GCSE
CHEMISTRY

H

Higher Tier   Paper 1

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.

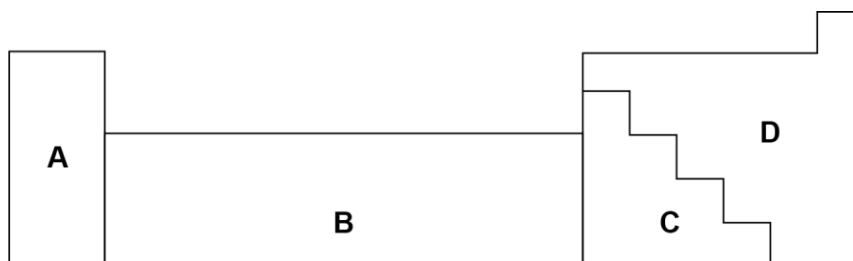| For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	

0 1 This question is about metals and non-metals.

Figure 1 shows an outline of part of the periodic table.

Figure 1

0 1 . 1 Element **Q** is a dull solid with a melting point of 44 °C.

Element **Q** does not conduct electricity.

Which section of the periodic table in **Figure 1** is most likely to contain element **Q**?

[1 mark]

Tick (✓) **one** box.

A ✓ B ☐ C ☐ D ☐

0 1 . 2 Element **R** forms ions of formula R^{2+} and R^{3+}

Which section of the periodic table in **Figure 1** is most likely to contain element **R**?

[1 mark]

Tick (✓) **one** box.

A ☐ B ✓ C ☐ D ☐

0 1 . 3 Give **two** differences between the physical properties of the elements in Group 1 and those of the transition elements.

[2 marks]

1 _____ have lower densities _____
      are less strong
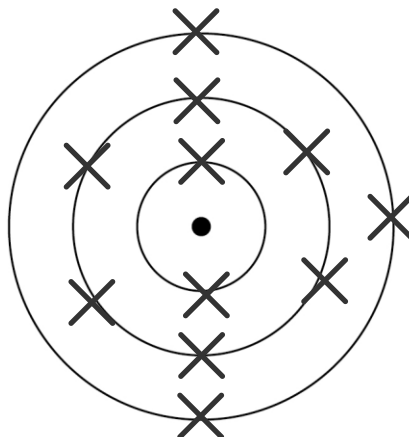
2 _____

0 1 . 4 Complete **Figure 2** to show the electronic structure of an aluminium atom.

Use the periodic table.

[1 mark]

Figure 2

0 1 . 5 Aluminium is a metal.

Describe how metals conduct electricity.

Answer in terms of electrons.

[3 marks]

delocalised electrons

(the electrons) carry (electrical) charge

(the electrons move) through the metal / aluminium / structure

0 1 . 6 Name the type of bonding in compounds formed between metals and non-metals.

[1 mark]

Ionic

Turn over ▶

0 1 . 7 Magnesium oxide is a compound formed from the metal magnesium and the non-metal oxygen.

Describe what happens when a magnesium atom reacts with an oxygen atom.

You should refer to electrons in your answer.

[4 marks]

magnesium (atom) loses electrons

oxygen (atom) gains electrons

two electrons (are transferred)

magnesium ions **and** oxide ions

are formed

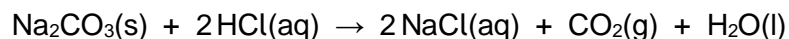**13**

0 2 Sodium carbonate reacts with hydrochloric acid in an exothermic reaction.

The equation for the reaction is:

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

A student investigated the effect of changing the mass of sodium carbonate powder on the highest temperature reached by the reaction mixture.

0 2 . **1** Plan a method to investigate the effect of changing the mass of sodium carbonate powder on the highest temperature reached.

[6 marks]

Level 3: The method would lead to the production of a valid ~~outcome. The key steps are identified and logically sequenced.~~

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.
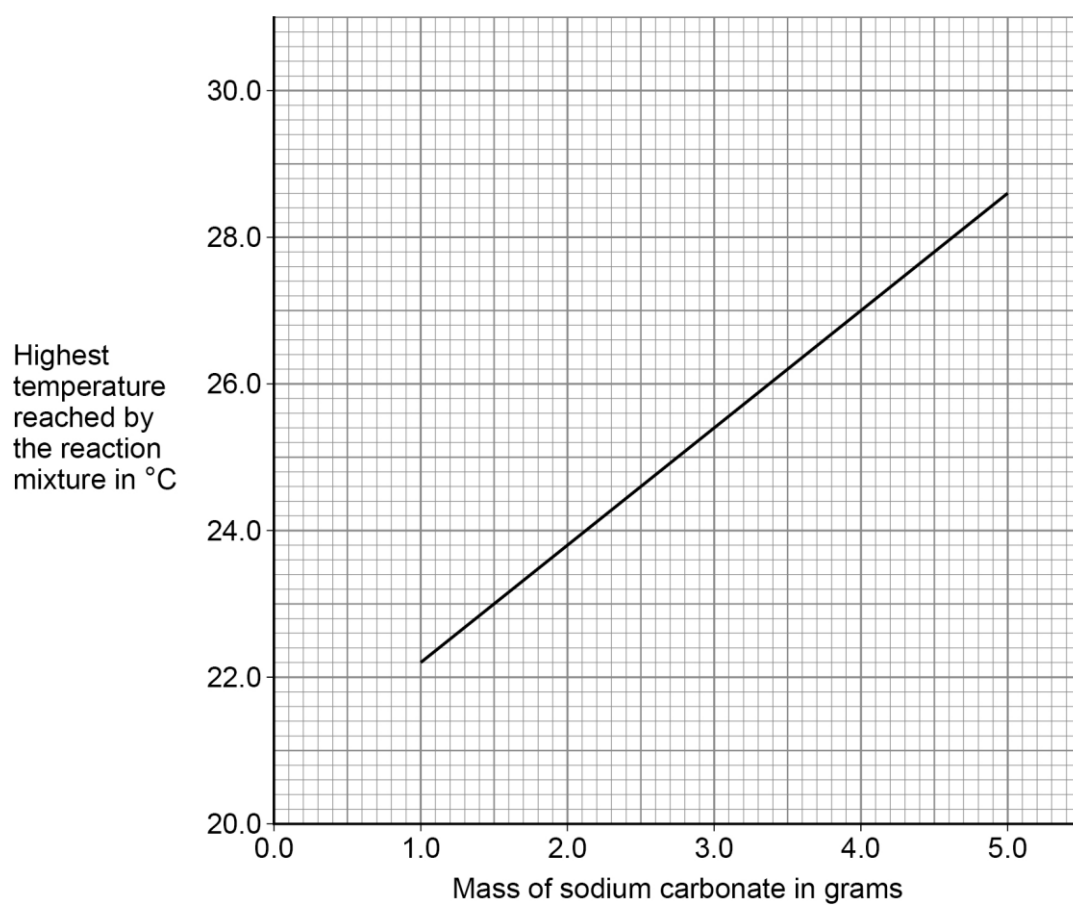
Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

Turn over ▶

Figure 3 shows a line of best fit drawn through the student's results.

Figure 3

Highest temperature reached by the reaction mixture in °C

Mass of sodium carbonate in grams

0 2 . 2 Determine the gradient of the line of best fit in **Figure 3**.

Use the equation:

$$\text{Gradient} = \frac{\text{Change in highest temperature}}{\text{Change in mass}}$$

Give the unit.

[5 marks]

change in highest temperature corresponding
change in mass (gradient =) change in highest temperature
change in mass
(gradient =) 1.6 °C/g

Gradient = _____   Unit _____

0 2 . 3 The initial temperature of the reaction mixture is where the line of best fit would meet the *y*-axis.

Determine the initial temperature of the reaction mixture.

Show your working on **Figure 3**.

[2 marks]

Initial temperature of the reaction mixture = __20.6__   °C

extrapolates line to the *y*-axis
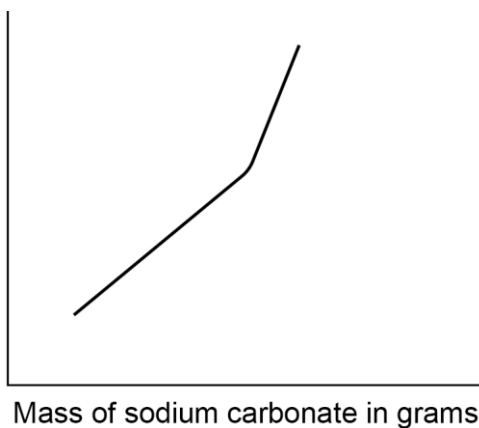20.6 (°C)

Turn over ▶

0 2 . 4 Another student repeated the investigation but added sodium carbonate until the sodium carbonate was in excess.

Which sketch graph shows the results obtained when sodium carbonate was added until in excess?
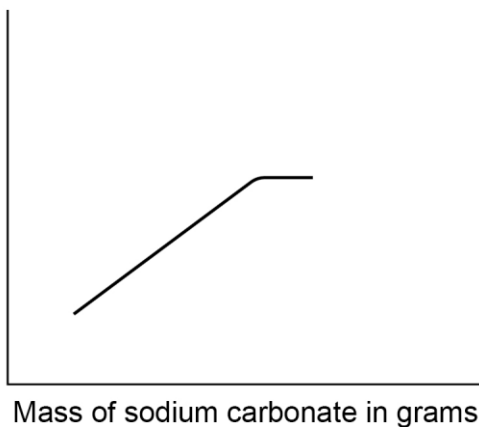
[1 mark]

Tick (✓) **one** box.

A   Highest temperature reached by the reaction mixture in °C

Mass of sodium carbonate in grams

✓

B   Highest temperature reached by the reaction mixture in °C

Mass of sodium carbonate in grams

C   Highest temperature reached by the reaction mixture in °C

Mass of sodium carbonate in grams
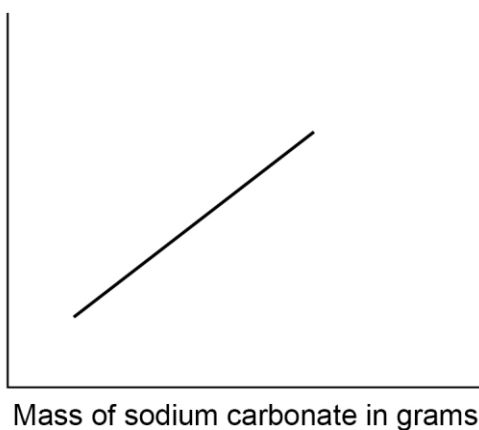
Figure 4 shows a reaction profile for the reaction of sodium carbonate with hydrochloric acid.

Figure 4

Progress of reaction
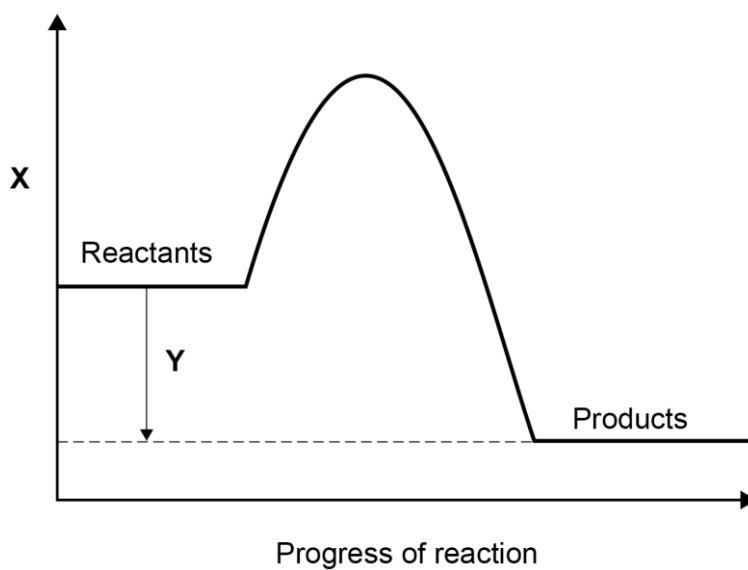
| 0 2 | . | 5 | What do labels **X** and **Y** represent on **Figure 4**?

[2 marks]

X _____ energy _____

Y _____ energy change _____

| 0 2 | . | 6 | How does the reaction profile show that the reaction is exothermic?

Use **Figure 4**.

[1 mark]

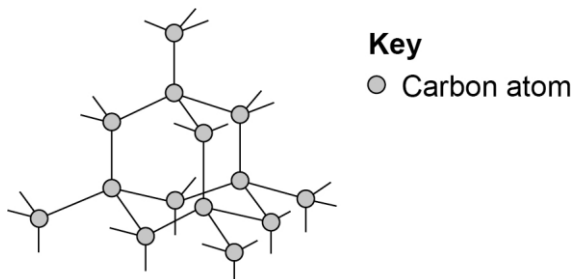(level of) products is below
(level of) reactants

17

Turn over ▶

0 3 This question is about different forms of carbon.

Figure 5 represents the structure of diamond.

Figure 5

Key
○ Carbon atom

0 3 . 1 Describe the structure and bonding of diamond.

[3 marks]

giant structure

covalent (bonds)

four bonds per carbon / atom

0 3 . 2 Explain why diamond has a very high melting point.
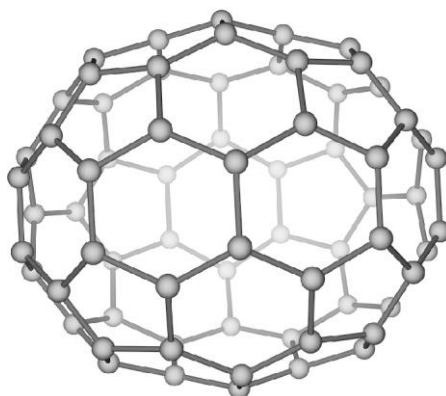
[3 marks]

(covalent) bonds are strong

(and many covalent) bonds must be broken

(so) a lot of energy is required

Figure 6 represents the molecule C_{70}

Figure 6

| 0 3 | . | 3 | What is the name of this type of molecule?

[1 mark]

Tick (✓) **one** box.

Fullerene   ✓

Graphene   ☐

Nanotube   ☐

Polymer   ☐

| 0 3 | . | 4 | Molecules such as C_{70} can be used in medicine to move drugs around the body.

Suggest **one** reason why the C_{70} molecule is suitable for this use.

[1 mark]

Not toxic

Turn over ►

0 3 . 5 Calculate the number of C_{70} molecules that can be made from one mole of carbon atoms.

The Avogadro constant = 6.02×10^{23} per mole

[3 marks]

(moles of C_{70} molecules =
$\frac{1}{70}$
=) 0.0142857

(molecules =)
$0.0142857 \times 6.02 \times 10^{23}$
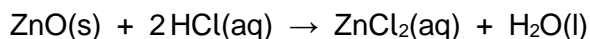$= 8.6 \times 10^{21}$

Number of molecules = _____

11

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

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

0 4 . 1 The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

[1 mark]

Solid Remaining

0 4 . 2 Why is excess zinc oxide used rather than excess hydrochloric acid?

[1 mark]

Zinc oxide can be filtered off

0 4 . 3 Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

[1 mark]

Zinc hydroxide

0 4 . 4 Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

[2 marks]

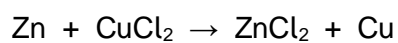heat (the solution) until crystallisation point is reached

leave the solution (to cool / crystallise)

Turn over ▶

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

0 4 . 5 Complete the ionic equation for this reaction.

[1 mark]

$$Zn + \underline{\quad Cu^{2+} \quad} \rightarrow Zn^{2+} + \underline{\quad Cu \quad}$$
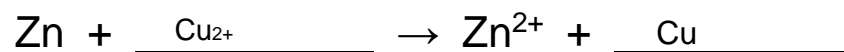
0 4 . 6 Why is zinc described as being oxidised in this reaction?

[1 mark]

Zinc atoms lose electron

**0 4 . 7** Zinc and copper can be used with another substance to produce electricity.

Complete **Figure 7** to show how zinc, copper and another substance can be used to light a lamp.
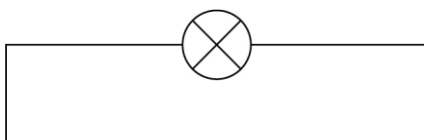
Label:

- zinc

- copper

- the other substance used.

The symbol —⊗— represents the lamp.

[3 marks]

Figure 7

(a diagram showing)
solution in a container
zinc electrode
and
copper electrode
both inserted into solution
complete circuit that would
function as an electrochemical
cell including a labelled
electrolyte

Turn over for the next question

10

0 5 This question is about groups in the periodic table.

The elements in Group 1 become more reactive going down the group.

Rubidium is below potassium in Group 1.

0 5 . 1 Rubidium and potassium are added to water.

Predict **one** observation you would see that shows that rubidium is more reactive than potassium.

[1 mark]

Brighter Flaming

0 5 . 2 Explain why rubidium is more reactive than potassium.

[3 marks]

(rubidium's) outer shell / electron is further from the nucleus

(so) there is less (electrostatic) attraction between the nucleus and the outer electron (in rubidium)

(so) the (outer) electron (in rubidium) is more easily lost

0 5 . 3 Complete the equation for the reaction of rubidium with water.

You should balance the equation.

[3 marks]

$$Rb \; + \; H_2O \; \rightarrow \; 2\,RbOH \; + \; H_2$$

The noble gases are in Group 0.

0 5 . 4 Which is a correct statement about the noble gases?

[1 mark]

Tick (✓) **one** box.

The noble gases all have atoms with eight electrons in the outer shell. ☐

The noble gases have boiling points that increase going down the group. ✓

The noble gases have molecules with two atoms. ☐

The noble gases react with metals to form ionic compounds. ☐

0 5 . 5 **Table 1** shows information about the three isotopes of neon.

Table 1

Mass number	Percentage abundance (%)
20	90.48
21	0.27
22	9.25

Calculate the relative atomic mass (A_r) of neon.

Give your answer to 3 significant figures.

[3 marks]

(relative atomic mass =)

$$\frac{(90.48 \times 20) + (0.27 \times 21) + (9.25 \times 22)}{100}$$

= 20.1877

= 20.2

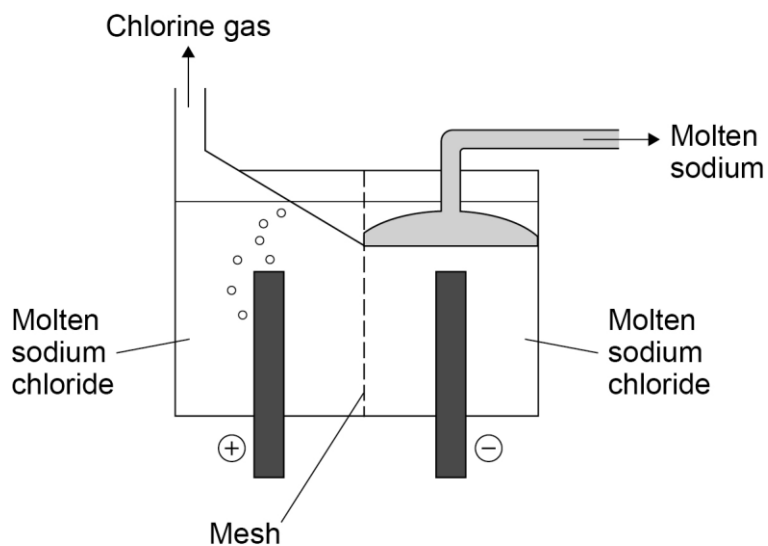Relative atomic mass (3 significant figures) = _____

11

Turn over ▶

0 6 This question is about electrolysis.

Molten sodium chloride is electrolysed in an industrial process to produce sodium.

Figure 8 shows a simplified version of the electrolysis cell used.

Figure 8
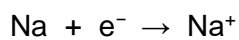

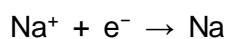
0 6 . 1 Which is the correct half equation for the production of sodium?

[1 mark]

Tick (✓) **one** box.

$Na + e^- \rightarrow Na^+$ ☐

$Na \rightarrow Na^+ + e^-$ ☐

$Na^+ + e^- \rightarrow Na$ ✓

$Na^+ \rightarrow Na + e^-$ ☐

A mesh is used to keep the products of the electrolysis apart.

0 6 . 2 Suggest **one** reason why the products of the electrolysis must be kept apart.

[1 mark]

so the products do not react (to
reform sodium chloride)

0 6 . 3 Which type of particle passes through the mesh in the electrolysis of molten sodium chloride?

[1 mark]

Tick (✓) **one** box.

Atom ☐

Electron ☐

Ion ✓

Molecule ☐

Question 6 continues on the next page

Turn over ▶

Aqueous sodium chloride solution is electrolysed in a different industrial process.

Two gases and an alkaline solution are produced.

0 6 . 4 Which **two** ions are present in aqueous sodium chloride solution in addition to sodium ions and chloride ions?

[2 marks]

1 _____ hydrogen / H+ (ions) _____

_____ hydroxide / OH (ions) _____

2 _____

0 6 . 5 Name the alkaline solution produced.

[1 mark]

_____ Sodium Hydroxide _____

0 6 . 6 Explain how the alkaline solution is produced.

You should refer to the processes at the electrodes.

[3 marks]

_____ sodium ions and hydroxide ions _____

_____ are left (in solution) _____

_____ (because) hydrogen ions are _____

_____ discharged / reduced (at the _____

_____ negative electrode to form _____

_____ hydrogen) _____

_____ (and because) chloride ions are _____

_____ discharged / oxidised (at the _____

_____ positive electrode to form _____
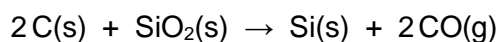
_____ chlorine) _____

9

0 7   This question is about silicon and compounds of silicon.

0 7 . 1   The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\,C(s) \;+\; SiO_2(s) \;\rightarrow\; Si(s) \;+\; 2\,CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

[2 marks]

silicon is less reactive than carbon

(because) carbon displaces silicon (from silicon dioxide)

0 7 . 2   Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

[2 marks]

More energy is needed (to obtain aluminium)
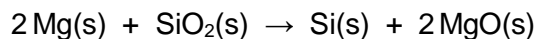
(because) aluminium is obtained (from aluminium oxide) by electrolysis

Turn over ▶

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

$$2\,Mg(s) \; + \; SiO_2(s) \; \rightarrow \; Si(s) \; + \; 2\,MgO(s)$$

0 7 . 3 Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

[1 mark]

Both products are solid

0 7 . 4 Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide.

Relative atomic masses (A_r):   O = 16   Mg = 24   Si = 28

[5 marks]

M_r of SiO_2
= 28 + (2 × 16)) = 60
(conversion 1.2 kg =) 1200 (g)
(number of moles of SiO_2 =
1200
60
) = 20
(number of moles of Mg
= 20 × 2) = 40
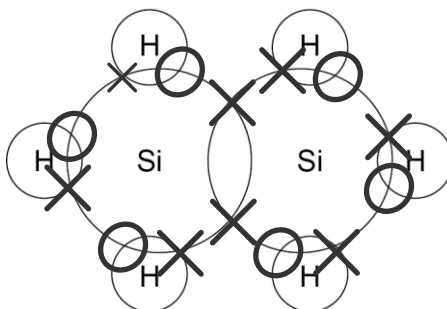(mass of Mg = 40 × 24)
= 960 (g)

Minimum mass of magnesium = _____ g

Si_2H_6 is a covalent compound of silicon and hydrogen.

0 7 . 5 Complete **Figure 9** to show the outer shell electrons in a molecule of Si_2H_6

[1 mark]

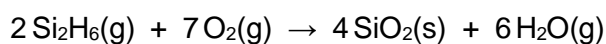**Figure 9**

0 7 . 6 Si_2H_6 reacts with oxygen.

The equation for the reaction is:

$$2\,Si_2H_6(g)\ +\ 7\,O_2(g)\ \rightarrow\ 4\,SiO_2(s)\ +\ 6\,H_2O(g)$$

30 cm³ of Si_2H_6 is reacted with 150 cm³ (an excess) of oxygen.

Calculate the total volume of gases present after the reaction.

All volumes of gases are measured at the same temperature and pressure.

[4 marks]

volume of oxygen for 30 cm₃ Si₂H₆
= 3.5 × 30)
= 105 (cm₃)
(volume of excess oxygen
= 150 − 105)
= 45 (cm₃)
(volume of water (vapour)
= 3 × 30)
= 90 (cm₃)
(volume of gases = 45 + 90)
= 135 (cm₃)

Volume of gases = _____ cm³

15

Turn over ►

0 8 This question is about acids and alkalis.

0 8 . 1 Explain why the pH of an acid depends on:

- the strength of the acid
- the concentration of the acid.

[4 marks]

Level 3: Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear

0 8 . 2 A student titrated 25.00 cm^3 of hydrochloric acid with 0.100 mol/dm^3 barium hydroxide solution.

Table 2 shows the results.

Table 2

Titration number	1	2	3	4	5
Volume of barium hydroxide solution used in cm^3	23.90	23.45	23.55	23.55	23.45

The student calculated the volume of barium hydroxide solution to be used in the titration calculation as 23.50 cm^3.

Explain why the student used a volume of 23.50 cm^3 of barium hydroxide solution in the titration calculation.

[2 marks]

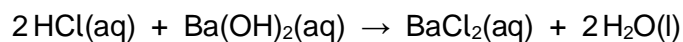the mean of titration numbers 2 to 5 values is calculated

(because) 23.90 (cm_3) is an anomalous result

| 0 | 8 | . | 3 |

25.00 cm³ of the hydrochloric acid reacted with 23.50 cm³ of the 0.100 mol/dm³ barium hydroxide solution.

The equation for the reaction is:

$$2\,HCl(aq) \;+\; Ba(OH)_2(aq) \;\rightarrow\; BaCl_2(aq) \;+\; 2\,H_2O(l)$$

Calculate the concentration of the hydrochloric acid in mol/dm³.

[4 marks]

(moles Ba(OH)$_2$ =
23.50
1000
× 0.100) = 0.00235
(moles HCl = 0.00235 × 2 =)
0.00470
(concentration =)
0.00470 × 1000
25.0

= 0.188 (mol/dm³)

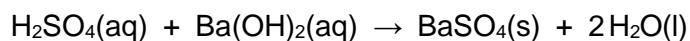Concentration of the hydrochloric acid = _____ mol/dm³

Question 8 continues on the next page

Turn over ▶

Another student titrated sulfuric acid with barium hydroxide solution.

The equation for the reaction is:

$$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$
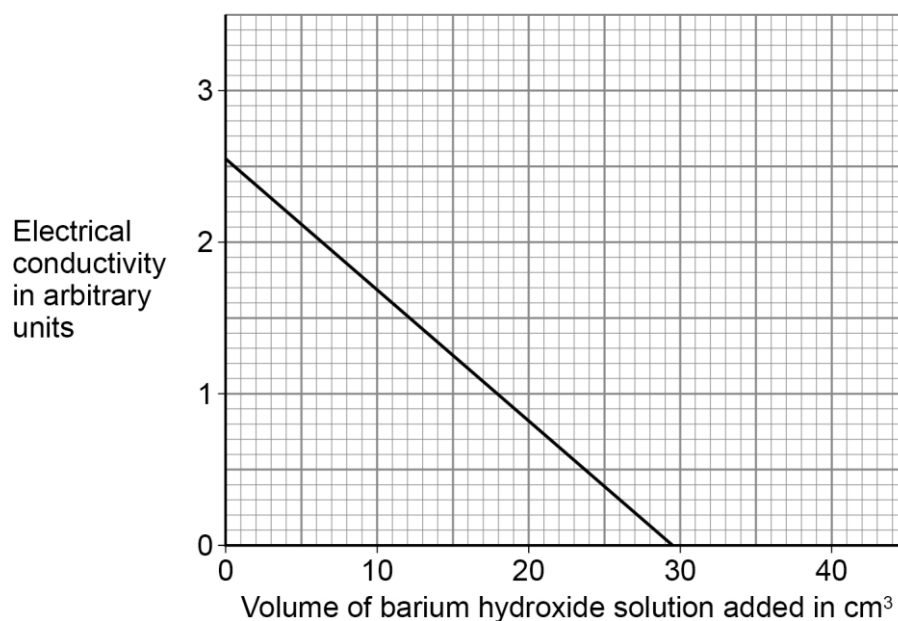
The student measured the electrical conductivity of the mixture during the titration.

The better a conductor, the higher the electrical conductivity value.

Figure 10 shows the results.

Figure 10

0 8 . 4 Explain why the electrical conductivity of the mixture was zero when the sulfuric acid had just been neutralised.

Use the equation for the reaction.

Refer to ions in your answer.

[3 marks]

there are no ions that are free to move
(because) barium sulfate is solid / insoluble
(and) hydrogen ions have reacted with hydroxide ions to produce water

0 8 . 5 The student then added a further 10 cm³ of barium hydroxide solution.

The electrical conductivity of the mixture increased.

Give **one** reason why.

[1 mark]

the mixture (now) contains
barium ions and hydroxide ions
that are free to move

END OF QUESTIONS

14

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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