Oxford Cambridge and RSA

Friday 17 May 2024 – Morning

GCSE (9−1) Chemistry B (Twenty First Century Science)

J258/01 Breadth 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:
- an HB pencil
- a scientific or graphical calculator

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 page 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 **[ ]**.
- This document has **28** pages.

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

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1 Fuels such as diesel and petrol are made from hydrocarbons.

(a)
(i) Hydrocarbons are made from carbon and one other element.

What is the other element?

Put a (ring) around the correct option.

Chlorine **Hydrogen** **Nitrogen** **Oxygen**

[1]

(ii) What is the main source of hydrocarbons?

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

(b) Alkanes are hydrocarbons.

Which compound is an alkane?

Tick (✓) **one** box.

Butanoic acid ☐

Ethanol ☐

Methane ☐

Propene ☐

[1]

(c) Alkenes are also hydrocarbons. They can be used to make polymers.

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

Tick (✓) **one** box in each row.

	True	**False**
All polymers are made from alkenes.		
Polymers are long chain molecules.		
Polymers can be synthetic or naturally occurring.		

[2]

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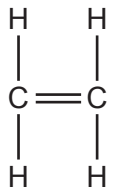
(d) Ethene is the monomer used to make a polymer called poly(ethene).

Fig. 1.1 shows the structure of ethene.

Fig. 1.1



(i) **Complete** the diagram below to show the repeating unit of poly(ethene).

C **C**

[2]

(ii) Describe what happens when ethene monomers react together to form poly(ethene).

.....

.....

.....

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

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2 Lithium is an element in Group 1 of the Periodic Table.

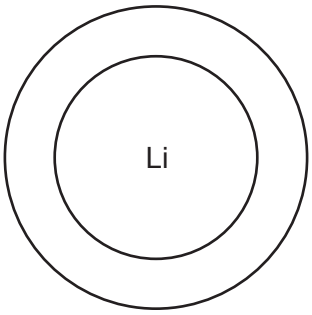
(a)
(i) Describe **one** physical property of lithium.

.....

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

(ii) **Complete** the diagram to show the arrangement of electrons in an atom of lithium.

Use the Periodic Table.



[2]

(b) Lithium reacts with water to form an alkaline solution and hydrogen gas.

Complete the **word** equation and **balanced symbol** equation for the reaction.

Include state symbols on the symbol equation.

lithium + water → ..... + hydrogen

2Li(s) + 2.....(l) → 2LiOH(.....) + ...(g)

[4]

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(c) The reaction between lithium and water is exothermic.

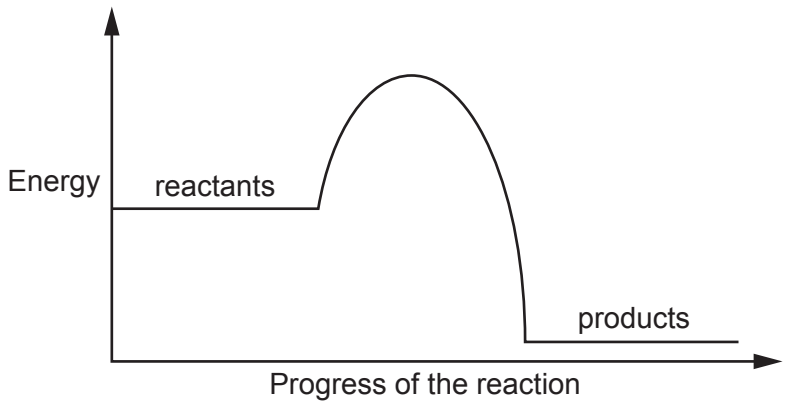
(i) Describe what happens to the temperature during the reaction.

.....

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

(ii) The diagram shows the reaction profile for an exothermic reaction.

Draw an arrow on the diagram to show the activation energy.



[1]

(iii) What is meant by the term activation energy?

.....

.....

.....

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

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3 As the world population increases, the demand for safe drinking water also increases.

(a) The table shows the processes used in the treatment of groundwater to produce safe drinking water.

Process 1	Process 2	Process 3	Process 4
	Clarification	Filtration	Disinfection

(i) In **Process 1** large solid items such as leaves or plastic are removed from the groundwater.

Name **Process 1**.

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

(ii) In **Process 4**, chlorine is used to kill microorganisms.

Describe a test and the result to identify chlorine.

Test .....

Result .....

.....

.....

.....

[3]

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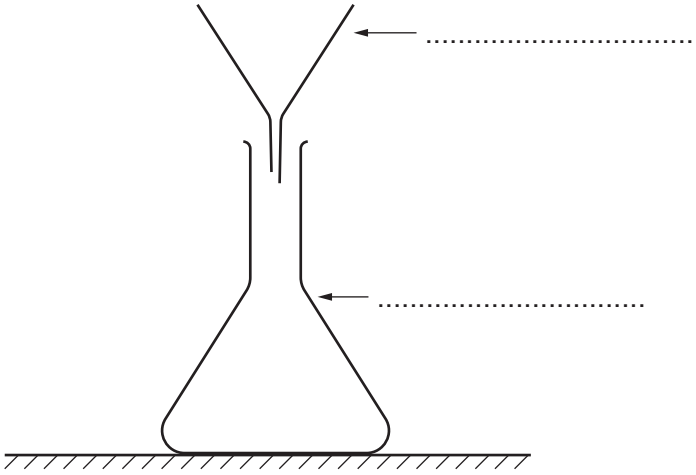
(b) A student removes some impurities from a sample of groundwater.

The diagram shows some of the apparatus they use.

(i) Complete the labels on the diagram.



[1]

(ii) Describe how the student uses the apparatus to remove some impurities from the groundwater.

.....

.....

.....

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

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4 An engineer designs a new chopping board.

The chopping board must be made from a material that is **strong** and **lightweight**.

The table shows the properties of four materials.

Material	**Type of material**	**Tensile strength (MPa)**	**Density (kg/m^3)**	**Melting Point (°C)**
Glass	Ceramic	7	2500	1648
Acrylic	Polymer	70	1200	160
Concrete	Composite	5	2300	1550
Steel		400	7750	1425

(a) What type of material is steel?

Tick (✓) **one** box.

Alloy ☐

Ceramic ☐

Composite ☐

Plastic ☐

[1]

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(b) Explain why the engineer decides to use acrylic to make the chopping board.

Use information from the table.

.....

.....

.....

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

(c)
(i) How many times bigger is the tensile strength of acrylic than the tensile strength of glass?

Number of times bigger = ... **[1]**

(ii) What is the order of magnitude of this increase?

Put a ring around the correct option.

1 **2** **3** **4**

[1]

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5 Sulfur dioxide reacts with oxygen to give sulfur trioxide.

This is the equation for the reaction:

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

(a)
(i) How does the equation show that the reaction is reversible?

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

(ii) The reaction reaches a dynamic equilibrium.

Complete the sentence about a dynamic equilibrium.

Put a (ring) around the correct option.

In a dynamic equilibrium, the rate of the forward reaction is **faster than** / **slower than** / **the same as** the rate of the reverse reaction.

[1]

(iii) The reaction needs a catalyst to form the product.

Which of these is a property of a catalyst?

Tick (✓) **one** box.

It is used up during the reaction. ☐

It lowers the temperature of the reaction. ☐

It speeds up the reaction. ☐

It supplies energy to the reaction. ☐

[1]

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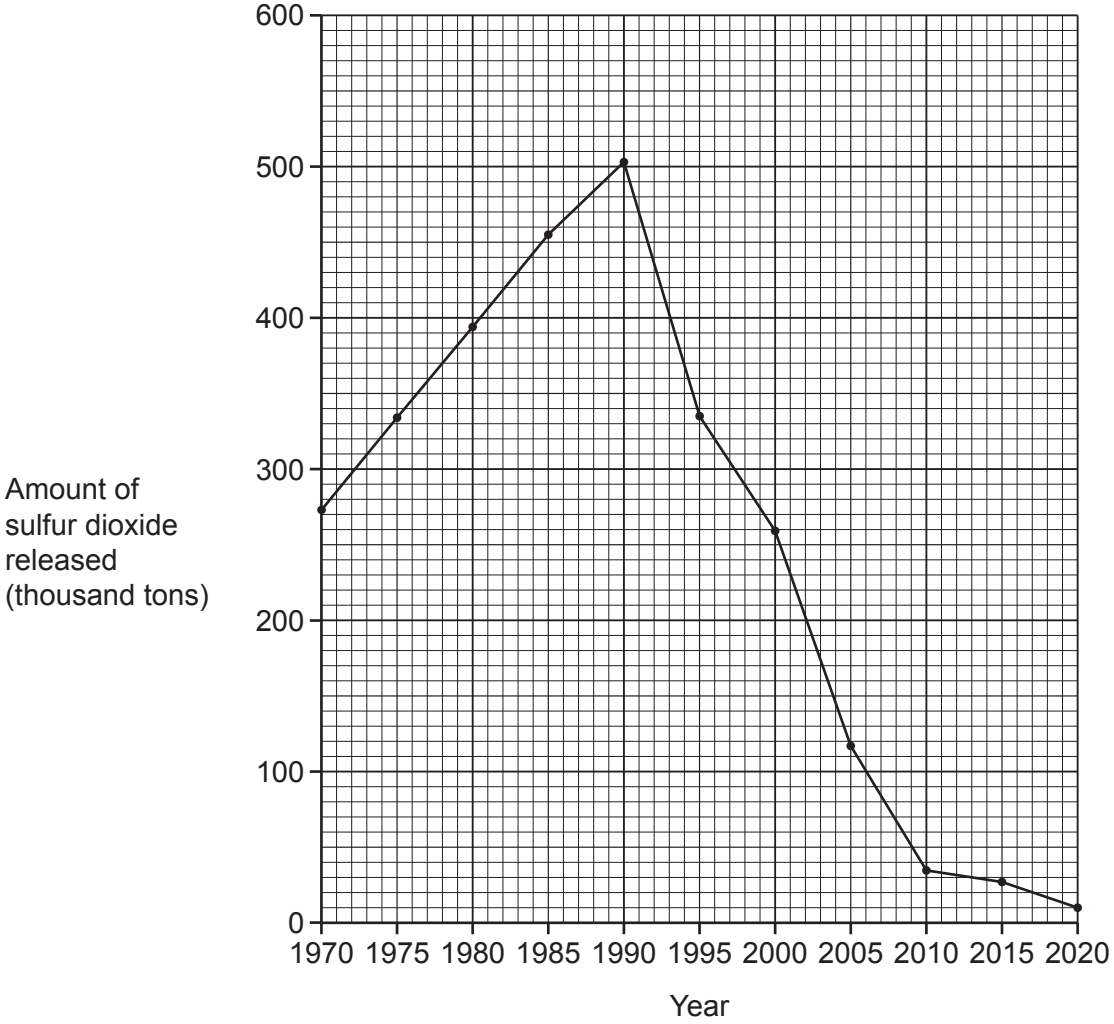
(b) Sulfur dioxide is an air pollutant.

Sulfur dioxide is released when cars burn fuel that contains sulfur.

The graph shows the amount of sulfur dioxide released from cars from 1970 to 2020.



(i) Describe the pattern in changes to the amount of sulfur dioxide emissions from cars from 1970 to 2020.

.....

.....

.....

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

(ii) Which year was the **most** sulfur dioxide released?

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

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(iii) State **one** environmental problem caused by an increase in the amount of sulfur dioxide.

.....

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

(iv) State **one** method used to reduce the amount of sulfur dioxide emissions from cars.

.....

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

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Turn over for the next question

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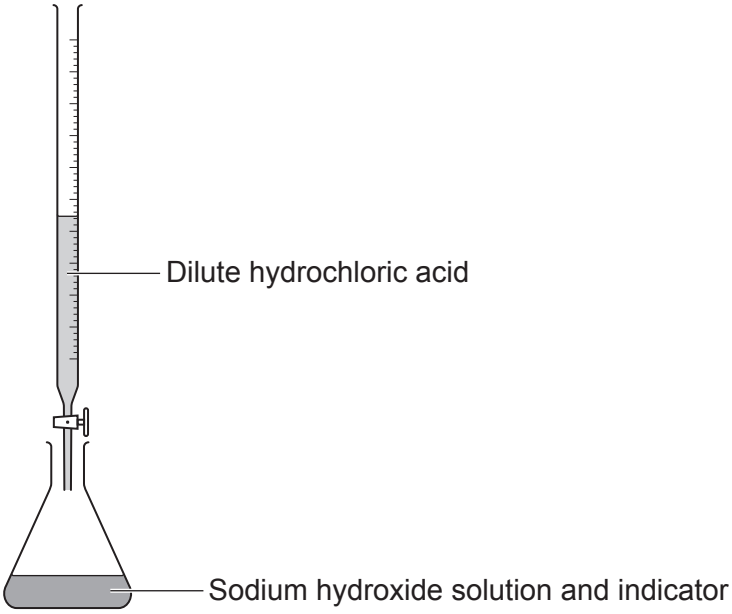
6 A student does a titration to find out the volume of dilute hydrochloric acid needed to fully react with sodium hydroxide solution.

The diagram shows the apparatus they used.



(a) The equation shows the reaction between sodium hydroxide and hydrochloric acid.

$NaOH + HCl \rightarrow NaCl + H_2O$

(i) What type of reaction occurs when sodium hydroxide reacts with hydrochloric acid?

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

(ii) Name the salt formed in the reaction.

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

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(b) The table shows the results.

	Titration		
	1	**2**	**3**
Burette reading at end (cm^3)	37.2	37.4	37.2
Burette reading at start (cm^3)		0.9	0.8
Volume added (cm^3)	36.6	36.5	36.4

(i) Calculate the burette reading at the start of titration **1**.

Burette reading at the start of titration **1** = ... cm^3 **[1]**

(ii) Calculate the mean volume added for the three titrations.

Mean volume added = ... cm^3 **[2]**

(iii) Explain why an indicator must be used in the titration.

.....

.....

.....

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

(iv) Describe **one** way the student can make sure that the burette readings are as accurate as possible.

.....

.....

.....

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

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7 The modern model of the atom has developed over time.

(a) The table shows the ideas of three scientists.

(i) Complete the table to show the name of the scientist who had the idea that all matter is made up of atoms.

Scientist	**Year**	**Idea**
.....	1803	All matter is made of tiny particles called atoms.
Thomson	1897	An atom contains negatively charged particles called electrons.
Rutherford	1909	Atoms have a central positive nucleus.

[1]

(ii) What is the name of the atomic model proposed by **Thomson**?

Tick (✓) **one** box.

Nuclear model ☐

Particle model ☐

Plum pudding model ☐

[1]

(b) In 1913, Bohr discovered that electrons move around the nucleus of an atom in orbits.

What are these orbits called?

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

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8 This question is about transition metals.

(a) Iron reacts with oxygen to form iron oxide, Fe_2O_3.

(i) Complete the **balanced symbol** equation for the formation of Fe_2O_3.

$$.....Fe + ...O_2 \rightarrow 2Fe_2O_3$$

[2]

(ii) What is the symbol for the positive ion in Fe_2O_3?

Tick (✓) **one** box.

Fe^{+} ☐

Fe^{2+} ☐

Fe^{3+} ☐

Fe_2^{+} ☐

[1]

(b) The table shows some information about three metals.

	Melting Point (°C)	**Density (g / cm^3)**	**Reaction with cold water**
Metal 1	1064	19.3	No reaction
Metal 2	98	0.97	Bubbles observed
Metal 3	660	2.7	Bubbles observed

Which metal is a transition metal?

Use the data from the table to explain your answer.

Metal .....

Explanation .....

.....

.....

.....

[3]

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(c) The equation shows the reaction between iron and chlorine to form iron chloride.

$2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$

A scientist reacts 2.0 g of iron with excess chlorine to form 4.4 g of iron chloride.

Calculate the percentage yield of iron chloride.

Use:

- percentage yield = $\frac{\text{actual yield} \times 100}{\text{theoretical yield}}$
- theoretical yield = 5.8 g.

Give your answer to **2** significant figures.

Percentage yield = ... % **[3]**

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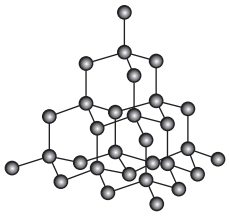
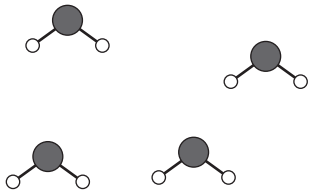
9

(a) The table shows some information about diamond and water.

	Diamond	**Water**
Diagram of structure		
Type of structure	Giant structure	Simple molecule
Melting point (°C)	Around 4000	0
Boiling point (°C)	Around 4000	100

(i) The information in the table shows that simple molecules have weak intermolecular forces between molecules.

Explain why.

.....

.....

.....

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

(ii) Describe the nature and arrangement of chemical bonds in diamond.

.....

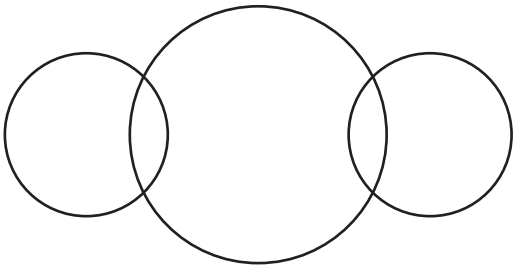
.....

.....

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

(iii) **Complete** the dot and cross diagram for water.

Atomic numbers: H = 1 O = 8



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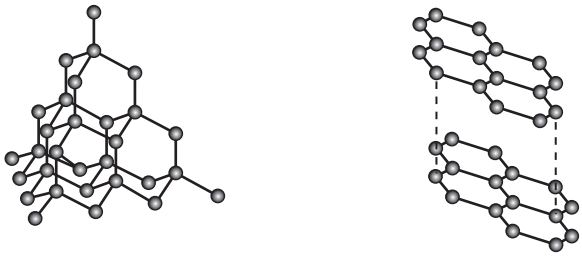
[2]

(b) Diamond and graphite are different forms of carbon.

Fig. 9.1 shows their structures.

Fig. 9.1



Diamond Graphite

(i) Graphite is a good conductor of electricity.

Use the structures to explain why.

.....

.....

.....

.....

.....

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

(ii) Glass can be cut by diamond but not by graphite.

Use the structures to explain why.

.....

.....

.....

.....

.....

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

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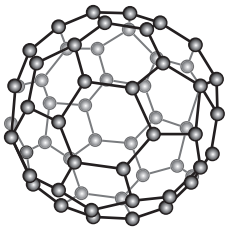
(c) Buckminsterfullerene is a nanoparticle made of 60 carbon atoms.

Fig. 9.2 shows the structure of Buckminsterfullerene.

Fig. 9.2



(i) Buckminsterfullerene has a diameter of 1 nm.

What is its diameter in m?

Put a (ring) around the correct option.

1×10^{10} **1×10^{9}** **1** **1×10^{-9}** **1×10^{-10}**

[1]

(ii) Buckminsterfullerene is used in medicine to carry drugs into the body.

Describe **two** properties of buckminsterfullerene that make it able to carry drugs into the body.

1 .....

2 .....

[2]

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Turn over for the next question

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10 Fertilisers are used to increase the growth of plants.

They are added to soil to provide essential plant nutrient elements.

(a) Nitrogen is one essential plant nutrient element.

Name **two other** essential plant nutrient elements.

1 .....

2 .....
[2]

(b)
(i) State **one** disadvantage of the over-use of synthetic fertilisers.

.....

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

(ii) Suggest why farmers still use synthetic fertilisers despite their disadvantages.

.....

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

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(c) An example of a synthetic fertiliser is ammonium nitrate, NH_4NO_3.

Ammonium nitrate is produced when ammonium hydroxide, NH_4OH, reacts with nitric acid, HNO_3.

$NH_4OH(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq) + H_2O(l)$

The relative formula masses for the reactants and products are shown in the table.

	NH_4OH	**HNO_3**	**NH_4NO_3**	**H_2O**
Relative formula mass	35.0	63.0	80.0	18.0

Calculate the atom economy for the formation of NH_4NO_3.

Use the equation:

$$\text{atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100\%$$

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

Atom economy = ... % **[4]**

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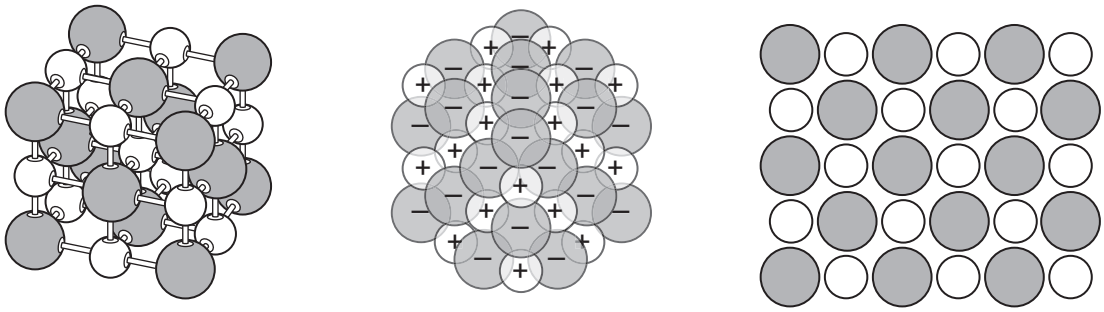
11 Sodium chloride is an ionic compound.

(a) **Fig. 11.1** shows three models of the arrangement of ions in sodium chloride.

Fig. 11.1



Model A **Model B** **Model C**

(i) Describe the attraction between ions in sodium chloride.

.....

.....

.....

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

(ii) Which **two** statements about the limitations of the models in **Fig. 11.1** are **true**?

Tick (✓) **two** boxes.

Model A does **not** show the relative sizes of the ions. ☐

Model C does **not** show the 3-D arrangement of ions. ☐

None of the models show that sodium chloride is a compound containing two elements. ☐

Only one model shows that a chloride ion is an anion. ☐

[2]

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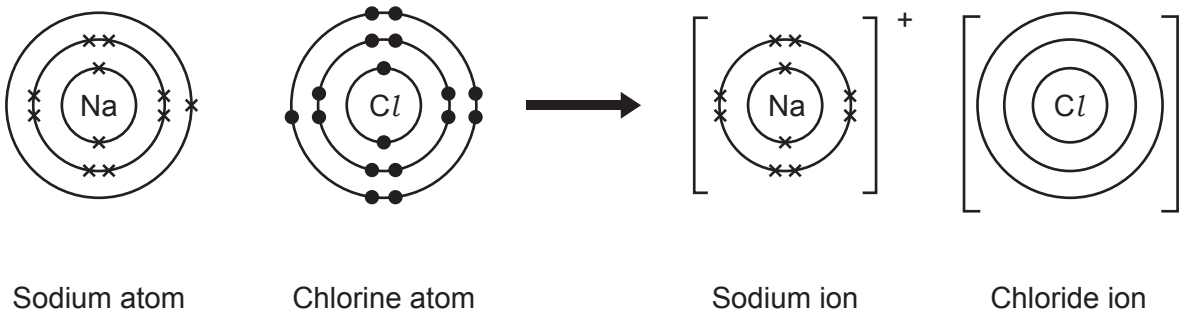
(iii) **Fig. 11.2** shows the dot and cross diagram for sodium chloride.

Complete Fig. 11.2 to show the structure and charge of the chloride ion.

Fig. 11.2



[2]

(b) How does the arrangement of electrons in atoms of sodium and chlorine relate to their group and period in the Periodic Table?

.....

.....

.....

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

(c) An atom of sodium has an atomic number of 11 and a mass number of 23.

State the number of protons, neutrons and electrons in a sodium atom.

Number of protons = ...

Number of neutrons = ...

Number of electrons = ...

[2]

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use this lined page. You must write the question numbers clearly in the margin.

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