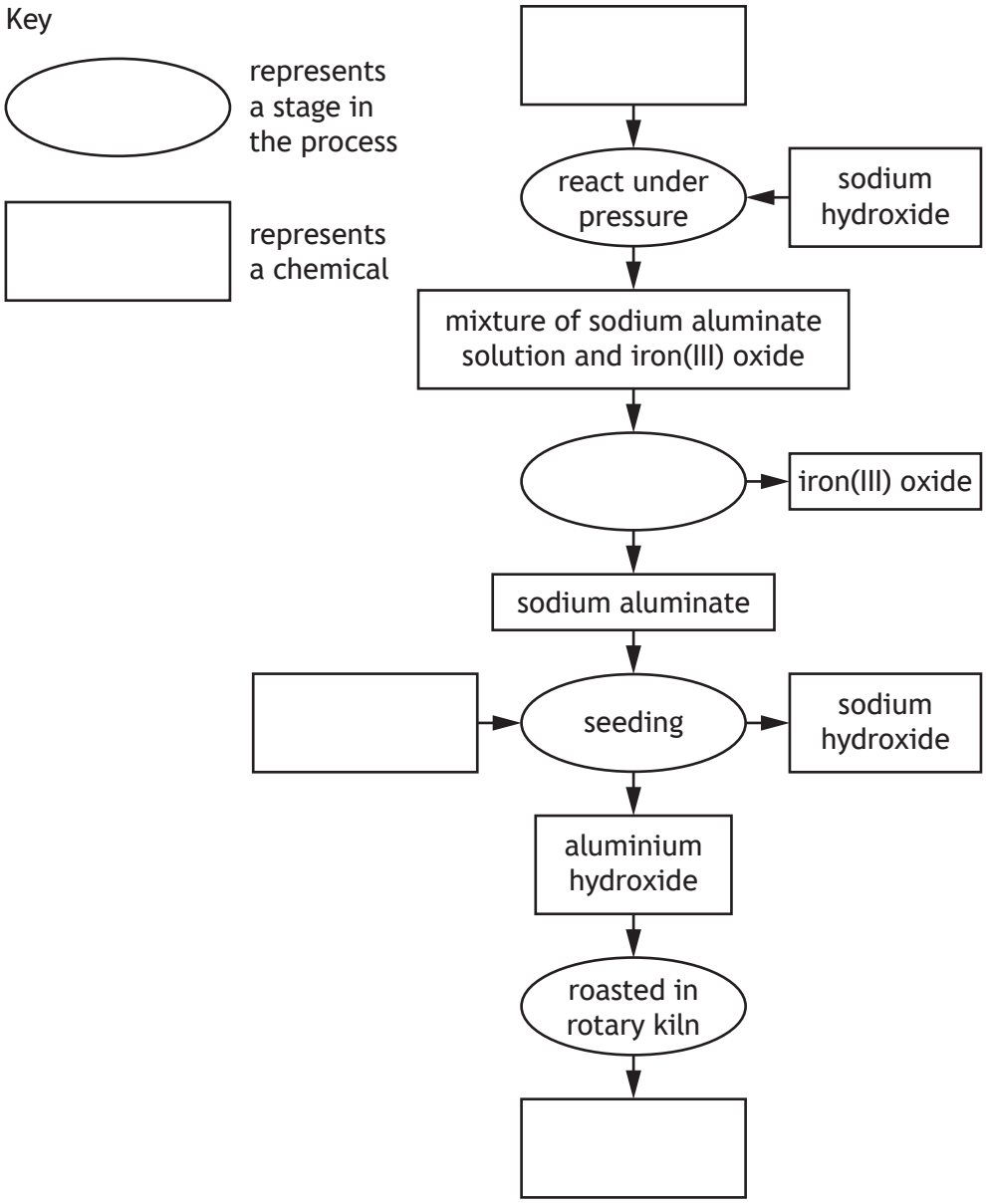
ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional diagram for question 6 (a) (ii)



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional diagram for question 9 (a) (i)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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