OCR
Oxford Cambridge and RSA

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Friday 19 November 2021 – Morning

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

J248/03 Paper 3 (Higher Tier)

Time allowed: 1 hour 45 minutes

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

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

J248803

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 **28** pages.

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

DC (LK/JG) 300804/5

SECTION A

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

1 Which statement about the subatomic particles in an atom is correct?

A Electrons have a relative mass of one.

B Neutrons and electrons are both found in the nucleus.

C Neutrons have a positive charge.

D Protons have a relative mass of one.

Your answer ☐ **[1]**

2 The formula of a sodium ion is Na^+. The formula of a phosphate ion is PO_4^{3-}.

What is the formula of sodium phosphate?

A $Na(PO_4)_3$

B Na_2PO_4

C Na_3PO_4

D Na_4PO_4

Your answer ☐ **[1]**

3 Which statement describes **ionic** bonding?

A Electrons are delocalised.

B Electrons are shared between atoms.

C Electrons are transferred from a metal to a non-metal.

D Electrons are transferred from a non-metal to a metal.

Your answer ☐ **[1]**

4 Oxygen has three naturally occurring **isotopes**.

Which statement about isotopes of oxygen is correct?

A All isotopes of oxygen have 8 electrons and 8 neutrons.

B All isotopes of oxygen have 8 electrons and 8 protons.

C All isotopes of oxygen have 8 neutrons and 8 protons.

D All isotopes of oxygen have the same mass number.

Your answer ☐ **[1]**

5 Which type of reaction occurs when the temperature of the surroundings increases?

A Crystallisation

B Endothermic

C Exothermic

D Reduction

Your answer ☐ **[1]**

6 Copper oxide reacts with carbon. Oxidation takes place in this reaction.

$2CuO + C \longrightarrow 2Cu + CO_2$

Which substance is **oxidised**?

A C

B CO_2

C Cu

D CuO

Your answer ☐ **[1]**

7 Sulfuric acid, H_2SO_4, reacts with sodium hydroxide, NaOH, in a neutralisation reaction.

What are the products of this reaction?

A Sodium sulfate and hydrogen

B Sodium sulfate and water

C Sodium sulfate, hydrogen and oxygen

D Sodium sulfate, hydrogen and water

Your answer ☐ **[1]**

8 Which statement is a reason that nanoparticles can be used as catalysts?

A Nanoparticles are safe and have no risks.

B Nanoparticles are smaller than atoms.

C Nanoparticles have a large surface area to volume ratio.

D Nanoparticles have a small surface area to volume ratio.

Your answer ☐ **[1]**

9 Sodium reacts with hydrochloric acid to give sodium chloride and hydrogen gas.

What is the **balanced** symbol equation for this reaction?

A $Na + HCl \longrightarrow NaCl + H$

B $Na + HCl \longrightarrow NaCl + H_2$

C $2Na + 2HCl \longrightarrow 2NaCl + H_2$

D $2Na + 2HCl \longrightarrow 2NaCl + 2H$

Your answer ☐ **[1]**

10 The table shows melting points and boiling points for some Group 7 elements.

Element	Melting point (°C)	Boiling point (°C)
Fluorine	−220	−188
Chlorine	−102	−34
Bromine	−7	59
Iodine	114	184

Which statement is correct at room temperature?

A Bromine is a liquid and chlorine is a solid.

B Fluorine is a gas and bromine is a liquid.

C Fluorine is a gas and iodine is a liquid.

D Iodine is a gas and fluorine is a solid.

Your answer ☐ **[1]**

11 The **empirical formula** of a hydrocarbon is CH_2.

The relative formula mass of the hydrocarbon is 126.0.

What is the **molecular formula** of the hydrocarbon?

A C_7H_{14}

B C_8H_{16}

C C_9H_{18}

D $C_{10}H_{20}$

Your answer ☐ **[1]**

12 Magnesium reacts with oxygen. Magnesium oxide is made.

The balanced symbol equation is shown.

$2Mg + O_2 \longrightarrow 2MgO$

Calculate how much magnesium is needed to make 10.0 g of magnesium oxide.

A 4.0 g

B 6.0 g

C 10.0 g

D 16.6 g

Your answer ☐ **[1]**

13 A student investigates if an unknown liquid sample is pure.

Which method should the student use?

A Filter the sample to see if any solid can be separated.

B Gas chromatography.

C Measure the boiling point of the sample.

D Titration.

Your answer ☐ **[1]**

14 Which statement about covalent bonding is **not** correct?

A Covalent bonds are broken when a compound changes state from a liquid to a gas.

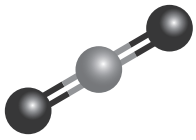
B Covalent bonds are strong.

C Covalent bonds can be found in both simple compounds and giant structures.

D Covalent bonds share electrons between atoms.

Your answer ☐ **[1]**

15 A carbon dioxide molecule is shown in the ball and stick model.



Which estimate of the distance between the oxygen atoms in a carbon dioxide molecule is correct?

A 2.0×10^{-7} m

B 2.0×10^{-10} m

C 2.0×10^{-15} m

D 2.0×10^{-20} m

Your answer ☐ **[1]**

SECTION B

Answer **all** the questions.

16 The table shows carbon can exist as several different structures called allotropes.

Allotrope	Covalent bonds
Diamond	.....
Graphite	.....
Graphene	3

(a) Complete the table to show how many covalent bonds carbon forms in these allotropes. **[2]**

(b) **(i)** Diamond can be used as a cutting tool because it is so hard.

Explain why diamond is so hard.

Use ideas about structure and bonding in diamond in your answer.

.....

.....

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

(ii) Graphite can be used as a lubricant because it is slippery.

Explain why graphite is slippery.

Use ideas about structure and bonding in graphite in your answer.

.....

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

(c) Explain why carbon forms many other compounds. Use ideas about the bonding in carbon compounds in your answer.

.....

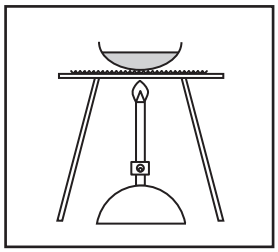
.....

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

17 The table shows information about some properties of four substances.

Substance	Melting point (°C)	Boiling point (°C)	Solubility in water	Does the substance conduct electricity?
M	−98	65	Soluble	No
N	−114	78	Soluble	No
O	661	1304	Soluble	Only when molten or dissolved
P	1085	2562	Insoluble	Yes

(a) Which diagram shows the apparatus that should be used to separate a mixture of substance **M** and substance **N**? Tick (✓) **one** box.



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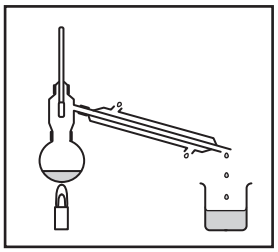

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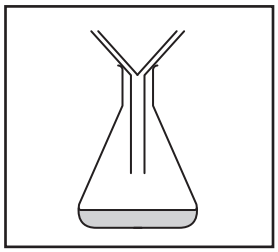

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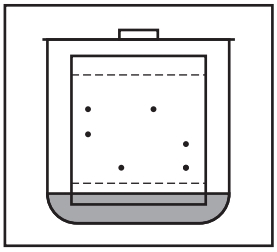

☐

[1]

(b) **(i)** Describe a method that could be used to separate a mixture of substance **O** and substance **P** to obtain pure samples.

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.....

.....

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

(ii) A student separates substance **O** from a mixture.

They start with 6.2 g of the mixture and obtain 2.6 g of pure substance **O**.

Calculate the mass of pure substance **O** that could be separated from 10.0 g of the mixture.

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

Mass of pure substance **O** = ... g **[3]**

(c) Draw lines to connect each substance with its correct type of structure and bonding.

Substance M	Giant Covalent
Substance O	Ionic
Substance P	Metallic
	Polymer
	Simple Covalent

[3]

18 All chemical reactions follow the law of conservation of mass.

(a) State the law of conservation of mass.

.....

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

(b) A student investigates the reaction of magnesium carbonate with dilute hydrochloric acid. Look at the equation for the reaction.

$MgCO_3(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$

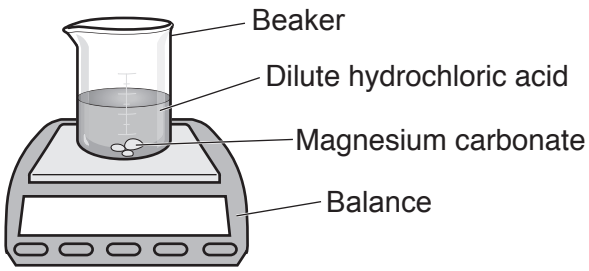
Describe the **movement** of the magnesium carbonate particles used in this reaction.

Use ideas about the particle model in your answer.

.....

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

(c) The student sets the experiment up on a balance as shown in the diagram.



(i) Explain why the mass on the balance **decreases** as the reaction occurs.

Use ideas about the particle model in your answer.

.....

.....

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

(ii) The particle model is not a perfect representation of the three states of matter.

Describe **two** limitations of the particle model.

1 .....

.....

2 .....

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

(d) The student wants to produce a pure, dry sample of magnesium chloride, $MgCl_2$, at the end of the reaction.

The student suggests a method:

1. Filter the remaining solid out of the reaction mixture in the beaker.
2. Wash the solid with distilled water.
3. Allow the water to evaporate to leave pure solid.

The student's method does **not** produce a pure, dry sample of magnesium chloride, $MgCl_2$.

(i) Explain why the student's method does **not** work.

.....

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

(ii) Suggest **two** ways the method could be changed to produce a pure, dry sample of magnesium chloride, $MgCl_2$.

1 .....

.....

2 .....

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

19 **(a)** Theories about atoms have developed as new evidence has been discovered.

J.J. Thomson's model of the atom was called the "plum pudding" model.

(i) Describe **two** differences between the current understanding of the structure of the atom and J.J. Thomson's "plum pudding" model.

1 .....

.....

2 .....

.....

[2]

(ii) Before new scientific theories are published, the theories are peer reviewed.

Which statements about peer review are correct?

Tick (✓) **two** boxes.

A scientist giving feedback on another scientist's experiments is peer review.	☐
A scientist should have more confidence in results that have **not** been peer reviewed.	☐
Peer review is important to make sure results are reproducible.	☐
Peer review is not important as everyone can have a different opinion.	☐
Two friends discussing science is peer review.	☐
Two scientists discussing science is peer review.	☐

[2]

(b) **(i)** Calculate the average mass of **one** atom of neon, Ne.

The Avogadro constant has a value of 6.02×10^{23}.

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

Average mass of one atom of neon = ... g **[3]**

(ii) Three isotopes of neon are shown.

20 **Ne** 10	21 **Ne** 10	22 **Ne** 10

How many neutrons does an atom of neon-21 contain?

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

(iii) Calculate how many **moles** of neon there are in 101 g of neon.

(The relative atomic mass, A_r, of Ne is 20.2.)

Moles of neon = ... mol **[2]**

(c) Neon is in Group 0 of the Periodic Table. Lithium is in Group 1 of the Periodic Table.

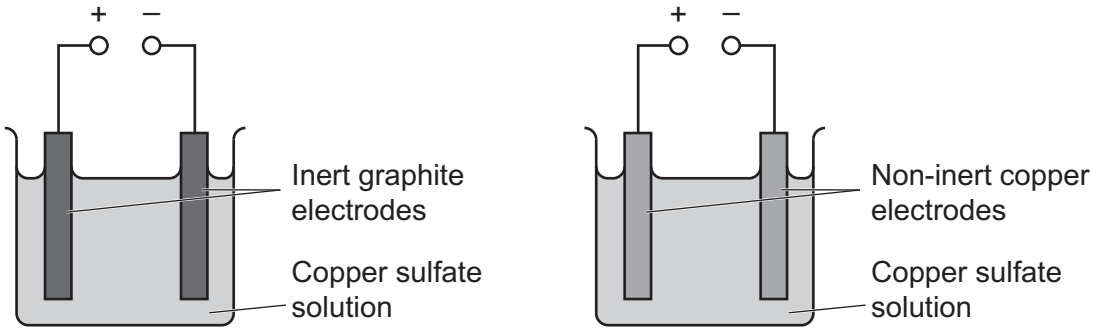
Explain, in terms of electronic structure, why elements in Group 1 are **more** reactive than elements in Group 0.

.....

.....

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

20 The diagrams show the electrolysis of copper sulfate solution, $CuSO_4$.



(a) In both experiments, copper is deposited at the cathode.

Describe a **difference** between the electrolysis of copper sulfate solution using inert graphite electrodes and non-inert copper electrodes.

.....

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

(b) A student investigates the electrolysis of sodium chloride solution.

(i) Hydrogen gas, H_2, is formed at the cathode.

Write the **balanced half equation** for this reaction.

Use e^- to represent an electron.

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

(ii) State the name of the substance made at the anode.

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

(iii) Sodium chloride **cannot** conduct electricity when it is solid.

Explain why sodium chloride can conduct electricity when it is dissolved in water but **not** when it is solid.

.....

.....

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

(c) The student investigates materials to use as inert electrodes in the electrolysis of aqueous sodium chloride.

They compare four materials **A**, **B**, **C**, and **D**. Their results are shown in the table.

Material	Soluble in water?	Does it conduct electricity?	Density (g/cm^3)
A	yes	yes	7.87
B	no	yes	12.41
C	no	only when molten	2.17
D	yes	no	1.54

Which material, **A**, **B**, **C** or **D**, is the **most suitable** for use as an inert electrode?

Explain your answer.

Material .....

Explanation .....

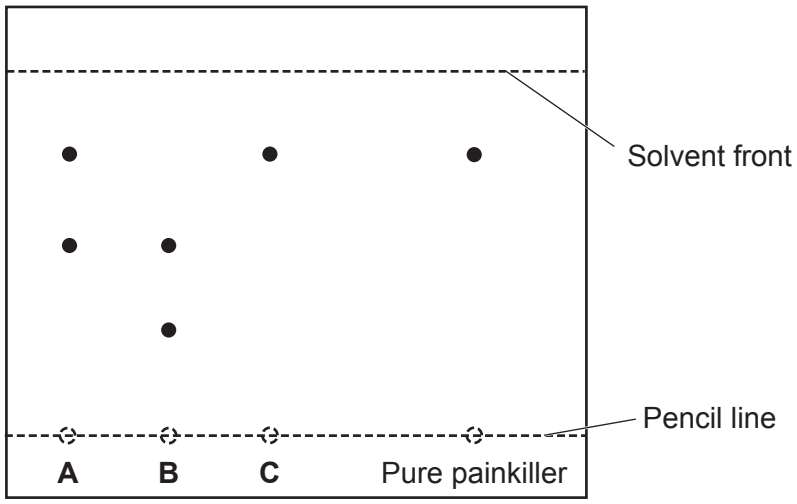
.....

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

21 A scientist uses chromatography and melting points to investigate the purity of three samples of a painkiller, **A**, **B** and **C**.

- The scientist compares the three samples with a pure sample of the painkiller.
- The scientist also compares the melting points of the three samples to the pure sample.

Look at the results.



Sample	Melting point (°C)
A	132 – 135
B	111 – 115
C	136
Pure painkiller	136

(a)* Use the chromatogram and melting point data provided to determine which samples, **A**, **B** and **C**, are pure and which contain the painkiller.

Explain your answer.

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

(b) When the painkiller is sold to the public, it is sold as a formulation, not as a pure substance.

Explain how a formulation and a mixture are different.

.....

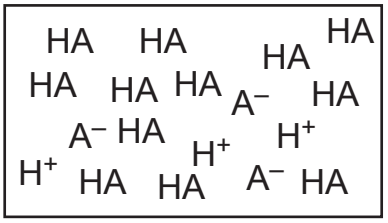
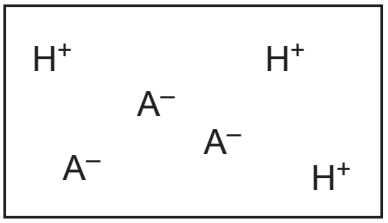
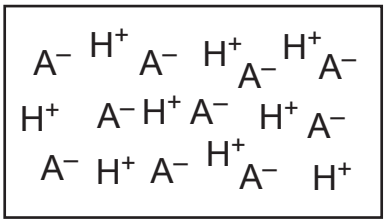
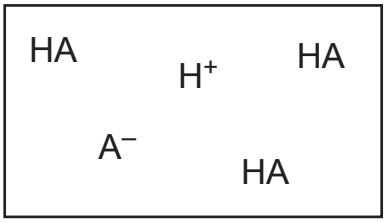
..... **[1]**

(c) The painkiller is an acid.

(i) The diagrams show **four** different types of acid solutions.

The acid molecule is represented as HA. The ions formed in solution are represented as H^+ and A^-.

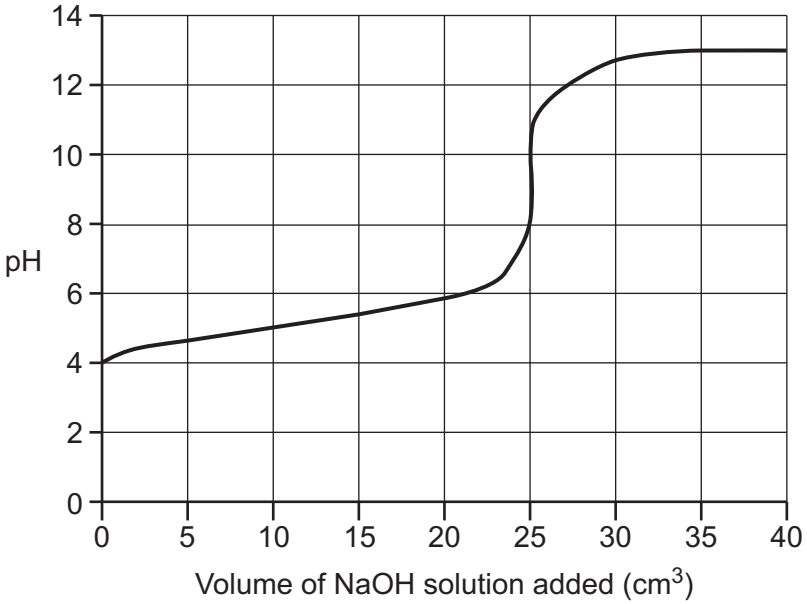
Draw lines to match each description with the correct acid solution diagram.

A dilute, strong acid	
A concentrated, weak acid	
A dilute, weak acid	
	

[3]

(ii) The scientist titrates a solution of the painkiller against a solution of sodium hydroxide, NaOH.

The titration curve is shown.



The scientist concludes that the painkiller is a **strong** acid.

Is the scientist correct?

Explain your answer.

.....

.....

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

22 Hydrogen sulfide, H_2S, reacts with oxygen, O_2, to form sulfur dioxide, SO_2, and water.

The balanced symbol equation is shown.

$2H_2S(g) + 3O_2(g) \longrightarrow 2SO_2(g) + 2H_2O(l)$

(a) A scientist sets up the reaction so that hydrogen sulfide is the limiting reactant.

(i) Explain what is meant by the term **limiting reactant**.

.....

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

(ii) Explain what effect a limiting reactant has on a reaction.

.....

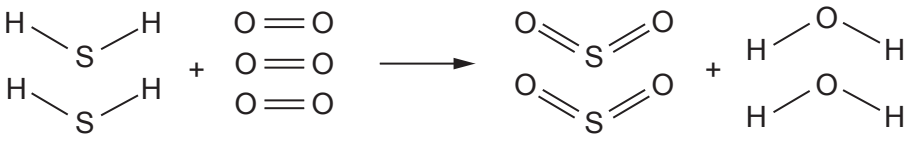
..... **[1]**

(b) Calculate the mass of sulfur dioxide made from 102.3 g of hydrogen sulfide.

(The relative atomic mass, A_r, of H is 1.0, of O is 16.0 and of S is 32.1).

Mass of sulfur dioxide = ... g **[3]**

(c) The reaction of hydrogen sulfide with oxygen is shown using displayed formulae.



The table shows the bond energies of the bonds in the reactants and products.

Bond	Bond energy (kJ / mol)
S–H	347
O=O	494
S=O	523
H–O	459

The energy needed to break the bonds in **two** moles of hydrogen sulfide is 1388 kJ.

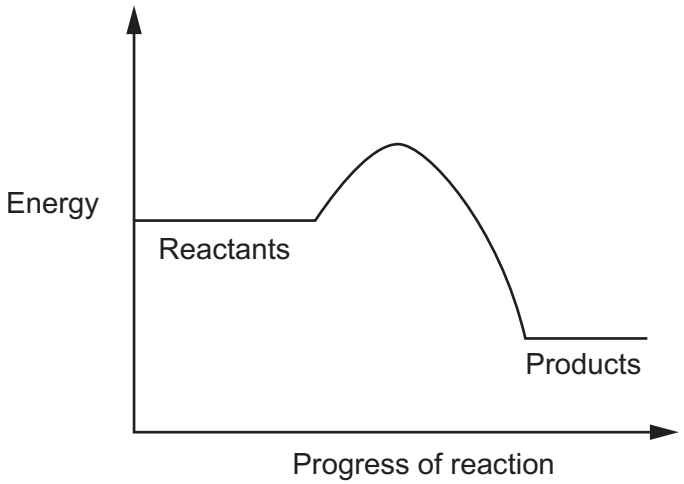
Use the bond energies to calculate the energy change of the reaction when **two** moles of hydrogen sulfide react with oxygen.

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

Energy change = ... kJ **[4]**

(d) Sulfur dioxide reacts with oxygen to form sulfur trioxide.

The reaction profile is shown.



(i) Which type of reaction happens when sulfur dioxide and oxygen react?

Tick (✓) **one** box.

Endothermic	☐
Exothermic	☐
Reduction	☐
Thermal decomposition	☐

Give a reason for your answer.

.....

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

(ii) Sulfur trioxide reacts with water to form sulfuric acid.

- A scientist measures the pH of some dilute sulfuric acid. The pH is 2.
- The scientist makes a solution by adding 990 cm^3 of water to 10 cm^3 of the dilute sulfuric acid.

Calculate the pH of the solution.

pH of solution = ... **[3]**

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).