Oxford Cambridge and RSA

# Tuesday 13 June 2023 – Morning

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

**J258/02** Depth in Chemistry (Foundation 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

F

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.

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**1** Poly(ethene) is a polymer which forms when ethene monomers react together in an addition polymerisation reaction.

The structure of an ethene monomer and the repeating unit of poly(ethene) are shown in **Fig. 1.1**.

**Fig. 1.1**

**Ethene monomer** **Repeating unit of poly(ethene)**

**(a)** Which statements are **true** only for an ethene monomer, which are **true** only for the repeating unit of poly(ethene) and which are **true** for both?

Tick (✓) **one** box in each row.

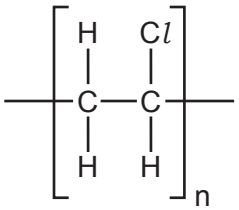
| | **True only for an ethene monomer** | **True only for the repeating unit of poly(ethene)** | **True for both** |
|---|---|---|---|
| Contains a double bond | | | |
| Contains a single bond | | | |
| Contains covalent bonds | | | |
| Represents a molecule with a long chain structure | | | |

**[4]**

**(b)** PVC is another addition polymer.

The structure of the repeating unit of PVC is shown in **Fig. 1.2**.

**Fig. 1.2**



Draw the structure of a **monomer** of PVC.

**[1]**

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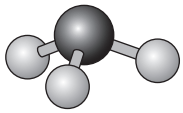
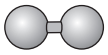
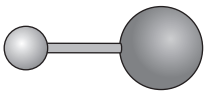
**2** Models are used to represent the structure of compounds.

**(a)** **(i)** Draw lines to connect each **formula** to the correct **model**.

| **Formula** | **Model** |
|---|---|
| $HCl$ |  |
| $NH_3$ |  |
| $H_2$ | |
| $CO_2$ |  |

**[3]**

**(ii)** Which formula contains an atom of a Group 17 (7) element?

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

**(iii)** Which formula contains an atom that is in both diamond and graphite?

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

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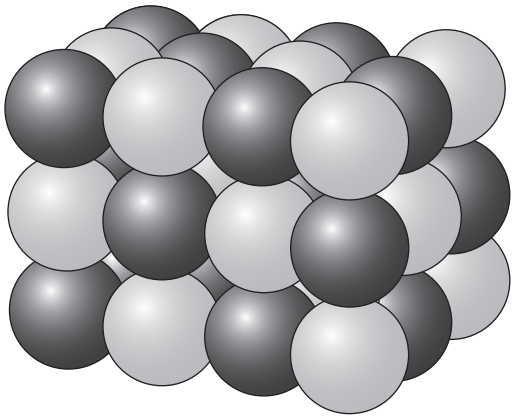
**(b)** Solid sodium chloride contains sodium ions, $Na^+$, and chloride ions, $Cl^-$.

**Fig. 2.1** shows a three-dimensional model of how the ions are arranged in solid sodium chloride.

**Fig. 2.1**



**(i)** Calculate the total number of ions in the model in **Fig. 2.1**.

Total number of ions = ..... **[2]**

**(ii)** Which descriptions about the structure of sodium chloride are **shown** by the model in **Fig. 2.1** and which are **not**?

Tick (✓) **one** box in each row.

| **Description** | **Shown by the model** | **Not shown by the model** |
|---|---|---|
| Ions in sodium chloride are arranged in a regular pattern. | | |
| There are two elements in sodium chloride. | | |
| The ions in sodium chloride have positive and negative charges. | | |

**[2]**

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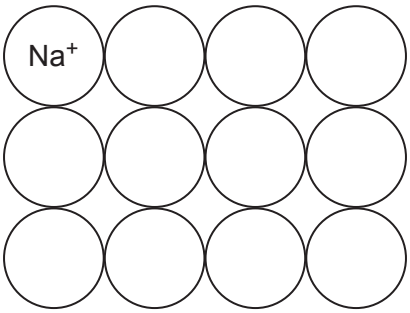
**(c)** **Fig. 2.2** shows a two-dimensional diagram of sodium chloride. One ion is labelled.

**Fig. 2.2**




Label the other ions in **Fig. 2.2**.

Use the symbols $Na^+$ and $Cl^-$. **[2]**

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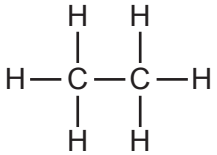
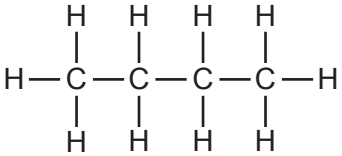
**3** Crude oil is a mixture of hydrocarbons.

**(a)** The table shows information about two hydrocarbons.

| | | |
|---|---|---|
| **Structure** |  |  |
| **Formula** | $C_2H_6$ | ..... |

**(i)** Complete the table. **[1]**

**(ii)** The hydrocarbons shown in the table are alkanes.

The general formula for alkanes is $C_nH_{2n+2}$.

What is the formula for an alkane that contains **5** carbon atoms?

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

**(iii)** Explain why these molecules are **hydrocarbons**.

.....

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

**(iv)** The alkanes from crude oil can be used in other processes to make more useful molecules.

Which process makes more useful molecules from alkanes?

Put a ring around the correct option.

**Combustion** **Cracking** **Filtration** **Neutralisation**

**[1]**

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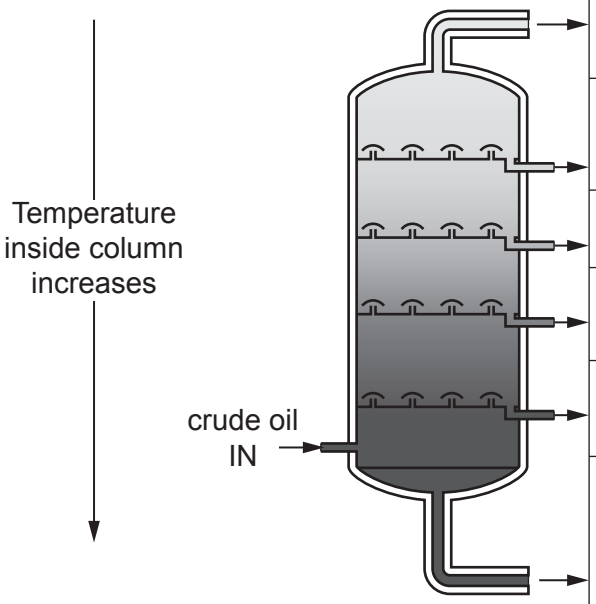
**(b)*** Crude oil is separated into fractions in a fractionating column.

The diagram shows information about a fractionating column and some of the molecules in the fractions that leave the column.




**Fractions OUT**

| Number of carbon atoms in the molecules | Boiling point (°C) |
|---|---|
| 1-4 | 0-30 |
| 5-9 | 30-180 |
| 10-16 | 180-260 |
| 14-20 | 250-350 |
| 20-50 | 350-580 |
| >50 | >580 |

Explain why the molecules leave the column at different heights.

Use ideas about number of carbon atoms and boiling points in your answer.

.....

.....

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

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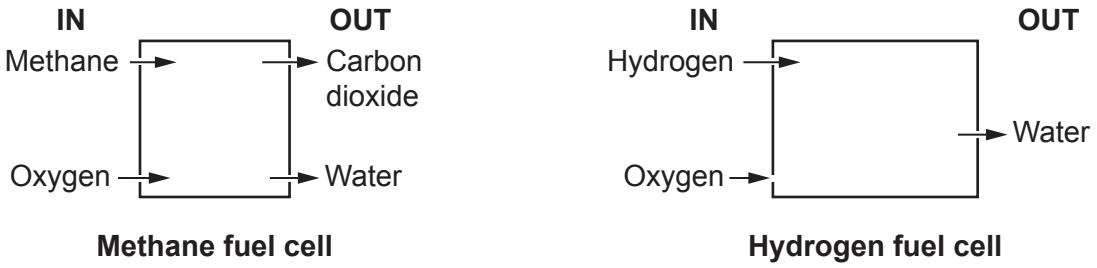
**4** Some cars use fuel cells as an energy source. Fuel cells can use methane or hydrogen as fuels.

The diagram shows the substances that go in and the waste products that come out of a methane fuel cell and a hydrogen fuel cell.




**(a)** Complete the **symbol equations** for the reactions in each fuel cell.

Use information from the diagram.

$CH_4$ + 2..... → $CO_2$ + 2.....

.....$H_2$ + ..... → 2.....

**[3]**

**(b)** The table shows the sources of methane and hydrogen.

| Fuel | Source |
|---|---|
| Methane | Extracted as a fossil fuel |
| Hydrogen | Electrolysis of water |

Explain the **advantages** to the **environment** of using hydrogen rather than methane in fuel cells in cars.

Use the information in the table and the diagram.

.....

.....

.....

.....

.....

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

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**(c)** A mixture of hydrogen and oxygen is very flammable but does **not** explode until it is ignited by a flame.

Which statement explains why?

Tick (✓) **one** box.

The flame brings the gases closer together. ☐

The flame provides activation energy for the reaction. ☐

The flame takes energy in from the hydrogen and oxygen. ☐

**[1]**

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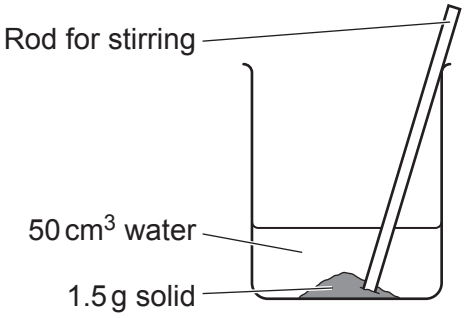
**5** Jamal does an experiment to investigate the energy changes when solids **A**, **B**, **C** and **D**, dissolve in water.

The method for the experiment and some of the apparatus he uses is shown.

**Method**
1. Measure 50 $cm^3$ water and put into a beaker.
2. Measure the temperature of the water.
3. Measure 1.5 g of solid and add to the water.
4. Stir until dissolved.
5. Measure the temperature after the solid dissolves.




**(a)** **(i)** Name **two** pieces of measuring equipment Jamal needs to use in his experiment.

1 .....

2 .....

**[2]**

**(ii)** Which **two** variables does Jamal need to control in his experiment?

Tick (✓) **two** boxes.

The final temperature. ☐

The mass of the solid. ☐

The time taken to dissolve the solid. ☐

The volume of water. ☐

**[2]**

**(b)** **Table 5.1** shows Jamal's results.

**Table 5.1**

| Solid | Temperature at the start (°C) | Temperature after solid dissolves (°C) |
|---|---|---|
| **A** | 18 | 23 |
| **B** | 20 | 12 |
| **C** | 19 | 15 |
| **D** | 17 | 27 |

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**(i)** Jamal thinks that the temperature changes in his experiment are too small.

Which **two** changes could Jamal make to increase the temperature **changes** in his experiment?

Tick (✓) **two** boxes.

Add more solid. ☐

Stir more slowly. ☐

Use boiling water at the start. ☐

Use less water. ☐

**[2]**

**(ii)** Which **two** solids shown in **Table 5.1** dissolve in an exothermic reaction?

Tick (✓) **two** boxes.

Explain your answer.

**A** ☐ **B** ☐ **C** ☐ **D** ☐

Explanation .....

.....

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

**(c)** Jamal measures the temperature change when solid **E** dissolves in water.

He repeats his experiment three times.

**Table 5.2** shows his results.

**Table 5.2**

| Experiment | Temperature at the start (°C) | Temperature after solid E dissolves (°C) |
|---|---|---|
| **1** | 20 | 22 |
| **2** | 21 | 24 |
| **3** | 19 | 22 |
| **4** | 18 | 20 |

Calculate the mean temperature change when solid **E** dissolves.

Mean temperature change = ..... °C **[3]**

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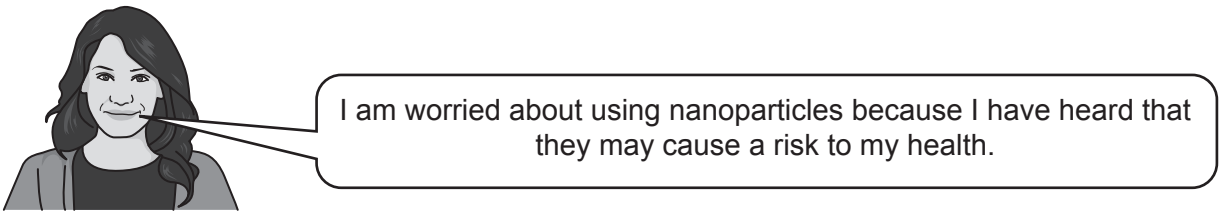
**6** Mia uses sunscreen on her skin when she is in the sun. The sunscreen contains nanoparticles. The nanoparticles block harmful radiation from the sun.

Mia talks about using nanoparticles.




**(a)** Give **two** reasons why using nanoparticles may cause a risk to health.

1 .....

.....

2 .....

.....

**[2]**

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

Tick (✓) **one** box in each row.

| | **True** | **False** |
|---|---|---|
| Fullerenes are examples of nanoparticles. | | |
| Nanoparticles are larger than atoms. | | |
| The properties of nanoparticles are related to their very small size. | | |
| The surface area of a nanoparticle is always equal to its volume. | | |

**[3]**

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**(c)** The table shows some data about the diameter of nanoparticles **A**, **B**, **C** and **D**.

| Nanoparticle | Diameter (m) |
|---|---|
| **A** | $8.25 \times 10^{-9}$ |
| **B** | $2.10 \times 10^{-9}$ |
| **C** | $9.18 \times 10^{-9}$ |
| **D** | $8.26 \times 10^{-9}$ |

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

Largest .....

↓ .....

.....

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

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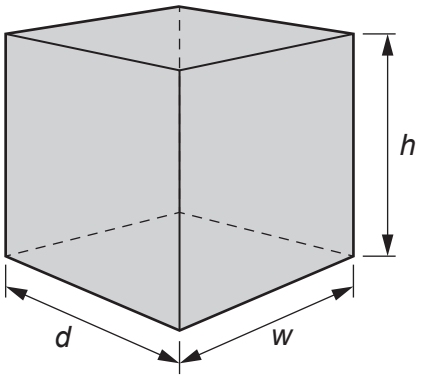
**(d)** Mia makes a 3D model of nanoparticle **B** in the shape of a cube.

She makes each side of her model 2.10 cm long.




**(i)** Calculate the volume of the model.

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

Use this formula:

volume = $h \times w \times d$

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

**(ii)** Calculate the surface area of the model.

Use this formula:

surface area = $6 \times (h \times d)$

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

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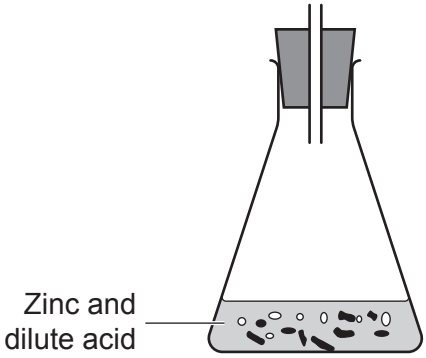
**7** Eve does an experiment to find out the rate of reaction when solid zinc reacts with dilute acid.

She adds the zinc to the dilute acid and measures the time taken to collect 10 $cm^3$ of gas.

**(a)** Complete the diagram by drawing **and** labelling the apparatus she needs to collect and measure 10 $cm^3$ gas.




**[2]**

**(b)** Eve repeats her experiment at different temperatures using zinc, copper, metal **X** and iron.

She adds the same amount of each metal and the same volume and concentration of acid each time.

Her results are shown in the table.

| **Metal** | **Time taken to collect 10 $cm^3$ gas at 20 °C (s)** | **Time taken to collect 10 $cm^3$ gas at 40 °C (s)** |
|---|---|---|
| Zinc | 18 | 9 |
| Copper | no gas collected | no gas collected |
| Metal **X** | 7 | 3 |
| Iron | 26 | 15 |

**(i)** What conclusion can you make about the effect of changing the temperature on the rate of the reaction?

Explain your answer.

.....

.....

.....

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

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**(ii)** Suggest why no gas is collected when copper is used in the experiment.

.....

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

**(iii)** Suggest the name of metal **X**.

Explain your answer.

Name .....

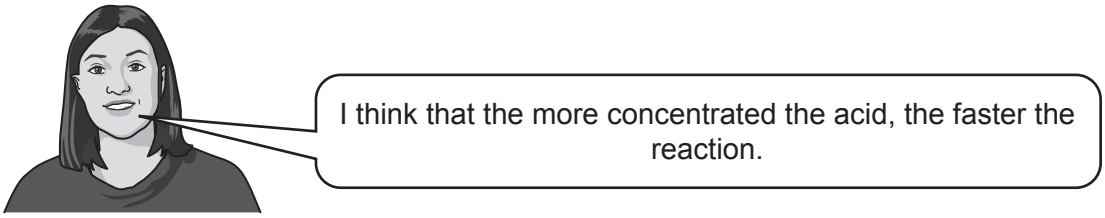
Explanation .....

.....

.....

**[2]**

**(c)*** Eve says:




Write a **method** for Eve to use to find out if her idea is correct.
Include in your answer:

- what variables to control and to change
- what results to expect.

.....

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

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**8** Ammonia is made on an industrial scale by the reaction between nitrogen and hydrogen.

The equation to make ammonia is shown.

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

**(a)** Which **two** statements explain why the atom economy of this reaction is 100%?

Tick (✓) **two** boxes.

All of the atoms in nitrogen and hydrogen are used to make ammonia. ☐

All the substances involved in the reaction are gases. ☐

The reaction makes only one product. ☐

There are two nitrogen atoms on both sides of the equation. ☐

**[2]**

**(b)** Ammonia is used to make fertilisers.

Using fertilisers has both risks and benefits to the environment and to people.

**(i)** Fertiliser from fields can get into rivers.

How does this cause a **risk** to the environment?

.....

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

**(ii)** Give one **benefit** of using fertilisers.

.....

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

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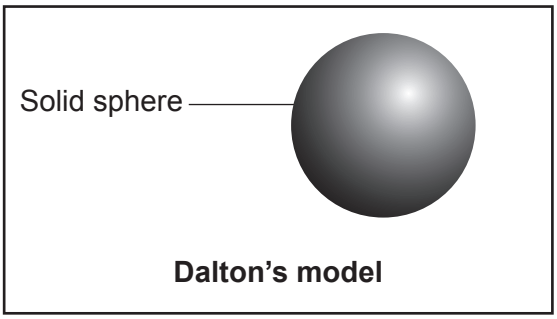
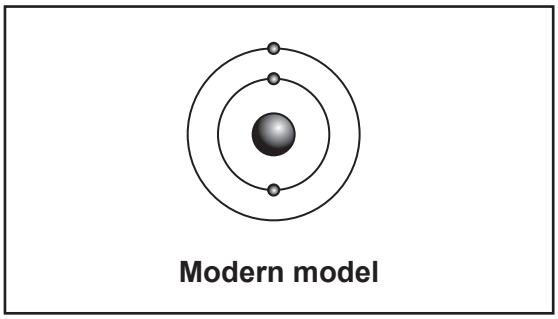
**9** Scientists use models to represent atoms. These models have changed over time.

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




**(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]**

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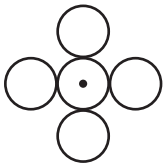
**(c)** Dalton used symbols for atoms to write formulae.

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]**

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**10** 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.

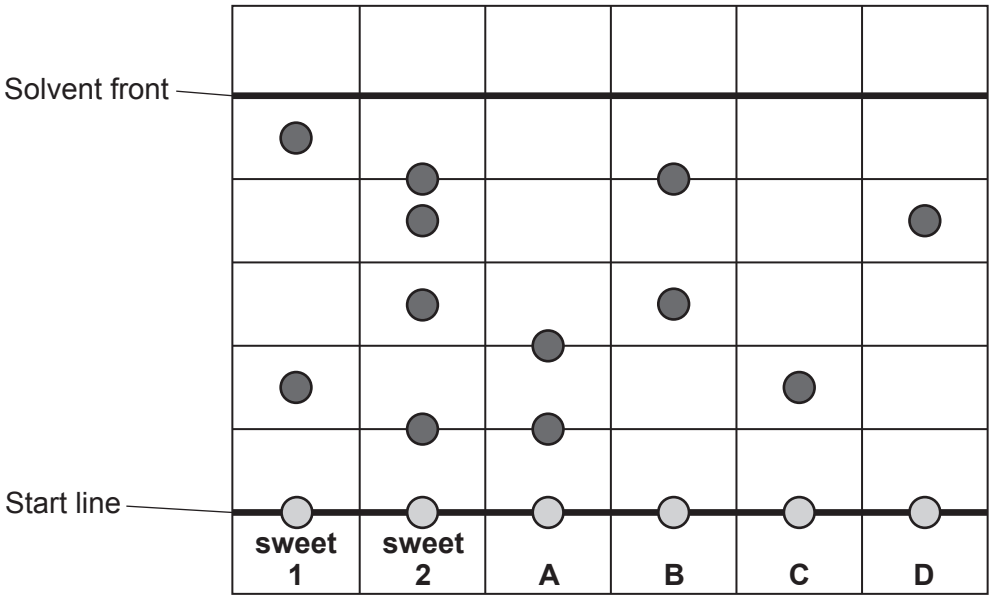
.....

..... **[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]**

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**(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]**

**END OF QUESTION PAPER**

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## 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).

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