OCR
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Friday 19 November 2021 – Morning

GCSE (9–1) Combined Science (Chemistry) A (Gateway Science)

J250/09 Paper 9 (Higher Tier)

Time allowed: 1 hour 10 minutes

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

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

J250/09

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 **60**.
- 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 **20** pages.

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

SECTION A

Answer **all** the questions.

You should spend a maximum of 20 minutes on this section.

Write your answer to each question in the box provided.

1 An atom of an element forms an ion with the formula X^{2-}.

Which **Group** of the Periodic Table is this element found in?

A Group 0

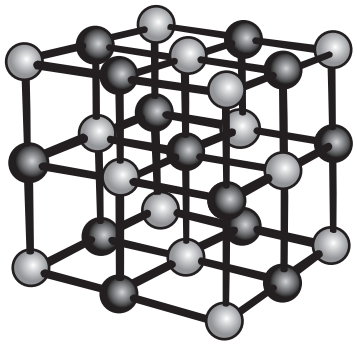
B Group 2

C Group 6

D Group 7

Your answer ☐ **[1]**

2 The diagram shows the 'ball and stick' model for an ionic compound.



Which statement about the 'ball and stick' model is correct?

A It shows all the forces between the ions.

B It shows the arrangement of the ions.

C It shows the charges on the ions.

D It shows the sizes of the ions.

Your answer ☐ **[1]**

3 Look at the symbol for boron.

5
B
11

Which is the symbol for the element with an atom that contains 1 more proton **and** 2 more neutrons than an atom of boron?

A

6
C
11

B

6
C
12

C

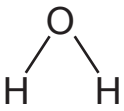
6
C
13

D

6
C
14

Your answer ☐ **[1]**

4 An O-H bond has a length of 9.6×10^{-11} nm.



What is the approximate size of a water molecule, H_2O?

A 1×10^{-11} nm

B 5×10^{-11} nm

C 1×10^{-10} nm

D 3×10^{-10} nm

Your answer ☐ **[1]**

5 A scientist wants to find out the amount of each chemical in a mixture.

Which row in the table shows the chromatographic techniques that the scientist could use?

	Paper chromatography	Thin layer chromatography	Gas chromatography
A	✓	✗	✗
B	✓	✓	✗
C	✗	✗	✓
D	✗	✓	✓

Your answer ☐ **[1]**

6 Which equation shows the ionisation of a **weak acid**?

A $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

B $HCOOH(aq) \rightleftharpoons HCOO^-(aq) + H^+(aq)$

C $NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

D $NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

Your answer ☐ **[1]**

7 A student completely reacts 0.403 g of magnesium oxide with an excess of carbon.

$2MgO(s) + C(s) \rightarrow 2Mg(s) + CO_2(g)$

What is the mass of **magnesium** made?

The relative atomic mass, A_r, of O is 16.0 and of Mg is 24.3

A 0.1215 g

B 0.243 g

C 0.486 g

D 0.668 g

Your answer ☐ **[1]**

8 Look at the ionic equation.

$Mg(s) + Cu^{2+}(aq) \longrightarrow Mg^{2+}(aq) + Cu(s)$

Which species is **reduced**?

A Cu(s)

B $Cu^{2+}(aq)$

C Mg(s)

D $Mg^{2+}(aq)$

Your answer ☐ **[1]**

9 A solution has a hydrogen ion concentration of 1×10^{-6} mol / dm^3. The solution has a pH of 6.

What is the hydrogen ion concentration of a solution with a pH of 3?

A 1×10^{-9} mol / dm^3

B 1×10^{-6} mol / dm^3

C 1×10^{-3} mol / dm^3

D 1×10^{-1} mol / dm^3

Your answer ☐ **[1]**

10 Which term is defined as 'The sum of the relative atomic masses of all the atoms in a chemical formula'?

A Mass number

B Molecular formula

C Relative formula mass

D The Avogadro constant

Your answer ☐ **[1]**

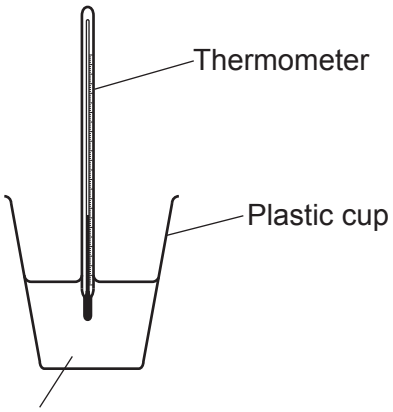
SECTION B

Answer **all** the questions.

11 The reaction between solid citric acid and sodium hydrogen carbonate solution is an endothermic reaction.

A student investigates the temperature change for the reaction.

The diagram shows the equipment the student uses.



The student adds 0.65 g of solid citric acid to an excess of sodium hydrogen carbonate solution.

The student measures the temperature change. The temperature change is 3.5 °C.

(a) (i) How does a temperature change show that a reaction is endothermic?

.....

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

(ii) How should the student have written the temperature change to show that this reaction is endothermic?

.....

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

(b) Describe how the student performed the experiment so that they could calculate the temperature change.

.....

.....

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

(c) The student repeats the experiment using a different mass of citric acid. This time the student measures a larger temperature change.

The temperature change is 10.0 °C.

If 0.65 g of citric acid gives a temperature change of 3.5 °C, calculate the mass of citric acid, **in milligrams**, that gives a 10.0 °C temperature change.

1 g = 1000 mg

Give your answer to **3** significant figures.

Mass of citric acid = ... mg **[4]**

(d) When the student washed out the plastic cup at the end of the second experiment they saw some excess solid left.

Explain how this affected the student's result **and** describe how the student could have improved their experiment.

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

(e) Citric acid and sodium hydrogen carbonate react to form sodium citrate.

Sodium citrate contains sodium ions, Na^+, and citrate ions, $C_6H_5O_7^{3-}$.

Write the **formula** of sodium citrate.

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

12 J. J. Thomson proposed the 'plum-pudding' model of the atom shown in **Fig. 12.1**.

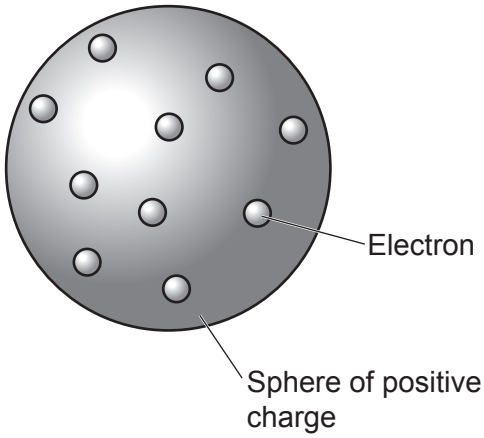

Fig. 12.1

Geiger and Marsden worked with Rutherford and tested the 'plum-pudding' model of the atom. **Fig. 12.2** shows their experiment.

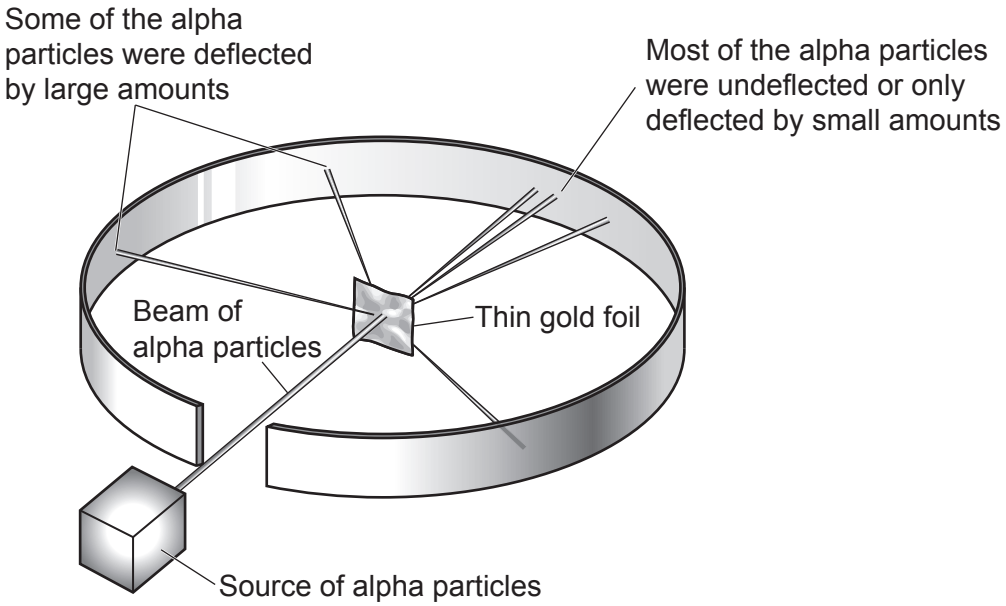

Fig. 12.2

A beam of **positively charged alpha particles** was fired at a piece of thin gold foil.

Geiger and Marsden found that:

- Most of the alpha particles passed straight through the gold foil without being deflected or were only deflected by small amounts.
- Some of the alpha particles were deflected by large amounts.

9

Describe **and** explain how Rutherford used the results to **further develop** the model of the atom.

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

13 Solder is a mixture of lead and tin. Solder can be used to join two electrical wires together as shown in **Fig. 13.1**.

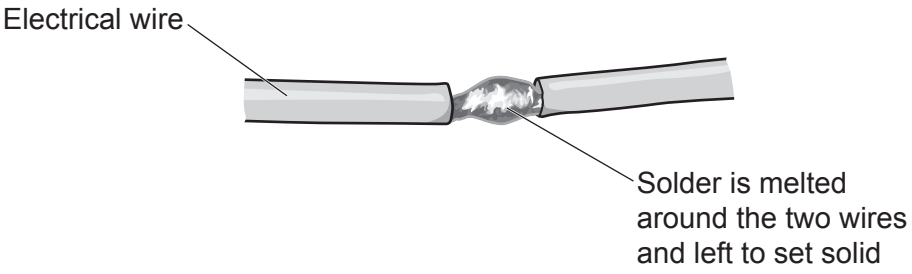

Fig. 13.1

The table shows how the melting point of solder changes with the percentage of tin it contains.

Percentage of tin in solder (%)	Melting point (°C)
0	320
20	280
40	240
80	220
90	230
100	240

(a) Plot the data on the grid shown in **Fig. 13.2**.

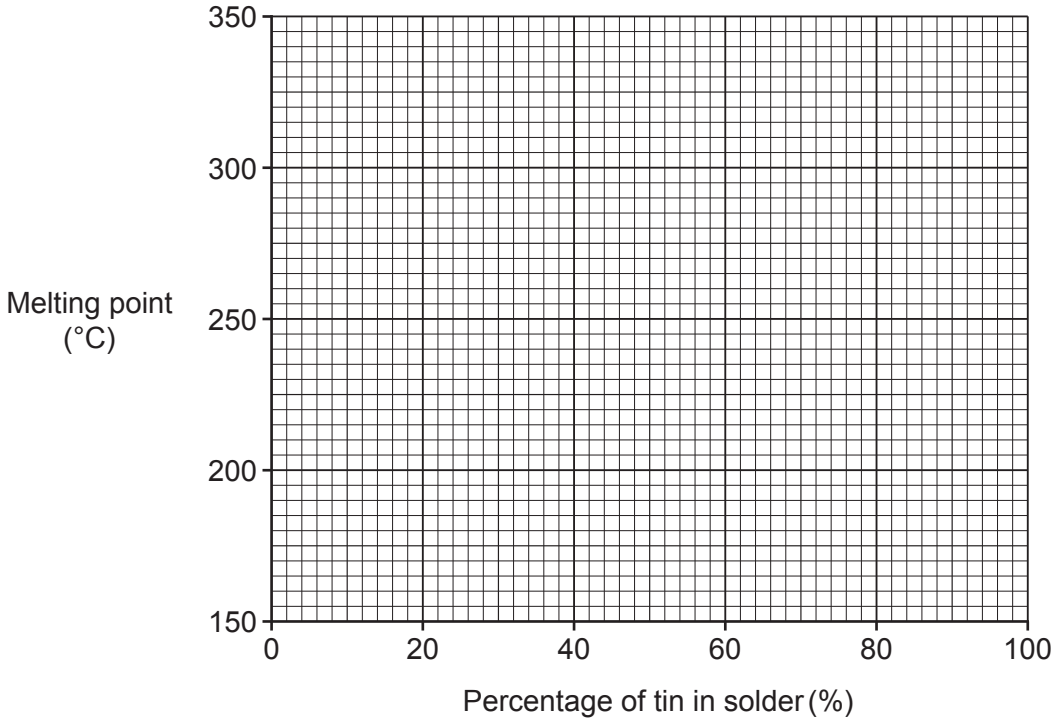

Fig. 13.2 **[2]**

(b) (i) On **Fig. 13.2** draw a line of best fit through the first three points and a second line of best fit through the last two points. **[1]**

(ii) Use the lines of best fit to work out the percentage of tin in solder with the **lowest** melting point.

Percentage of tin = ... % **[2]**

(c) Solder conducts electricity like a typical metal.

Explain why.

Use knowledge of the properties of metals in your answer.

.....

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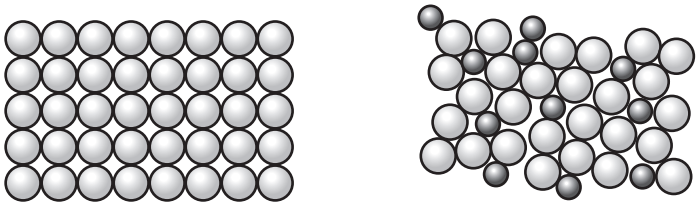
..... **[2]**

(d) Look at **Fig. 13.3**. It shows how the atoms are arranged in pure lead and in solder.



Pure lead **Solder**

Fig. 13.3

(i) Solder is an example of a formulation.

What name is given to a formulation which is a mixture of metals such as solder?

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

(ii) Suggest whether solder is harder, softer or the same hardness as pure lead.

Explain your answer using your knowledge of the properties of metals.

Solder is .....

Explanation .....

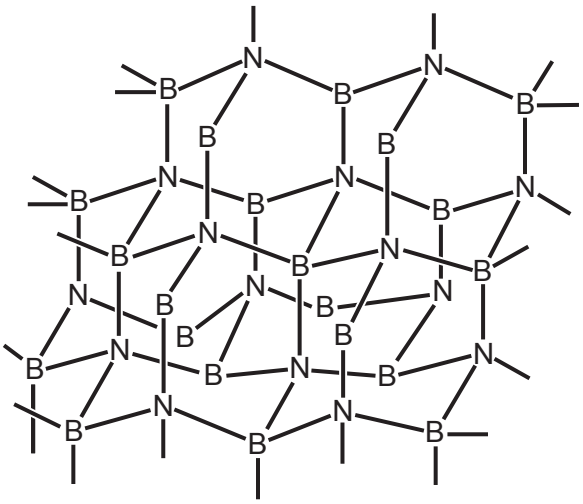
.....

.....

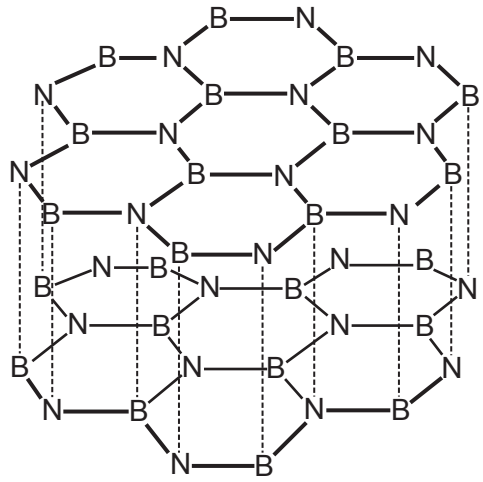
..... **[3]**

14* Boron nitride is a compound made from boron and nitrogen.

Boron nitride can exist in two different forms similar to graphite and diamond. The diagrams show the structures of two different forms of boron nitride.



Structure 1



Structure 2

Structure 1 can be used as an alternative to diamond in drill tips.

Structure 2 can be used as a lubricant when the electrical conductivity of graphite is a problem.

Both structures can be used at high temperatures.

Describe and explain the **similarities** and **differences** in the properties of the two structures of boron nitride which allow them to be used as alternatives to diamond and graphite.

Use knowledge of the structure and bonding of diamond and graphite in your answer.

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

15 Carbon dioxide, CO_2, is a covalently bonded molecule.

(a) Explain what is meant by a covalent bond.

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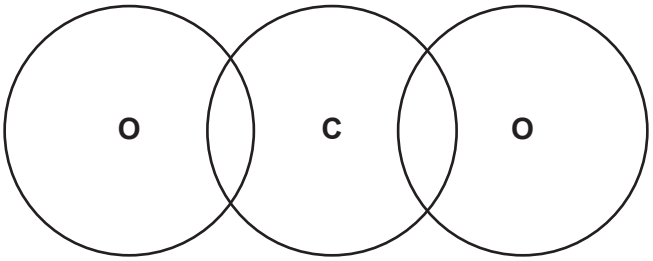
..... **[2]**

(b) Look at the diagram. It shows the structure of carbon dioxide.

O ═ C ═ O

Complete the dot and cross diagram for carbon dioxide.



[2]

(c) The equation shows the formation of 1 mole of carbon dioxide from carbon monoxide and oxygen.

The table shows the bond energies of some bonds.

Bond	Bond energy (kJ / mol)
C≡O	1070
O=O	496
C=O	743

Calculate the energy change for the formation of 1 mole of carbon dioxide.

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

(d) **(i)** Explain the term activation energy.

.....

.....

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

(ii) Look at your calculation in **(c)**.

Suggest a value for the activation energy for the formation of 1 mole of carbon dioxide in this reaction.

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

16 The mole is a unit of measurement used in chemistry for the amount of a substance.

(a) Define the term **mole**.

.....

.....

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

(b) Iron, Fe, reacts with steam, H_2O. An oxide of iron and hydrogen, H_2, are made.

The oxide of iron has the formula Fe_xO_y where **x** and **y** are whole numbers.

In a reaction 1.67 g of iron, Fe, reacts with 0.72 g of steam, H_2O. 0.08 g of hydrogen, H_2, are made.

(i) Calculate the number of moles of iron, steam and hydrogen.

Give your answers to **2** decimal places.

The relative atomic mass, A_r, of H is 1.0, of O is 16.0 and of Fe is 55.8

Moles of iron = ...

Moles of steam = ...

Moles of hydrogen = ...

[3]

(ii) Look at the reaction equation. It shows the formation of **1** mole of the oxide of iron, Fe_xO_y.

.....Fe(s) + ...H_2O(g) $\rightarrow$ Fe_xO_y(s) + ...H_2(g)

Use your answers to **(b)(i)** to balance the reaction equation **and** work out the formula of the oxide of iron, Fe_xO_y.

Formula of oxide of iron = ... **[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).