AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.3.2.2

Amounts of substances in equations (HT only)

Past-paper questions

Tier	**Higher**
Question groups	**20**
Available paper years	**2018–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

5.3.2.2 Amounts of substances in equations (HT only)

Question 01

June 2018 | 8464/C/1H | Original Q6

0 6 Group 2 metal carbonates thermally decompose to produce a metal oxide and a gas.

0 6 . 1 Give the formula of each product when calcium carbonate ($CaCO_3$) is heated.

[2 marks]

_____ and _____

0 6 . 2 The relative formula mass (M_r) of a Group 2 metal carbonate is 197

Relative atomic masses (A_r): C = 12 O = 16

Calculate the relative atomic mass (A_r) of the Group 2 metal in the metal carbonate.

Name the Group 2 metal.

[3 marks]

Relative atomic mass (A_r) = _____

Metal _____

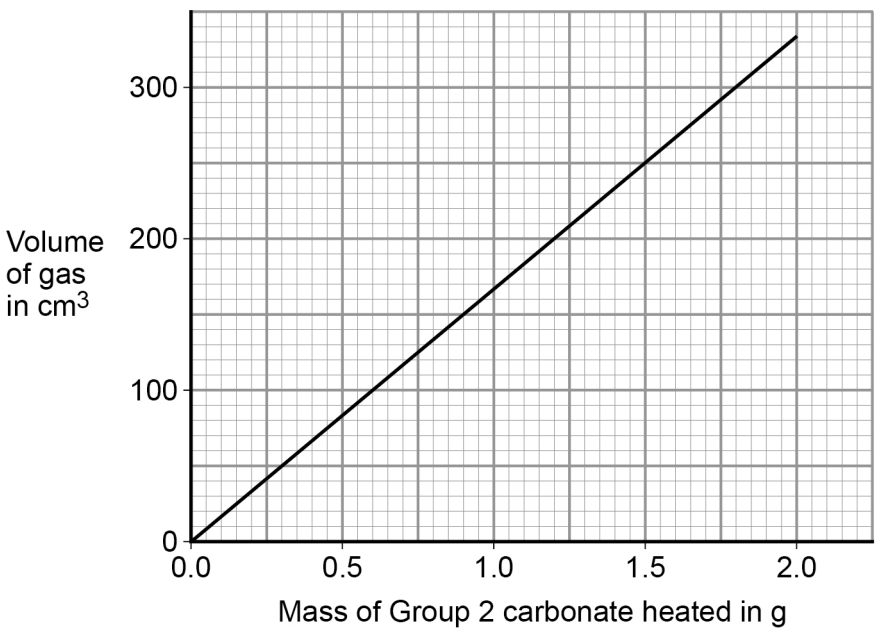
Question 6 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 01 · continued

Figure 8 shows the volume of gas produced when a different Group 2 carbonate, **W**, is heated.

Figure 8



0 6 . 3 Calculate the gradient of the line in **Figure 8**

Give the unit.

[3 marks]

Gradient _____

Unit _____

5.3.2.2 Amounts of substances in equations (HT only)

Question 01 · continued

0 6 . 4 24 dm^3 of gas is produced when one mole of a Group 2 carbonate is heated.

Determine the relative formula mass of the Group 2 carbonate **W**.

Use **Figure 8**

[4 marks]

Relative formula mass (M_r) = _____

12

5.3.2.2 Amounts of substances in equations (HT only)

Question 02

June 2018 | 8464/C/1H | Original Q8

0 8 This question is about iron.

Iron reacts with dilute hydrochloric acid to produce iron chloride solution and one other product.

0 8 . 1 Name the other product.

[1 mark]

0 8 . 2 Suggest how any unreacted iron can be separated from the mixture.

[1 mark]

Magnesium reacts with iron chloride solution.

$$3\ Mg + 2\ FeCl_3 \rightarrow 2\ Fe + 3\ MgCl_2$$

0 8 . 3 0.120 g of magnesium reacts with excess iron chloride solution.

Relative atomic masses (A_r): Mg = 24 Fe = 56

Calculate the mass of iron produced, in mg

[5 marks]

Mass of iron = _____ mg

Question 8 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 02 · continued

0 8 . 4 Explain which species is reduced in the reaction between magnesium and iron chloride.

$$3\ Mg + 2\ FeCl_3 \rightarrow 2\ Fe + 3\ MgCl_2$$

Your answer should include the half equation for the reduction.

[3 marks]

10

5.3.2.2 Amounts of substances in equations (HT only)

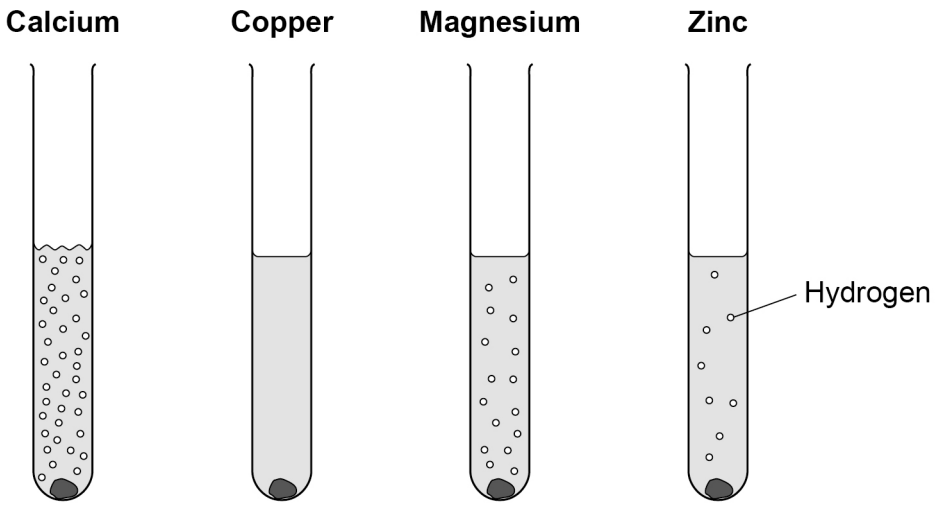
Question 03

June 2019 | 8464/C/1H | Original Q1

0 1 This question is about reactions of metals.

Figure 1 shows what happens when calcium, copper, magnesium and zinc are added to hydrochloric acid.

Figure 1



0 1 . 1 What is the order of decreasing reactivity of these four metals?

[1 mark]

Tick (✓) **one** box.

Zn Ca Cu Mg ☐

Ca Cu Mg Zn ☐

Cu Zn Ca Mg ☐

Ca Mg Zn Cu ☐

5.3.2.2 Amounts of substances in equations (HT only)

Question 03 · continued

A student wants to make a fair comparison of the reactivity of the metals with hydrochloric acid.

0 1 . 2 Name **two** variables that must be kept constant.

[2 marks]

1 _____

_____

2 _____

_____

0 1 . 3 What is the independent variable in this reaction?

[1 mark]

_____

_____

0 1 . 4 Predict the reactivity of beryllium compared with magnesium.

Give a reason for your answer.

Use the periodic table.

[2 marks]

_____

Reason _____

_____

_____

0 1 . 5 A solution of hydrochloric acid contains 3.2 g of hydrogen chloride in 50 cm^3

Calculate the concentration of hydrogen chloride in g per dm^3

[3 marks]

_____

_____

_____

_____

Concentration = _____ g per dm^3

9

5.3.2.2 Amounts of substances in equations (HT only)

Question 04

June 2019 | 8464/C/1H | Original Q2

0 2 This question is about salts.

Ammonium nitrate solution is produced when ammonia gas reacts with nitric acid.

0 2 . 1 Give the state symbol for ammonium nitrate solution.

[1 mark]

_____

0 2 . 2 What is the formula of nitric acid?

[1 mark]

Tick (✓) **one** box.

HCl ☐

HNO_3 ☐

H_2SO_4 ☐

NH_4OH ☐

0 2 . 3 Ammonia gas dissolves in water to produce ammonia solution.

Ammonia solution contains hydroxide ions, OH^-

A student adds universal indicator to solutions of nitric acid and ammonia.

What colour is observed in each solution?

[2 marks]

Colour in nitric acid _____

Colour in ammonia solution _____

5.3.2.2 Amounts of substances in equations (HT only)

Question 04 · continued

0 2 . 4 The student gradually added nitric acid to ammonia solution.

Which row, **A**, **B**, **C** or **D**, shows the change in pH as the nitric acid is added until in excess?

[1 mark]

Tick (✓) **one** box.

	pH of ammonia solution at start	pH after addition of excess nitric acid	
A	10	7	☐
B	2	10	☐
C	7	1	☐
D	10	2	☐

0 2 . 5 Calculate the percentage by mass of oxygen in ammonium nitrate (NH_4NO_3).

Relative atomic masses (A_r): H = 1 N = 14 O = 16

Relative formula mass (M_r): NH_4NO_3 = 80

[3 marks]

Percentage by mass of oxygen = _____ %

Question 2 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 04 · continued

0 2 . 6 Describe a method to investigate how the temperature changes when different masses of ammonium nitrate are dissolved in water.

You do **not** need to write about safety precautions.

[6 marks]

14

5.3.2.2 Amounts of substances in equations (HT only)

Question 05

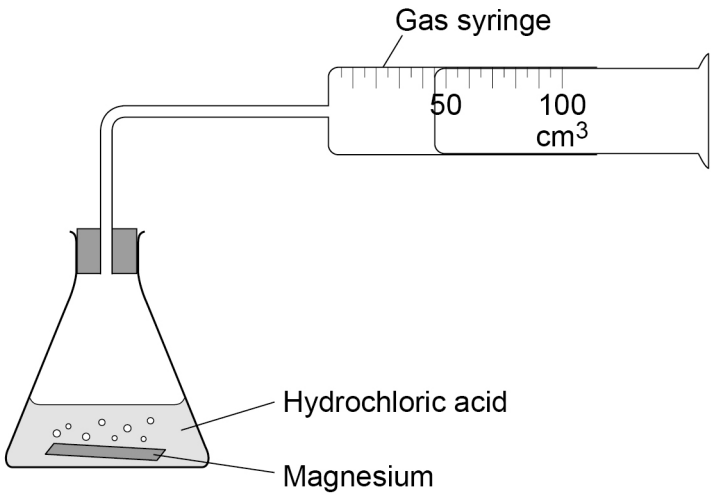
June 2019 | 8464/C/2H | Original Q5

0 5 This question is about magnesium.

A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 2 shows the apparatus.

Figure 2



0 5 . 1 Which is the correct ionic equation for the reaction?

[1 mark]

Tick (✓) **one** box.

$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ ☐

$Mg^{2+} + 2Cl^- \rightarrow MgCl_2$ ☐

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ ☐

$Mg^+ + Cl^- \rightarrow MgCl$ ☐

5.3.2.2 Amounts of substances in equations (HT only)

Question 05 · continued

0 5 . 2 What happens in the reaction between magnesium and hydrochloric acid?

[1 mark]

Tick (✓) **one** box.

Electron sharing ☐

Electron transfer ☐

Proton transfer ☐

Question 5 continues on the next page

Question 05 · continued

0 5 . 3 **Table 2** shows the student's results.

Table 2

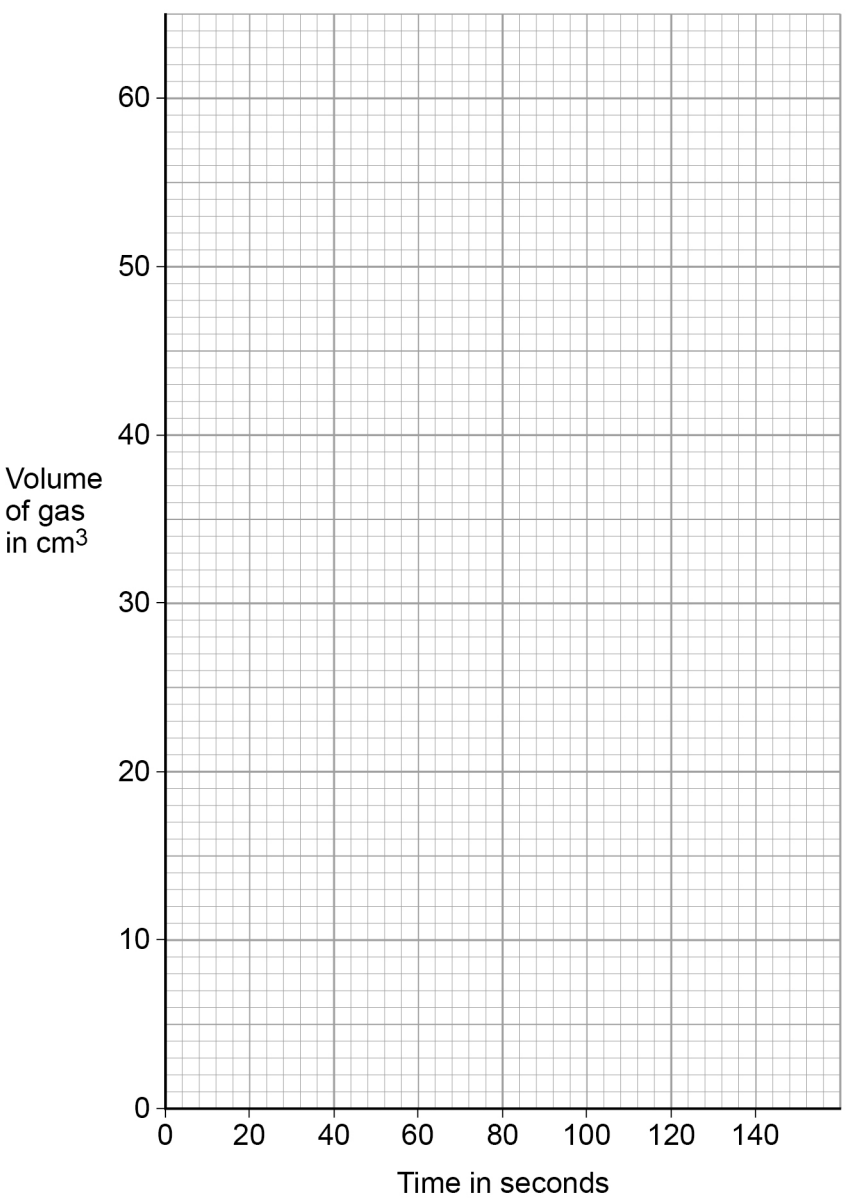
Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm^3	0.0	12.5	36.0	43.5	59.0	60.0	60.0

Plot the data from **Table 2** on **Figure 3**.

Draw a line of best fit.

[3 marks]

Figure 3



5.3.2.2 Amounts of substances in equations (HT only)

Question 05 · continued

0 5 . 4 Describe the changes in the rate of this reaction.

[3 marks]

0 5 . 5 Explain why the rate of this reaction changes.

Give your answer in terms of collision theory.

[3 marks]

11

5.3.2.2 Amounts of substances in equations (HT only)

Question 06

June 2019 | 8464/C/2H | Original Q6

0 6 This question is about oxygen (O_2) and sulfur dioxide (SO_2).

0 6 . 1 Give the test and result for oxygen gas.

[2 marks]

Test _____

Result _____

0 6 . 2 The reaction between oxygen and sulfur dioxide is at equilibrium.

$$O_2(g) + 2SO_2(g) \rightleftharpoons 2SO_3(g)$$

Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

[2 marks]

_____

_____

_____

_____

5.3.2.2 Amounts of substances in equations (HT only)

Question 06 · continued

0 6 . 3 Sulfur dioxide is an atmospheric pollutant.

Sulfur dioxide pollution is reduced by reacting calcium oxide with sulfur dioxide to produce calcium sulfite.

$$CaO + SO_2 \rightarrow CaSO_3$$

7.00 g of calcium oxide reacts with an excess of sulfur dioxide.

Relative atomic masses (A_r): O = 16 S = 32 Ca = 40

Calculate the mass of calcium sulfite produced.

[4 marks]

Mass of calcium sulfite produced = _____ g

8

5.3.2.2 Amounts of substances in equations (HT only)

Question 07

November 2020 | 8464/C/1H | Original Q5

0 5 A student investigated the temperature change when magnesium was added to copper sulfate solution.

This is the method used.

1. Pour 30 cm^3 of copper sulfate solution into a polystyrene cup.

2. Measure the temperature of copper sulfate solution every minute for 3 minutes.

3. Add magnesium on the fourth minute.

4. Measure the temperature of the mixture at 5 minutes and then every minute up to 14 minutes.

0 5 . 1 What is the dependent variable in this investigation?

[1 mark]

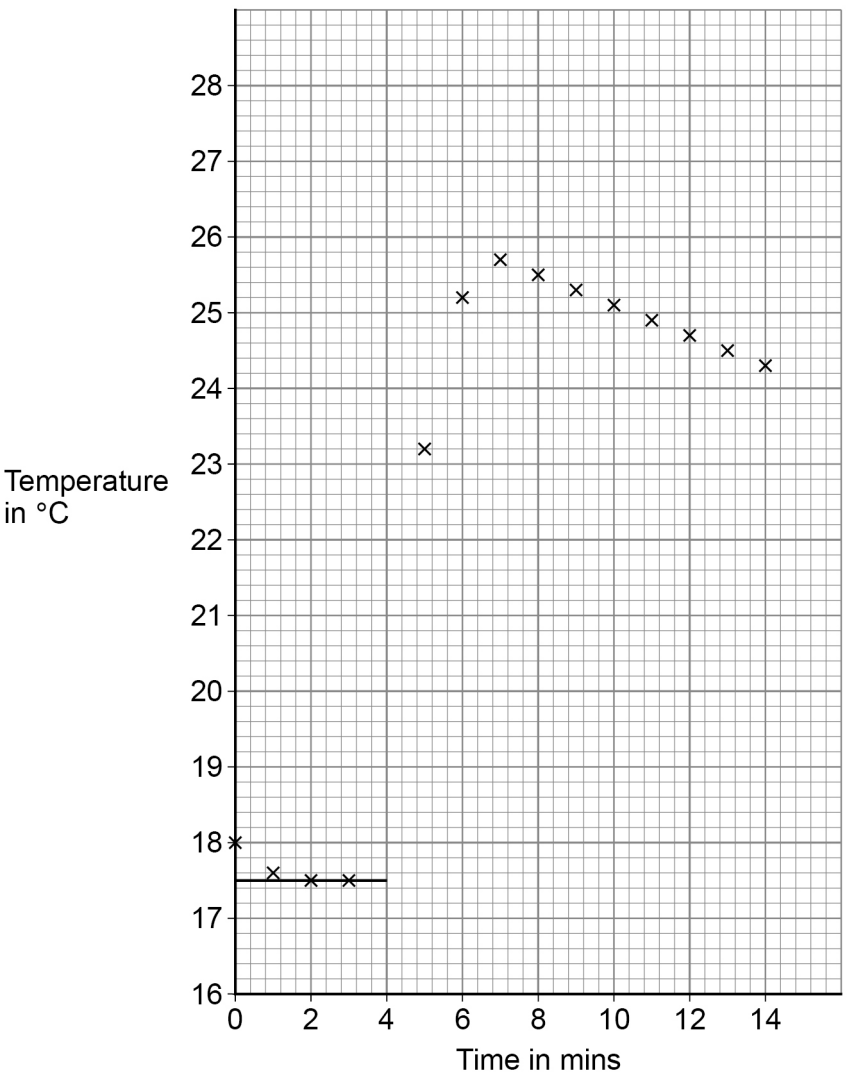
Question 5 continues on the next page

Question 07 · continued

The student used the results to plot a graph.

Figure 4 shows the graph.

Figure 4



5.3.2.2 Amounts of substances in equations (HT only)

Question 07 · continued

0 5 . 2 Suggest why the copper sulfate solution was left for four minutes before adding the magnesium.

[1 mark]

0 5 . 3 Complete **Figure 4** by:

- drawing a line of best fit through all the points after 7 minutes
- extending the line back to 4 minutes.

[2 marks]

0 5 . 4 The temperature change for the reaction is the temperature difference between the two graph lines at 4 minutes.

Determine the temperature change for the reaction.

Use **Figure 4**.

[2 marks]

Temperature change = _____ °C

0 5 . 5 Explain why the temperature of the mixture decreases after 7 minutes.

[2 marks]

5.3.2.2 Amounts of substances in equations (HT only)

Question 07 · continued

0 5 . 6 The student repeated the experiment with an unknown metal **Q** instead of magnesium.

All the other variables were kept the same.

The student recorded a smaller temperature change.

Suggest the identity of metal **Q**.

Give **one** reason for your answer.

[2 marks]

Metal **Q** _____

Reason _____

_____

0 5 . 7 A copper sulfate solution contained 0.100 moles of copper sulfate dissolved in 0.500 dm^3 of water.

Calculate the mass of copper sulfate in 30.0 cm^3 of this solution.

Relative formula mass (M_r): $CuSO_4$ = 159.5

[4 marks]

_____

_____

_____

_____

_____

_____

Mass = _____ g

14

5.3.2.2 Amounts of substances in equations (HT only)

Question 08

November 2020 | 8464/C/1H | Original Q6

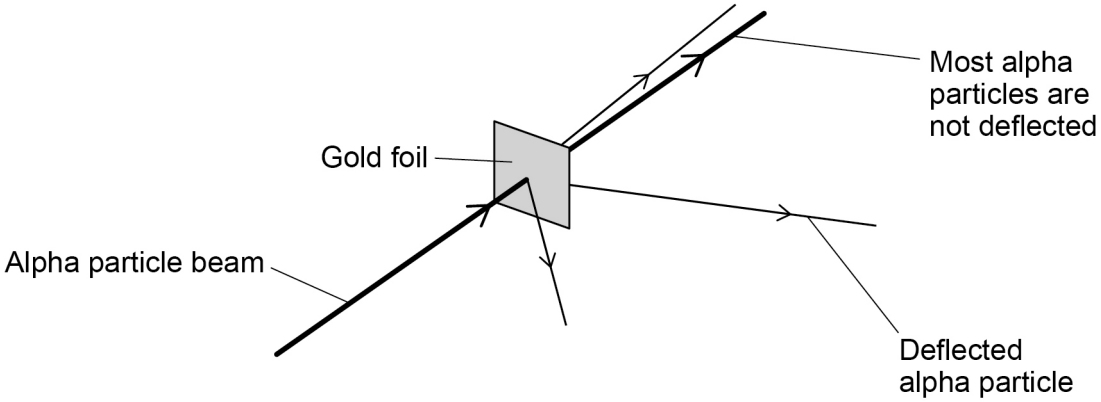
0 6 This question is about gold and compounds of gold.

0 6 . 1 In the alpha particle scattering experiment alpha particles are fired at gold foil.

Alpha particles are positively charged.

Figure 5 shows the results.

Figure 5



What **two** conclusions can be made from the results?

[2 marks]

Tick (✓) **two** boxes.

Atoms are balls of positive charge with embedded electrons. ☐

Atoms are tiny spheres that cannot be divided. ☐

Atoms have a positively charged nucleus. ☐

Mass is concentrated in the nucleus in the centre of atoms. ☐

Neutrons exist within the nucleus. ☐

Question 6 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 08 · continued

0 6 . 2 The gold foil is:

- 4.00×10^{-7} metres thick
- 2400 atoms thick.

What is the diameter of one gold atom in metres?

Give your answer to 3 significant figures.

[3 marks]

Diameter of one gold atom (3 significant figures) = _____ m

5.3.2.2 Amounts of substances in equations (HT only)

Question 08 · continued

0 6 . 3 Gold reacts with the elements in Group 7 of the periodic table.

0.175 g of gold reacts with chlorine.

The equation for the reaction is:

$$2\ Au + 3\ Cl_2 \rightarrow 2\ AuCl_3$$

Calculate the mass of chlorine needed to react with 0.175 g of gold.

Give your answer in mg

Relative atomic masses (A_r): Cl = 35.5 Au = 197

[5 marks]

Mass of chlorine = _____ mg

10

5.3.2.2 Amounts of substances in equations (HT only)

Question 09

November 2021 | 8464/C/1H | Original Q1

0 1 This question is about the periodic table.

0 1 . 1 **Figure 1** shows part of Mendeleev's version of the periodic table.

Figure 1

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn		Ti	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	I	Ru Rh Pd

Which group of elements had **not** been discovered when Mendeleev's version of the periodic table was published?

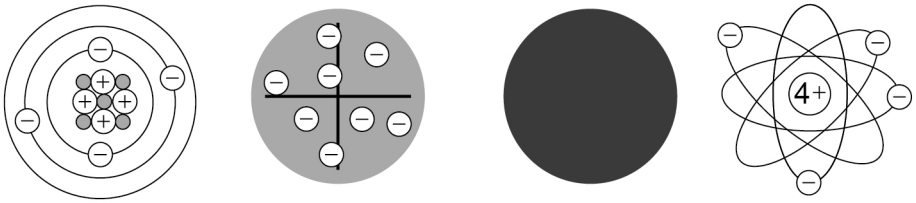
[1 mark]

5.3.2.2 Amounts of substances in equations (HT only)

Question 09 · continued

Figure 2 represents different models of the atom.

Figure 2



A B C D

0 1 . 2 Which model represents the plum pudding model?

[1 mark]

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☐

0 1 . 3 Which model resulted from Chadwick's experimental work?

[1 mark]

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☐

Question 1 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 09 · continued

Potassium has different isotopes.

0 1 . 4 What is meant by 'isotopes'?

You should refer to subatomic particles.

[2 marks]

0 1 . 5 **Table 1** shows the mass numbers and the percentage abundance of two isotopes of potassium.

Table 1

Mass number	Percentage abundance
39	93.1
41	6.9

Calculate the relative atomic mass (A_r) of potassium.

Give your answer to 1 decimal place.

[3 marks]

Relative atomic mass (1 decimal place) = _____

8

5.3.2.2 Amounts of substances in equations (HT only)

Question 10

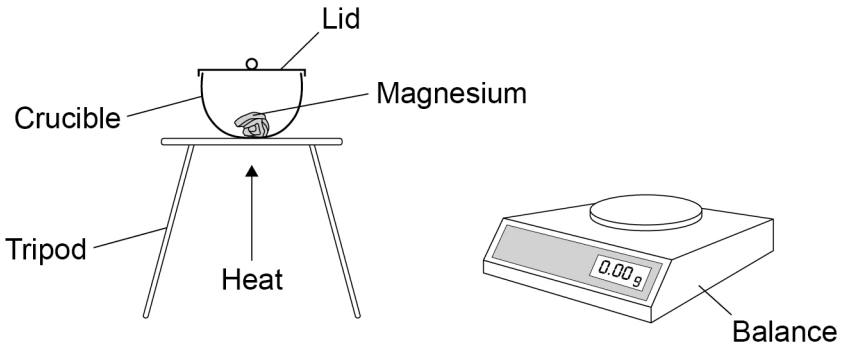
November 2021 | 8464/C/1H | Original Q6

0 6 Metal oxides are produced when metals are heated in air.

A student investigated the change in mass when 0.12 g of magnesium was heated in air.

Figure 5 shows the apparatus.

Figure 5



The student measured the mass of magnesium oxide produced.

0 6 . 1 0.12 g of magnesium reacted to produce 0.20 g of magnesium oxide.

Calculate the number of moles of oxygen gas (O_2) that reacted.

Relative atomic mass (A_r): O = 16

[3 marks]

Moles of oxygen gas = _____

5.3.2.2 Amounts of substances in equations (HT only)

Question 10 · continued

0 6 . 2 The student repeated the experiment **without** a lid on the crucible.

Suggest why the mass of magnesium oxide produced would be different without a lid on the crucible.

[2 marks]

0 6 . 3 Copper reacts with oxygen to produce copper oxide.

63.5 g of copper produces 79.5 g of copper oxide.

Calculate the mass of copper oxide produced when 0.50 g of copper reacts with oxygen.

Give your answer to 3 significant figures.

[3 marks]

Mass (3 significant figures) = _____ g

Question 6 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 10 · continued

0 6 . 4 Iron reacts with oxygen to produce an oxide of iron.

0.015 moles of iron reacts with 0.010 moles of oxygen gas (O_2).

Determine:

- the formula of the iron oxide produced
- the balanced symbol equation for the reaction.

[4 marks]

Formula of iron oxide = _____

Balanced symbol equation

_____

12

5.3.2.2 Amounts of substances in equations (HT only)

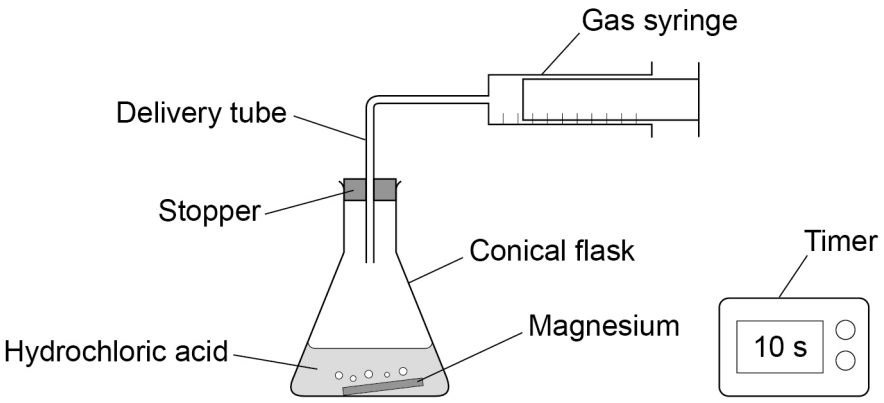
Question 11

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bo

0 1 A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Pour 50 cm^3 of hydrochloric acid into a conical flask.

2. Add a piece of magnesium.

3. Insert stopper and delivery tube and start a timer.

4. Collect the gas produced in a gas syringe.

5. Record the volume of gas produced every 20 seconds for 2 minutes.

6. Repeat steps 1 to 5 with higher concentrations of hydrochloric acid.

0 1 . 1 Give the independent variable and **one** control variable in this investigation.

[2 marks]

Independent variable _____

Control variable _____

Question 1 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 11 · continued

Table 1 shows the results from the first experiment using hydrochloric acid with a low concentration.

Table 1

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm^3	0	48	72	90	97	98	98

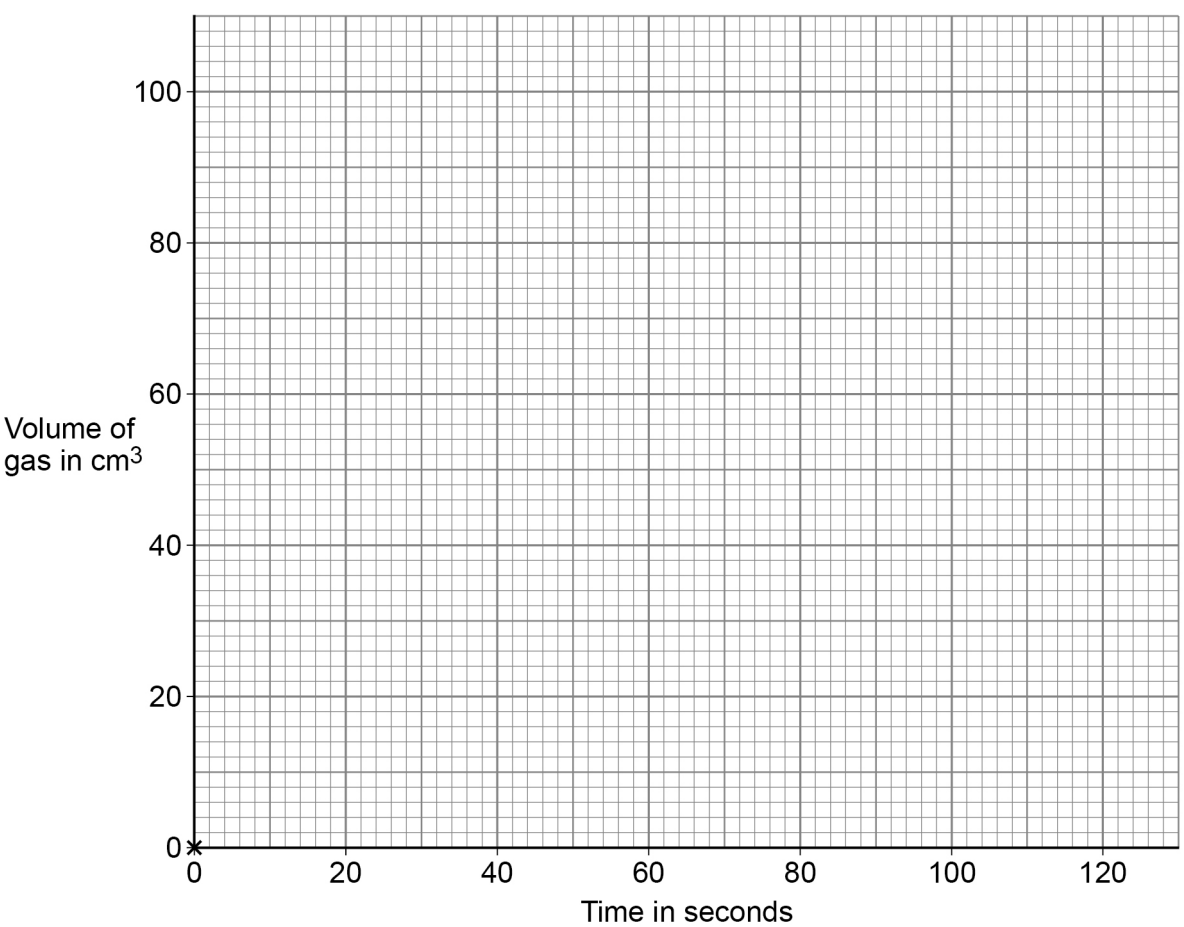
0 1 . 2 Complete **Figure 2**.

You should:

- plot the data from **Table 1** (the point 0,0 has been plotted for you)
- draw a line of best fit.

[3 marks]

Figure 2



5.3.2.2 Amounts of substances in equations (HT only)

Question 11 · continued

0 1 . 3 How does the **rate** of this reaction change with time?

Use **Table 1**.

[1 mark]

Tick (✓) **one** box.

The rate decreases. ☐

The rate stays the same. ☐

The rate increases. ☐

0 1 . 4 The student repeated the experiment using hydrochloric acid with a higher concentration.

Which statement is correct?

[1 mark]

Tick (✓) **one** box.

The activation energy for the reaction was higher. ☐

The magnesium reacted more quickly. ☐

The reaction finished at the same time. ☐

The total volume of gas collected was smaller. ☐

Question 1 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 11 · continued

0 1 . 5 Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions.

[3 marks]

10

5.3.2.2 Amounts of substances in equations (HT only)

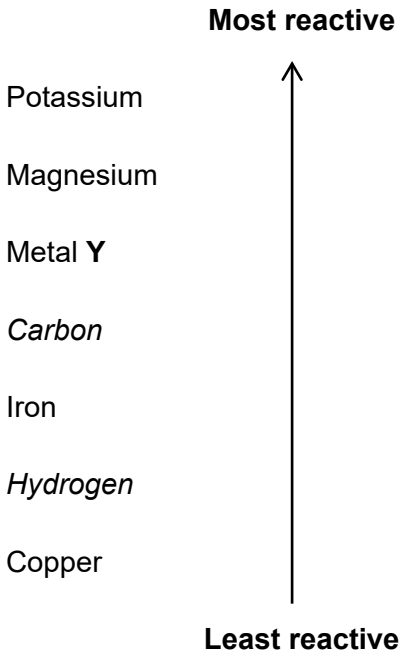
Question 12

June 2022 | 8464/C/1H | Original Q7

0 7 This question is about elements and compounds.

0 7 . 1 **Figure 8** shows a reactivity series.

Figure 8



Give the method and conditions used to extract metal **Y** from a compound of metal **Y**.

[2 marks]

Question 7 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 12 · continued

Sodium reacts with titanium chloride ($TiCl_4$) to produce titanium.

0 7 . 2 Complete the equation.

You should balance the equation.

[2 marks]

____ Na + $TiCl_4$ → _____ + _____

0 7 . 3 The reaction between sodium and titanium chloride is a redox reaction.

Write a half-equation to show that sodium is oxidised in this reaction.

[2 marks]

5.3.2.2 Amounts of substances in equations (HT only)

Question 12 · continued

0 7 . 4 108 g of aluminum reacts with 1.21 kg of copper chloride to produce copper.

The equation for the reaction is:

$$2\,Al + 3\,CuCl_2 \rightarrow 3\,Cu + 2\,AlCl_3$$

Calculate the maximum mass of copper produced in grams (g).

You should determine the limiting reactant.

Relative atomic masses (A_r): Al = 27 Cu = 63.5

Relative formula masses (M_r): $CuCl_2$ = 134.5 $AlCl_3$ = 133.5

[6 marks]

Limiting reactant is _____

Mass of copper = _____ g

Question 7 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 12 · continued

Sodium metal and sodium chloride are both able to conduct electricity.

0 7 . 5 Describe how sodium metal conducts electricity.

[2 marks]

0 7 . 6 Explain how sodium chloride can conduct electricity.

[3 marks]

17

5.3.2.2 Amounts of substances in equations (HT only)

Question 13

June 2023 | 8464/C/1H | Original Q2

0 2 Lithium hydroxide reacts with sulfuric acid to produce lithium sulfate.

The equation for the reaction is:

$$2\,LiOH + H_2SO_4 \longrightarrow Li_2SO_4 + 2\,H_2O$$

0 2 . 1 What type of reaction is this?

[1 mark]

0 2 . 2 Calculate the relative formula mass (M_r) of sulfuric acid (H_2SO_4).

Relative atomic masses (A_r): H = 1 O = 16 S = 32

[2 marks]

Relative formula mass (M_r) = _____

5.3.2.2 Amounts of substances in equations (HT only)

Question 13 · continued

0 2 . 3 Calculate the percentage by mass of oxygen in lithium sulfate (Li_2SO_4).

Relative atomic mass (A_r): O = 16

Relative formula mass (M_r): Li_2SO_4 = 110

Give your answer to 2 significant figures.

[4 marks]

Percentage by mass of oxygen (2 significant figures) = _____ %

0 2 . 4 A solution of lithium sulfate contains 0.30 g of lithium sulfate in 25 cm^3.

Calculate the concentration of lithium sulfate in g/dm^3.

[3 marks]

Concentration = _____ g/dm^3

10

5.3.2.2 Amounts of substances in equations (HT only)

Question 14

June 2023 | 8464/C/1H | Original Q4

0 4 Group 7 elements are known as the halogens.

All atoms of Group 7 elements contain protons, neutrons and electrons.

0 4 . 1 What is the order of discovery of the proton, neutron and electron?

[1 mark]

Tick (✓) **one** box.

electron → neutron → proton ☐

electron → proton → neutron ☐

neutron → proton → electron ☐

proton → electron → neutron ☐

0 4 . 2 **Table 1** shows the mass of a proton and of an electron.

Table 1

Name of particle	Mass in kg
Proton	1.673×10^{-27}
Electron	9.109×10^{-31}

Calculate how many times heavier a proton is than an electron.

[2 marks]

Times heavier a proton is than an electron = _____

Question 14 · continued

A bromine atom can be represented as $^{81}_{35}Br$.

0 4 . 3 What is the number of neutrons in this bromine atom?

[1 mark]

_____

0 4 . 4 What is the number of electrons in a bromide **ion**?

[1 mark]

_____

0 4 . 5 Chlorine has two isotopes.

Table 2 shows the percentage abundance of the two isotopes of chlorine.

Table 2

Isotope	Percentage (%) abundance
$^{35}_{17}Cl$	75.77
$^{37}_{17}Cl$	24.23

Calculate the relative atomic mass (A_r) of chlorine.

Give your answer to 2 decimal places.

[3 marks]

_____

_____

_____

_____

_____

Relative atomic mass (2 decimal places) = _____

5.3.2.2 Amounts of substances in equations (HT only)

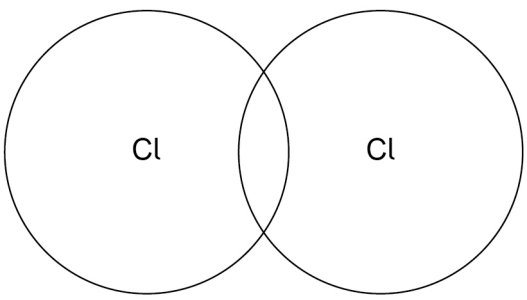
Question 14 · continued

0 4 . 6 **Figure 4** shows the outer shells in one molecule of chlorine (Cl_2).

Complete the dot and cross diagram to show the electrons in the outer shells.

[2 marks]

Figure 4



10

5.3.2.2 Amounts of substances in equations (HT only)

Question 15

June 2023 | 8464/C/1H | Original Q6

0 6 Acids react with some metals to produce soluble salts.

A student adds magnesium to hydrochloric acid until no more acid reacts and excess magnesium remains.

The equation for the reaction is:

$$Mg(s) + 2\,HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

0 6 . 1 Describe how solid magnesium chloride is obtained from the reaction mixture.

[2 marks]

0 6 . 2 The reaction between magnesium and hydrochloric acid is a redox reaction.

Explain what happens to the magnesium atoms in this reaction.

[2 marks]

5.3.2.2 Amounts of substances in equations (HT only)

Question 15 · continued

0 6 . 3 0.72 g of magnesium is added to 100 cm^3 of hydrochloric acid.

The hydrochloric acid is in excess.

Calculate the concentration of the magnesium chloride ($MgCl_2$) solution produced in g/dm^3.

Relative atomic mass (A_r): Mg = 24

Relative formula mass (M_r): $MgCl_2$ = 95

[6 marks]

Concentration = _____ g/dm^3

10

5.3.2.2 Amounts of substances in equations (HT only)

Question 16

June 2024 | 8464/C/1H | Original Q4

0 4 Nitric acid (HNO_3) is a strong acid.

0 4 . 1 What is meant by a 'strong acid'?

[1 mark]

0 4 . 2 Nitric acid is used as a dilute aqueous solution.

What is meant by 'dilute aqueous solution'?

[1 mark]

Question 4 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 16 · continued

0 4 . 3 10 cm^3 of a nitric acid solution has a pH of 1

Water is added to the nitric acid solution to change the pH of the nitric acid solution to pH 3

How does the hydrogen ion concentration change?

[1 mark]

Tick (✓) **one** box.

- Decreases by a factor of 100 ☐
- Decreases by a factor of 10 ☐
- Increases by a factor of 10 ☐
- Increases by a factor of 100 ☐

0 4 . 4 Write the **ionic** equation for the reaction between an acid and an alkali.

[1 mark]

_____ + _____ → _____

5.3.2.2 Amounts of substances in equations (HT only)

Question 16 · continued

The equation shows the reaction between magnesium carbonate and nitric acid.

$$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$$

0 4 . 5 What is the ratio of the number of moles of magnesium carbonate to the number of moles of nitric acid in the reaction?

[1 mark]

Tick (✓) **one** box.

1 : 1 ☐

1 : 2 ☐

2 : 1 ☐

2 : 2 ☐

0 4 . 6 A student mixed some magnesium carbonate with excess nitric acid.

The student then added two drops of universal indicator to the solution.

What colour was the solution after the addition of universal indicator?

[1 mark]

Tick (✓) **one** box.

Red ☐

Green ☐

Blue ☐

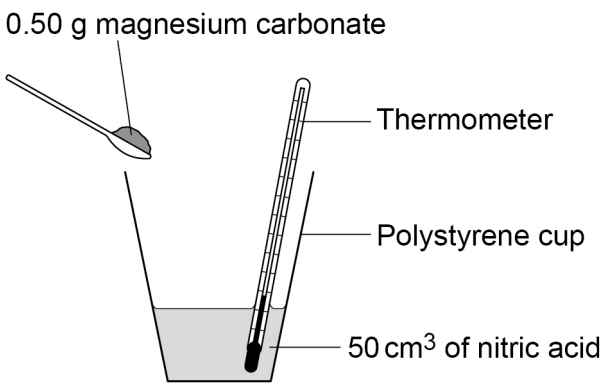
5.3.2.2 Amounts of substances in equations (HT only)

Question 16 · continued

A student investigated the temperature change when different masses of magnesium carbonate were reacted with excess nitric acid.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Pour 50 cm^3 of nitric acid into a polystyrene cup.
2. Measure the temperature of the solution.
3. Add 0.50 g of magnesium carbonate.
4. Stir the mixture.
5. Measure the temperature.
6. Repeat steps 1 to 5 with different masses of magnesium carbonate.

0 4 . 7 Give **two** improvements to the **method** to produce more accurate results.

Do **not** refer to improvements to the apparatus in your answer.

[2 marks]

1 _____

_____

2 _____

_____

8

5.3.2.2 Amounts of substances in equations (HT only)

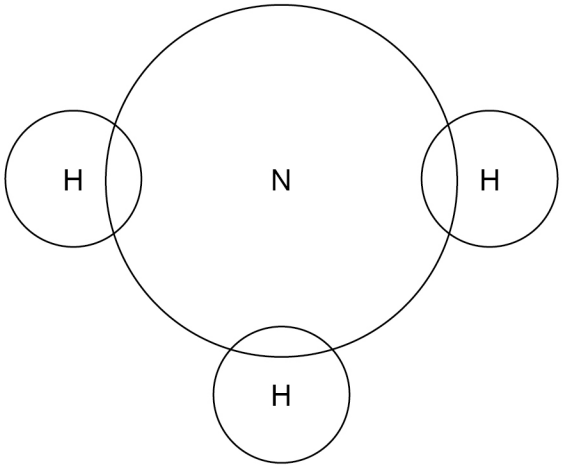
Question 17

June 2024 | 8464/C/1H | Original Q5

0 5 Nitrogen reacts with hydrogen to produce ammonia (NH_3).

0 5 . 1 Complete the dot and cross diagram for an ammonia molecule.

[2 marks]



5.3.2.2 Amounts of substances in equations (HT only)

Question 17 · continued

0 5 . 2 The equation for the reaction between nitrogen and hydrogen to produce ammonia is:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Calculate the mass of hydrogen that is needed to produce 25 g of ammonia.

Relative atomic masses (A_r): H = 1 N = 14

[4 marks]

Mass of hydrogen = _____ g

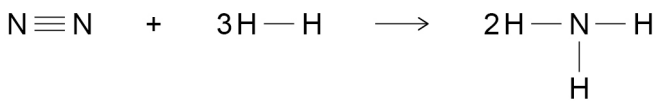
Question 5 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 17 · continued

Figure 7 shows the displayed formulae equation for the reaction of nitrogen with hydrogen.

Figure 7



In the reaction the energy released forming new bonds is 93 kJ/mol greater than the energy needed to break existing bonds.

Table 3 shows bond energies.

Table 3

Bond	N≡N	H—H	N—H
Bond energy in kJ/mol	945	**X**	391

0 5 . 3 Calculate the bond energy **X** for the H—H bond.

Use **Figure 7** and **Table 3**.

[5 marks]

X = _____ kJ/mol

5.3.2.2 Amounts of substances in equations (HT only)

Question 17 · continued

0 5 . 4 Energy is released from the reaction to produce ammonia.

Figure 8 shows part of the reaction profile for the reaction between nitrogen and hydrogen to produce ammonia.

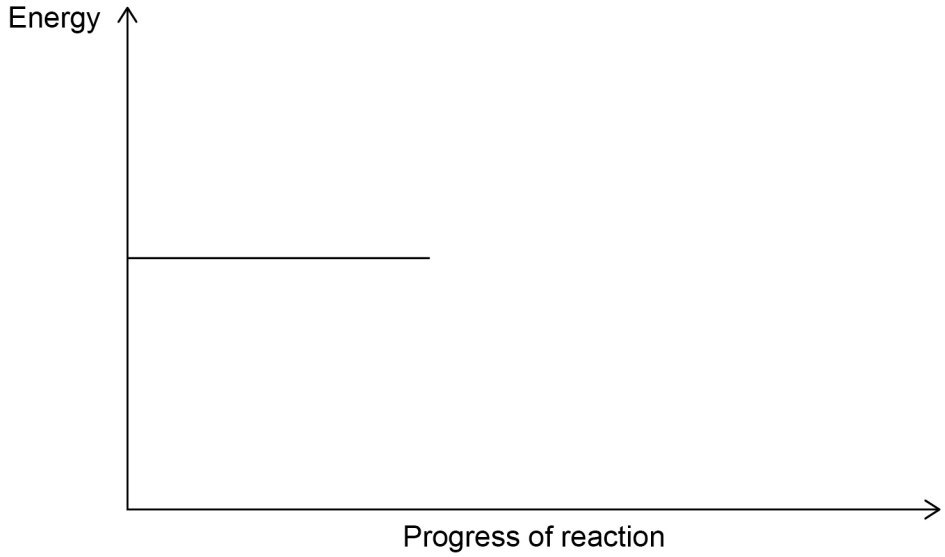
Complete **Figure 8**.

You should:

- complete the profile line
- label the energy level of the reactants and the product
- label the **overall** energy change.

[3 marks]

Figure 8



14

5.3.2.2 Amounts of substances in equations (HT only)

Question 18

June 2025 | 8464/C/1H | Original Q2

0 2 A student investigated an exothermic reaction.

The student reacted solid calcium oxide with water to produce calcium hydroxide.

0 2 . 1 What is meant by an 'exothermic' reaction?

[1 mark]

0 2 . 2 The formula of calcium hydroxide is $Ca(OH)_2$

Calculate the percentage by mass of oxygen in calcium hydroxide.

Relative atomic mass (A_r): O = 16

Relative formula mass (M_r): $Ca(OH)_2$ = 74

[3 marks]

Percentage = _____ %

Question 2 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 18 · continued

0 2 . 3 When solid calcium oxide is added to water, the temperature of the reaction mixture changes.

Plan a method to investigate how changing the mass of calcium oxide affects the temperature change of the reaction mixture.

[6 marks]

Extra space

10

5.3.2.2 Amounts of substances in equations (HT only)

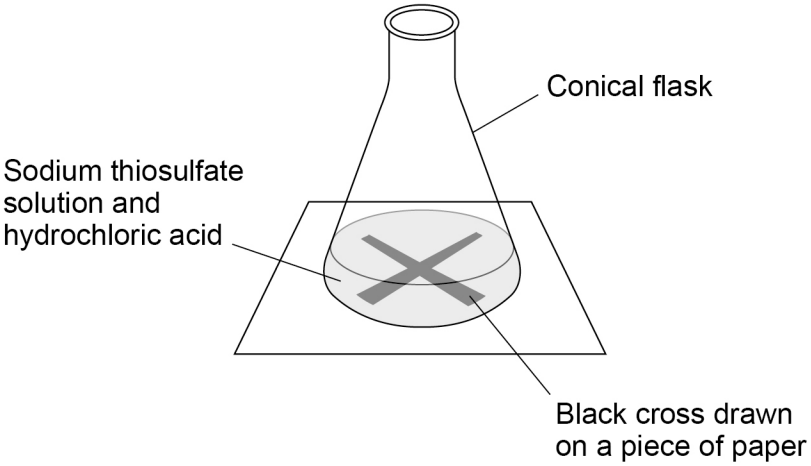
Question 19

0 5 Students investigated the effect of changing the concentration on the rate of chemical reactions.

A student reacted sodium thiosulfate solution with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



This is the method used.

1. Measure 50 cm^3 of sodium thiosulfate solution into a conical flask.

2. Put the conical flask on a black cross drawn on a piece of paper.

3. Add 10 cm^3 of hydrochloric acid to the conical flask.

4. Start a timer.

5. Stop the timer when the cross is no longer visible.

6. Record the time taken.

7. Repeat steps 1 to 6 using different concentrations of sodium thiosulfate solution.

5.3.2.2 Amounts of substances in equations (HT only)

Question 19 · continued

0 5 . 1 What is the dependent variable in this investigation?

[1 mark]

0 5 . 2 The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

The mixture becomes cloudy as the reaction takes place.

Explain why the mixture becomes cloudy.

[2 marks]

0 5 . 3 Explain the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

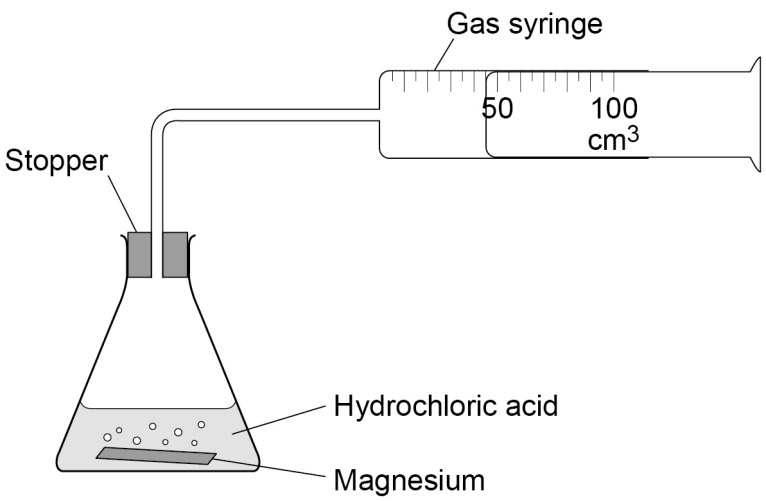
[3 marks]

Question 19 · continued

A different student reacted magnesium with hydrochloric acid.

Figure 4 shows the apparatus.

Figure 4



This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a conical flask.
2. Add 0.1 g of magnesium ribbon to the conical flask.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a timer.
5. Record the volume of gas collected every 20 seconds for 5 minutes.
6. Repeat steps 1 to 5 using different concentrations of hydrochloric acid.

0 5 . 4 Why is the stopper inserted into the conical flask as quickly as possible in step 3?

[1 mark]

5.3.2.2 Amounts of substances in equations (HT only)

Question 19 · continued

0 5 . 5 The equation for the reaction of magnesium with hydrochloric acid is:

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Describe a test for the gas produced in the reaction.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

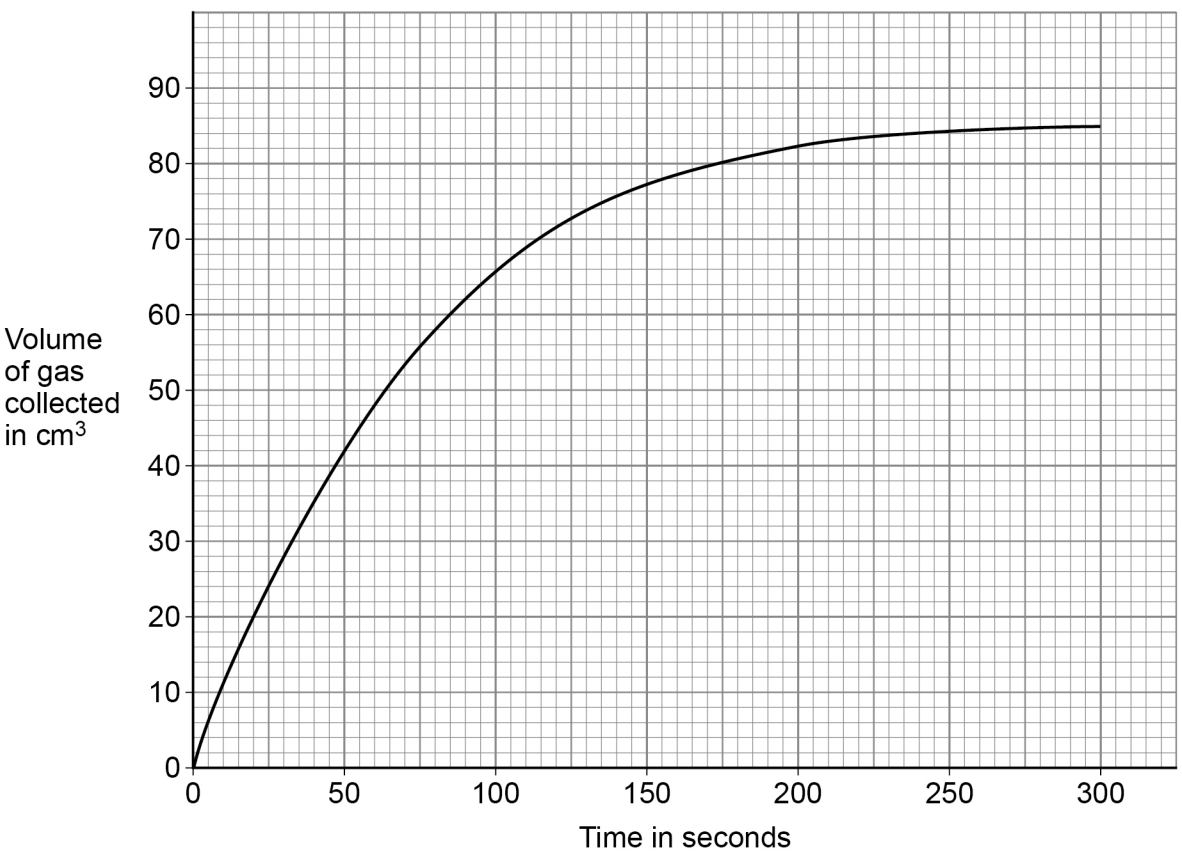
Question 5 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 19 · continued

0 5 . 6 **Figure 5** shows the results for one concentration of hydrochloric acid.

Figure 5



Determine the rate of reaction at 75 seconds.

[4 marks]

Rate = _____ cm^3/s

13

5.3.2.2 Amounts of substances in equations (HT only)

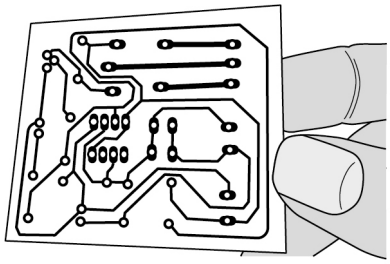
Question 20

June 2025 | 8464/C/2H | Original Q6

0 6 Gold is used in the printed circuit boards found in smartphones.

Figure 6 shows a printed circuit board.

Figure 6



A type of smartphone contains 1.73×10^{-4} moles of gold.

0 6 . 1 In one year, a manufacturer sold 2.48 million of this type of smartphone.

Calculate the total mass of gold contained in 2.48 million of these smartphones.

Give your answer in kilograms.

Relative atomic mass (A_r): Au = 197

[5 marks]

Total mass of gold = _____ kg

5.3.2.2 Amounts of substances in equations (HT only)

Question 20 · continued

0 6 . 2 What is the total number of gold atoms in one of this type of smartphone?

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

[1 mark]

Tick (✓) **one** box.

2.87×10^{-28} ☐

1.04×10^{20} ☐

3.48×10^{27} ☐

0 6 . 3 The materials in printed circuit boards can be recycled.

Bioleaching is one method used to extract gold from printed circuit boards.

Describe how bioleaching is used to extract gold.

[3 marks]

Question 6 continues on the next page

5.3.2.2 Amounts of substances in equations (HT only)

Question 20 · continued

0 6 . 4 Copper is also extracted using bioleaching.

Copper can also be extracted from low-grade ores using phytomining.

Phytomining has **not** been widely used to extract copper.

Suggest **two** reasons why.

[2 marks]

1 _____

_____

2 _____

_____

11