



GCSE

Combined Science: Trilogy

8464/C/1H Combined Science: Trilogy Chemistry Paper 1H

Report on the exam

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Overview

This paper is one of the six examined components for Combined Science: Trilogy. All of these papers follow a similar structure and test the same assessment objectives.

This paper has 70 marks available to students and is made up of seven questions.

- Approximately 40% of marks assess AO1; 40% of marks assess AO2; and 20% of marks assess AO3.
- Approximately 40% of marks target Standard demand, 40% of marks target Standard/high demand and 20% of marks target High demand.

Questions 1, 2 and 3 on this paper and questions 6, 7 and 8 on the Foundation Tier paper are common. These questions are identical and are targeted at standard demand.

Questions are set at three levels of demand for this paper:

- **Standard demand** questions are designed to broadly target grades 4–5.
- **Standard/high demand** questions are designed to broadly target grades 6–7.
- **High demand** questions are designed to broadly target grades 8–9.

A student's final grade is based on their attainment across all six papers.

Summary of overall performance

In the extended response question common with the Foundation tier (question 03), students were better at describing bonding than structure.

Students had several opportunities to demonstrate use of correct chemical terminology and understanding of chemical processes (questions 07.1 and 07.2). Knowledge of the electrolysis of aluminium was not well demonstrated.

Generally, students found application (AO2) and analysis (AO3) questions more challenging and many of these questions were not well answered (eg 01.2, 04.3, 04.7, 06.2 and 07.1).

The questions assessing maths skills in this paper (01.3 and 01.7 and graph plotting in 02.4 which were at standard demand) were generally answered well, with the exception of some unstructured calculations and one including standard form (questions 05.2, 05.3 and 08.3) which were at standard/high and high demand.

Less than 20% of students gained full marks in any of the recall questions (AO1) at standard/high demand (04.1, 04.4, 06.3 and 06.4) although these questions did differentiate between students well.

Some questions about practical techniques proved more difficult than others. Students were better at describing different steps taken in Required Practical Activities than suggesting improvements or interpreting results.

Question 1 (standard demand)

- 01.1** Nearly three-quarters of students scored at least 1 mark. The graph showed that the mass of copper produced each year slowly increased from 1900 to 1930 and then rapidly increased until 2010. Students were asked to give two conclusions, so statements that merely quoted numerical values and years from the graph or made predictions of the future were insufficient.

Non-creditworthy responses referred to use or demand of copper or involved incorrect readings, for example 'rapid increase from 1950' (rather than from 1925 to 1930) was common.

- 01.2** Students should know that metals are soft so are mixed with other metals to make alloys, which are harder. A diagram representing the structures of pure copper and of an alloy of copper and zinc was given that showed larger zinc atoms disrupting the layers of atoms in the alloy, thus the layers of atoms cannot easily slide. Some students did not read the question carefully and talked about copper rather than the alloy.

Just under half of students gained 1 mark or more and approximately a quarter of students scored 2 marks or more. Those who gained a mark usually referred to the difference in the sizes of the atoms and the second most common mark was for layers not being able to slide. The diagram showed that the layers are distorted in the alloy compared to the pure metal but this marking point was less frequently given.

- 01.3** In this calculation students were told that the alloy contains 13.5% zinc by mass and were asked to calculate the mass of copper in the alloy. As always there are a number of approaches students took and those who showed their working often gained credit even after making errors. In the calculation working with an accompanying percentage sign, such as 13.5% or 86.5% are considered to be equivalent to $13.5 \div 100$ and $86.5 \div 100$ respectively eg 13.5% of 5.25 gains marking point 1 in the second method.

Nearly two-thirds of students scored 4 marks. Those who only gained 3 marks either failed to round their answer to 3 significant figures or determined the mass of zinc rather than the mass of copper.

0 6 . 3 A 5.25 g sample of an alloy of copper and zinc contains 13.5% zinc by mass.
Calculate the mass of **copper** in the 5.25 g sample.
Give your answer to 3 significant figures. [4 marks]

$13.5\% \text{ of } 5.25 = 0.70875$

0.709

This response (from a Foundation tier paper) used mark scheme method 2. The student correctly determined the mass of zinc to 3 significant figures but did not subtract this from the mass of the sample. They achieved marking points 1, 2 and 4 so scored 3 of the 4 marks.

0 1 3 A 5.25 g sample of an alloy of copper and zinc contains 13.5% zinc by mass.

Calculate the mass of **copper** in the 5.25 g sample.

Give your answer to 3 significant figures.

[4 marks]

$$\cancel{13.5 \times 100 = 1350}$$

$$\cancel{13.5} : 16$$
$$1 : 4 = 5$$

$$\cancel{5.25} = 5.25 \times 13.5\% = 0.709$$

$$\frac{5.25}{5} = 1.05 \quad 1.05 \times 4 = 4.2$$

Mass of **copper** (3 significant figures) = 4.20 g

This response (from a Higher tier paper) has several different methods in the answer box. Initially the student might gain marking points 1, 2 and 4 from method 2 (as the previous example did). However, the student then gives a totally different method which gives the answer on the answer line and this is the one that takes precedence so the method attached to this is the one that is marked. Although 4.20 is correctly rounded to 3 significant figures it does not come from a calculation using all values in the question (ie 13.5% has not been used) so gains no credit.

Question 2 (standard demand)

- 02.1** By selecting H_2SO_4 70% of students answered correctly. HCl was the most common incorrect response.
- 02.2** Excess copper carbonate is used to ensure all the acid reacts. More than a quarter of students answered this correctly. Common incorrect responses included that copper carbonate needs to dissolve, to make sure all the copper carbonate reacted (rather than the acid), to get the most product, so everything had reacted or in terms of the rate of reaction. In responses 'it' refers to copper carbonate.

07.2	Why is excess copper carbonate used in stage 1?	[1 mark]
<i>So that we know we have added enough for the it to have fully reacted.</i>		
02.2	Why is excess copper carbonate used in stage 1?	[1 mark]
<i>so the acid is fully neutralised or reacted</i>		

The first response (from a Foundation tier paper) is not creditworthy as 'it' refers to the copper carbonate. The second response gains a mark as 'acid is the limiting reactant' or 'to fully neutralise the acid' are equivalent to all the acid reacting.

- 02.3** The method would work if filtration was carried out immediately before or after heating so was ignored in any response. Just over a third of students gained both marks.

0 7 . 3 Beaker N contained copper sulfate solution.

Describe how the student could produce copper sulfate crystals from the copper sulfate solution in beaker N.

[2 marks]

The student could heat it with a bunsen burner ~~and~~ until it boils and then pour it out on a tray

0 2 . 3 Beaker N contained copper sulfate solution.

Describe how the student could produce copper sulfate crystals from the copper sulfate solution in beaker N.

[2 marks]

By filtering it and then heating the solution up, leaving to cool for 24 hours and patting it dry as crystals have formed.

The first response gains the first mark but there is insufficient detail to gain the second mark (leave to cool/crystallise). In the second response (from a Higher tier paper) filtering is ignored and 2 marks are awarded.

- 02.4** At low demand all points would lie exactly on a 'line of best fit' whereas at standard demand there will be points either side of the line as below, so students need to 'make a decision' when drawing their line. The line of best fit did not need to extend beyond the five points, although extrapolations were allowed and many included the origin (0,0). If students plotted any point(s) incorrectly they could still gain the mark for 'their' line of best fit.

A large number of students did not use a ruler and as such were unable to draw an acceptable straight line. Nearly two-thirds of students gained all 3 marks and more than a third 2 marks.

- 02.5** Investigation of mass changes using various apparatus is an opportunity for skill development in the specification, eg thermal decompositions of metal carbonates. This was not well answered on this paper. Many students incorrectly referred to evaporation or gave answers such as 'some of it escapes', which is insufficient. Some recognised that a gas is made but needed to say that the gas escapes to explain the decrease in mass.

Question 3 (standard demand)

- 03** This was an 'extended response' style of question. Such questions are marked holistically. There are overall generic descriptions for the two levels of response at the top of the mark scheme, giving a hierarchy of response. Within each level there are 3 marks.

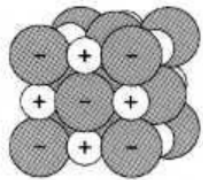
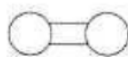
Students were asked to compare the structure and bonding of sodium chloride and oxygen; diagrams which represent the structures were given. The indicative content was not an exhaustive list and examiners used professional judgement with other content.

At Level 1, students needed to identify some relevant features of each substance and note some differences. To enter Level 2 students needed to clearly show the way(s) in which the structure and bonding of the two substances are similar/different and note the magnitude of the similarity/difference. Examples of magnitude include strong (bond), weak (forces), giant (structure of ions), small (molecule) and two or one (elements). To access Level 2 a minimum of four comments on the relevant features were required, at least one of which must include a comparison, and a reference to magnitude had to have been made. To gain 5 or 6 marks there needed to be a minimum of two comparative statements, a reference to magnitude and statement(s) referring to the structures.

Students often gave sufficient relevant features; many included properties, which was ignored. Those responses that did not access Level 2 usually did not include *both* a comparison *and* reference to magnitude. There were, however, some excellent and concise 6-mark descriptions that included a minimum of two comparisons, one of which included the structures and magnitudes of both substances.

Table 8 shows diagrams which represent the structures of two substances.

Table 8

Substance	Structure
Sodium chloride NaCl metal + non	
Oxygen O ₂ non	

Compare the structure and bonding of sodium chloride and oxygen.

[6 marks]

Sodium chloride is ionic bonding which is between a metal and a non metal. They use electrostatic forces to transfer electrons. They create giant structures and have a high melting point. ① Oxygen is a non metal which is used for covalent bonding as is for two non metals. They have strong covalent bonds but have weak intermolecular forces. They can conduct electricity. ① They can also conduct electricity but only when molten

This response (from a Foundation tier paper) includes references to magnitude (*weak* intermolecular forces and *strong* bonds) and sufficient indicative content to access Level 2 (bullet points 4, 10, 11, 15). However, there is no comparison (simply a list of statements referring to sodium chloride and then a list for oxygen), so the response does not meet the Level 2 descriptor. They have identified a number of relevant features, so the response was awarded 3 marks, top of Level 1.

Table 8 shows diagrams which represent the structures of two substances.

Table 8

Substance	Structure
Sodium chloride NaCl	
Oxygen O ₂	

Compare the structure and bonding of sodium chloride and oxygen.

[6 marks]

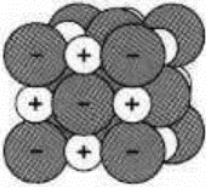

Oxygen is an element and Sodium Chloride is a compound which is arranged in a lattice structure with positive and negative ~~ions~~ ions. Oxygen has 2 Sodium Chloride has ~~strong~~ ionic bonds.

This response (from a Foundation tier paper) is set out as a comparison with sufficient indicative content to access Level 2 (bullet points 5, 3, 9 and 8) but there is no reference to magnitude (strong/weak, giant/small or one/two element(s)). Therefore, similarly to the previous example, the response does not meet the Level 2 descriptor. It was awarded 3 marks.

0 3

Table 2 shows diagrams which represent the structures of two substances.

Table 2

Substance	Structure	
Sodium chloride NaCl		Ionic
Oxygen O ₂		Covalent

Compare the structure and bonding of sodium chloride and oxygen.

[6 marks]

In NaCl, ionic bonding occurs. Sodium will transfer its outer electron to chlorine to form a positive ion and when chlorine receives this transferred electron, it will form a 1⁻ ion. Due to the ions being oppositely charged, strong electrostatic forces hold them together. In O₂ however, covalent bonding occurs as it is non metal and O₂ will form a double covalent bond as it shares 2 electrons from their outer shell with each other in order to get a full outer shell and make it stable.

This response (from a Higher tier paper) is set out as a comparison (use of 'however' on line 8) with sufficient indicative content to access Level 2 (bullet points 8, 9, 10, 11, 13 and 14). Bullet points 1 and 2 are mentioned for oxygen but not sodium chloride. In addition to the comparison a reference to magnitude (*strong* electrostatic forces) is included so 4 marks are awarded. Statement(s) referring to the *structure* of sodium chloride and/or oxygen were required for 5+ marks.

Question 4 (standard & standard/high demand)

04.1 Many students stated that strong acids completely ionise but omitted to include that this happens in water or in aqueous solution. 10% of students gave the correct definition.

04.2 Less than 5% of students gave a correct explanation for 'dilute aqueous solution'. Very few students made reference to being dissolved in water or used the term (low) concentration.

Common incorrect responses made reference to reducing the concentration of the acid or stating that there would be a small volume of acid per unit volume or small volume of acid in aqueous solution. A number of students stated that a high concentration of substance/acid had been dissolved.

04.3 This question proved challenging. To deduce the change in the hydrogen ion concentration students need to know that as the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10. A third of students gained the mark with approximately equal numbers choosing the alternative responses.

04.4 Nearly one-fifth of students were able to recall an ionic equation to represent the neutralisation between an acid and an alkali. This question had the highest not attempted rate at 12.5%, which was nearly double that of any other question. A common response was 'acid + alkali → salt' suggesting that students were not familiar with the ions present in acid or alkaline solutions or that this involved neutralisation to produce water.

04.5 Most students were able to deduce the correct ratio of moles from the equation. The most common distractor was 2:1 where the correct ratio was reversed.

04.6 Just over half of students recognised that universal indicator would turn red in the acidic solution produced when magnesium carbonate and excess nitric acid were reacted. Green was the most common distractor which was not correct as excess acid was used in the reaction.

04.7 This question required improvements to the method, so references to changing the volume or concentration of solution were insufficient. Many students wrote that the experiment should be repeated but to be creditworthy they needed to include that the mean should be calculated. 'Measuring until the temperature stopped increasing' was taken as equivalent to 'measure the highest temperature'. However, 'measuring until the temperature is constant' is insufficient as this may not be the highest temperature or the mixture may have cooled to room temperature.

Just under a quarter of students gained 1 mark and 1% gained 2 marks.

04.7

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 Repeat more than 5 times

2 Have more nitric acid. ~~Measure the temperature of the acid before~~

This student did not gain any credit: repeating the experiment on its own is insufficient as the mean is not calculated (after anomalous results are discarded).

Question 5 (standard/high & high demand)

- 05.1** Around two-thirds of students were able to complete the dot and cross diagram for an ammonia molecule.

Some students gained just 1 mark for correctly adding either three shared pairs of electrons or two non-bonding electrons on the outer shell of nitrogen, or included non-bonding electrons on hydrogen, so were not able to access mark point 2.

- 05.2** In this reacting mass calculation students were asked to calculate the mass of hydrogen needed to produce 25 g of ammonia. As always, a number of approaches were taken and students who showed their working often gained credit even after making errors. More than half of students scored at least 1 mark.

Those who answered with a moles method usually scored 4 marks for the correct answer, 3 marks for 2.94 g (because they missed the molar ratio) or 1 mark for determining the M_r of ammonia.

Those who used a ratio method usually either scored 4 marks for the correct answer or 1 mark for $2 \times M_r$ of ammonia; few showed clear working to gain either marking point 2 or marking point 3.

- 05.3** In this question students were asked to calculate the bond energy for the H—H bond. The working for breaking bonds needed to show that the values 945 and $3X$ have been added together.

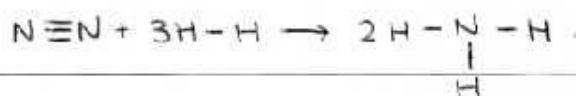
Many students were good at calculating the energy changes for bonds broken but went on to simply subtract the bond breaking value from the bond making value without taking into account the H—H bond energy. In the reaction more energy was released than was needed to break existing bonds so this value, 93 kJ/mol, needed to be correctly used in the next stage of the calculation before the H—H bond energy was determined by dividing by 3.

This question differentiated well, with higher-attaining students showing clear working where they equated the energy released to the difference between the bonds made and the bonds broken.

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

Use Figure 7 and Table 3.

[5 marks]



$$\text{N}\equiv\text{N} = 945$$

$$\text{H}-\text{N} = 391$$

$$6(391) = 2346$$

$$945 + 3\text{H}-\text{H} \rightarrow 2346$$

$$2346 - 93$$

$$2346 + 93 = 2349$$

$$\cancel{2346 - 945 = 1401}$$

$$= 2253$$

$$2349 - 945 = 1404$$

$$\cancel{1401 - 3 = 467}$$

$$2253 - 945$$

$$1404 \div 3 = 468$$

$$= 1308$$

$$\cancel{1308 \div 3 = 436}$$

$$x = 467 \quad \begin{array}{l} 436 \\ 998 \end{array} \text{ kJ/mol}$$

This student gained 3 marks for 498 kJ/mol. They gained the first 2 marks for calculating the energy to break bonds and the energy released when bonds are made but did not then include the value of 93 so were unable to gain the next 2 marks. They then correctly divided 1494 by 3 to determine the average H—H bond energy so gained the final mark.

The student has made three attempts at the calculation, two of which they have crossed out. In the middle they did not use the value of 93, which gave a common incorrect answer of 436; this answer would have also scored 3 marks. On the right (also crossed out) they used the value of 93 correctly to give the correct answer of 436, which would have scored all 5 marks.

05.4 This question was well answered with approximately 20% of students gaining 3 marks, 40% gaining 2 marks and 20% of students gaining 1 mark.

Those students who gained 2 marks usually either drew the arrow indicating the overall energy change incorrectly or completed a correct profile for an endothermic reaction.

When 1 mark was scored this was usually for the correct shape for an exothermic reaction but labels for reactants and/or product were omitted and the arrow indicating the overall energy change was incorrect. On this occasion any sort of arrow was allowed accompanied with the label for the overall energy change, and ΔH is an equivalent response for the label.

Question 6 (standard, standard/high & high demand)

- 06.1** Many students correctly named a metal that is found in the Earth as the metal itself. The most common answer was gold.
- 06.2** Students were given a reactivity series and asked to suggest the most economical method for extracting a metal from its metal oxide. 18% of students answered this correctly. Electrolysis was a common incorrect response as this would not be the most economical method.
- Many students used 'it' in their response but 'it' refers to the metal so heating 'it' with carbon was not creditworthy but displacing 'it' with carbon was.
- 06.3** Few students were able to identify that cryolite was the unknown substance in the molten mixture used in electrolysis to extract aluminium from aluminium oxide.
- 06.4** This question proved challenging with just under 10% gaining 2 or 3 marks. It was common for students to refer to oxygen being attracted to the electrode or oxide ions reacting with carbon. Some answers focused on explaining why oxygen gas was produced, suggesting that oxide ions were discharged because of the absence of halide ions but not then describing what further happens to the oxygen and the electrode whilst others described the production of aluminium by the reduction of aluminium ions. Thus, oxygen being produced at the positive electrode was frequently omitted.

When students gained 1 mark it was either for saying that carbon dioxide is produced or that the electrode has to be continually replaced.

06.4

Explain what happens to the positive carbon electrodes during the extraction of aluminium from aluminium oxide.

[3 marks]

During the aluminium ^{oxide} extraction.
The oxygen goes to the carbon ^{electrode} ~~electrode~~.
The oxygen and carbon react to form carbon dioxide, and the electrodes start to wear away.

This response does not state that oxygen is produced at the positive electrode but 2 marks are awarded for oxygen reacting with the carbon electrode to form carbon dioxide (so the electrode) has to be continually replaced.

- 06.5** Students found writing the half equation at the negative electrode to show the reduction of aluminium ions very challenging. A number did not attempt the question and few gained 2 marks. One mark was infrequently scored, since identifying the correct reactants and not the balancing appeared to be the problem.

Question 7 (standard/high & high demand)

07.1 This question was a good differentiator between students. Electron transfer from a metal to a non-metal to form an ionic compound is frequently asked.

Most students understood the processes involved in this question, but their weak use of chemical language meant they often did not achieve the marks. Students often referred to calcium and chlorine, rather than calcium atoms and chlorine atoms. There were many incorrect terms such as 'atoms sharing electrons to form ionic bonds', 'metal ions losing electrons' and 'non-metal ions gaining electrons'. Formation of Ca^+ was a common misconception, rather than recognising that two electrons are lost by one calcium atom and two chlorine atoms each gain one electron. To achieve the final mark students had to use the word 'ion', and this was often missing. A common error was for students to write chlorine ion instead of chloride ion.

0 7 . 1 Calcium reacts with chlorine to produce calcium chloride.

Explain what happens to calcium atoms and to chlorine atoms when calcium reacts with chlorine to produce calcium chloride.

[4 marks]

When calcium reacts with chlorine to produce calcium chloride, the atoms share electrons. Calcium is in group 2 meaning it has 2 electrons on its outer shell and chlorine is in group 7 meaning it has 7 electrons on its outer shell. Two chlorine atoms will be present shared with one calcium atom so that each chlorine atom gets 1 electron to complete its outer shell.

A number of students did not appreciate that ionic bonding occurs when a metal reacts with a non-metal. The sharing of electrons described here contradicts the transfer of electrons from the metal to the non-metal for the first two marking points. This response gains 1 mark for the correct ratio between calcium atoms and chlorine atoms but does not say that ions are formed.

07.2 This question was also a good differentiator between students. Nearly half of students were able to gain some credit but few gained all 4 marks. Those students who gained 1 or 2 marks invariably described chlorine as having fewer shells, that the outer shell is closer to the nucleus or that chlorine atoms gain an electron more easily (or the converse for bromine). A stronger attraction between the nucleus and the electron gained was rarely seen.

07.3 Students were given the boiling points of four hydrogen halides and were asked to describe how the boiling points change as the relative formula mass changes. Many students found it challenging to interpret the negative numbers and deduced an incorrect trend whilst others referred to the halogens and not the hydrogen halides. Few gained 2 marks by correctly stating that the boiling points increase as the formula mass increases and that HF was anomalous and does not follow the trend.

Question 8 (standard & high demand)

08.1 A third of students scored one mark. A diagram was included to help students describe the structure of fullerenes as based on hexagonal rings of carbon atoms.

08.2 A third of students gave an appropriate use of nanotubes.

08.3 In this question students were asked to calculate the number of moles of carbon in a nanotube that contains 2380 carbon atoms. Students needed to divide the number of carbon atoms by the Avogadro constant. Just under 20% of students gained 1 mark with about half of these being able to continue and evaluate the expression correctly.

08.4 Students found it challenging to explain why carbon nanotubes can conduct electricity. Responses were frequently too vague to access a marking point. Those who looked at the diagram of the nanotube would have seen that each atom forms three covalent bonds. Students might have linked the hexagonal structure as also being present in the more familiar structures of graphene and graphite where one electron from each atom is delocalised and that these delocalised electrons carry electrical charge through the structure.

08.4 Explain why carbon nanotubes can conduct electricity.

Refer to bonding between carbon atoms in your answer.

[3 marks]

- Strong covalent bonds between carbon atoms
- sea of delocalised electrons that are free to move.
- They carry current meaning they conduct electricity.

Each of the three statements in this response is close to one of the marking points but is not sufficient to gain credit:

- strong covalent bonds also exist in diamond where each carbon atom forms 4 covalent bonds
- the origin of the delocalised electrons has not been stated
- the word 'they' could refer to the carbon atoms or the delocalised electrons, but there is no reference to 'carry charge through the structure' so the mark is not awarded.

Contact us

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

Tel: 01483 477756

Email: gcsescience@aqa.org.uk

aqa.org.uk