AQA

Please write clearly in block capitals.

Centre number	
Candidate number	
Surname	
Forename(s)	
Candidate signature	

I declare this is my own work.

GCSE
CHEMISTRY

Higher Tier Paper 1

H

Monday 22 May 2023 Morning Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:
- a ruler
- a scientific calculator
- the periodic table (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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
- The maximum mark for this paper is 100.
- 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.

For Examiner's Use	
Question	Mark
1	
2	
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5	
6	
7	
8	
9	
10	
TOTAL	

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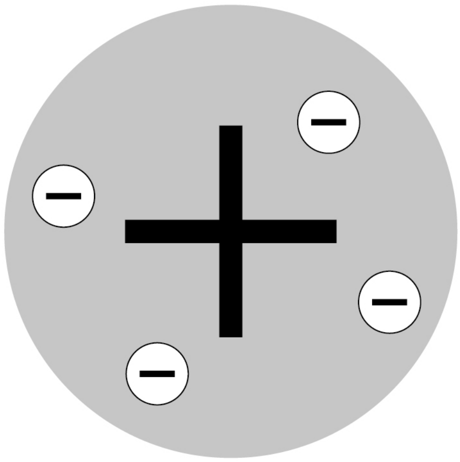
0 1 Discoveries in chemistry led to a better understanding of atomic structure.

0 1 . 1 Atoms were originally thought to be tiny spheres that could not be divided.

The plum pudding model of the atom was then developed.

Figure 1 represents the plum pudding model of the atom.

Figure 1



Describe the plum pudding model of the atom.

[2 marks]

____

____

____

____

0 1 . 2 Atoms contain electrons, neutrons and protons.

Write these three particles in order of their discovery.

[1 mark]

Earliest ____________________

____

Latest ____________________

Very few atoms of the element tennessine (Ts) have ever been identified.

The atomic number of tennessine is 117

0 1 . 3 Predict the number of outer shell electrons in an atom of tennessine.

Give **one** reason for your answer.

Use the periodic table.

[2 marks]

Number of outer shell electrons ________

Reason ____

____

0 1 . 4 Tennessine was first identified by a small group of scientists in 2010.

Suggest **one** reason why tennessine was **not** accepted as a new element by other scientists until 2015.

[1 mark]

____

____

Question 1 continues on the next page

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0 1 . 5 The discovery of isotopes explained why some relative atomic masses are not whole numbers.

Element **R** has two isotopes.

Table 1 shows the mass numbers and percentage abundances of the isotopes of element **R**.

Table 1

Mass number	Percentage abundance (%)
6	7.6
7	92.4

Calculate the relative atomic mass (A_r) of element **R**.

Give your answer to 1 decimal place.

[3 marks]

Relative atomic mass (1 decimal place) = ______________________

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 2 This question is about temperature changes.

A student investigated the change in temperature of a solution when different masses of ammonium nitrate were dissolved in water.

This is the method used.

1. Measure 200 cm^3 of water into a polystyrene cup.
2. Measure the temperature of the water.
3. Add 4.0 g of ammonium nitrate to the water.
4. Stir the solution until all the ammonium nitrate has dissolved.
5. Measure the lowest temperature reached by the solution.
6. Repeat steps 1 to 5 with different masses of ammonium nitrate.

0 2 . 1 Give the independent variable and the dependent variable in the investigation.

[2 marks]

Independent variable ______________________________

Dependent variable ______________________________

Table 2 shows the results.

Table 2

Mass of ammonium nitrate added in grams	Lowest temperature of solution in ºC
4.0	18.2
8.0	16.2
12.0	15.2
16.0	13.6
20.0	12.4
24.0	10.6

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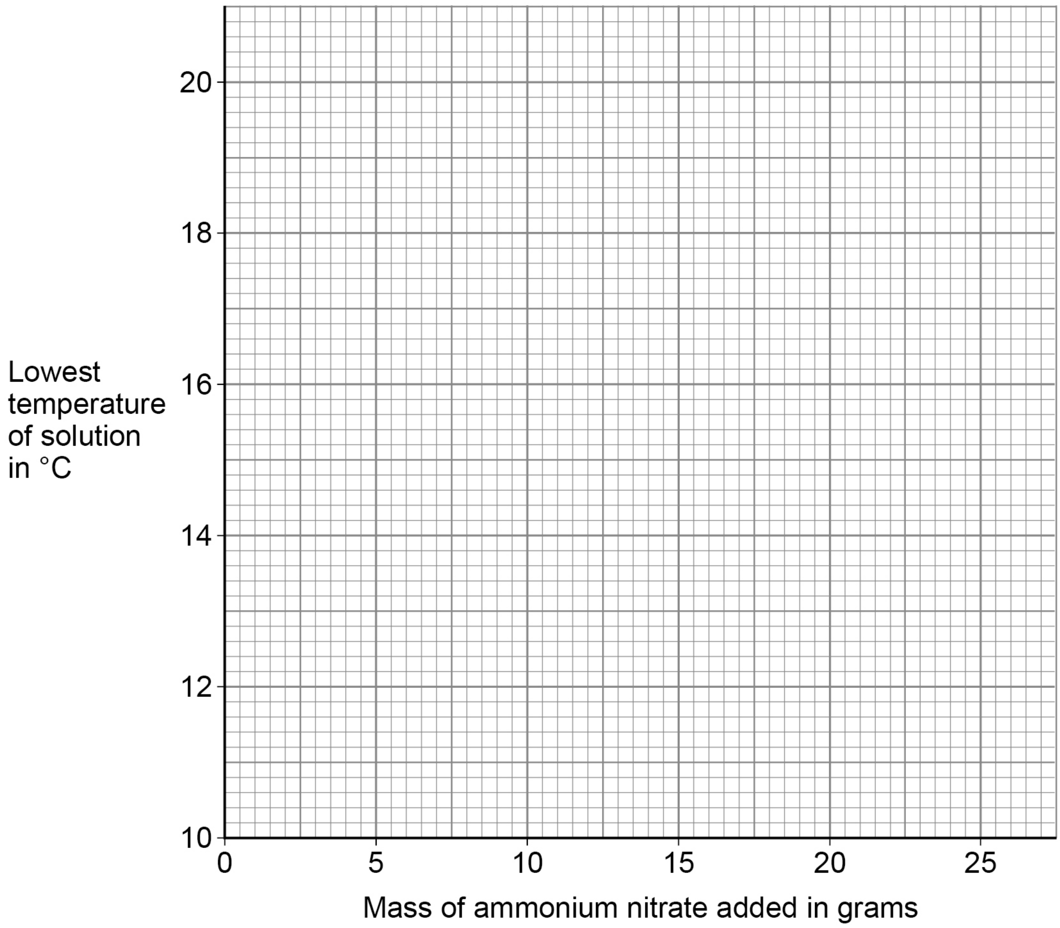
0 2 . 2 Plot the data from **Table 2** on **Figure 2**.

Draw a line of best fit.

[3 marks]

Figure 2



0 2 . 3 Determine the initial temperature of the water.

You should extend your line of best fit on **Figure 2**.

[2 marks]

Initial temperature of the water = ______________ °C

0 2 . 4 How do the results show that dissolving ammonium nitrate in water is endothermic?

[1 mark]

____

____

Turn over ►

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The student repeated the experiment three more times.

Table 3 shows the results for 8.0 g of ammonium nitrate.

Table 3

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Mean**
Lowest temperature of solution in ºC	16.2	16.6	16.8	16.4	16.5

0 2 . 5 The student recorded the mean lowest temperature of the solution for 8.0 g of ammonium nitrate as 16.5 ± 0.3 ºC.

Explain why the student included ± 0.3 ºC after the mean lowest temperature.

[2 marks]

0 2 . 6 What type of error is shown by the results in **Table 3**?

[1 mark]

Tick (✓) **one** box.

Random error ☐

Systematic error ☐

Zero error ☐

11

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0 3 This question is about making a soluble salt.

0 3 . 1 Plan a method to make pure, dry crystals of zinc chloride from zinc carbonate and a dilute acid.

[6 marks]

0 3 . 2 Name **two** other substances that can each be reacted with a dilute acid to make zinc chloride.

Do **not** refer to zinc carbonate in your answer.

[2 marks]

1 ______

2 ______

8

Do not write outside the box

0 4 This question is about hydrogen and compounds of hydrogen.

Figure 3 shows the displayed formulae for the reaction between hydrogen and chlorine.

Figure 3

$$H - H \quad + \quad Cl - Cl \longrightarrow 2\, H - Cl$$

Table 4 shows the bond energies.

Table 4

Bond	H — H	Cl — Cl	H — Cl
Bond energy in kJ/mol	436	346	432

0 4 . 1 Which expression shows how to calculate the overall energy change for the reaction in **Figure 3**?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

436 + 346 + 432 kJ/mol ☐

436 + 346 + (2 × 432) kJ/mol ☐

436 + 346 − 432 kJ/mol ☐

436 + 346 − (2 × 432) kJ/mol ☐

Do not write outside the box

The reaction between hydrogen and chlorine is exothermic.

0 4 . 2 Explain why this reaction releases energy to the surroundings.

[2 marks]

0 4 . 3 **Figure 4** shows part of a reaction profile for the reaction between hydrogen and chlorine.

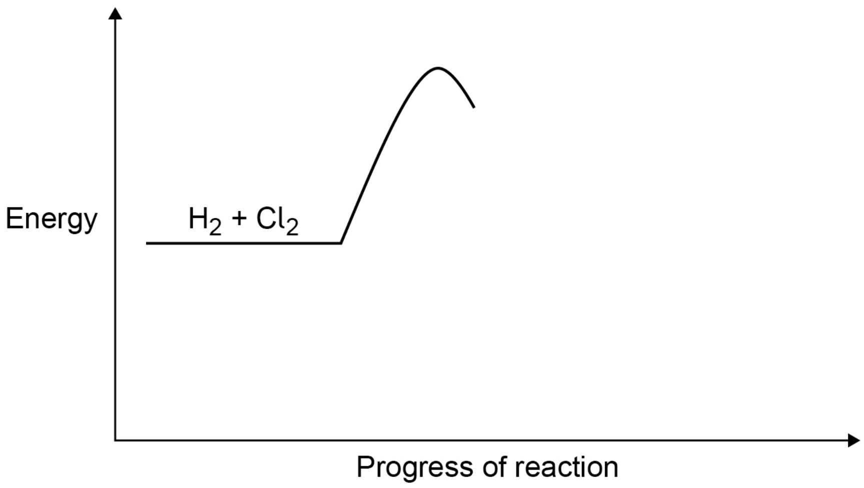
Complete the reaction profile in **Figure 4**.

You should:

- label the activation energy
- label the overall energy change.

[3 marks]

Figure 4



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0 4 . 4 Draw a dot and cross diagram for a molecule of hydrogen chloride (HCl).

Show the outer shell electrons only.

[2 marks]

0 4 . 5 **Figure 5** represents molecules of methane and of poly(ethene).

Figure 5

Methane Poly(ethene)

Methane is a gas at room temperature but poly(ethene) is a solid at room temperature.

Explain why methane and poly(ethene) exist in different states at room temperature.

[4 marks]

____

____

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____

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____

____

12

Turn over for the next question

0 5 This question is about acids and alkalis.

0 5 . 1 Ethanoic acid is a weak acid.

What is meant by 'weak acid'?

Answer in terms of ionisation.

[1 mark]

____

____

0 5 . 2 The concentration of an acid can be measured in mol/dm^3.

Which combination of changes **increases** the concentration of an acid?

[1 mark]

Tick (✓) **one** box.

The mass of acid dissolved is halved and the volume of the solution is halved. ☐

The mass of acid dissolved is halved and the volume of the solution is doubled. ☐

The mass of acid dissolved is doubled and the volume of the solution is halved. ☐

The mass of acid dissolved is doubled and the volume of the solution is doubled. ☐

0 5 . 3 The concentration of an acid can be determined by titration.

An indicator is added to an alkali in a flask.

Name an indicator that can be used in this titration.

Give the colour change of the indicator when acid from a burette is added to the alkali in the flask.

[2 marks]

Name of indicator ______________________________

Colour change from ____________________ to ____________________

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0 5 . 4 Sodium carbonate dissolves in water to produce an alkaline solution.

Give the formula of the ion that makes a solution alkaline.

[1 mark]

____

0 5 . 5 A student does a titration using sodium carbonate solution and nitric acid.

The equation for the reaction is:

$$Na_2CO_3 + 2\,HNO_3 \rightarrow 2\,NaNO_3 + CO_2 + H_2O$$

25.0 cm^3 of 0.124 mol/dm^3 sodium carbonate solution is neutralised by 23.6 cm^3 of nitric acid.

Calculate the concentration of the nitric acid.

Give your answer to 3 significant figures.

You should calculate:

- the number of moles of sodium carbonate in 25.0 cm^3 of the solution
- the number of moles of nitric acid in 23.6 cm^3 of the nitric acid
- the concentration of the nitric acid in mol/dm^3.

[5 marks]

Concentration (3 significant figures) = ______________ mol/dm^3

Turn over ►

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When hydrochloric acid dissolves in water, hydrogen ions (H^+) and chloride ions (Cl^-) are produced.

0 5 . 6 A solution of hydrochloric acid with pH 4.5 has a concentration of H^+ ions of 3.16×10^{-5} mol/dm^3.

What is the concentration of H^+ ions in a solution of hydrochloric acid with pH 2.5?

[1 mark]

____

____

Concentration of H^+ ions = ________________ mol/dm^3

0 5 . 7 Which element has atoms that have the same electronic structure as the chloride ion?

Use the periodic table.

[1 mark]

____

12

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

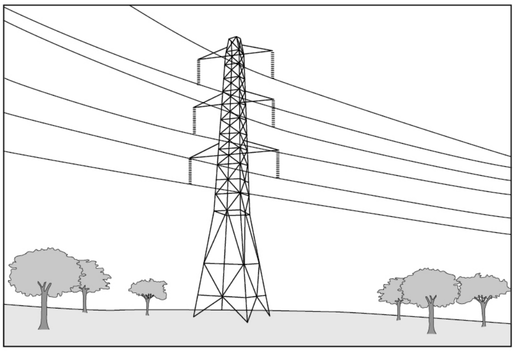
0 6 This question is about uses of metals in electrical wires.

Electrical wires can be made from:

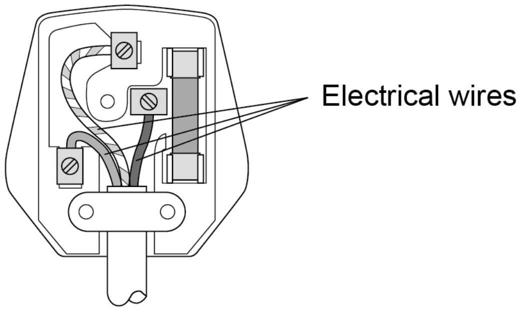
- aluminium
- copper
- silver.

Figure 6 shows three uses of electrical wires.

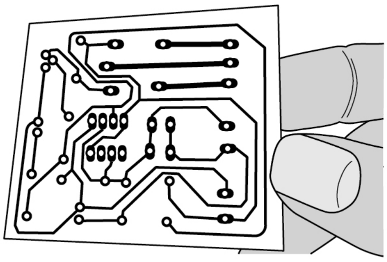
Figure 6



Overhead power cables



Wiring in homes



Printed circuit boards

Table 5 shows information about the metals.

The higher the value for electrical conductivity, the better the metal is at conducting electricity.

Table 5

	Aluminium	**Copper**	**Silver**
Electrical conductivity in arbitrary units	37.7	59.6	63.0
Density in g/cm^3	2.7	9.0	10.5
Cost of metal per kg in £	1.50	7.00	640.00

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0 6 . 1 Evaluate the use of aluminium, copper and silver for the types of electrical wires shown in **Figure 6**.

Use **Table 5**.

[4 marks]

0 6 . 2 Describe how metals conduct electricity.

[3 marks]

Question 6 continues on the next page

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0 6 . 3 Electrical wires are usually made of pure metals and **not** alloys. This is because pure metals are better electrical conductors.

Suggest why alloys do **not** conduct electricity as well as pure metals.

Answer in terms of structure and bonding.

[2 marks]

9

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0 7 This question is about electrolysis.

Aluminium is manufactured by electrolysing a molten mixture of aluminium oxide (Al_2O_3) and cryolite (Na_3AlF_6).

0 7 . 1 Complete the half equation for the reaction occurring at the negative electrode.

[1 mark]

$$Al^{3+} + \_\_\_\_ e^- \rightarrow Al$$

0 7 . 2 Cryolite contains Na^+ ions as well as Al^{3+} ions.

Suggest **one** reason why sodium is **not** a product of the electrolysis.

[1 mark]

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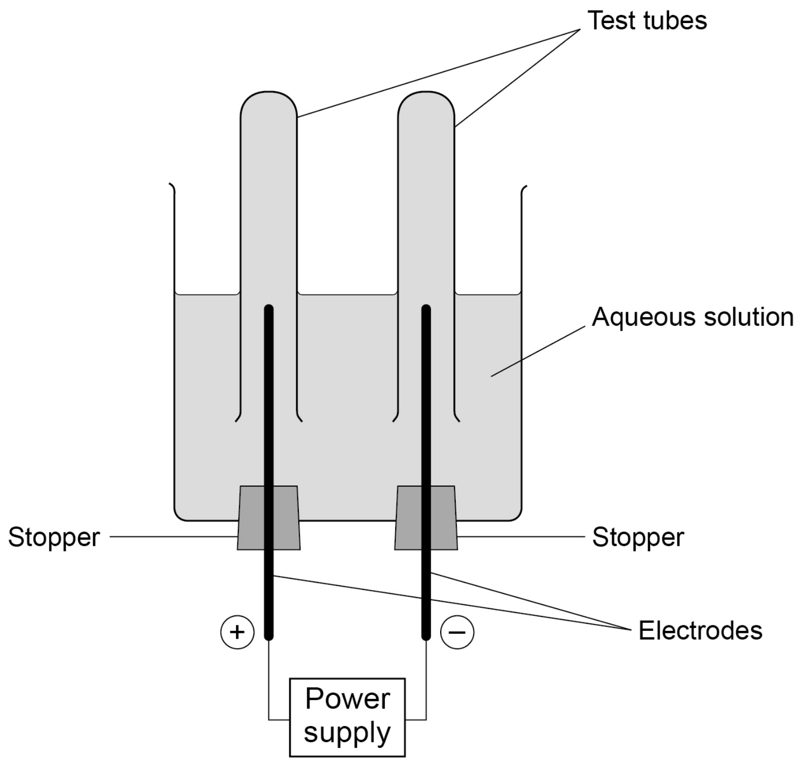
____

Question 7 continues on the next page

A student investigated the electrolysis of an aqueous solution of a different compound.

Figure 7 shows the apparatus.

Figure 7



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Hydrogen was produced at the negative electrode and oxygen was produced at the positive electrode.

0 7 . 3 Explain how oxygen was produced from water during the electrolysis of this aqueous solution.

[4 marks]

0 7 . 4 The student compared the volumes of the two gases collected.

How can the student change the apparatus in **Figure 7** to compare the volumes of the two gases produced more accurately?

Give **one** reason for your answer.

[2 marks]

Change

Reason

0 7 . 5 The overall equation for the reaction is:

$$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g)$$

What is the volume of oxygen produced when 20 cm^3 of hydrogen has been produced?

[1 mark]

Tick (✓) **one** box.

10 cm^3 ☐ 20 cm^3 ☐ 30 cm^3 ☐ 40 cm^3 ☐

9

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0 8 This question is about elements in the periodic table.

0 8 . 1 Argon has the atomic number 18

Explain why argon does **not** form compounds.

Answer in terms of electrons.

[2 marks]

____

____

____

____

0 8 . 2 Phosphorus (P) is the element below nitrogen in the periodic table.

Predict the formula of the compound formed between phosphorus and hydrogen.

[1 mark]

Formula = ____________________

0 8 . 3 Tellurium is the element with atomic number 52

Predict whether tellurium reacts with metals.

Explain your answer.

Answer in terms of the position of tellurium in the periodic table.

[2 marks]

____

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Barium (Ba) is an element in Group 2 of the periodic table.

Barium reacts with hydrochloric acid.

0 8 . 4 Suggest **two** observations that could be made when barium reacts with hydrochloric acid.

[2 marks]

1 ____

____

2 ____

____

0 8 . 5 Write a balanced symbol equation for the reaction between barium and hydrochloric acid.

[3 marks]

__________ + __________ → __________ + __________

10

Turn over for the next question

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0 9 This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

0 9 . 1 Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

[2 marks]

Substance reduced ____________________________

Reason ____

____

0 9 . 2 Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide?

Relative atomic mass (A_r): C = 12

[1 mark]

Tick (✓) **one** box.

$\frac{1}{3} \times 12$ g ☐

$\frac{3}{2} \times 12$ g ☐

1×12 g ☐

3×12 g ☐

Question 9 continues on the next page

A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

A, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

Table 6 shows information about three of the reaction mixtures.

Table 6

Reaction	Metal	Metal nitrate solution	Equation
1	**A**	$\mathbf{B}NO_3$	$\mathbf{A} + 2\mathbf{B}NO_3 \rightarrow 2\mathbf{B} + \mathbf{A}(NO_3)_2$
2	**C**	$\mathbf{A}(NO_3)_2$	$2\mathbf{C} + 3\mathbf{A}(NO_3)_2 \rightarrow 3\mathbf{A} + 2\mathbf{C}(NO_3)_3$
3	**C**	$\mathbf{D}(NO_3)_2$	no reaction

0 9 . 3 The ionic equation for **Reaction 1** is:

$$\mathbf{A} + 2\mathbf{B}^{+} \rightarrow 2\mathbf{B} + \mathbf{A}^{2+}$$

Why is this a redox reaction?

[1 mark]

Tick (✓) **one** box.

A gains electrons and $\mathbf{B}^{+}$ loses electrons. ☐

A loses electrons and $\mathbf{B}^{+}$ gains electrons. ☐

Both **A** and $\mathbf{B}^{+}$ gain electrons. ☐

Both **A** and $\mathbf{B}^{+}$ lose electrons. ☐

Do not write outside the box

0 9 . 4 Which of the four metals has the greatest tendency to form positive ions?

Use **Table 6**.

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 9 . 5 The nitrate ion has the formula NO_3^-

Which of the four metals could be aluminium?

Explain your answer.

Use **Table 6**.

[3 marks]

Metal _____

Explanation ____

____

____

____

Question 9 continues on the next page

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0 9 . 6 Metal **X** is extracted from an oxide of metal **X** by reaction with hydrogen.

The equation for the reaction is:

$$\mathbf{X}O_3 + 3H_2 \rightarrow \mathbf{X} + 3H_2O$$

The percentage atom economy for obtaining metal **X** by this method is 77.3%.

Calculate the relative atomic mass (A_r) of metal **X**.

Relative atomic masses (A_r): H = 1 O = 16

[4 marks]

Relative atomic mass (A_r) = ________________

12

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1 0 This question is about titanium dioxide (TiO_2).

1 0 . 1 Self-cleaning windows are coated with a layer of nanoparticles of titanium dioxide.

Titanium dioxide:

- helps sunlight break down dirt particles
- attracts water, so dirt is washed away by rain.

Nanoparticles of titanium dioxide are used instead of fine particles of titanium dioxide for coating self-cleaning windows.

Suggest **two** reasons why.

[2 marks]

1 ____

____

2 ____

____

Question 10 continues on the next page

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1 0 . 2 Titanium is extracted from titanium dioxide in a two-stage process.

The equation for the first stage in the process is:

$$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$$

Calculate the volume of chlorine gas needed to react completely with 100 kg of titanium dioxide.

Relative atomic masses (A_r): O = 16 Ti = 48

The volume of one mole of gas = 24 dm^3

[6 marks]

Volume = ______________ dm^3

8

END OF QUESTIONS

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