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

H

Higher Tier Paper 1

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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6	
7	
8	
9	
10	
TOTAL	

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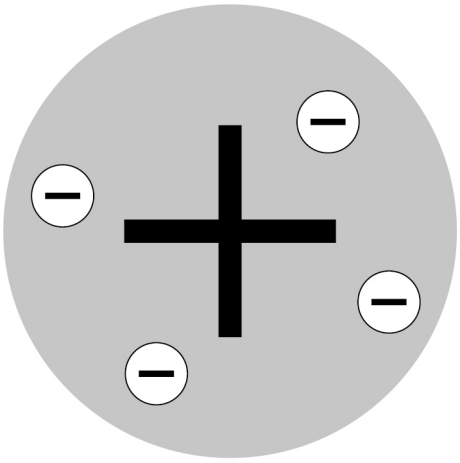
0 1 Discoveries in chemistry led to a better understanding of atomic structure.

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]

Represents the atom as a sphere of positive charge with negatively charged electrons embedded.

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

Write these three particles in order of their discovery.

[1 mark]

Earliest electrons

protons

Latest neutrons

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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 7

Reason Tennessine is in group 7 in the periodic table.

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]

Time was required for peer review.

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]

$A_r = \dfrac{(6 \times 7.6) + (7 \times 92.4)}{100}$

$= 6.924$

$= 6.9$ (1 d.p.)

Relative atomic mass (1 decimal place) = 6.9

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 Mass of ammonium nitrate

Dependent variable lowest temperature reached by solution

Table 2 shows the results.

Table 2

Mass of ammonium nitrate added in grams	Lowest temperature of solution in °C
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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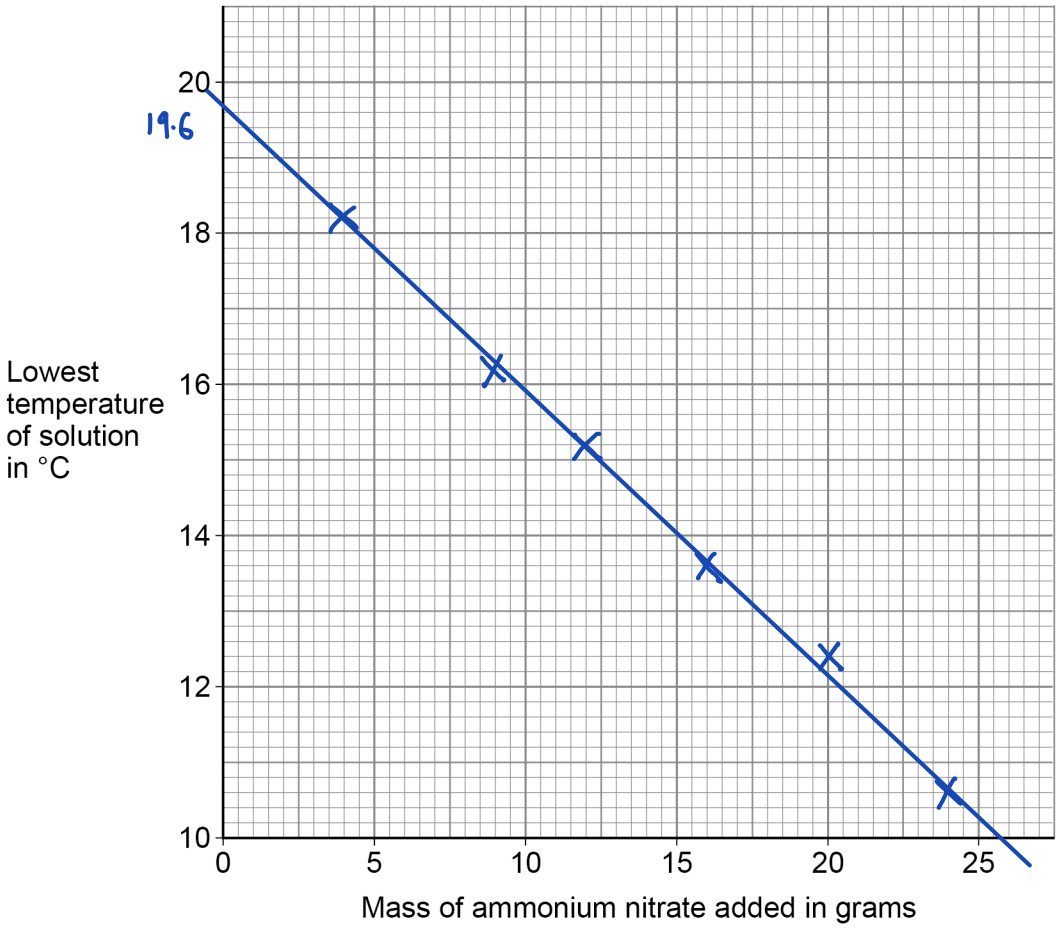
0 2 . 2 Plot the data from **Table 2** on **Figure 2**.

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 = 19.6 °C

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

[1 mark]

Reaction is endothermic since temperature decreased.

Turn over ►

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 °C	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 °C.

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

[2 marks]

Because 0·3°C is the uncertainty. The range about the mean value

16·8 = 16·5 + 0·3

16·2 = 16·5 − 0·3

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]

Use zinc carbonate and hydrochloric acid

Add zinc carbonate to the hydrochloric acid in a beaker and stir.

continue adding until the zinc carbonate is in excess shown by excess (undissolved) solid and no further effervescence

Filter the reaction mixture to remove the excess zinc carbonate

Heat the solution using a water bath or electric heater to crystallisation point.

Leave the solution to crystallise

pat crystals dry with filter paper.

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 Zinc

2 Zinc oxide

8

Turn over ►

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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

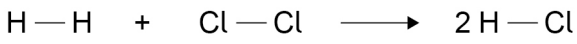


Table 4 shows the bond energies.

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 ☑

ΔH = Reactants − Products
= (H−H) + (Cl−Cl) − 2H−Cl
= (436 + 346) − (2 × 432)

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]

Energy is needed to break the bonds of the reactants and energy is released when product bonds form. In this exothermic reaction, the energy released is greater than the energy needed.

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

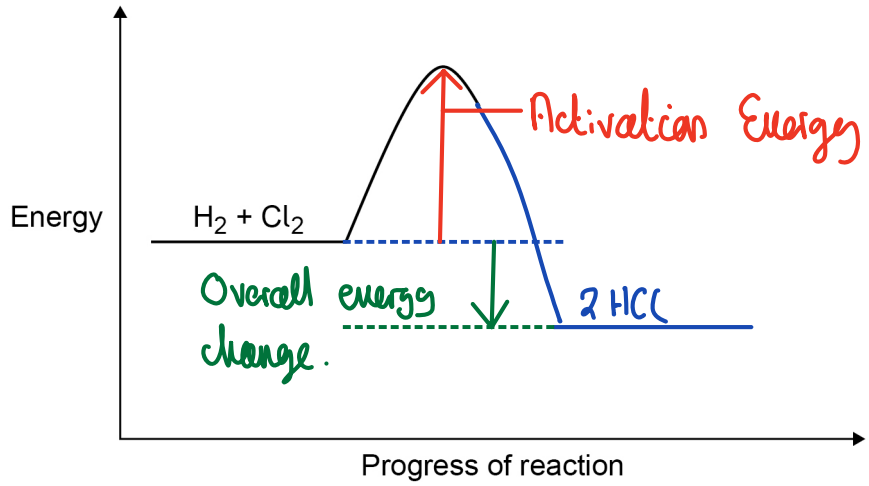
Complete the reaction profile in **Figure 4**.

You should:

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

[3 marks]

Figure 4



Question 4 continues on the next page

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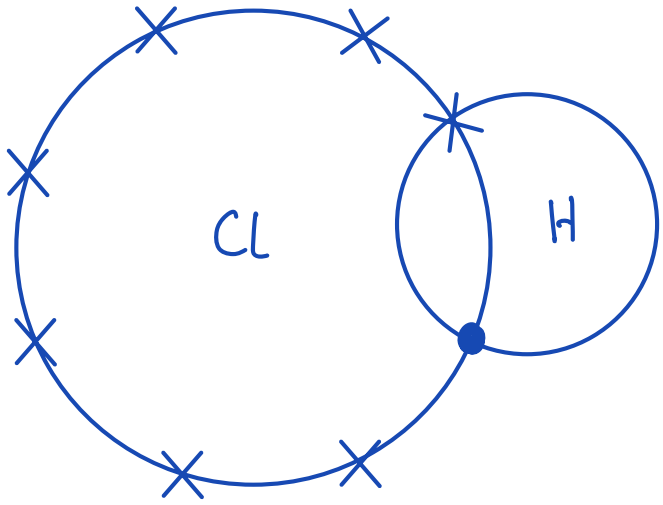
0 4 . 4 Draw a dot and cross diagram for a molecule of hydrogen chloride (HCl).

Show the outer shell electrons only. H Group 1
Cl " 7

[2 marks]



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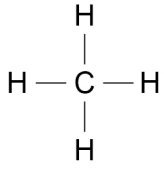
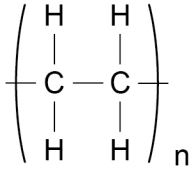
0 4 . 5 **Figure 5** represents molecules of methane and of poly(ethene).

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]

Methane has much smaller molecules than poly(ethene). so has weaker intermolecular forces.
Less energy is needed to overcome these weaker intermolecular forces.
So the boiling point is lower and methane is a gas at room temperature whereas poly(ethene) is a solid.

12

Turn over for the next question

Do not write outside the box

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]

The weak acid is only partially ionised in aqueous solution.

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 Methyl orange

Colour change from yellow to red/orange

Do not write outside the box

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]

OH^-

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]

N° moles Na_2CO_3 (in 25 cm^3) $= \frac{25.0}{1000} \times 0.124\ mol/dm^3$

$= 3.1 \times 10^{-3}$ mol

1 mol Na_2CO_3 reacts with 2 mol HNO_3

N° moles HNO_3 in 23.6 cm^3 $= 2 \times 3.1 \times 10^{-3} = 6.2 \times 10^{-3}$ mol

Concentration of $HNO_3 = \frac{6.2 \times 10^{-3}\ mol}{(23.6 \div 1000)\ dm^3} = 0.2627\ mol/dm^3$

Concentration (3 significant figures) = 0.263 mol/dm^3

Turn over ►

Do not write outside the box

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]

pH decreases by $4.5 - 2.5 = 2$

Factor that H^+ ion conc^n changed by $= 10^{-2}$

$\frac{3.16 \times 10^{-5}}{1 \times 10^{-2}} = 3.16 \times 10^{-5-(-2)}$

Concentration of H^+ ions = 3.16×10^{-3} 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]

Ar

Cl = Group 7, $7e^-$

Cl^- = extra e^- = $7 + 1 = 8$

Element in group 8 with same electronic structure

7 8

Cl Ar

12

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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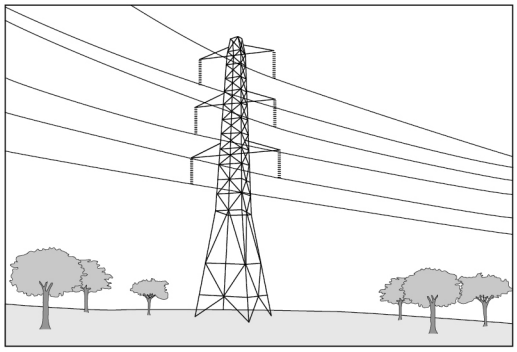
0 6 This question is about uses of metals in electrical wires.

Electrical wires can be made from:

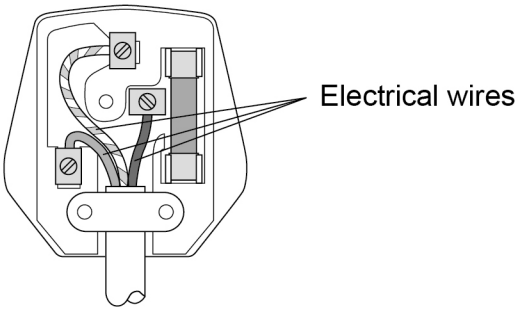
- aluminium
- copper
- silver.

Figure 6 shows three uses of electrical wires.

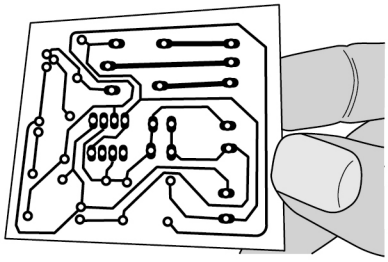
Figure 6



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]

Silver is the best electrical conductor
Aluminium is the least dense and least expensive
Copper is a better conductor than aluminium.
Copper is almost as good a conductor as silver
Copper is much less expensive than silver.

Overhead power cables need a low density metal - Aluminium
Wiring in homes needs to be affordable - Copper is a good conductor and not too expensive.
Printed circuit boards only require small amounts of material, so silver would be appropriate.

0 6 . 2 Describe how metals conduct electricity.

[3 marks]

Metals have delocalised electrons.
The electrons carry electrical charge
The electrons move through the metal structure and conduct electricity.

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]

In alloys, different sized atoms distort the layers and structure, so the movement of electrons is restricted.

9

Do not write outside the box

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]

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

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]

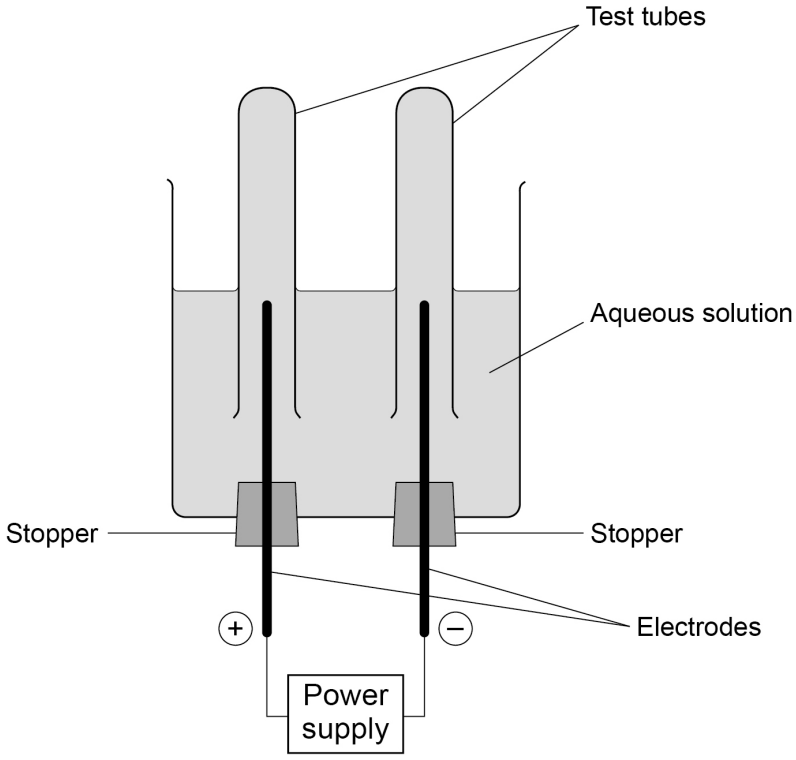
Sodium is more reactive than aluminium

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]

Water molecules break down to produce H^+ and OH^- ions.
OH^- ions are attracted to the positive electrode where OH^- ions are discharged (oxidised) to give oxygen molecules.

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 Use measuring cylinders instead of test tubes

Reason Because there is a scale on the measuring cylinders

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

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

2 mol H_2 : 1 mol O_2
20 cm^3 : 10 cm^3

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

Do not write outside the box

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]

Argon is in group 8 and has a full outer shell of electrons. Atoms of argon have a stable arrangement of electrons, so do not share or transfer electrons.

N in group 5 needs 3 more e^- for full outer shell
each H shares 1 e^-
∴ need 3 H

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 = PH_3

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]

Tellurium is in Group 6 so will gain electrons from a metal and so react. Tellurium is towards the right of the periodic table, so is a non-metal.

Do not write outside the box

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 Effervescence, bubbles

2 Forms a colourless solution

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

[3 marks]

$Ba + 2HCl \rightarrow BaCl_2 + H_2$

10

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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 Fe_2O_3

Reason because Fe_2O_3 loses oxygen

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

$3C \rightarrow 2Fe$

$\frac{3}{2}C \rightarrow Fe$

Mass C = $\frac{3}{2} \times 12$

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

Do not write outside the box

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**	**B**NO_3	**A** + 2 **B**NO_3 → 2 **B** + **A**$(NO_3)_2$
2	**C**	**A**$(NO_3)_2$	2 **C** + 3 **A**$(NO_3)_2$ → 3 **A** + 2 **C**$(NO_3)_3$
3	**C**	**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? (most reactive)

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? Al^{3+} $Al(NO_3)_3$

Explain your answer.

Use **Table 6**.

[3 marks]

Metal C

Explanation Aluminium forms ions with charge 3+ So 3 NO_3^- ions are required for 1 Al^{3+} ion $Al(NO_3)_3$

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]

atom economy = $\frac{\text{Mass of desired product}}{\text{Mass of all products}} \times 100\%$

$77.3 = \frac{A_r X}{A_r X + 54} \times 100$

$100\ A_r X = 77.3(A_r X + 54)$

$100\ A_r X = 77.3\ A_r X + 4174.2$

$100\ A_r X - 77.3\ A_r X = 4174.2$

$22.7\ A_r X = 4174.2$

Relative atomic mass (A_r) = 184

$A_r X = \frac{4174.2}{22.7}$

$= 183.89$

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 Nanoparticles have a higher surface area to volume ratio

2 Less material needed for the same effect.

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:

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

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]

$M_r\ TiO_2 = 48 + (2 \times 16) = 80\ g/mol$

Mass of TiO_2 = 100 kg

$= 100 \times 1000 = 100\,000\ g$

N° moles $TiO_2 = \frac{100\,000\ g}{80\ g/mol}$

$= 1250\ mol$

1 mol TiO_2 needs 2 mol Cl_2

N° moles $Cl_2 = 1250 \times 2 = 2500\ mol$

Volume of $Cl_2 = 2500\ mol \times 24\ dm^3$

$= 60\,000\ dm^3$

8

Volume = _____ dm^3

END OF QUESTIONS

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