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 2

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.

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

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.

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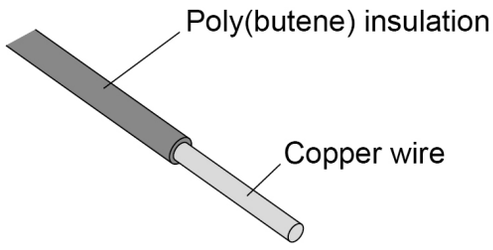
0 1 This question is about copper wire and copper compounds.

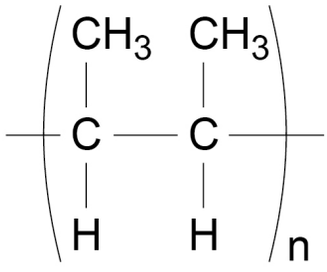
Copper is used to make electrical wires.

Figure 1 shows how copper electrical wire is insulated using an addition polymer called poly(butene).

Figure 1



0 1 . 1 The addition polymer poly(butene) has the displayed structural formula:

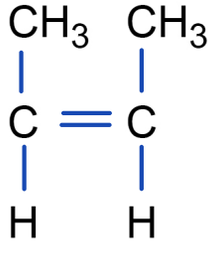


Poly(butene) is produced from the monomer butene.

Complete **Figure 2** to show the displayed structural formula of butene.

[2 marks]

Figure 2



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Copper can be obtained by recycling scrap copper wire.

0 1 . 2 Suggest why poly(butene) insulation must be removed from scrap copper wire before the copper is recycled.

[1 mark]

Otherwise copper would be impure (insulation recycled separately)

0 1 . 3 Describe how scrap copper wire can be recycled to make new copper water pipes.

[2 marks]

Copper wire heated until copper melts re-cast into pipes

0 1 . 4 Suggest **two** reasons why recycling scrap copper is more sustainable than extracting copper from copper ores.

[2 marks]

1 Recycling uses less energy

2 Conserves copper ore.

Question 1 continues on the next page

Do not write outside the box

Copper sulfate is a compound of copper.

Copper sulfate solution contains copper(II) ions and sulfate ions.

0 1 . 5 A solution can be added to copper sulfate solution to show the presence of copper(II) ions.

Name the solution added.

Give the result of the test.

[2 marks]

Name of solution added sodium hydroxide

Result blue precipitate

0 1 . 6 Describe **one** test to show the presence of sulfate ions in copper sulfate solution.

Give the result of the test.

[2 marks]

Test add acidified barium chloride solution

Result white precipitate ($BaSO_4$) formed

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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 A student investigated the change in mass when hydrated cobalt chloride was heated.

The word equation for the reaction is:

hydrated cobalt chloride ⇌ anhydrous cobalt chloride + water

This is the method used.

1. Add 2.0 g of hydrated cobalt chloride to an empty test tube.
2. Measure the mass of the test tube and contents.
3. Heat the test tube and contents gently for 30 seconds.
4. Allow the test tube and contents to cool.
5. Measure the mass of the test tube and contents.
6. Repeat steps 3 to 5 until the mass of the test tube and contents does not change.

Table 1 shows the results.

Table 1

Total heating time in seconds	Mass of test tube and contents in grams
0	26.5
30	26.2
60	25.9
90	25.6
120	25.6

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0 2 . 1 Determine the mass of the empty test tube.

[1 mark]

t=0, Mass of tube + 2.0g $CoCl_2$ = 26.5 g

∴ Mass of empty tube = 26.5 − 2.0 = 24.5

Mass of empty test tube = 24.5 g

0 2 . 2 Explain why the mass of the test tube and contents decreased.

[2 marks]

Because water vapour was produced and escaped from the tube.

0 2 . 3 Suggest why the test tube and contents were heated until the mass did not change.

[1 mark]

To make sure that the reaction was complete.

Question 2 continues on the next page

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Energy is taken in from the surroundings when hydrated cobalt chloride is heated.

0 2 . 4 When 238 g of hydrated cobalt chloride is heated until the mass does not change, 88.1 kJ of energy is taken in.

The student heated 2.00 g of hydrated cobalt chloride until the mass did not change.

Calculate the energy taken in during this reaction.

Give your answer to 3 significant figures.

[3 marks]

238 g $CoCl_2.xH_2O$ takes in 88.1 kJ

1 g " " ∴ $\frac{88.1}{238} = 0.37$ kJ

2.00 g " " ∴ $0.37 \times 2 = 0.740$ kJ

Energy taken in (3 significant figures) = 0.740 kJ

0 2 . 5 What type of reaction takes place when hydrated cobalt chloride is heated?

[1 mark]

Endothermic reaction

8

Turn over for the next question

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0 3 This question is about life cycle assessments (LCAs).

0 3 . 1 Milk bottles can be made from glass or from a polymer.

Table 2 shows information about milk bottles of equal volume.

Table 2

	Glass	**Polymer**
Raw materials	Limestone Sand Sodium carbonate	Crude oil
Energy needed to process raw materials in kilojoules	6750	1710
Energy needed to manufacture bottle in kilojoules	750	90
Mass of bottle in grams	200	20
Mean number of times used during lifetime of bottle	25	1
One disposal method at end of useful life	Recycled to make different glass products	Recycled to make different polymer products

Evaluate the use of glass for milk bottles compared with the use of a polymer for milk bottles.

Use features of life cycle assessments (LCAs) in your answer.

Use **Table 2**.

[6 marks]

Raw Materials: Crude oil is finite
Mining pollutes the environment
Glass uses more energy to process

Manufacturing: Glass uses more energy to make bottles
Glass is heavier - increased transport cost

Use & Operation: Glass bottles are reusable
Reuse of glass conserves natural resources
" " consumes energy to wash
" " " water

Do not write outside the box

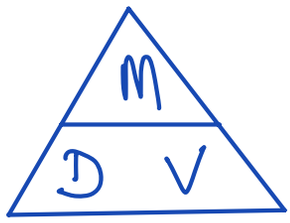
Disposal: Both glass and plastic can be recycled
Recycling polymer conserves resources
Recycling glass + polymer less energy than manufacture
Recycling reduces use of landfill.

Other Points: Energy needed may derive from fossil fuels
Use of fossil fuels causes pollution
Total energy for glass bottle (7500 kJ) greater than for polymer bottle (1800 kJ)

0 3 . 2 Milk is also sold in cardboard cartons.

A carton is made using 40 cm^3 of cardboard.

The density of the cardboard is 0.40 g/cm^3.



Calculate the mass of the carton.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

[3 marks]

$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \Rightarrow \text{Mass} = \text{Density} \times \text{Volume}$

$= 0.40\ g/cm^3 \times 40\ cm^3$

$= 16\ g$

Mass = 16 g

9

Turn over ►

Do not write outside the box

0 4 This question is about the fractions obtained from crude oil.

0 4 . 1 Crude oil is separated into fractions by fractional distillation.

The fractions obtained from crude oil include:

- lubricating oil
- naphtha
- petroleum gases.

Table 3 shows the boiling point range of these fractions.

Table 3

Fraction	Boiling point range in °C
Lubricating oil	300–350
Naphtha	90–200
Petroleum gases	< 25

Explain how these fractions are obtained from crude oil by fractional distillation.

[4 marks]

Crude oil is heated to vaporise the hydrocarbons. There is a temperature gradient in the fractionating column. so the gases condense at different levels

Do not write outside the box

0 4 . 2 Fractions from crude oil can be processed to produce feedstock for the petrochemical industry.

Which **two** are useful materials produced from this feedstock?

[2 marks]

Tick (✓) **two** boxes.

Alloys	☐	metals !
Ceramics	☐	x
Detergents	✓	
Fertilisers	☐	(contain nitrogen)
Solvents	✓	

Another fraction obtained from crude oil is petrol.

0 4 . 3 Petrol contains a hydrocarbon with the formula C_9H_{20}

Complete the equation for the complete combustion of C_9H_{20}

You should balance the equation.

[2 marks]

C_9H_{20} + 14 O_2 → 9 CO_2 + 10 H_2O

0 4 . 4 Petrol obtained from crude oil contains sulfur impurities.

Explain why sulfur impurities are removed before petrol is burned in car engines.

[2 marks]

When sulfur impurities are burned, they produce sulfur dioxide, which causes acid rain and respiratory problems.

0 4 . 5 **Table 4** shows information about two more fractions obtained from crude oil.

Table 4

Fraction	Range of number of carbon atoms in each molecule
Kerosene	11–15
Heavy fuel oil	20–40

A student predicted that heavy fuel oil is more viscous than kerosene.

The student's prediction was correct.

Justify the student's prediction.

[2 marks]

As molecular size increases, viscosity increases and heavy fuel oil has larger molecules than kerosene

Do not write outside the box

The heavy fuel oil fraction can be processed to produce smaller hydrocarbon molecules.

0 4 . 6 Name the process which produces smaller hydrocarbon molecules from heavy fuel oil.

Give the conditions used in this process.

[3 marks]

Name of process Cracking

Conditions High temperature steam / catalyst

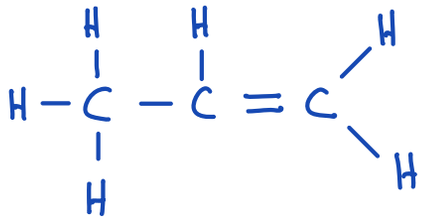
0 4 . 7 Hydrocarbon molecules containing seven and eight carbon atoms can be produced when heavy fuel oil is processed.

Which pair of hydrocarbon molecules would **both** turn bromine water colourless?

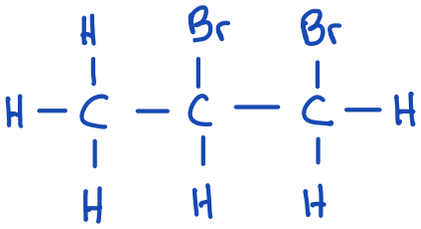
[1 mark]

Tick (✓) **one** box.

- C_7H_{14} and C_8H_{16} ☑ — C_nH_{2n+2} = alkane
- C_7H_{14} and C_8H_{18} ☐ — C_nH_{2n} = alkene
- C_7H_{16} and C_8H_{16} ☐
- C_7H_{16} and C_8H_{18} ☐



$Br - Br$



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0 5 This question is about water.

0 5 . 1 Sewage is waste water.

Sewage contains organic matter.

Describe how sewage is treated to remove organic matter.

[4 marks]

· Screening or grit removal

Sedimentation to produce sewage sludge and effluent

Anaerobic digestion of solid sewage sludge

Aerobic biological treatment of liquid effluent

Question 5 continues on the next page

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Sea water and ground water are treated to make them potable.

Table 5 shows information about the composition and treatment of sea water and of ground water.

Table 5

	Sea water	**Ground water**
Concentration of sodium ions and chloride ions before **Process 1**	Na^+ : 0.5 mol/dm^3 Cl^- : 0.5 mol/dm^3	Na^+ : 0.001 mol/dm^3 Cl^- : 0.001 mol/dm^3
Process 1	Reverse osmosis	Filtration
Concentration of sodium ions and chloride ions after **Process 1**	**X**	Na^+ : 0.001 mol/dm^3 Cl^- : 0.001 mol/dm^3
Process 2	Add ozone	Expose to ultraviolet light

0 5 . 2 Sea water is desalinated during **Process 1**.

Which pair of concentrations could represent **X** in **Table 5**?

[1 mark]

Tick (✓) **one** box.

Na^+ : 0.003 mol/dm^3 ✓	Cl^- : 0.003 mol/dm^3 ✓	☑
Na^+ : 0.003 mol/dm^3	Cl^- : 0.5 mol/dm^3	☐
Na^+ : 0.5 mol/dm^3	Cl^- : 0.003 mol/dm^3	☐
Na^+ : 0.5 mol/dm^3	Cl^- : 0.5 mol/dm^3	☐

No difference.'

0 5 . 3 Explain why the concentrations of sodium ions and of chloride ions in the ground water in **Table 5** are unchanged by **Process 1**.

[2 marks]

The Na^+ and Cl^- ions pass through the filter because the ions are in solution.

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0 5 . 4 Explain why the ground water in **Table 5** requires **Process 2** before the water is safe to drink.

[2 marks]

The ground water contains microbes which are harmful to health, so the water is sterilised to destroy the microbes.

0 5 . 5 After treatment the ground water in **Table 5** is sold by a company as pure water.

The ground water in **Table 5** is not chemically pure because the water contains sodium ions and chloride ions.

Suggest what the company means by 'pure'.

[1 mark]

The water is in its natural state, or unadulterated.

0 5 . 6 Chlorine is also used to treat some ground water.

Describe the test for chlorine gas.

Give the result of the test.

[2 marks]

Test Use damp litmus paper

Result the litmus paper is bleached, and turns white.

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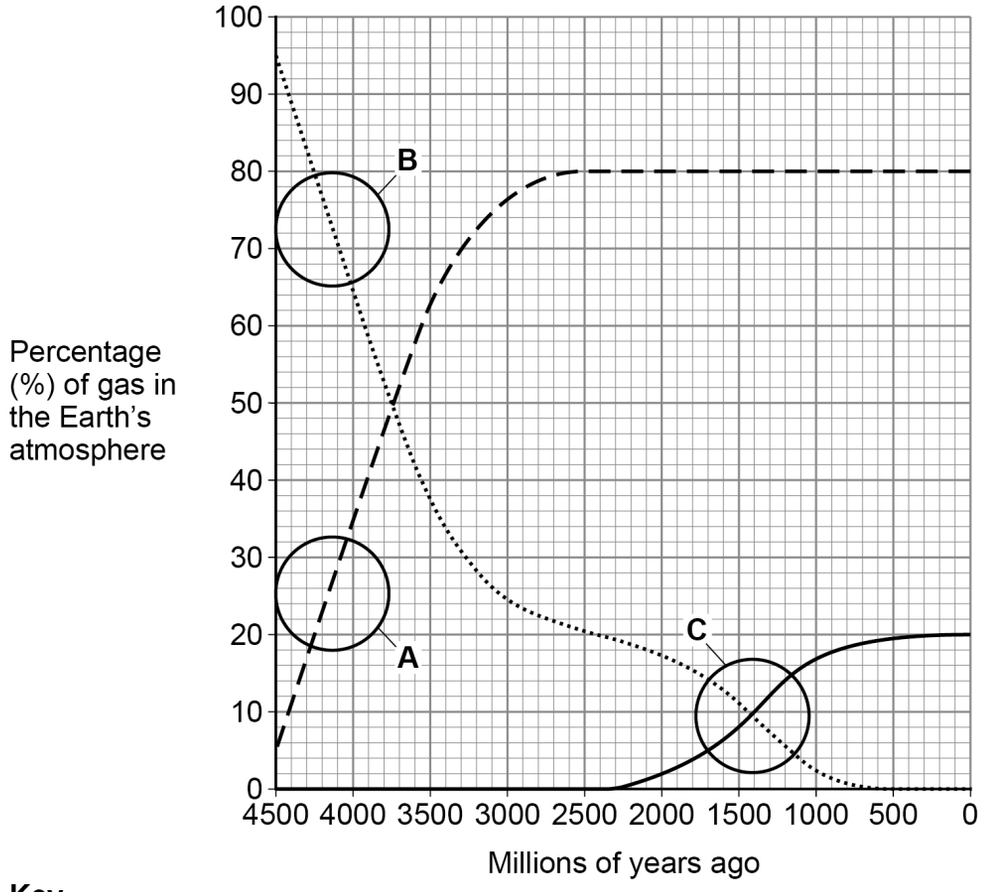
0 6 This question is about the chemistry of the Earth's atmosphere.

Figure 3 shows how the percentages of gases in the Earth's atmosphere may have changed since the atmosphere was formed.

Figure 3



0 6 . 1 Explain the change in the percentage of gas in the region labelled **A** on **Figure 3**.

[2 marks]

The percentage of nitrogen increased because of intense volcanic activity

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0 6 . 2 Explain the change in the percentage of gas in the region labelled **B** on **Figure 3**.

[2 marks]

The percentage of carbon dioxide decreased, because carbon dioxide dissolved in oceans, or formed carbonate (precipitates/sediments).

0 6 . 3 Compare the changes in the percentages of gases in the region labelled **C** on **Figure 3**.

[2 marks]

The percentage of carbon dioxide decreased and the percentage of oxygen increased.
The increase and decrease occur at similar rates.

0 6 . 4 What process caused the changes in the percentages of gases in the region labelled **C** on **Figure 3**?

[1 mark]

Photosynthesis

0 6 . 5 Natural gas is a fossil fuel.

Describe how deposits of natural gas were formed.

[3 marks]

Plankton die and the organisms were covered by sediments and subjected to high temperatures and pressures over millions of years.

10

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0 7 Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

0 7 . 1 Give the sources of the nitrogen and of the hydrogen used in the Haber process.

[2 marks]

Nitrogen air

Hydrogen natural gas

0 7 . 2 How does the equation for the reaction show that the atom economy of the forward reaction is 100%?

[1 mark]

There is only one product.

Atom economy = $\frac{\text{amount of desired product}}{\text{amount of all products}}$

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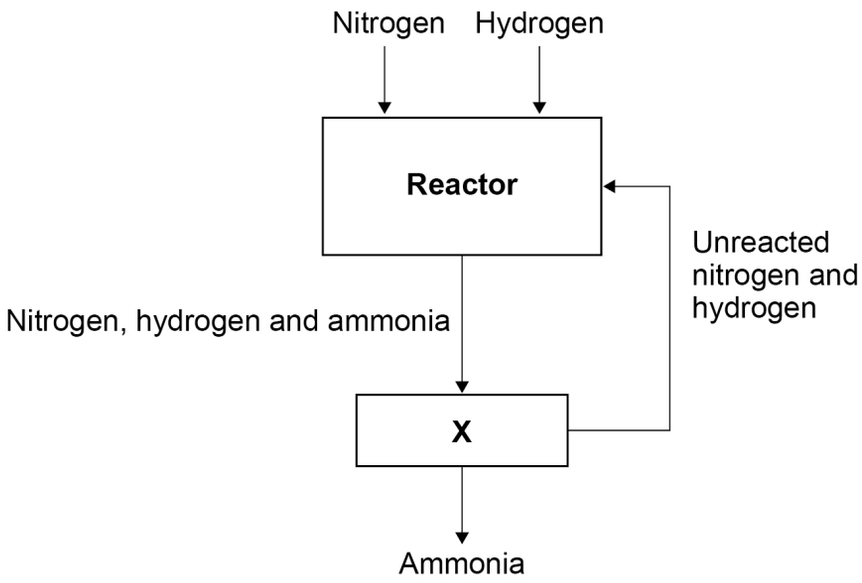
0 7 . 3 **Figure 4** represents the Haber process.

Figure 4



Explain how the ammonia produced is separated from the unreacted nitrogen and hydrogen in **X**.

[2 marks]

The mixture is cooled so that only ammonia liquefies.

Question 7 continues on the next page

The Haber process uses a temperature of 450 °C and a pressure of 200 atmospheres.

Table 6 shows the percentage yield of ammonia produced at 450 °C using different pressures.

Table 6

Pressure in atmospheres	Percentage (%) yield of ammonia
60	9
120	18
180	25
240	31
300	36
360	40
420	43

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0 7 . 4 Complete **Figure 5**.

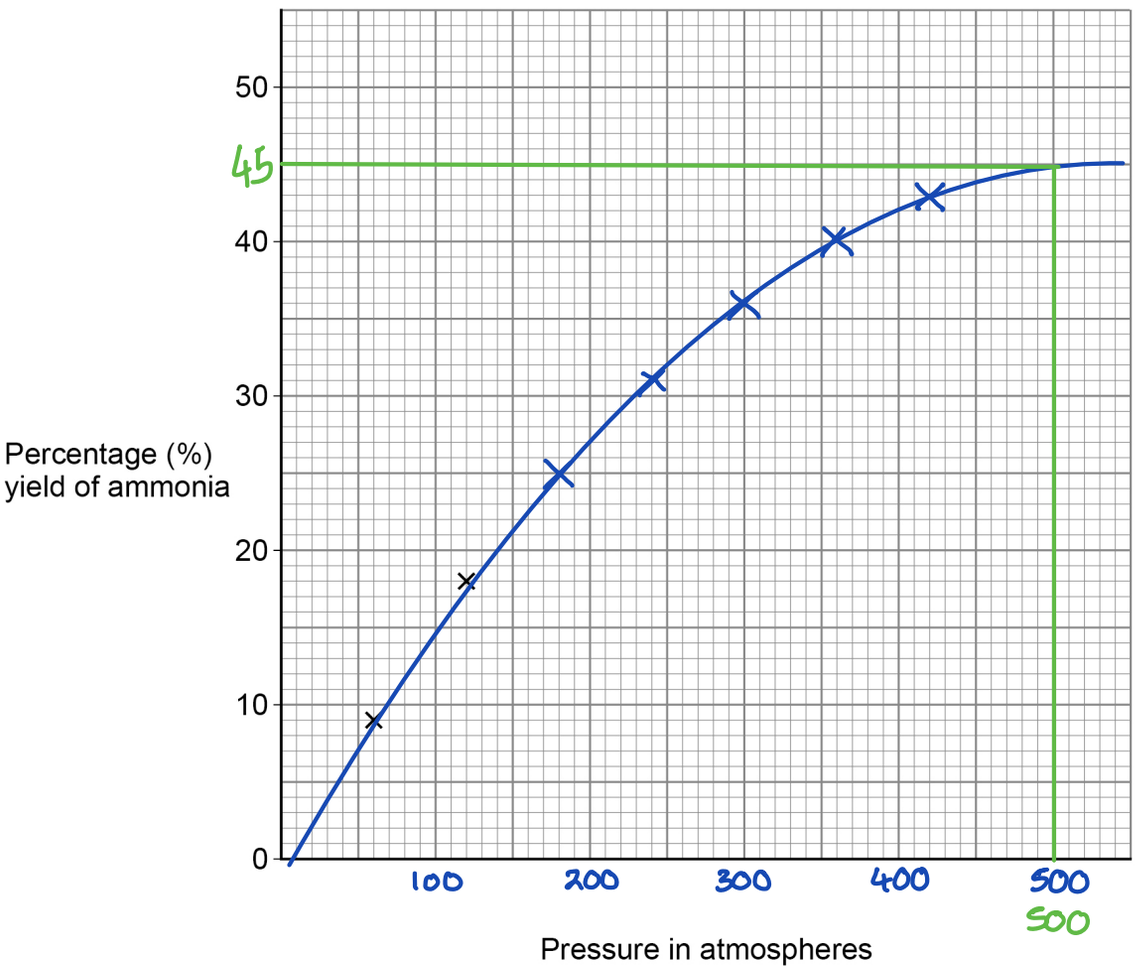
The first two points have been plotted.

You should:

- use a suitable scale for the *x*-axis
- plot the remaining data from **Table 6**
- draw a line of best fit.

[4 marks]

Figure 5



0 7 . 5 Determine the percentage yield of ammonia at 450 °C and 500 atmospheres.

Show your working on **Figure 5**.

[2 marks]

Percentage yield = 45 %

Turn over ►

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0 7 . 6 The equation for the production of ammonia in the Haber process is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic. → exothermic +heat

The conditions used are:

- a temperature of 450 °C
- a pressure of 200 atmospheres
- the presence of an iron catalyst.

Explain why these conditions are chosen for economical production of ammonia in the Haber process.

You should include references to the rate of reaction and the position of equilibrium.

[6 marks]

Rate:

Higher temperature gives higher rate because of more frequent collisions

Higher temperature gives higher rate because more particles have the activation energy.

Higher pressure gives higher rate because of more frequent collisions

Use of catalyst gives higher rate because the activation energy is lowered

Equilibrium:

Higher temperature shifts the position of the equilibrium to the left because reaction is exothermic.

Higher pressure shifts the position of the equilibrium to the right because more molecules on left hand side.

Use of catalyst has no effect on position of equilibrium

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Turn over for the next question

Other factors:

High temperature (> 450 °C) uses more energy so increases costs.

High pressure (> 200 atm) uses more energy so increases costs

High pressure (> 200 atm) requires stronger reaction vessels, so increases costs.

Use of a catalyst reduces energy costs.

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ANSWER IN THE SPACES PROVIDED

Compromise

Temperature chosen is a compromise between rate of reaction and position of equilibrium.

Temperature chosen is a compromise between rate and cost.

Pressure chosen is a compromise between yield/rate and cost.

Turn over ►

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0 8 This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

When hydrochloric acid is added to sodium thiosulfate solution, the mixture gradually becomes cloudy.

The equation for the reaction is:

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

0 8 . 1 Sulfur is produced in the reaction.

Why does the mixture become cloudy?

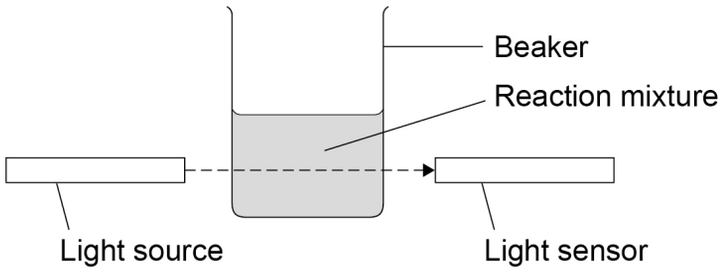
[1 mark]

Sulfur is a solid precipitate as it is insoluble

A student investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.

Figure 6 shows the apparatus used.

Figure 6



A smaller percentage of light from the light source reaches the light sensor as the mixture becomes more cloudy.

This is the method used.

1. Measure 50 cm^3 of 0.10 mol/dm^3 sodium thiosulfate solution into the beaker.

2. Add 10 cm^3 of hydrochloric acid to the sodium thiosulfate solution.

3. Immediately start a timer.

4. Record the percentage of light from the light source that reaches the light sensor every 20 seconds for 120 seconds.

5. Repeat steps 1 to 4 using 0.20 mol/dm^3 sodium thiosulfate solution.

Question 8 continues on the next page

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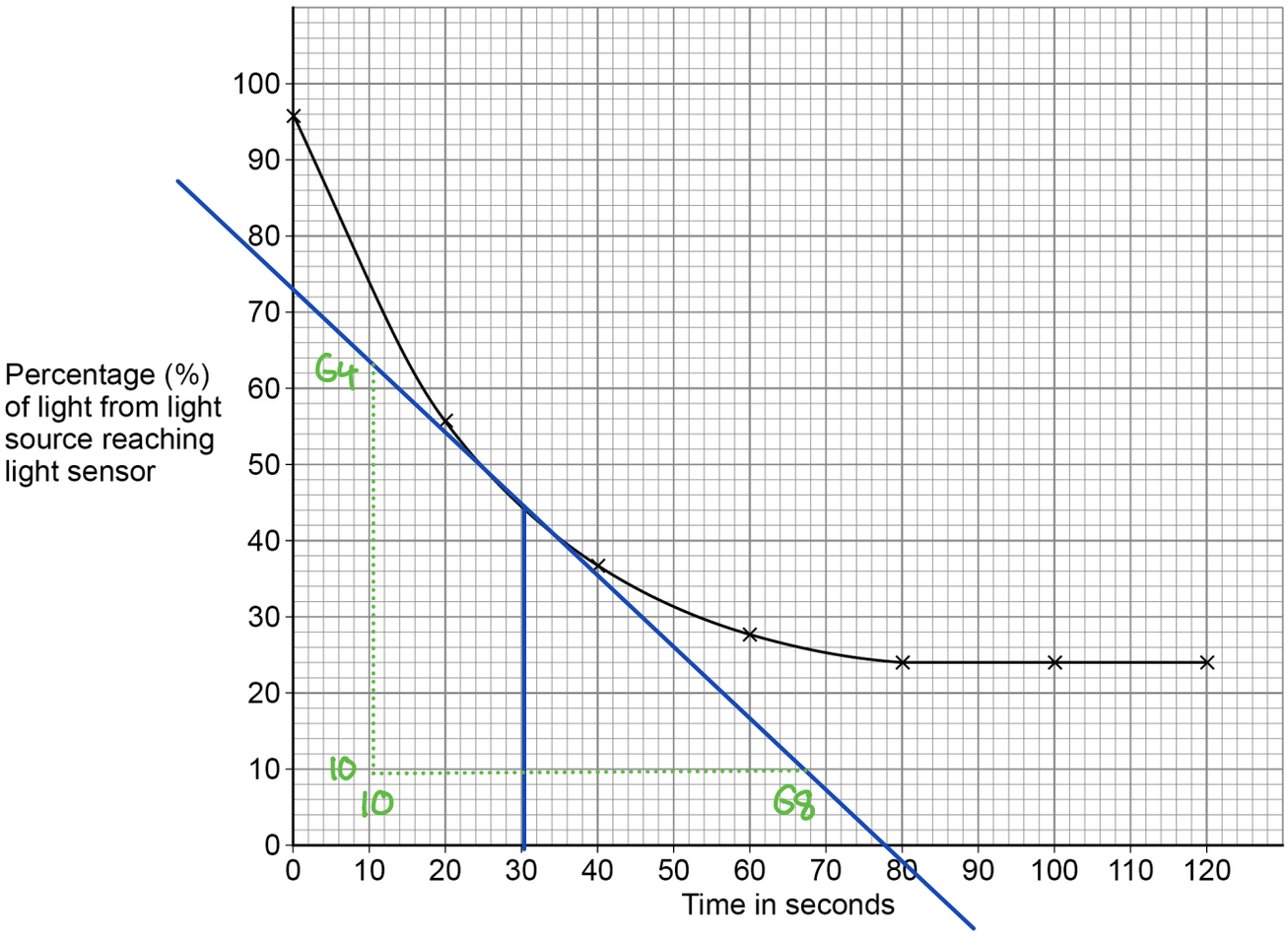
Figure 7 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Figure 7



Gradient = $\frac{\text{Change in } y}{\text{Change in } x}$

$= \frac{10 - 64}{68 - 10}$

$= -0.9310 \ \% \ s^{-1}$

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0 8 . 2 The percentage of light reaching the light sensor decreases by 1% when 7.1×10^{-5} moles of sulfur is produced.

Determine the rate of reaction in mol/s for the production of sulfur at 30 seconds.

You should draw a tangent on **Figure 7**.

[5 marks]

Gradient of tangent to curve at $t = 30$ s = rate

Gradient $= -0.9310$ % s^{-1}

Light decreases by 1% when 7.1×10^{-5} mol S produced.

∴ Rate $= -0.9310$ % $s^{-1} \times 7.1 \times 10^{-5}$ mol %$^{-1}$

$\simeq -6.61 \times 10^{-5}$ mol s^{-1}

(− sign shows % light or concentration decreasing)

Rate = 6.61×10^{-5} mol/s

0 8 . 3 Explain why the rate of reaction changes between 0 and 60 seconds.

Answer in terms of concentration.

Use **Figure 7**.

[2 marks]

Rate decreases because concentration of reactants decreases.

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Figure 8 is a repeat of **Figure 7**.

Figure 8

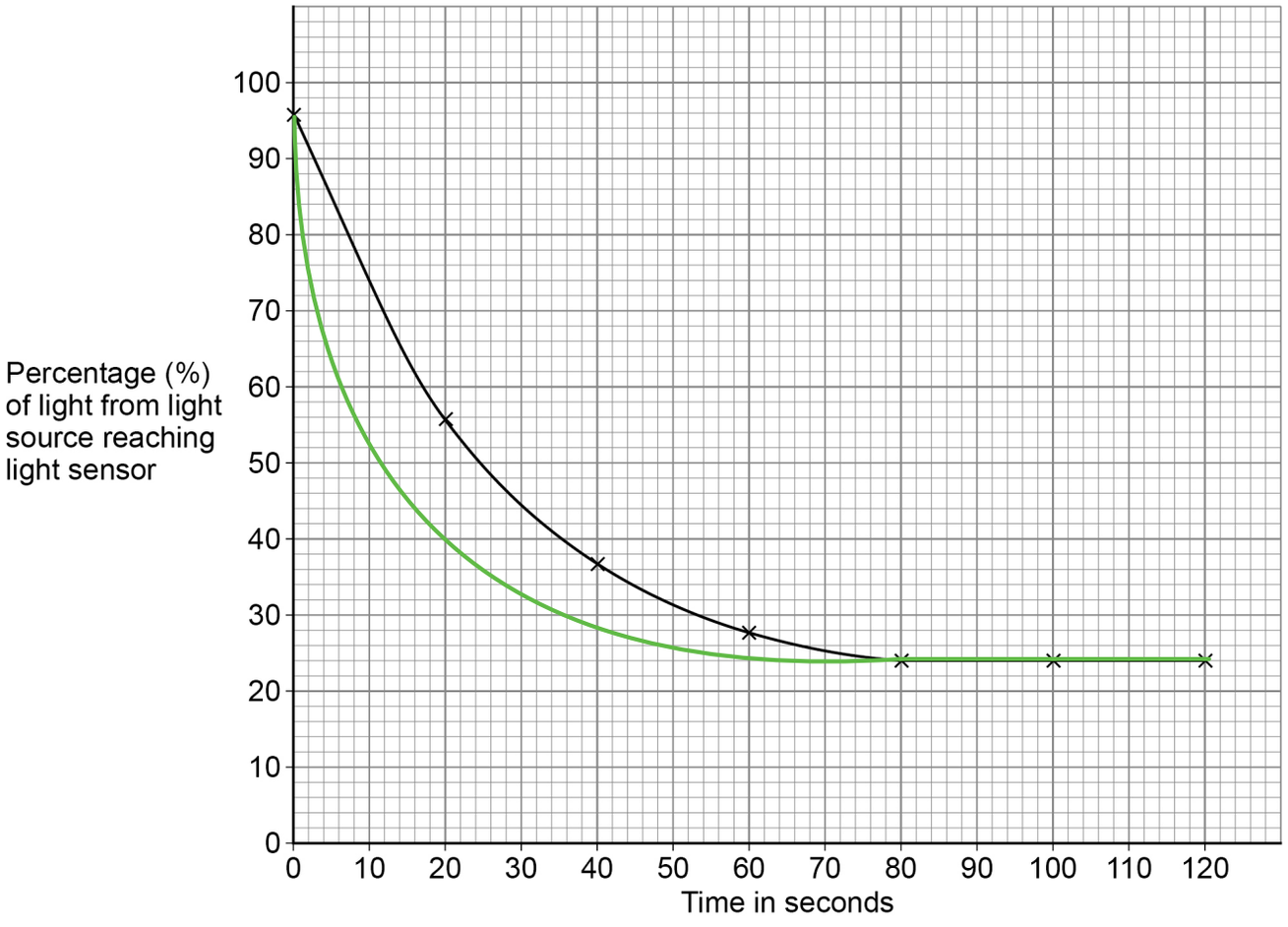

Figure 8 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Sodium thiosulfate solution was in excess in the investigation.

0 8 . 4 The line of best fit on **Figure 8** is horizontal between 80 and 120 seconds because the reaction stopped.

Why did the reaction stop?

[1 mark]

(Sodium thiosulfate is in excess). Therefore the reaction stopped as the hydrochloric acid is used up.

0 8 . 5 Sketch a line on **Figure 8** to show the results you would predict for 0.20 mol/dm^3 sodium thiosulfate solution.

[2 marks]

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The same student did the investigation again the next day.

The student found that the same method produced different results for the percentage of light reaching the light sensor.

0 8 . 6 How could the student improve the method so that the same percentages of light reached the light sensor?

[1 mark]

Tick (✓) **one** box.

Record the percentage of light every 10 seconds. ☐

Stop light from other sources reaching the light sensor. ☑

Use a larger volume of sodium thiosulfate solution. ☐

Use a more sensitive light sensor. ☐

0 8 . 7 The student improved the method so that similar results were obtained on different days.

What name is given to similar results obtained on different days under the same conditions by the same student?

[1 mark]

Tick (✓) **one** box.

Anomalous ☐

Precise ☐

Repeatable ☑

Reproducible ☐

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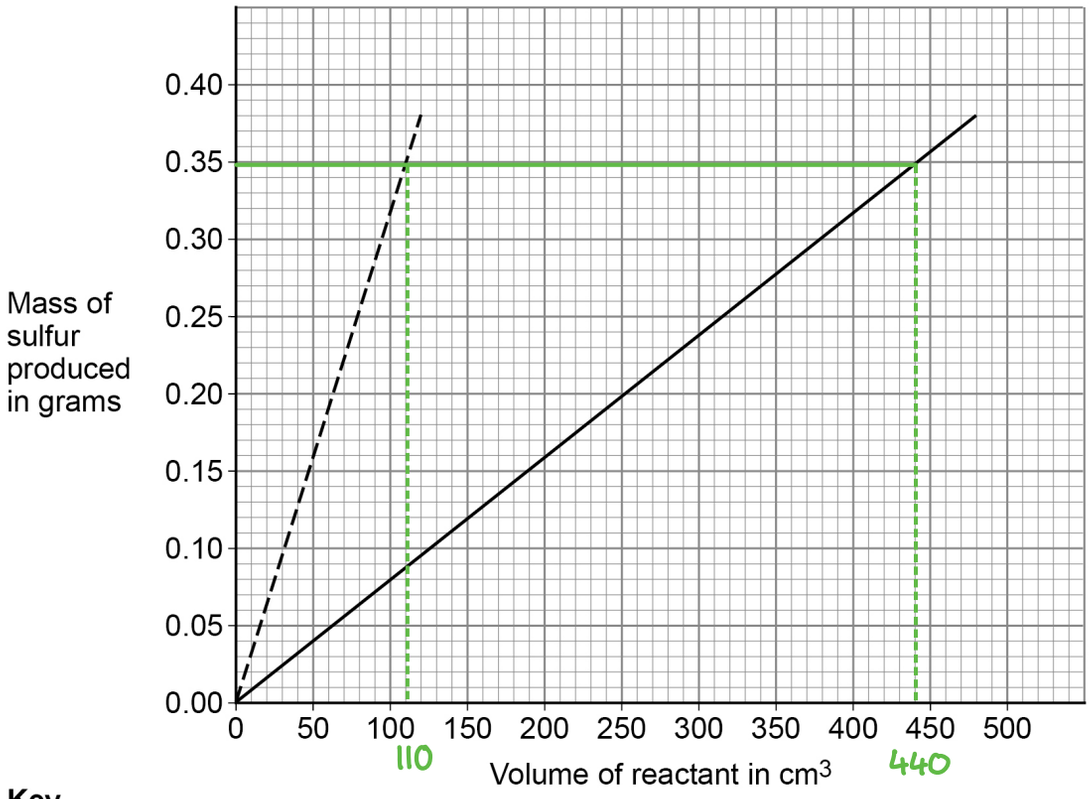
Figure 9 shows the volumes of:

- sodium thiosulfate solution of concentration 0.10 mol/dm^3
- hydrochloric acid of concentration 0.05 mol/dm^3

which completely react to produce different masses of sulfur.

Figure 9



Key

– – – 0.10 mol/dm^3 sodium thiosulfate solution

—— 0.05 mol/dm^3 hydrochloric acid

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0 8 . 8 Which expression represents the relationship between the volume (V) of sodium thiosulfate solution used and the mass (m) of sulfur produced?

Use **Figure 9**.

[1 mark]

Tick (✓) **one** box.

V ∝ m ✓

V ~ m

V << m

V = m

0 8 . 9 Determine the simplest whole number ratio of the volumes of

sodium thiosulfate solution : hydrochloric acid

which completely react with each other.

Use **Figure 9**.

[3 marks]

Volume of $Na_2S_2O_3$ and HCl at any fixed mass.

$$\frac{\text{Volume of } Na_2S_2O_3 \text{ solution}}{\text{Volume of HCl solution}}$$

@ M = 0·35

$= \frac{110}{440} = 0.25$

$Na_2S_2O_3$: HCl

110 : 440

1 : 4

Simplest whole number ratio = 1 : 4

END OF QUESTIONS

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

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