At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.
For this paper you must have:
• a ruler
• a scientific calculator
• the periodic table (enclosed).

INSTRUCTIONS

• Use black ink or black ball-point pen.

• Answer ALL questions in the spaces provided.

• Do all rough work in this book. Cross through any work you do not want to be marked.

• In all calculations, show clearly how you work out your answer.
INFORMATION

- There are 100 marks available on this paper.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

DO NOT TURN OVER UNTIL TOLD TO DO SO
This question is about mixtures.

Substances are separated from a mixture using different methods.

Draw ONE line from each substance and mixture to the best method of separation. [3 marks]
<table>
<thead>
<tr>
<th>Substance and mixture</th>
<th>Method of separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol from ethanol and water</td>
<td>Chromatography</td>
</tr>
<tr>
<td>Salt from sea water</td>
<td>Crystallisation</td>
</tr>
<tr>
<td>The different colours in black ink</td>
<td>Electrolysis</td>
</tr>
<tr>
<td></td>
<td>Filtration</td>
</tr>
<tr>
<td></td>
<td>Fractional distillation</td>
</tr>
</tbody>
</table>

[Turn over]
01.2 A student filters a mixture.

FIGURE 1 shows the apparatus.

FIGURE 1

Beaker

Mixture

Filter paper cone

Flask

Suggest ONE improvement to the apparatus. [1 mark]
Complete the sentences.

Choose answers from the list below. [2 marks]

- condense
- evaporate
- freeze
- melt
- solidify

In simple distillation, the mixture is heated to make the liquid ____________________.

The vapour is then cooled to make it ____________________.

[Turn over]
FIGURE 2 shows the arrangement of atoms in a pure metal and in a mixture of metals.
Calculate the percentage of metal B atoms in the mixture of metals shown in FIGURE 2. [2 marks]

Percentage of metal B atoms = %
What is a mixture of metals called? [1 mark]

Tick ONE box.

- An alloy
- A compound
- A molecule
- A polymer
Repeat of FIGURE 2

Pure metal

Mixture of metals

Metal A

Metal A

Metal B
Why is the mixture of metals in FIGURE 2 harder than the pure metal? [1 mark]

Tick ONE box.

- The atoms in the mixture are different shapes.
- The layers in the mixture are distorted.
- The layers in the mixture slide more easily.
- The mixture has a giant structure.

[Turn over]
A nanoparticle of pure metal A is a cube.

Each side of the cube has a length of 20 nm.

FIGURE 3 shows the cube.
What is the volume of the nanoparticle? [1 mark]

Tick ONE box.

- [ ] 20 nm$^3$
- [ ] 60 nm$^3$
- [ ] 400 nm$^3$
- [ ] 8000 nm$^3$
The halogens are elements in Group 7.

Bromine is in Group 7.

Give the number of electrons in the outer shell of a bromine atom. [1 mark]
Bromine reacts with hydrogen. The gas hydrogen bromide is produced.

What is the structure of hydrogen bromide? [1 mark]

Tick ONE box.

- Giant covalent
- Ionic lattice
- Metallic structure
- Small molecule

[Turn over]
What is the formula for fluorine gas? [1 mark]

Tick ONE box.

- [ ] F
- [ ] F₂
- [ ] F²
- [ ] 2F
A student mixes solutions of halogens with solutions of their salts.

TABLE 1 shows the student’s observations.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>Potassium chloride (colourless)</th>
<th>Potassium bromide (colourless)</th>
<th>Potassium iodide (colourless)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine (colourless)</td>
<td>Solution turns orange</td>
<td>Solution turns brown</td>
<td></td>
</tr>
<tr>
<td>Bromine (orange)</td>
<td>No change</td>
<td></td>
<td>Solution turns brown</td>
</tr>
<tr>
<td>Iodine (brown)</td>
<td>No change</td>
<td>No change</td>
<td></td>
</tr>
</tbody>
</table>
02.4 Explain how the reactivity of the halogens changes going down Group 7.

Use the results in TABLE 1 on page 20. [3 marks]

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

[Turn over]
A company uses chlorine to produce titanium chloride from titanium dioxide.

What is the relative formula mass ($M_r$) of titanium dioxide, TiO$_2$?

Relative atomic masses ($A_r$):
O = 16  Ti = 48  [1 mark]

Tick ONE box.

- [ ] 64
- [ ] 80
- [ ] 128
- [ ] 768
The company calculates that 500 g of titanium dioxide should produce 1.2 kg of titanium chloride.

However, the company finds that 500 g of titanium dioxide only produces 900 g of titanium chloride.

Calculate the percentage yield. [2 marks]

Percentage yield = _____________%
This question is about the structure of the atom.

Complete the sentences.

Choose answers from the list below.

Each word may be used once, more than once, or not at all.

[5 marks]

- electron
- ion
- neutron
- nucleus
- proton
The centre of the atom is the _____.

The two types of particle in the centre of the atom are the proton and the _____.

James Chadwick proved the existence of the _____.

Niels Bohr suggested particles orbit the centre of the atom. This type of particle is the _____.

The two types of particle with the same mass are the neutron and the _____.

[Turn over]
TABLE 2 shows information about two isotopes of element X.

### TABLE 2

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Mass Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotope 1</td>
<td>63</td>
<td>70</td>
</tr>
<tr>
<td>Isotope 2</td>
<td>65</td>
<td>30</td>
</tr>
</tbody>
</table>
03.2 Calculate the relative atomic mass \( (A_r) \) of element X using the equation:

\[
A_r = \frac{(\text{mass number} \times \text{percentage}) \text{ of isotope 1} + (\text{mass number} \times \text{percentage}) \text{ of isotope 2}}{100}
\]

Use TABLE 2 on page 26.

Give your answer to 1 decimal place. [2 marks]

\[
A_r = \text{[Your answer here, rounded to 1 decimal place]}
\]

[Turn over]
Suggest the identity of element X.

Use the periodic table. [1 mark]

Element X is ____________________
The radius of an atom of element X is \(1.2 \times 10^{-10}\) m.

The radius of the centre of the atom is \(\frac{1}{10\,000}\) the radius of the atom.

Calculate the radius of the centre of an atom of element X.

Give your answer in standard form. [2 marks]

\[
\text{Radius} = \quad \text{m}
\]
A student investigated the electrolysis of sodium chloride solution.

FIGURE 4 shows the apparatus.

FIGURE 4
The student measured the volume of gas collected in each measuring cylinder every minute for 20 minutes.
FIGURE 5 shows the volume of hydrogen gas collected in the measuring cylinder after 8 minutes.

FIGURE 5
What is the volume of hydrogen gas collected? [1 mark]

Volume = cm³
FIGURE 6 shows the results of the investigation.

FIGURE 6

Volume of gas collected in cm³

Hydrogen

Chlorine

Time in minutes
Which of the lines on FIGURE 6, on page 34, show that the volume of gas collected is directly proportional to the time? [1 mark]

Tick ONE box.

- Both lines
- Chlorine line only
- Hydrogen line only
- Neither line

[Turn over]
Repeat of FIGURE 6

Volume of gas collected in cm$^3$

Time in minutes

Hydrogen

Chlorine
Which of the lines on FIGURE 6, on page 36, show a positive correlation between the volume of gas collected and time? [1 mark]

Tick ONE box.

- Both lines
- Chlorine line only
- Hydrogen line only
- Neither line

[Turn over]
A teacher demonstrates the electrolysis of different substances using graphite electrodes.

FIGURE 7 shows the apparatus used.

FIGURE 7
Why can graphite conduct electricity? [1 mark]

Tick ONE box.

- Graphite exists in layers of atoms.
- Graphite has a giant structure.
- Graphite has a high melting point.
- Graphite has delocalised electrons.

[Turn over]
The teacher demonstrates the electrolysis of:

- molten zinc chloride
- potassium bromide solution.

Complete TABLE 3 on page 41 to predict the products.

Choose answers from the list below. [4 marks]

- chlorine
- bromine
- hydrogen
- oxygen
- potassium
- zinc
TABLE 3

<table>
<thead>
<tr>
<th>Substance electrolysed</th>
<th>Product at cathode (negative electrode)</th>
<th>Product at anode (positive electrode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molten zinc chloride</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium bromide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>solution</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A student investigated the mass of copper oxide produced by heating copper carbonate.

This is the method used.

1. Weigh an empty test tube.

2. Weigh 2.00 g of copper carbonate into the test tube.

3. Heat the copper carbonate until there appears to be no further change.

4. Re-weigh the test tube and copper oxide produced.

5. Subtract the mass of the empty tube to find the mass of copper oxide.
6. Repeat steps 1–5 twice.

7. Repeat steps 1–6 with different masses of copper carbonate.

TABLE 4, on page 44, shows the student’s results.

[Turn over]
### TABLE 4

<table>
<thead>
<tr>
<th>Mass of copper carbonate in g</th>
<th>Mass of copper oxide in g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>2.00</td>
<td>1.29</td>
</tr>
<tr>
<td>4.00</td>
<td>2.89</td>
</tr>
<tr>
<td>6.00</td>
<td>3.85</td>
</tr>
<tr>
<td>8.00</td>
<td>5.12</td>
</tr>
<tr>
<td>10.00</td>
<td>6.42</td>
</tr>
</tbody>
</table>

The equation for the reaction is:

$$\text{CuCO}_3(\text{s}) \rightarrow \text{CuO(}\text{s}) + \text{CO}_2(\text{g})$$
Complete the sentence. [1 mark]

The state symbol shows carbon dioxide is a ____________________.

[Turn over]
Repeat of TABLE 4

<table>
<thead>
<tr>
<th>Mass of copper carbonate in g</th>
<th>Mass of copper oxide in g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>2.00</td>
<td>1.29</td>
</tr>
<tr>
<td>4.00</td>
<td>2.89</td>
</tr>
<tr>
<td>6.00</td>
<td>3.85</td>
</tr>
<tr>
<td>8.00</td>
<td>5.12</td>
</tr>
<tr>
<td>10.00</td>
<td>6.42</td>
</tr>
</tbody>
</table>
05.2 Why do the contents of the test tube lose mass in the investigation? [1 mark]

05.3 Calculate the mean mass X in TABLE 4 on page 46. [1 mark]

X = _____________ g

[Turn over]
One of the results in TABLE 4, on page 46, is anomalous.

Which result is anomalous? [1 mark]

Mass of copper carbonate ________________ g

Trial ________________

4.5.4
Suggest how the investigation could be improved to make sure the reaction is complete. [2 marks]

[Turn over]
Another student repeated the investigation using magnesium carbonate instead of copper carbonate.

The word equation for the reaction is:

\[ \text{magnesium carbonate} \rightarrow \text{magnesium oxide} + \text{carbon dioxide} \]

FIGURE 8, on page 51, shows the results of the investigation.
FIGURE 8

Mass of magnesium oxide in g

Mass of magnesium carbonate in g
05.6 Draw a line of best fit on FIGURE 8 on page 51. [1 mark]

05.7 Determine the mass of magnesium oxide produced by 8.4 g of magnesium carbonate.

Use FIGURE 8 on page 51. [1 mark]

Mass = ______________________ g
53

05.8 Calculate the mass of magnesium oxide produced when 168 g of magnesium carbonate is heated.

Use your answer to Question 05.7 [2 marks]

______________________________

______________________________

______________________________

______________________________

Mass of magnesium oxide produced =

______________________________ g

[Turn over]
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm$^3$ of the copper sulfate solution into a polystyrene cup.

2. Record the starting temperature of the copper sulfate solution.

3. Add the metal and stir the solution.

4. Record the highest temperature the mixture reaches.

5. Calculate the temperature increase for the reaction.

6. Repeat steps 1–5 with different metals.
0 6.1 Draw ONE line from each type of variable to the name of the variable in the investigation. [2 marks]

<table>
<thead>
<tr>
<th>Type of variable</th>
<th>Name of variable in the investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td>Concentration of solution</td>
</tr>
<tr>
<td></td>
<td>Particle size of solid</td>
</tr>
<tr>
<td>Independent variable</td>
<td>Temperature change</td>
</tr>
<tr>
<td></td>
<td>Type of metal</td>
</tr>
<tr>
<td></td>
<td>Volume of solution</td>
</tr>
</tbody>
</table>
The student used a polystyrene cup and NOT a glass beaker.

Why did this make the investigation more accurate? [1 mark]

Tick ONE box.

- Glass is breakable
- Glass is transparent
- Polystyrene is a better insulator
- Polystyrene is less dense
TABLE 5 shows the student’s results.

**TABLE 5**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Temperature increase in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>38</td>
</tr>
<tr>
<td>Nickel</td>
<td>8</td>
</tr>
<tr>
<td>Zinc</td>
<td>16</td>
</tr>
</tbody>
</table>

Complete FIGURE 9, on the opposite page.

Use data from TABLE 5 above.

[2 marks]
FIGURE 9

Temperature increase in °C

[Turn over]
The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give ONE reason why this conclusion is NOT correct. [1 mark]

________________________________________

________________________________________

________________________________________

Repeat of TABLE 5

<table>
<thead>
<tr>
<th>Metal</th>
<th>Temperature increase in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>38</td>
</tr>
<tr>
<td>Nickel</td>
<td>8</td>
</tr>
<tr>
<td>Zinc</td>
<td>16</td>
</tr>
</tbody>
</table>
The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use TABLE 5 on page 60. [1 mark]

Most reactive

Least reactive

[Turn over]
Y is an unknown metal.

Describe a method to find the position of Y in the reactivity series in Question 06.5 on page 61 [3 marks]
FIGURE 10 shows the reaction profile for the reaction between zinc and copper sulfate solution.
Which letter represents the products of the reaction?
[1 mark]

Tick ONE box.

A

B

C

D

E

[Turn over]
Repeat of FIGURE 10

Energy

Progress of reaction

A

C

B

D

E
Which letter represents the activation energy? [1 mark]

Tick ONE box.

A

B

C

D

E

[Turn over]
This question is about elements in Group 1.

A teacher burns sodium in oxygen.

Complete the word equation for the reaction. [1 mark]

\[
\text{sodium} + \text{oxygen} \rightarrow \quad
\]
What is the name of this type of reaction? [1 mark]

Tick ONE box.

- Decomposition
- Electrolysis
- Oxidation
- Precipitation

[Turn over]
The teacher dissolves the product of the reaction in water and adds universal indicator.

The universal indicator turns purple.

What is the pH value of the solution? [1 mark]

Tick ONE box.

- 1
- 4
- 7
- 13
The solution contains a substance with the formula NaOH

Give the name of the substance. [1 mark]
All alkalis contain the same ion.

What is the formula of this ion? [1 mark]

Tick ONE box.

- H⁺
- Na⁺
- OH⁻
- O²⁻
A solution of NaOH had a concentration of 40 g/dm$^3$.

What mass of NaOH would there be in 250 cm$^3$ of the solution? [2 marks]

Mass = ______________________ g
The melting points of the elements in Group 1 show a trend.

TABLE 6 shows the atomic numbers and melting points of the Group 1 elements.

TABLE 6

<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic number</th>
<th>Melting point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium</td>
<td>3</td>
<td>181</td>
</tr>
<tr>
<td>Sodium</td>
<td>11</td>
<td>98</td>
</tr>
<tr>
<td>Potassium</td>
<td>19</td>
<td>63</td>
</tr>
<tr>
<td>Rubidium</td>
<td>37</td>
<td>X</td>
</tr>
<tr>
<td>Caesium</td>
<td>55</td>
<td>29</td>
</tr>
</tbody>
</table>

Plot the data from TABLE 6 on FIGURE 11 on page 75. [2 marks]
FIGURE 11
Melting point in °C

[Turn over]
Predict the melting point, $X$, of rubidium, atomic number 37

Use FIGURE 11 on page 75.
[1 mark]

Melting point = _______________ °C

[Turn over]
Soluble salts are formed by reacting metal oxides with acids.

Give ONE other type of substance that can react with an acid to form a soluble salt. [1 mark]

Calcium nitrate contains the ions \( \text{Ca}^{2+} \) and \( \text{NO}_3^- \)

Give the formula of calcium nitrate. [1 mark]
Describe a method to make pure, dry crystals of magnesium sulfate from a metal oxide and a dilute acid. [6 marks]
This question is about metals and metal compounds.

Iron pyrites is an ionic compound.

FIGURE 12 shows a structure for iron pyrites.

FIGURE 12

KEY

- Fe
- S
Determine the formula of iron pyrites.

Use FIGURE 12. [1 mark]

An atom of iron is represented as $^{56}_{26} \text{Fe}$

Give the number of protons, neutrons and electrons in this atom of iron. [3 marks]

Number of protons
Number of neutrons
Number of electrons

[Turn over]
Iron is a transition metal.

Sodium is a Group 1 metal.

Give TWO differences between the properties of iron and sodium. [2 marks]

1 __________________________________________________________

__________________________________________________________

__________________________________________________________

2 __________________________________________________________

__________________________________________________________

__________________________________________________________
Nickel is extracted from nickel oxide by reduction with carbon.

09.4 Explain why carbon can be used to extract nickel from nickel oxide. [2 marks]

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

[Turn over]
An equation for the reaction is:

\[ \text{NiO} + \text{C} \rightarrow \text{Ni} + \text{CO} \]

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses \((A_r)\):
C = 12 \quad \text{Ni} = 59

Relative formula mass \((M_r)\):
NiO = 75

Give your answer to 3 significant figures. \([3 \text{ marks}]\)

\[ \]
Percentage atom economy =

__________________________ %

[Turn over]
Chemical reactions can produce electricity.

FIGURE 13 shows a simple cell.

FIGURE 13

Electrode A

Electrode B

Electrolyte
Which of these combinations would **NOT** give a zero reading on the voltmeter in FIGURE 13? [1 mark]

Tick ONE box.

<table>
<thead>
<tr>
<th>Electrode A</th>
<th>Electrode B</th>
<th>Electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Copper</td>
<td>Sodium chloride solution</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zinc</td>
<td>Water</td>
</tr>
<tr>
<td>Copper</td>
<td>Zinc</td>
<td>Sodium chloride solution</td>
</tr>
<tr>
<td>Copper</td>
<td>Zinc</td>
<td>Water</td>
</tr>
</tbody>
</table>

[Turn over]
Alkaline batteries are non-rechargeable.

10.2 Why do alkaline batteries eventually stop working? [1 mark]

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

10.3 Why can alkaline batteries NOT be recharged? [1 mark]

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Hydrogen fuel cells and rechargeable lithium-ion batteries can be used to power electric cars.

Complete the balanced equation for the overall reaction in a hydrogen fuel cell. [2 marks]

\[ \underline{\text{ }} \text{H}_2 \ + \ \underline{\text{ }} \rightarrow \ \underline{\text{ }} \text{H}_2\text{O} \]

[Turn over]
TABLE 7 shows data about different ways to power electric cars.

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen fuel cell</th>
<th>Rechargeable lithium-ion battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time taken to refuel or recharge in minutes</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Distance travelled before refuelling or recharging in miles</td>
<td>Up to 415</td>
<td>Up to 240</td>
</tr>
<tr>
<td>Distance travelled per unit of energy in km</td>
<td>22</td>
<td>66</td>
</tr>
</tbody>
</table>
Evaluate the use of hydrogen fuel cells compared with rechargeable lithium-ion batteries to power electric cars.

Use TABLE 7 and your own knowledge. [6 marks]

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

[Turn over]
END OF QUESTIONS
There are no questions printed on this page.

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