OCR
Oxford Cambridge and RSA

# Tuesday 13 June 2023 – Morning

## GCSE (9–1) Chemistry B (Twenty First Century Science)

**J258/04** Depth in Chemistry (Higher Tier)

**Time allowed: 1 hour 45 minutes**

**You must have:**
- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Chemistry B (inside this document)

**You can use:**
- a scientific or graphical calculator
- an HB pencil

H

* J 2 5 8 0 4 *

* 9 9 2 9 5 1 5 7 0 6 *

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____



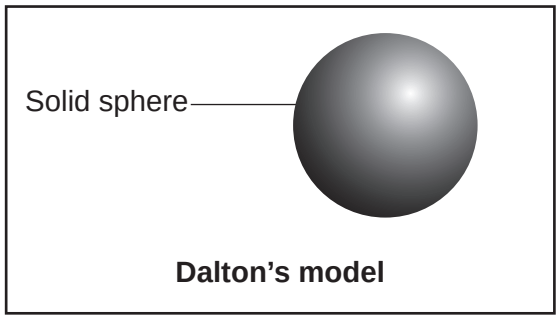
**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

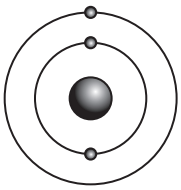
**ADVICE**
- Read each question carefully before you start your answer.

**1** Scientists use models to represent atoms. These models have changed over time.

Dalton's model and a modern model of an atom are shown in the diagrams.




**Dalton's model**



**Modern model**

**(a)** Give **two** differences between the modern model and Dalton's model.

1 .....

.....

2 .....

.....

**[2]**

**(b)** Which element is represented by the modern model in the diagram?

Explain your answer.

Use the Data Sheet.

Element .....

Explanation .....

.....

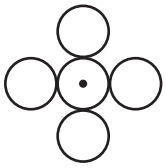
.....

**[2]**

**(c)** Dalton used symbols for atoms to write formulae.

Each symbol represented a different type of atom.

Some of Dalton's formulae are shown in the table.

| | **Dalton's formula** |
|---|---|
| **Carbon dioxide** |  |
| **Chlorine** |  |

**(i)** Explain how Dalton's formula for carbon dioxide **agrees** with its modern formula.

.....

..... **[1]**

**(ii)** Give **two** reasons why Dalton's formula for chlorine **disagrees** with its modern formula.

1 .....

.....

2 .....

.....

**[2]**

**(d)** Put the particles in order from largest to smallest.

**Atom** **Electron** **Molecule of oxygen** **Polymer** **Proton**

Largest .....

.....

.....

.....

Smallest .....

**[2]**

**2** Ali works in a laboratory that tests food to make sure it is safe to eat.

He tests some sweets. The sweets are sold to shops in large boxes which each contain 100 packets of sweets.

**(a)** **(i)** Describe how Ali should choose sweets to test to make sure that his sample is **representative**.

.....

..... **[1]**

**(ii)** Explain why it is important that the sample Ali tests is representative.

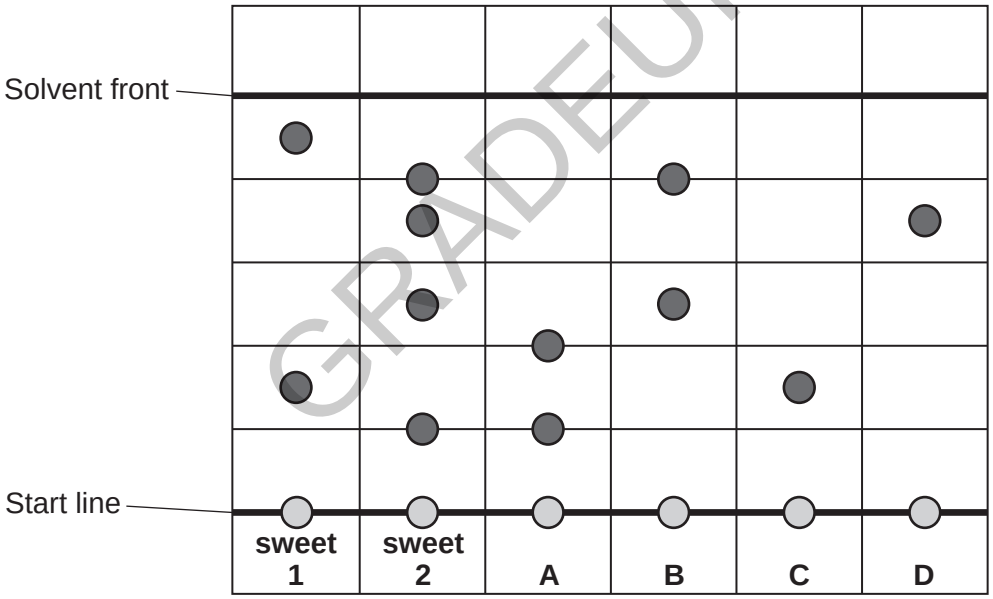
.....

..... **[1]**

**(b)** Ali uses paper chromatography to test two sweets, sweet 1 and sweet 2.

He also tests some samples of safe food colours, **A**, **B**, **C** and **D**.

The diagram shows Ali's results.




**(i)** Calculate the Rf value of food colour **D**.

Rf value = ..... **[2]**

**(ii)** Which safe food colours, **A**, **B**, **C** and **D**, are pure?

Explain your answer.

Food colours .....

Explanation .....

.....

.....

**[2]**

**(iii)** Which **two** safe food colours have been used to make sweet 2?

Tick (✓) **two** boxes.

**A** ☐

**B** ☐

**C** ☐

**D** ☐

**[2]**

**(iv)** Ali says that he **cannot** be sure that the food colours used in sweet 1 are safe.

Explain why Ali is correct.

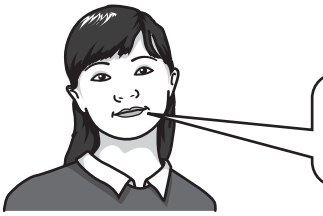
.....

..... **[1]**

**3** Some people use sunscreens on their skin when they are exposed to the sun.

The sunscreens contain nanoparticles. The nanoparticles block harmful radiation from the sun.

Mia talks about using sunscreen which contains nanoparticles.



I work outside all the time. I know that there are risks to using sunscreen but I think overall it is beneficial.

**(a)** Explain the risks **and** benefits to Mia of using a sunscreen which contains nanoparticles.

.....

.....

.....

..... **[3]**

**(b)** Which statements about nanoparticles are **true** and which are **false**?

Tick (✓) **one** box in each row.

| | True | False |
|---|---|---|
| Fullerenes and graphite are examples of nanoparticles. | | |
| Nanoparticles are usually larger than atoms. | | |
| Nanoparticles have a large volume compared to their surface area. | | |
| The properties of nanoparticles are related to their sizes and shapes. | | |

**[2]**

**(c)** Some data about the diameter of nanoparticles **A**, **B**, **C** and **D** is shown in the table.

| Nanoparticle | Diameter (m) |
|---|---|
| **A** | $8.2 \times 10^{-9}$ |
| **B** | $2.1 \times 10^{-9}$ |
| **C** | $9.1 \times 10^{-10}$ |
| **D** | $8.9 \times 10^{-9}$ |

Put the nanoparticles **A**, **B**, **C** and **D** in order from largest to smallest.

Largest .....

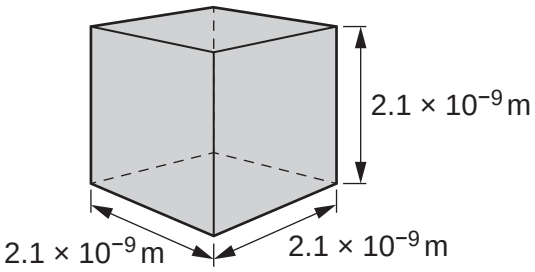
.....

.....

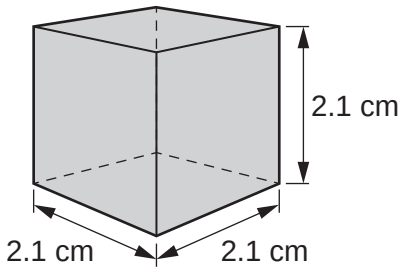
Smallest ..... **[2]**

**(d)** Nanoparticle **B** is the same shape as a cube. Each side of nanoparticle **B** measures $2.1 \times 10^{-9}$ m.

Mia makes a model of nanoparticle **B**. She makes each side of her model 2.1 cm long.




**Nanoparticle B**




**Model of nanoparticle B**

**(i)** How many times longer is each side of the model compared to nanoparticle **B**?

Put a (ring) around the correct option.

**1 000 000 000 x** **10 000 000 x** **900 x** **109 x** **100 x**

**[1]**

**(ii)** Calculate the volume of the model of nanoparticle **B**.

Give your answer to **1** decimal place.

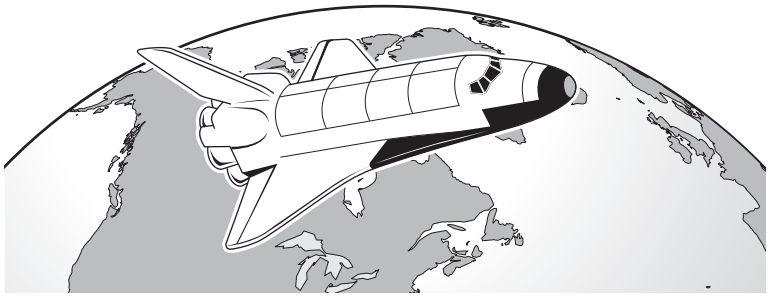
Volume = ..... $cm^3$ **[2]**

**(iii)** The model of nanoparticle **B** has 6 sides.

Calculate the surface area of the model of nanoparticle **B**.

Surface area = ..... $cm^2$ **[2]**

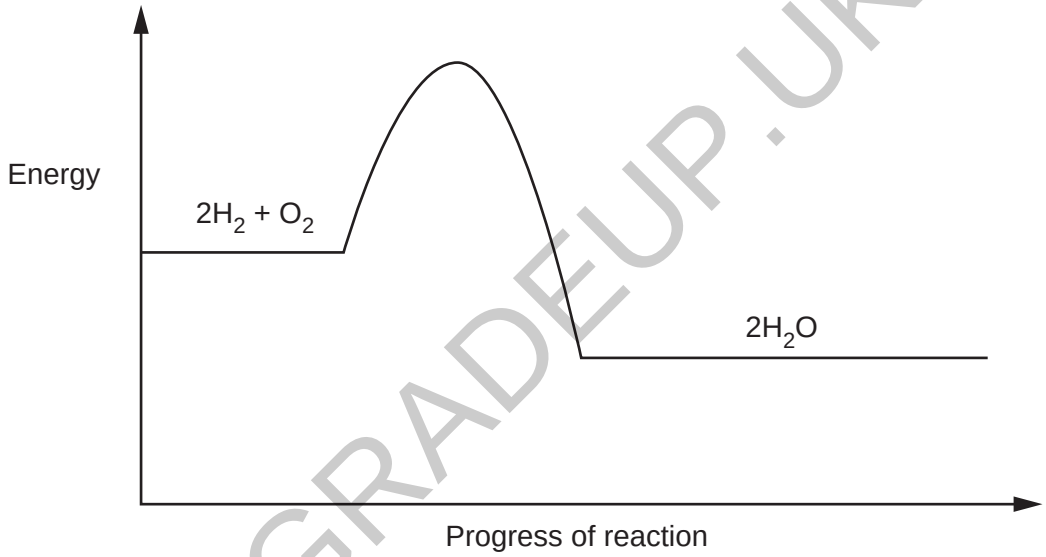
**4** Space shuttles are used to transport people into space stations in space.



Space shuttles use hydrogen-oxygen fuel cells to provide some of their power.

The shuttles carry a supply of liquid hydrogen and liquid oxygen stored under pressure.

**(a)** The reaction profile diagram shows the energy change when hydrogen reacts with oxygen.






**(i)** Label the activation energy, $E_a$, on the diagram. **[1]**

**(ii)** Explain the meaning of **activation energy**.

Use ideas about bonds in your answer.

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..... **[2]**

**(iii)** Platinum acts as a catalyst for the reaction between hydrogen and oxygen.

Explain the effect of a catalyst on the reaction between hydrogen and oxygen.

Use ideas about activation energy in your answer.

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..... **[2]**

**(b)** The equation shows the molecules involved in the reaction between hydrogen and oxygen.

$$\begin{matrix} H–H \\ \\ H–H \end{matrix} \quad + \quad O=O \quad \rightarrow \quad \begin{matrix} H–O–H \\ \\ H–O–H \end{matrix}$$

The table shows the bond energies of the bonds in the molecules (per formula mass).

| Bond | Energy (kJ) |
|---|---|
| H–H | 436 |
| O=O | 498 |
| O–H | 463 |

Calculate the energy needed to break all of the bonds in the hydrogen and oxygen molecules and to make all of the bonds in the water molecules.

Use your values to then calculate the overall energy change of the reaction.

Energy needed to break bonds = ..... kJ

Energy needed to make bonds = ..... kJ

Energy change of reaction = ..... kJ

**[3]**

**(c)** Evaluate the advantages **and** disadvantages of using hydrogen-oxygen fuel cells in space shuttles.

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..... **[3]**

**5*** The box gives information about what happens when calcium chloride and ammonium chloride dissolve in water.

| |
|---|
| There is an exothermic change when calcium chloride dissolves in water.<br><br>There is an endothermic change when ammonium chloride dissolves in water. |

Describe an experiment to show that the information in the box is correct.

Include in your answer:

- what measuring equipment you need
- your method
- how you will control variables
- the measurements you will make and the results that you expect.

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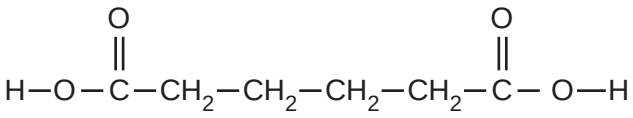
..... **[6]**

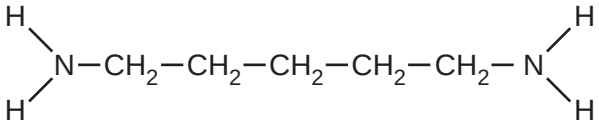
**6** Nylon is a condensation polymer.

The structure of the monomer molecules that react together to make nylon are shown in **Fig. 6.1**.

**Fig. 6.1**



**Monomer 1**



**Monomer 2**

**(a) (i)** Put a ring around each of the functional groups in monomer 1 **and** monomer 2. **[2]**

**(ii)** Explain why monomers of condensation polymers need to contain functional groups.

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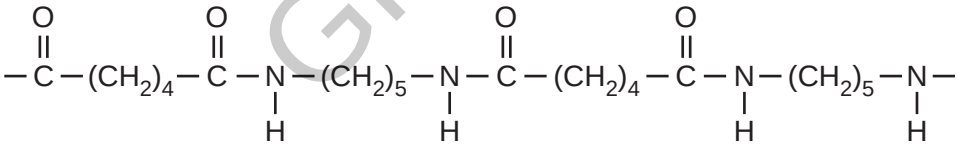
..... **[1]**

**(b)** Monomer 1 and monomer 2 react to form a polymer of nylon.

The structure of part of the polymer is shown in **Fig. 6.2**.

**Fig. 6.2**



**(i)** How many repeating units of the polymer are shown in **Fig. 6.2**?

..... **[1]**

**(ii)** Write the name and formula of the **other** product formed in the reaction between monomer 1 and monomer 2.

Name .....

Formula .....

**[1]**

**(c)** Some polymers, such as DNA, are naturally occurring.

Which statements about polymers are **true** and which are **false**?

Tick (✓) **one** box in each row.

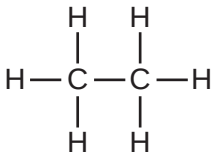
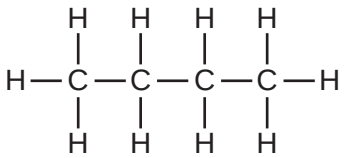
| | True | False |
|---|---|---|
| DNA forms a polymer from four different monomers. | | |
| Sugars and amino acids are monomers of naturally occurring polymers. | | |

**[1]**

**7** Fractional distillation separates crude oil into fractions. Each fraction contains hydrocarbons.

**(a)** **Table 7.1** shows information about two hydrocarbons.

**Table 7.1**

| | **Hydrocarbon 1** | **Hydrocarbon 2** |
|---|---|---|
| **Structure** |  |  |
| **Empirical formula** | $CH_3$ | ..... |

**(i)** Complete **Table 7.1**. **[1]**

**(ii)** The general formula for the hydrocarbons in **Table 7.1** is $C_nH_{2n+2}$.

Explain why this formula is true for hydrocarbon 2.

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.....

.....

..... **[2]**

**(iii)** Name the homologous series to which both hydrocarbons belong.

..... **[1]**

**(b)** **Table 7.2** shows information about the hydrocarbons in six fractions of crude oil.

**Table 7.2**

| Fraction number | Number of carbon atoms in the molecules | Boiling point (°C) |
|---|---|---|
| 1 | 1 <5 | 0–30 |
| 2 | >4 <10 | 30–180 |
| 3 | >9 <17 | 180–260 |
| 4 | >13 <21 | 250–350 |
| 5 | >19 <51 | 350–580 |
| 6 | >50 | >580 |

**(i)** A hydrocarbon in crude oil has a boiling point of 69 °C.

Suggest a formula for this hydrocarbon.

..... **[1]**

**(ii)** Give the formula for the smallest hydrocarbon molecule in fraction **5**.

..... **[1]**

**(c)** Explain the trend in boiling points of the hydrocarbons in **Table 7.2**.

Use ideas about the size of molecules and intermolecular forces in your answer.

.....

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.....

..... **[2]**

**(d)** Which **two** statements explain why modern life depends on crude oil?

Tick (✓) **two** boxes.

Crude oil is a fossil fuel and is a renewable resource. ☐

Fractional distillation of crude oil is done on a very large scale. ☐

Fuels made from crude oil produce greenhouse gases when they burn. ☐

Hydrocarbons are feedstocks for the petrochemical industry. ☐

There is not a large enough supply of renewable energy sources to meet the needs of modern life. ☐

**[2]**

**8** Ammonia is made on an industrial scale in a reaction between nitrogen and hydrogen.

The equation to make ammonia is shown.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

**(a)** What is the atom economy of this reaction?

Explain your answer.

Atom economy = ..... %

Explanation .....

.....

..... **[2]**

**(b)** Why does this reaction **not** give a 100% yield?

.....

..... **[1]**

**(c)** The reaction used to make ammonia takes place in a reactor.

Unreacted nitrogen and hydrogen left at the end of the reaction are recycled back into the reactor.

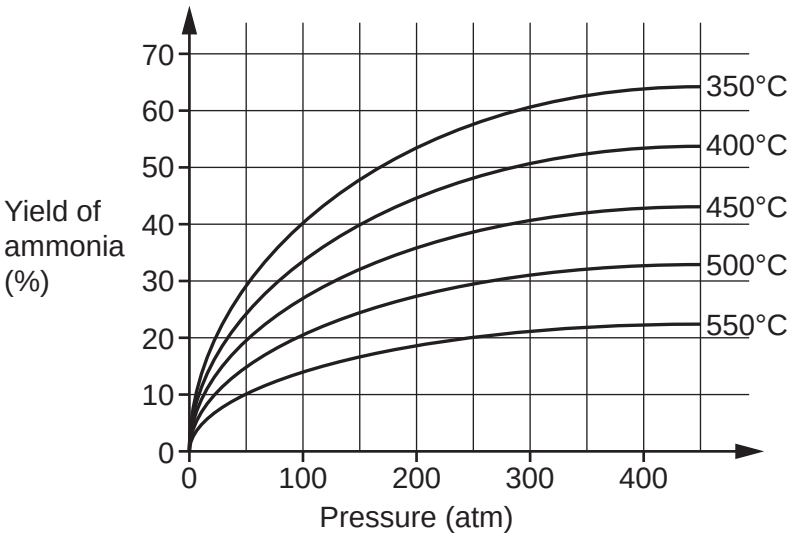
Which **two** statements explain why this increases the sustainability of the process?

Tick (✓) **two** boxes.

- Less feedstock is used. ☐
- The atom economy is increased. ☐
- The overall yield increases. ☐
- The rate of reaction increases. ☐
- There is more eutrophication. ☐

**[2]**

**(d)*** The graph shows the yield of ammonia when different conditions of temperature and pressure are used.




The table shows the conditions used in an industrial process to make ammonia.

| Conditions used | |
|---|---|
| **Temperature (°C)** | 450 |
| **Pressure (atm)** | 200 |
| **Catalyst** | Finely powdered iron |

Explain why each of these conditions are chosen.

Use the graph and ideas about yield and rate of reaction in your answer.

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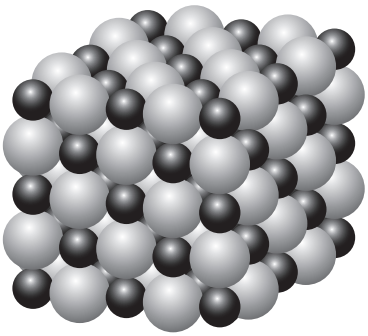
..... **[6]**

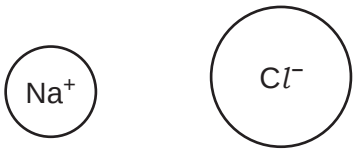
**9** A three-dimensional model for solid sodium chloride is shown in **Fig. 9.1**.

**Fig. 9.1**



**(a)** Draw a **two-dimensional** diagram to show the arrangement of ions in sodium chloride.

Use these symbols.




Show at least **eight** ions.



**[2]**

**(b)** Explain why the model shown in **Fig. 9.1 cannot** be used to show the arrangement of ions in calcium chloride, $CaCl_2$.

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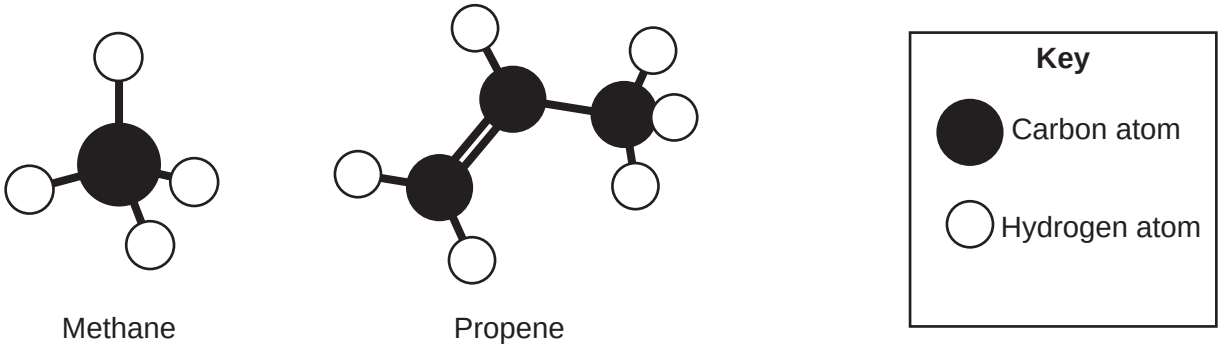
..... **[2]**

**(c)** Three-dimensional models for the arrangement of atoms in methane and propene are shown in **Fig. 9.2**.

**Fig. 9.2**




Methane Propene

**(i)** There are two types of bonds between carbon atoms in propene.

Explain how the different types of bonds between carbon atoms in propene are formed.

Use ideas about electrons in your answer.

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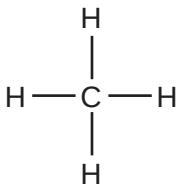
..... **[2]**

**(ii)** The displayed formula of methane is shown in **Fig. 9.3**.

**Fig. 9.3**

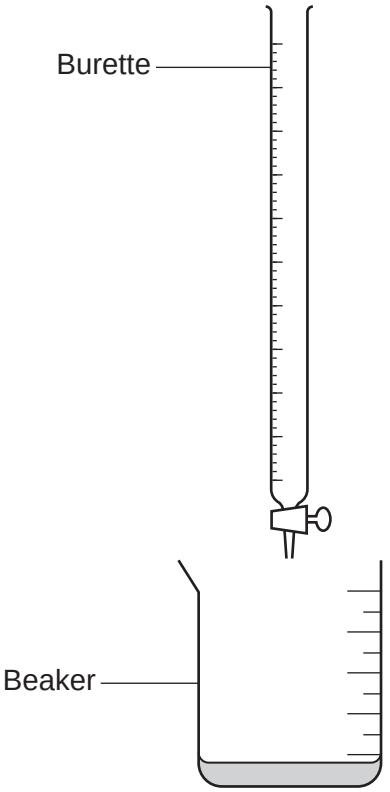



Draw the displayed formula of propene.

**[1]**

**10** Nina does a titration using dilute hydrochloric acid and dilute sodium hydroxide.

She uses this apparatus.




**(a)** Nina uses this method:

- Fill the burette with dilute hydrochloric acid.
- Use a beaker to measure 25 $cm^3$ of dilute sodium hydroxide.
- Add universal indicator to the dilute sodium hydroxide in the beaker.
- Add the acid to the beaker quickly from the burette.
- Stop adding acid after the indicator has fully changed colour.

Describe **two** improvements that Nina should make to the titration method **and** explain why these will improve her results.

Improvement 1 .....

Explanation .....

.....

.....

Improvement 2 .....

Explanation .....

.....

.....

**[4]**

**(b)** Nina uses an improved method to do more titrations. She uses the same concentration of dilute sodium hydroxide each time.

She uses different concentrations of dilute hydrochloric acid in the burette. She measures the volume of acid needed to neutralise 25.0 $cm^3$ of dilute sodium hydroxide.

Nina's results are shown in the table.

| Concentration of acid ($mol/dm^3$) | 0.1 | 0.05 | 0.2 |
|---|---|---|---|
| Volume of acid needed ($cm^3$) | 12.5 | 25.1 | 6.3 |

Describe the relationship between the concentration of the acid and the volume of acid needed.

.....

.....

.....

..... **[2]**

**(c)** Nina uses 25.0 $cm^3$ of dilute sodium hydroxide in each titration.

The equation for the reaction is shown.

$HCl + NaOH \rightarrow NaCl + H_2O$

**(i)** Which concentration of sodium hydroxide is most likely to be correct?

Use the table.

Put a (ring) around the correct option.

**0.05 mol / $dm^3$** **0.1 mol / $dm^3$** **0.2 mol / $dm^3$** **1.0 mol / $dm^3$**

**[1]**

**(ii)** Explain your answer to **(c)(i)**.

.....

.....

.....

..... **[2]**

**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).