OCR
Oxford Cambridge and RSA

Monday 22 May 2023 – Morning

GCSE (9–1) Combined Science B (Twenty First Century Science)

J260/02 Chemistry (Foundation Tier)

Time allowed: 1 hour 45 minutes

F

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

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

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 **95**.
- 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 **32** pages.

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

1 The diagram shows part of Mendeleev's Periodic Table.

B 11	**C** 12	**N** 14	**O** 16	**F** 19
A*l* 27	**Si** 28	**P** 31	**S** 32	**C*l*** 35.5
		As 75	**Se** 79	**Br** 80
In 115	**Sn** 119	**Sb** 122	**Te** 128	**I** 127

(a) Give the symbols of the **two** elements shown in the diagram which are **not** in order of atomic mass.

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

(b) Mendeleev left gaps for elements that had **not** been discovered.

(i) Name the **two** elements that had **not** been discovered when Mendeleev wrote his Periodic Table.

Use the diagram and the Data Sheet.

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

(ii) Describe how the discovery of new elements supported Mendeleev's decision to leave gaps.

.....

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

(c) The table shows the atomic number and electron arrangement of some of the elements in Group 1 of the modern Periodic Table.

Element	Atomic number	Electron arrangement
Lithium	3	2.1
Sodium	11	2.8.1
Potassium	19	2.8.8.1

Which **two** statements explain how the reactions of lithium, sodium and potassium are related to their electron arrangements and so to their atomic number?

Tick (✓) **two** boxes.

The atomic number is the mass of the atom. ☐

The atomic number is the number of electrons in the atom. ☐

The atomic number is the number of neutrons in the atom. ☐

The elements all have the same electron arrangement. ☐

The elements all have the same number of electrons in their outer shell. ☐

[2]

(d) Lithium reacts with cold water to produce hydrogen gas and a solution of lithium hydroxide.

(i) Complete the equation by adding the state symbols.

$2Li\ (.....) + 2H_2O\ (.....) \rightarrow 2\ LiOH\ (.....) + H_2\ (.....)$

[2]

(ii) Describe an experiment to show that the reactivity of the Group 1 elements increases down the group.

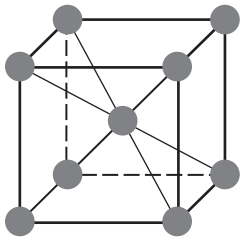
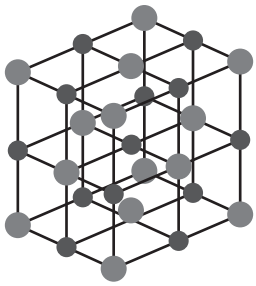
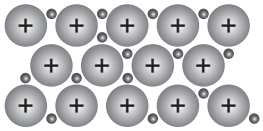
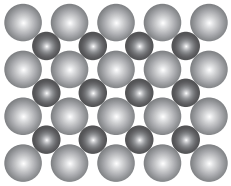
.....

.....

.....

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

2 The table shows the structures and some properties of sodium and sodium chloride.

	Sodium	**Sodium chloride**
Three - dimensional structure		
Two - dimensional structure		
Electrical conductivity	Good conductor when solid or liquid	Good conductor when liquid or in aqueous solution only
Melting point (°C)	98	801

(a) Sodium is a metal and sodium chloride is an ionic compound.

Draw lines to connect sodium and sodium chloride with the correct structure and nature of their chemical bonds.

Giant lattice	Sodium	Attraction between ions and mobile electrons
Big molecule	Sodium chloride	Attraction between oppositely charged ions
Simple molecule		Attraction between atoms

[3]

(b) Complete the sentences to explain the electrical conductivity of sodium and sodium chloride.

Put a (ring) around each correct option.

Sodium is a good conductor of electricity when solid because its **atoms / electrons / ions** are **fixed / mobile**.

Sodium chloride conducts electricity when liquid because its **atoms / electrons / ions** are **fixed / mobile** but does not conduct when solid because they are **fixed / mobile**.

[3]

(c) Complete the sentences to explain the difference in melting points of sodium and sodium chloride.

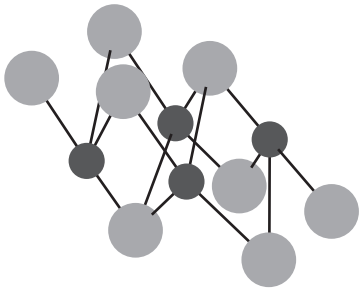
Put a (ring) around each correct option.

The melting point of sodium chloride is **higher / lower / the same** compared to the melting point of sodium.

This is because the forces of attraction between the particles in sodium chloride are **higher / lower / the same** compared to those in sodium and so the energy needed to separate the particles is **higher / lower / the same**.

[2]

(d) The diagram shows the structure of potassium oxide.



Key

O^{2-}

K^{+}

What is the chemical formula of potassium oxide?

Tick (✓) **one** box.

K_2O ☐

KO_2 ☐

KO ☐

[1]

3 Acids react with alkalis to form salt and water. This reaction is called neutralisation.

An example is shown:

$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

(a) Complete the sentence to describe neutralisation in terms of ions.

Use the ions and formulae.

H^+ Na^+ OH^- NO_3^- $NaNO_3$ H_2O HNO_3 NaOH

Neutralisation is when ..... ions from an acid react with ..... ions from an alkali to form ..... molecules. **[2]**

(b) Felix wants to find the concentration of some dilute nitric acid using a titration.

He finds this simple method in a book:

- measure 25.0 cm^3 sodium hydroxide solution into a conical flask using a measuring cylinder
- add dilute nitric acid from a burette to the sodium hydroxide solution until neutralisation
- write down the volume of acid used.

(i) The method does not say how he will know when neutralisation has occurred.

Explain what should be added to the method so that he knows when to stop adding acid.

.....

.....

.....

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

(ii) Felix uses the method to get a rough idea of the volume of acid needed.

He makes changes to the method to improve the quality of his data.

Draw lines to connect the description of the change in method with the explanation for the change.

Description	Explanation
Add acid drop by drop when nearly neutral	Exactly the same volume of sodium hydroxide used each time
Repeat the experiment until the volumes of acid used are close together	So that too much acid is not used
Use a pipette instead of a measuring cylinder to measure the sodium hydroxide	To check that the results are repeatable

[2]

(c) The table shows the results of Felix's experiment.

	Rough	**Repeat 1**	**Repeat 2**	**Repeat 3**
Second reading on burette (cm^3)	27.6	23.4	46.9	23.9
First reading on burette (cm^3)	0.0	0.0	23.4	0.5
Volume used (cm^3)	27.6	23.4	23.5	23.4

(i) Complete the sentence to evaluate the quality of his repeated results.

Put a (ring) around each correct option.

These results are **high / low** quality because the repeated results are

close together / far apart / the same.

[1]

(ii) Calculate the mean of the repeated results.

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

Mean = ... cm^3 **[3]**

4 The halogens are in Group 17(7) of the Periodic Table.

(a) The halogens are all molecules with two atoms joined together by covalent bonds.

(i) Complete the sentence to explain covalent bonding.

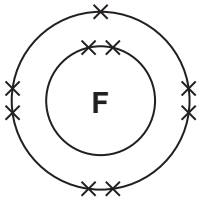
Put a (ring) around the correct option.

The atoms in a covalent bond are held together when electrons are **gained / lost / shared.**

[1]

(ii) **Fig. 4.1** shows the electron arrangement of a fluorine atom.

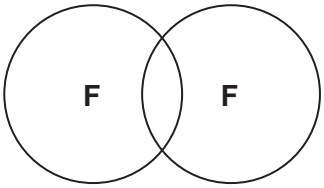
Fig. 4.1



Complete **Fig. 4.2** to show the dot and cross diagram for F_2.

Show outer shell electrons only.

Fig. 4.2



[2]

(b) The halogens all react with iron wool.

The reactivity of the halogens decreases down Group 17(7).

The table shows the reactions when iron wool is put into jars containing each gaseous halogen.

Halogen	Reaction with iron wool
Fluorine	Cold iron wool burns.
Chlorine	Hot iron wool burns vigorously.
Bromine	
Iodine	Hot iron wool reacts slowly.

Predict the reaction of bromine with iron wool.

.....

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

(c) Aqueous solutions of the halogens react with aqueous solutions of less reactive halides.

Alex plans an experiment to find the order of reactivity of some halogens.

The table shows the solutions they use.

Aqueous halogens	Aqueous halides
Cl_2(aq)	KCl (aq)
Br_2(aq)	KBr(aq)
I_2(aq)	KI(aq)

The halogens all have different colours in aqueous solution.
The halide solutions are all colourless.

Which **two** statements describe how Alex can find the order of reactivity of these halogens?

Tick (✓) **two** boxes.

Mix each halogen separately with the other halogens. ☐

Mix each halide separately with the other halides. ☐

Mix each halogen separately with each halide. ☐

See if there is a colour change. ☐

See if there is a precipitate. ☐

See if solution goes colourless. ☐

[2]

5 Ammonia is manufactured by reacting nitrogen and hydrogen gases together.

(a) The reaction to produce ammonia is reversible.

(i) Complete the equation with the symbol to show that it is reversible.

$N_2(g) + 3H_2(g)$ ..... $2NH_3(g)$ **[1]**

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

.....

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

(iii) If the nitrogen and hydrogen are left in a closed container, eventually the reaction will reach a dynamic equilibrium.

Complete the sentence to describe when a dynamic equilibrium occurs in the reaction.

Put a (ring) around the correct option.

When the rate of the forward reaction is **faster / slower / the same** compared to the rate of the reverse reaction.

[1]

(b) A catalyst of iron is used when ammonia is manufactured.

What effect does a catalyst have on a reaction?

Tick (✓) **two** boxes.

It decreases the activation energy. ☐

It decreases the temperature of the mixture. ☐

It increases the concentration of the gases. ☐

It increases the kinetic energy of the molecules. ☐

It increases the rate of reaction. ☐

It increases the yield. ☐

[2]

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6 Crude oil is a mixture of hydrocarbons.

(a) **(i)** Give **one** reason why modern life depends on crude oil.

.....

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

(ii) Give **one** reason why we **cannot** depend on crude oil in the future.

.....

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

(b) Carbon bonds covalently with more carbons and with other elements to form lots of different compounds.

(i) How many covalent bonds does each carbon atom form?

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

(ii) Which statement explains why carbon can form so many different compounds?

Tick (✓) **one** box.

It forms chains and rings with other carbons. ☐

It is a natural element. ☐

It is a non-metal. ☐

It is unreactive. ☐

[1]

(c) Hydrocarbons are compounds of carbon and hydrogen.

Alkanes are one type of hydrocarbon. They have the general formula C_nH_{2n+2}.

(i) What is the formula of the alkane with five carbons?

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

(ii) Hexane has the formula C_6H_{14}.

What is its empirical formula?

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

(d) The table gives some information about ethene, poly(ethene) and diamond.

	Ethene	**Poly(ethene)**	**Diamond**
Formula	C_2H_4	$(C_2H_4)_n$	C
Bonding	.....	Covalent	.....
Structure	....	Large molecule	....
Melting point (°C)	–169	Approximately 110	Approximately 4000

(i) Complete the table. **[3]**

(ii) Explain why the melting point of poly(ethene) is higher than the melting point of ethene.

Use ideas about chain length and forces between the particles in your answer.

.....

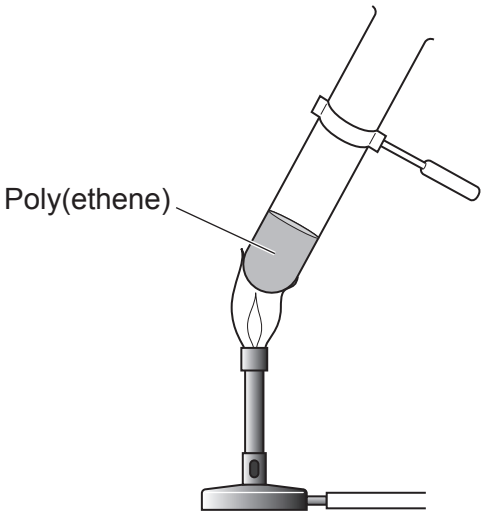
.....

.....

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

(e) Umi wants to check the melting point of the poly(ethene).

They have a sample of solid poly(ethene) in a test tube.



Describe how they can measure the melting point of the solid poly(ethene).

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

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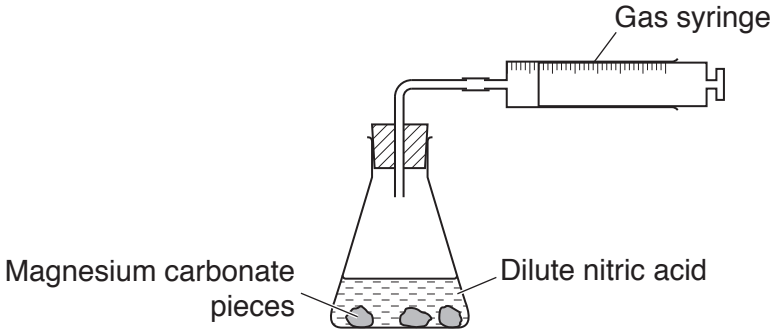
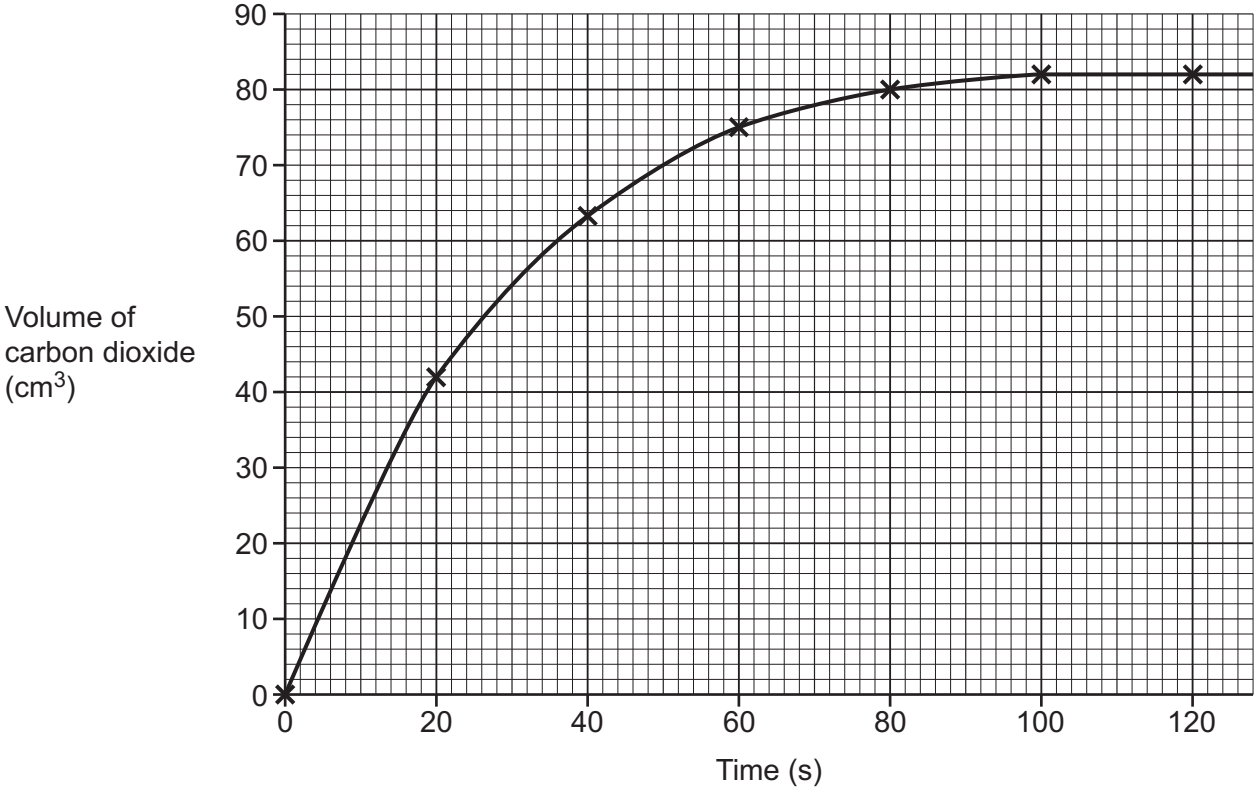
7 Sasha uses this apparatus to find the rate of the reaction between pieces of magnesium carbonate and dilute nitric acid.



Sasha adds the pieces of magnesium carbonate to the dilute nitric acid and measures the volume of carbon dioxide collected every 20 seconds.

Sasha draws this graph.



(a) What is the total volume of carbon dioxide collected?

Volume of carbon dioxide = ... cm^3 **[1]**

(b) How long does it take for the reaction to finish?

Time taken = ... s **[1]**

(c) Draw a tangent to the curve and use it to find the rate of reaction at 40 seconds.

Rate of reaction = ...cm^3/s **[4]**

8 Atoms are too small to see with the naked eye.

Models can be used to help show the size of atoms compared with objects that we can see.

(a) What is the typical size of atoms and small molecules?

Put a (ring) around the correct option.

1×10^{-10} m **1×10^{-6} m** **1×10^{-2} m** **1 m**

[1]

(b) A sphere with a diameter of 2 cm is used as a model of an atom.

Calculate the diameter of a model of a tennis ball on the same scale.

Give your answer in metres, **m**.

Use this formula:

$$\frac{\text{diameter of model atom}}{\text{diameter of a model of a tennis ball}} = \frac{1}{7 \times 10^{8}}$$

Diameter of a model of a tennis ball = ... m **[3]**

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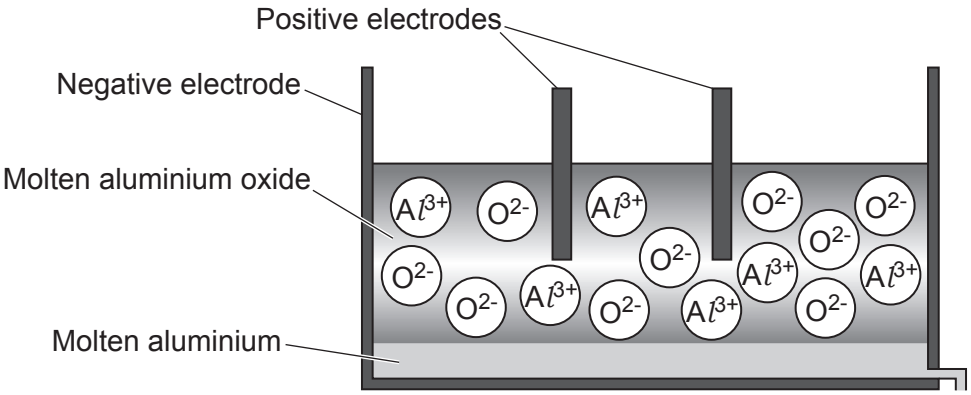
9 The diagram shows how aluminium is extracted from its ore by electrolysis of molten aluminium oxide.

It is carried out at high temperature with carbon electrodes.



(a) (i) Complete the **balanced symbol equation** for the decomposition of aluminium oxide by electrolysis.

$2Al_2O_3 \rightarrow$ ..... Al + ... O_2 **[2]**

(ii) During electrolysis, reactions take place at the positive and negative electrodes.

Complete the table to explain the reactions at each electrode.

Use the diagram **and** the symbol equation to help you.

Electrode	Formula of ions attracted	Loss or gain of electrons	Product
Positive			
Negative			

[2]

(iii) Explain why carbon dioxide is also produced.

.....

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

(b) Zinc is extracted from its oxide using carbon:

$2ZnO + C \rightarrow 2Zn + CO_2$

Which **two** statements explain why aluminium must be extracted by electrolysis and **not** by reaction with carbon?

Tick (✓) **two** boxes.

Aluminium does not react with carbon. ☐

Aluminium is more reactive than carbon. ☐

Aluminium is less reactive than zinc. ☐

Aluminium oxide does not react with carbon. ☐

[2]

(c)* When salts are dissolved in water the solution contains H^+ and OH^- ions from the water as well as the ions from the salt. The products formed depend on the tendency of the ions to lose or gain electrons.

The table shows the tendency of ions to lose or gain electrons.

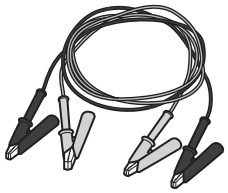
Positive ions		**Negative ions**	
Li^+	Increasing tendency to gain electrons	SO_4^{2-}	Increasing tendency to lose electrons
Na^+		NO_3^-	
Zn^{2+}		Cl^-	
Fe^{2+}		Br^-	
H^+		OH^-	
Cu^{2+}			

Jamila does an experiment to electrolyse an aqueous solution of sodium chloride.

She identifies the products formed as oxygen and hydrogen.

She uses this apparatus.

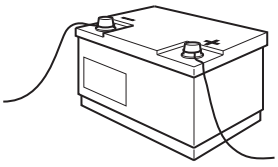
Carbon rods



Wires with clips

Aqueous solution of sodium chloride

Beaker



Battery

Describe how Jamila should use the apparatus to electrolyse an aqueous solution of sodium chloride, **and** explain why oxygen and hydrogen are formed.

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.....

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

10 The combustion of fossil fuels for energy produces harmful substances.

(a) (i) Draw lines to connect each **harmful substance** with the description of its major source.

Harmful substance	Major source
Carbon monoxide	Combustion of sulfur impurities in fossil fuels
Particulates	Incomplete combustion of fossil fuels
Nitrogen oxides	Oxidation of nitrogen at high temperatures.
Sulfur dioxide	

[2]

(ii) Explain **one** problem caused by increased amounts of sulfur dioxide in the atmosphere.

.....

.....

.....

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

(iii) Describe **one** method that is used to decrease the amount of harmful substances put into the atmosphere by petrol cars.

.....

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

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(b) The combustion of fossil fuels produces carbon dioxide. Most scientists now accept that recent climate change can be explained by increased carbon dioxide emissions.

Fig. 10.1 shows the change in concentration of CO_2 in the atmosphere over time.

Fig. 10.1

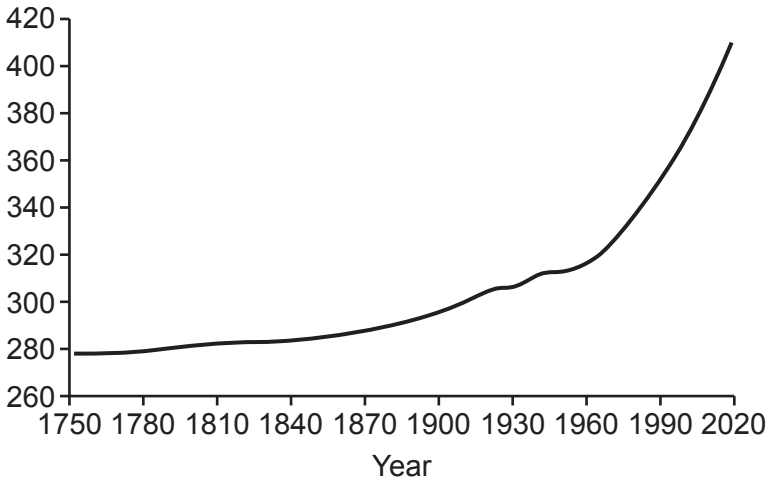


Fig. 10.2 shows the change in world carbon dioxide emissions from fossil fuels over time.

Fig. 10.2

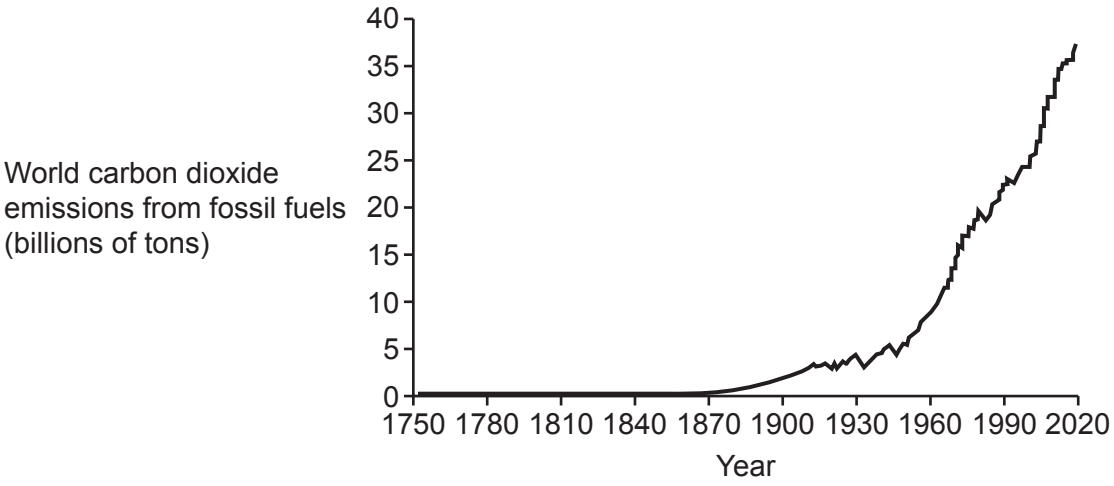
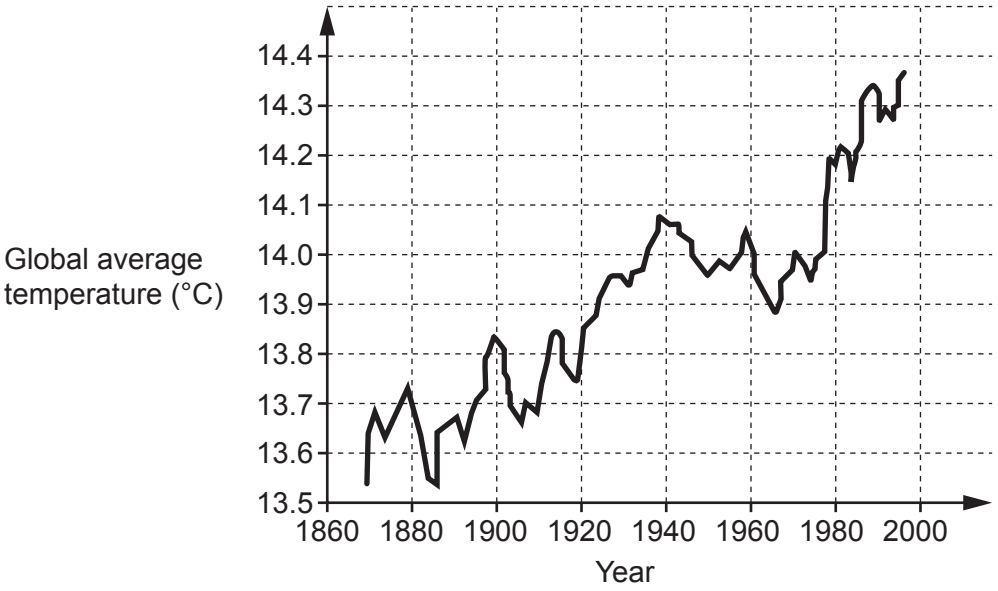


Fig. 10.3 shows the change in global average temperature over time.

Fig. 10.3



Describe the trends in **Fig. 10.1** and **Fig. 10.2 and** explain how this can be used with **Fig. 10.3** to show that human activity is causing the global temperature to increase.

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.....

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.....

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.....

.....

..... **[4]**

11 A company called Healthyfood make food colourings.

The diagram shows the label from one of their food colourings.

Healthyfood

Orange food colouring

All ingredients natural and tested

Ingredients: dye 1, dye 2, solvent

(a) A representative for Healthyfood says that the food colouring is pure.

A scientist says that it is not pure.

Explain the different meanings of the word 'pure' used by the Healthyfood representative and the scientist.

Healthyfood representative .....

.....

Scientist .....

.....

[2]

(b) The table shows the melting points of some substances.

Substance	Melting point (°C)
A	42
B	60–66
C	92–98
D	104

Which **two** substances are chemically pure?

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

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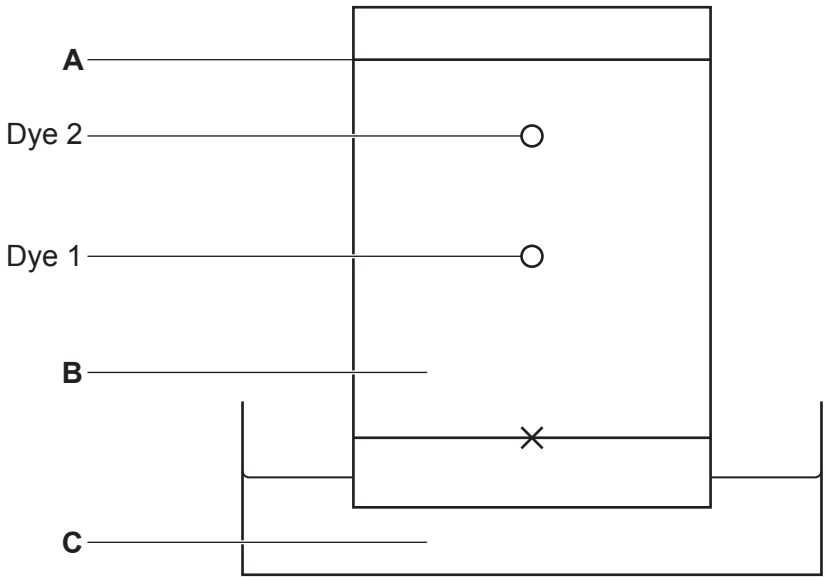
(c) The dyes in the food colouring can be separated using paper chromatography.

The diagram shows the apparatus used to separate the dyes and the chromatogram that is produced.



(i) Draw lines to connect each letter with its correct label.

A	Mobile phase
B	Solvent front
C	Stationary phase

[2]

(ii) Which property causes the dyes in the food colouring to separate?

Tick (✓) **one** box.

Their different boiling points. ☐

Their different colours. ☐

Their different distribution between phases. ☐

Their different melting points. ☐

[1]

(d) The chromatogram can be used to find the Rf values for the dyes.

(i) Measure the distance moved by dye 1 and by the solvent.

Use a ruler.

Distance moved by dye 1 = ... cm

Distance moved by solvent = ... cm **[2]**

(ii) Calculate the Rf value of dye 1.

Use this formula.

$$\text{Rf} = \frac{\text{distance moved by the dye (cm)}}{\text{distance moved by the solvent (cm)}}$$

Rf = ... **[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).