OCR
Oxford Cambridge and RSA

Monday 22 May 2023 – Morning

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

J260/06 Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

H

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 **28** pages.

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

1 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	Incomplete combustion of fossil fuels
Particulates	Oxidation of nitrogen at high temperatures.
Nitrogen oxides	Combustion of sulfur impurities in fossil fuels
Sulfur dioxide	

[2]

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

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

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

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..... **[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. 1.1 shows the change in concentration of CO_2 in the atmosphere over time.

Fig. 1.1

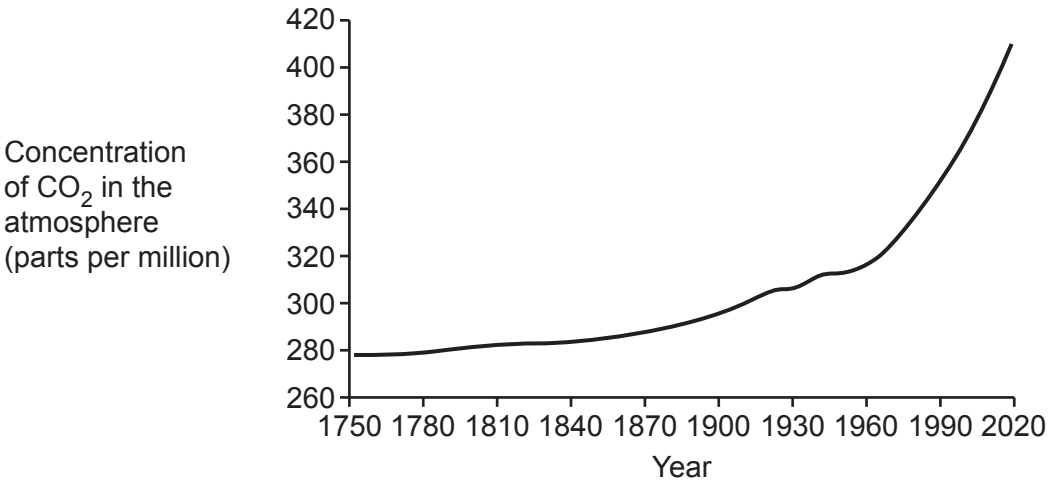


Fig. 1.2 shows the change in world carbon dioxide emissions from fossil fuels over time.

Fig. 1.2

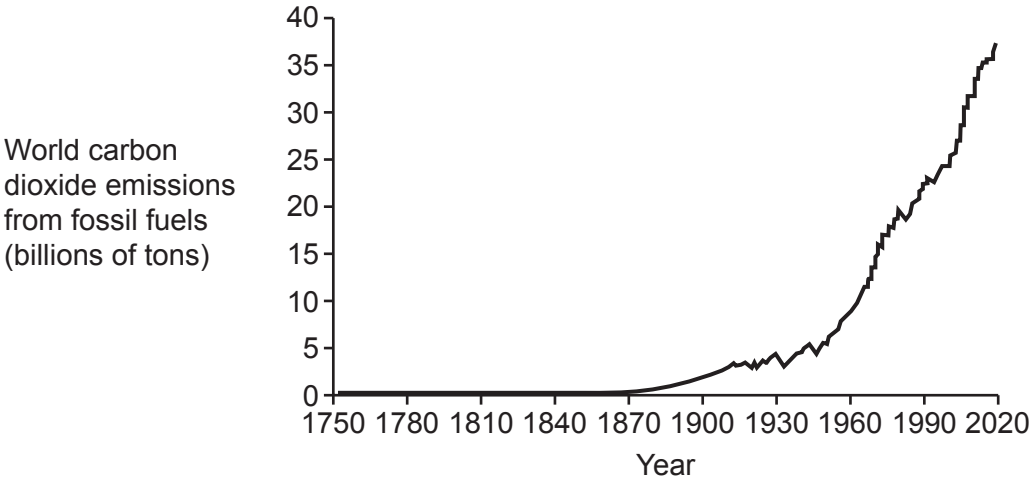
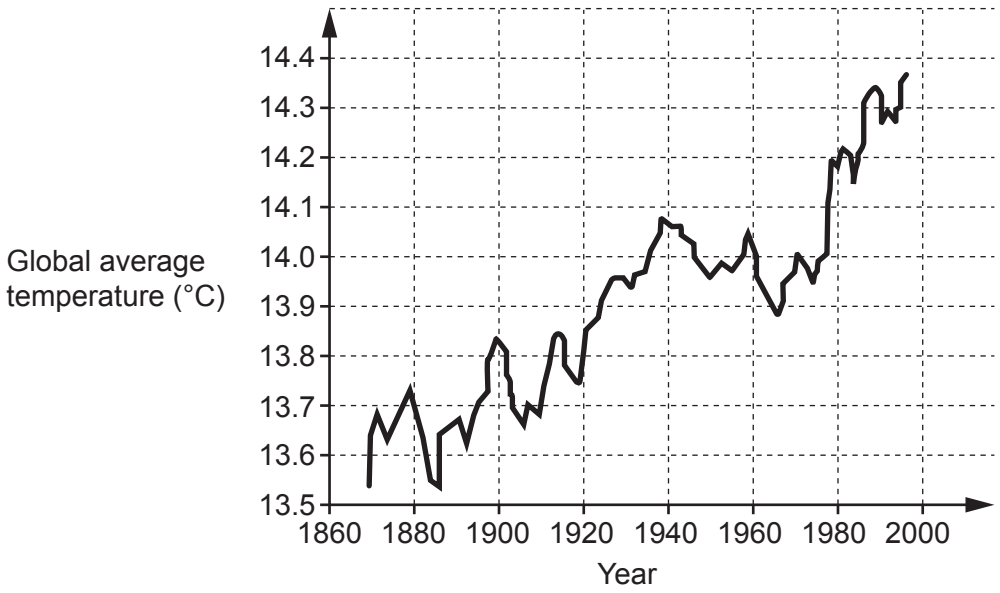


Fig. 1.3 shows the change in global average temperature over time.

Fig. 1.3



Describe the trends in **Fig. 1.1** and **Fig. 1.2 and** explain how this can be used with **Fig. 1.3** to show that human activity is causing the global temperature to increase.

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

2 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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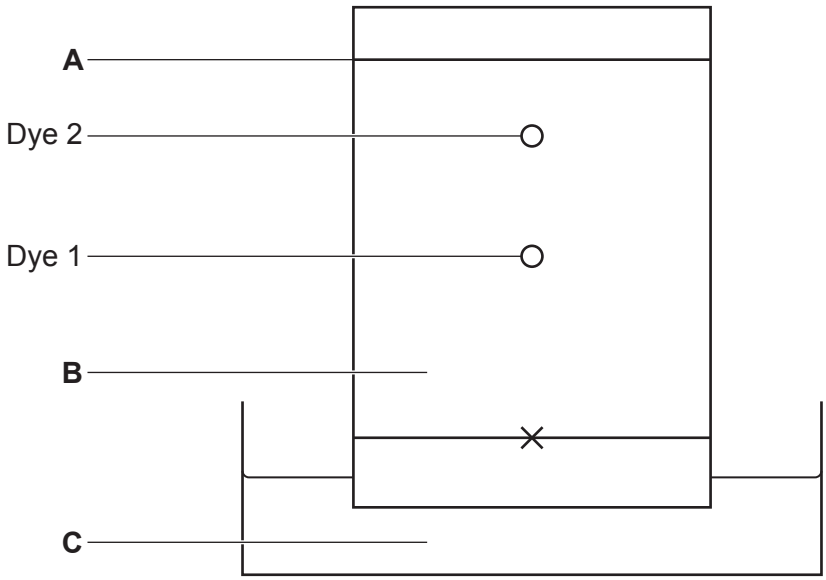
(c) The dyes in the food colouring can be separated using paper chromatography.

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]**

3 **(a)** One type of reaction is called neutralisation.

An example of a neutralisation reaction is when magnesium hydroxide reacts with nitric acid.

(i) Describe neutralisation by naming each **type** of compound in this reaction.

$Mg(OH)_2$ + $2HNO_3$ → $Mg(NO_3)_2$ + $2H_2O$

..... + ... → ..... + water

[2]

(ii) Neutralisation can also be described as the reaction between ions.

Give the formulae of the ions that are involved in neutralisation **and** the product of the reaction of these ions.

Ion from nitric acid .....

Ion from magnesium hydroxide .....

Product .....

[2]

(b) When some metals are added to acids, bubbles are seen in the solution.

(i) Complete the word equation for the reaction between zinc and hydrochloric acid.

zinc + hydrochloric acid → ..... + ...

[2]

(ii) Explain why bubbles form very quickly when zinc is added to the acid but very slowly when lead is added to the acid.

Use ideas about electrons in your answer.

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

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4 Crude oil is a mixture of different length hydrocarbon chains.

(a) Explain how modern life is dependent on hydrocarbons from crude oil.

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

(b) **(i)** Cracking is used to turn the longer-chain hydrocarbons into more useful products.

Describe how the products of cracking are more useful than the long chain hydrocarbons.

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

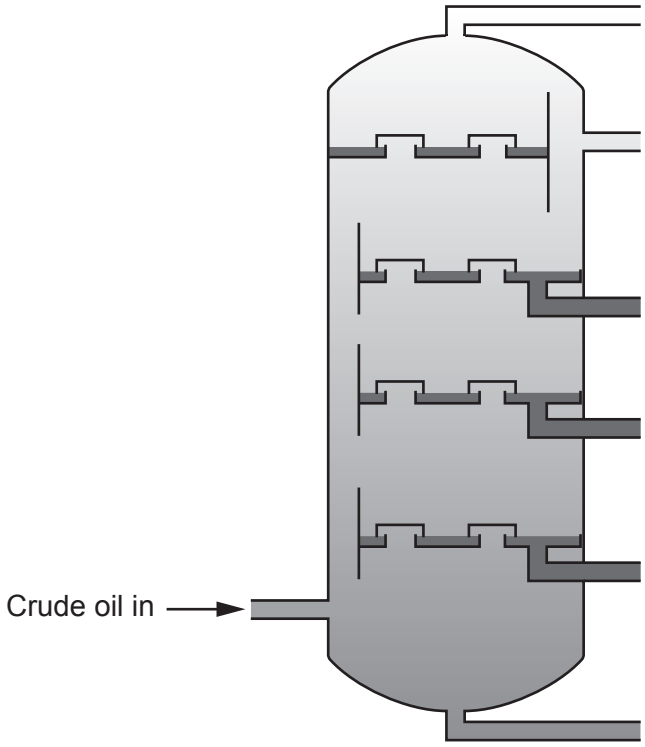
(ii) When decane, $C_{10}H_{22}$, is cracked, one of the products is ethene, C_2H_4.

Complete the symbol equation to show the formula of the other product.

$C_{10}H_{22} \rightarrow C_2H_4 +$ ..... **[1]**

(c)* The mixture of hydrocarbons in crude oil is separated using fractional distillation.

The diagram shows the apparatus used by industry.



Describe how crude oil is separated using fractional distillation **and** explain why the separation occurs.

Use ideas about the size of molecules **and** intermolecular forces.

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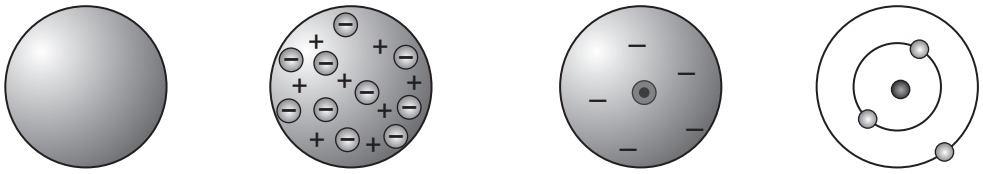
..... **[6]**

5 **(a)** Around 1800, Dalton stated that atoms are the smallest particles that exist.

The models show how the atomic model has developed further over time:



Draw lines to connect each scientist with **how and why** the model was changed.

Scientist	How model changed	Why model changed
Bohr	Solid positive sphere with small negative particles embedded in it.	Most of mass and positive charge must be in a small volume.
Rutherford	Small, heavy, positive nucleus with electrons orbiting in space around it.	Electrons must be in fixed orbits.
Thomson	Positive nucleus with electrons in shells in space around it.	Atom must contain smaller particles.

[2]

(b) The diameter of an atom is approximately 50 000 times bigger than its nucleus.

The diameter of an atom is approximately 1×10^{-10} m.

Estimate the diameter of a nucleus.

Diameter of nucleus = ... m **[2]**

(c) Group 0 elements exist as single atoms and are very unreactive.

(i) Why are Group 0 elements very unreactive?

.....

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

(ii) Give **two** physical properties of Group 0 elements.

1 .....

2 .....

[2]

(d) Group 1 elements react with water to form a metal hydroxide and hydrogen.

(i) Complete the symbol equation for the reaction of sodium with water.

sodium + water → sodium hydroxide + hydrogen

2..... + 2..... → 2NaOH + ...

[1]

(ii) Complete the table by predicting the observations for the reaction of rubidium with water.

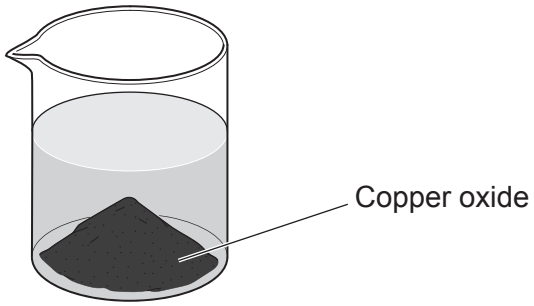
Element	Formula of hydroxide	Observations
Lithium	LiOH	Fizzes steadily; slowly becomes smaller until it disappears.
Sodium	NaOH	Fizzes rapidly; melts to form a ball; quickly becomes smaller until it disappears.
Potassium	KOH	Burns violently; quickly melts to form a ball; disappears rapidly, often with a small explosion.
Rubidium	RbOH	

[2]

6 Alex plans to make a pure, dry sample of copper sulfate crystals.

(a) Alex adds solid copper oxide to aqueous sulfuric acid in a beaker until **no** more solid reacts. This is the symbol equation for the reaction:

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$



(i) Why should there be some solid copper oxide left in the beaker?

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

(ii) Alex finds that the reaction is slow.

Give **two** ways in which Alex can make the reaction faster.

1 .....

2 .....

[2]

(b) When the reaction has finished, Alex uses the contents of the beaker to make pure, dry crystals of copper sulfate.

Describe the method that Alex uses.

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

(c) Alex used 20 cm^3 of 0.5 mol/dm^3 sulfuric acid.

(i) Calculate the number of moles of sulfuric acid used.

Use the formula: concentration (mol/dm^3) = $\frac{\text{number of moles}}{\text{volume } (dm^3)}$

Number of moles of sulfuric acid = ... **[3]**

(ii) How many moles of copper sulfate are formed?

Use the symbol equation and your answer to **(c)(i)**:

$CuO(s) + H_2SO_4(aq) \longrightarrow CuSO_4(aq) + H_2O(l)$

Number of moles of copper sulfate = ... **[1]**

(iii) Calculate the mass of copper sulfate crystals formed.

The relative formula mass of the copper sulfate crystals is 249.6.

Use your answer to **(c)(ii)** and the relationship:

number of moles = $\frac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

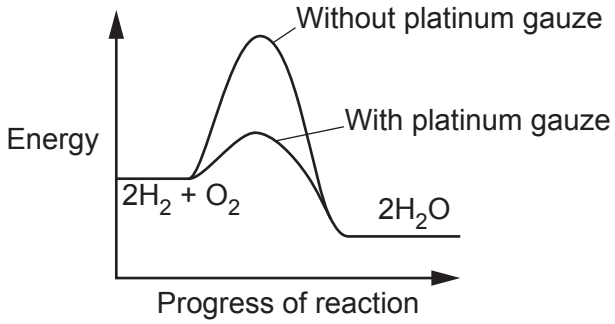
Give your answer to **1** decimal place.

Mass of copper sulfate crystals = ... g **[3]**

7 This question is about exothermic and endothermic reactions.

(a) Hydrogen reacts with oxygen to form water.

To observe the reaction, a platinum gauze is required.
The diagram shows the energy profile for the reaction with **and** without a platinum gauze.



(i) Why is this an example of an oxidation reaction?

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

(ii) State the role of the platinum gauze **and** explain why it causes the reaction to occur.

Role .....

Explanation .....

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[3]

(iii) The table shows some bond energies.

	Bond energy (kJ / mol)
H-H	436
O=O	498
O-H	464

Calculate the energy change for this reaction:

2 H-H + O=O $\longrightarrow$ 2 H-O-H

Energy change = ...kJ **[3]**

(b) A student reads in a textbook:

> 'When solid ammonium nitrate dissolves in water the reaction is endothermic.'

(i) Describe an experiment the student could do and their expected results to confirm the statement in the box.

Experiment .....

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Results .....

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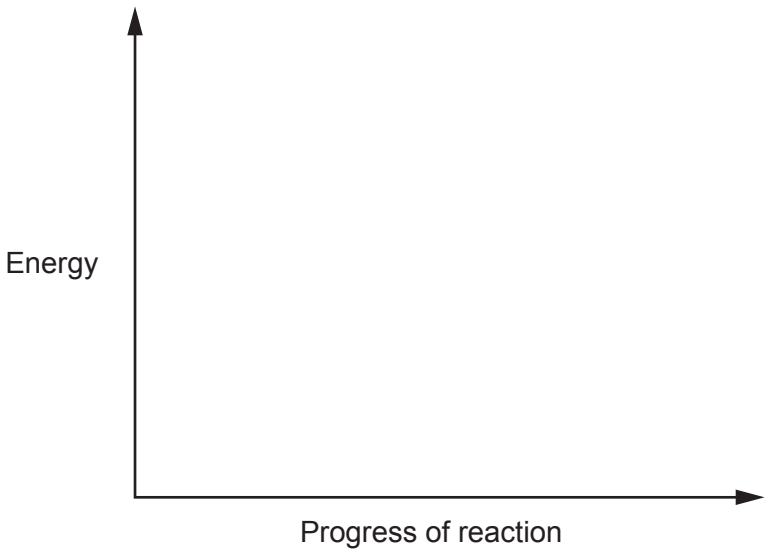
[3]

(ii) Complete the energy profile for ammonium nitrate dissolving in water.

Label the energy profile to show the:
- activation energy
- reactants
- products.

Use the equation:

NH_4NO_3 (s) ⟶ NH_4^+ (aq) + NO_3^- (aq)



[3]

8 Manufactured products can often be made from a range of different materials.

A company wants to make saucepans. A good saucepan needs to spread heat evenly, be easy to lift and be durable.

The table shows the properties of some materials.

Material	Melting point (°C)	Thermal conductivity (W / m K)	Density (kg / m^3)	Scratch resistance (1 = low 10 = high)
Copper	1085	401	8900	3
Aluminium	660	235	2700	2.5–3
Polymer	160–210	0.19	1300	2
Lead	327	35	11 000	1.5
Glass	1250	1.14	2230	5

(a) The company has chosen to use copper to make saucepans.

Evaluate the company's choice.

Use the table.

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

(b) Suggest **one** other factor that should be considered by the **company** when deciding which material to use.

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

(c) Companies also need to consider the life-cycle assessment of a product when comparing materials.

A life-cycle assessment analyses the environmental impact of each stage of a product's lifetime.

(i) One of the things considered during the manufacturing stage of the process is the use of the raw materials.

Describe **two** other resources which should be considered during the **manufacturing** stage.

1 .....

.....

2 .....

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

(ii) Describe one **other** stage of a product's lifetime which should be considered in a life-cycle assessment.

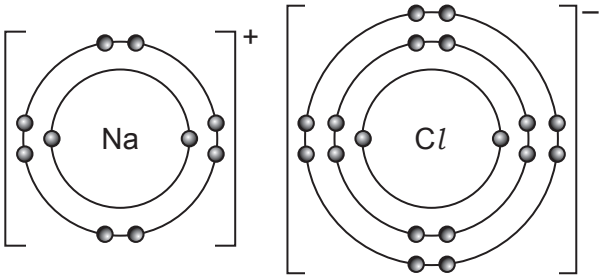
.....

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

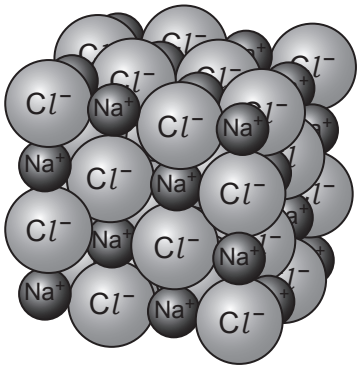
9 Compounds are bonded together ionically or covalently. Models are used to represent these compounds.

(a) Sodium (electron arrangement 2.8.1) reacts with chlorine (electron arrangement 2.8.7) to form sodium chloride. Sodium chloride is bonded ionically.

Two models are shown to represent sodium chloride:



Dot and cross model



3-D model

(i) Describe **one** limitation of representing sodium chloride by each of these models.

Dot and cross model .....

.....

3-D model.....

.....

[2]

(ii) Explain how the ionic bond is formed in sodium chloride.

Use ideas about electrons and electrostatic forces in your answer.

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

(iii) Magnesium (electron arrangement 2.8.2) reacts with oxygen (electron arrangement 2.6) to form magnesium oxide.

Draw the dot and cross diagram for magnesium oxide.

[2]

(b) Iron also forms ionic compounds.

Complete **Table 9.1** by giving the formulae of the compounds formed from the ions present.

Table 9.1

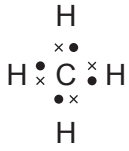
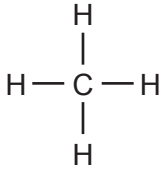
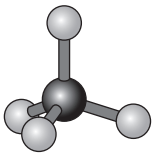
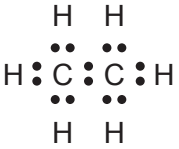
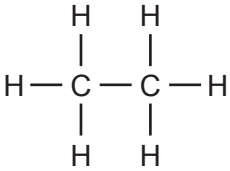
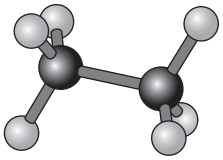
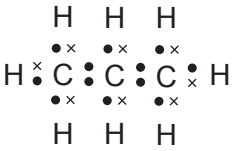
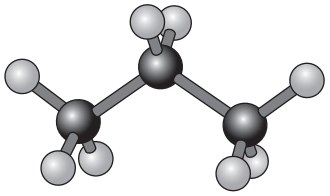
Compound	Ions present	Formula of compound
Iron(III) bromide	Fe^{3+} Br^-	.....
Iron(III) sulfate	Fe^{3+} SO_4^{2-}	.....

[2]

(c) Hydrocarbons are bonded covalently.

Table 9.2 shows different ways of representing three hydrocarbons.

Table 9.2

Name	Dot and cross model	2-D model	3-D model
Methane			
Ethane			
Propane			

(i) Complete **Table 9.2** by showing the 2-D model of propane. **[1]**

(ii) All these models show the number of each atom and the order in which the atoms are joined together.

Describe **one** limitation of representing the structure of propane that is true for **both** the dot and cross model **and** the 2-D model.

.....

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

(iii) The empirical formula shows the simplest ratio of atoms in a molecule.

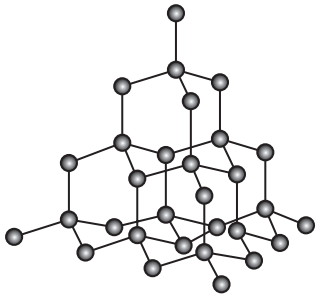
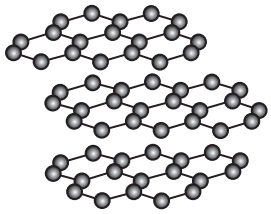
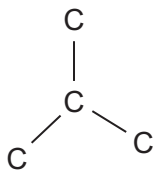
What is the empirical formula of ethane?

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

(d) Some elements form giant covalent structures.

Table 9.3 shows the structures of two allotropes of carbon.

Table 9.3

	Diamond	**Graphite**
3-D model		
2-D model		

Complete **Table 9.3** by showing the 2-D model for diamond. **[1]**

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).